LOWER CREEK

WATERSHED MANAGEMENT PLAN

CATAWBA RIVER BASIN
CALDWELL AND BURKE COUNTIES
NORTH CAROLINA

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Table of Contents

1.0 EXECUTIVE SUMMARY

In 2003, the North Carolina Ecosystem Enhancement Program (EEP) began its local watershed planning effort in the Lower Creek watershed, which drains 98 square miles in Caldwell and Burke Counties. Its objectives were to (1) perform a detailed assessment of watershed conditions, identifying key stressors for stream health, and (2) develop a comprehensive strategy to restore and preserve stream integrity. In order to make the plan useful to the local community, EEP worked with a Technical Advisory Committee, made up of local planning and natural resource staff, who reviewed detailed watershed assessment work and helped to develop management recommendations.

The Lower Creek watershed was divided into 29 subwatersheds. It is characterized by three distinct areas—a rural northern area, typified by agricultural activities, low density residential use, and steep, forested headwaters; a central urban area of Lenoir, characterized by high impervious cover and a mix of industrial, commercial, and residential use; and a rural southern area, which has a mix of agricultural, low density residential, and forested land uses. Lower Creek itself and four of its tributaries—Zacks Fork, Spainhour Creek, Greasy Creek, and Bristol Creek—are on the 303(d) list of impaired waters. In addition, Lower Creek's receiving water, Lake Rhodhiss, is on the draft 2006 303(d) list due to issues related to high nutrient levels.

Watershed assessment activities included biological, chemical, and toxicological monitoring of water quality for 303(d) listed streams and their degraded tributaries, assessment of channel stability and habitat, and Geographic Information System (GIS) data development and analysis. These data were analyzed to (1) characterize 303(d) listed streams and their degraded tributaries, (2) summarize functional integrity (or health) of streams on a subwatershed scale, and (3) determine key stressors for watershed streams.

Key stressors for streams in the Lower Creek watershed and management strategies to address them are listed in the Table 1.

Table 1: Key Stressors for Watershed Streams and Applicable Management Strategies

Stressor	Management Strategy
Stream bank erosion	Stream restoration, riparian buffers, livestock exclusion, sand dredging BMPs
Lack of adequate forested buffer	Stream restoration, riparian buffers
Stream channelization	Stream restoration
Impervious cover	Stormwater BMPs, stormwater ordinance, low impact development
Upland erosion	Agriculture & forestry BMPs, erosion and sedimentation control ordinance, subdivision ordinance modifications, steep slope ordinance, public education
Livestock access to streams	Livestock exclusion
Floodplain development	Floodplain development ordinance
Urban toxicants	Illicit discharge program, landfill strategy, watershed education program, stormwater BMPs
Nutrients	Illicit discharge program, ag BMPs, riparian buffers, watershed education program, stormwater BMPs, additional studies
Fecal coliform bacteria	Retrofit wastewater collection system, agricultural BMPs, illicit discharge program, watershed education program, stormwater BMPs

These management strategies address known stressors for the Lower Creek watershed using a combination of stream and wetland restoration, institutional measures, best management practices (BMPs), and stressor-specific solutions. In order to improve degraded streams and reduce the Lower Creek watershed's impacts on Lake Rhodhiss, it is essential for multiple stakeholders—State, County, and local governments, natural resource programs, land trusts, and local citizens—to participate in a coordinated strategy for watershed restoration.

Institutional measures. Ordinances, regulations, codes, and other instruments should be revised or developed by Lenoir, Gamewell, and Burke and Caldwell Counties to minimize negative impacts of development and other land use activities. The following measures are highly recommended:

1. Adopt the Lower Creek *Watershed Management Plan* as a supplement to comprehensive plans.
2. Develop comprehensive stormwater management ordinances
3. Amend subdivision ordinances to promote Low Impact Development and other measures that limit development impacts
4. Adopt and enforce more comprehensive riparian buffer ordinances
5. Monitor compliance with and enforcement of erosion and sedimentation control ordinances
6. Develop steep slope ordinances
7. Amend ordinances to prohibit development in the 100 year floodplain
8. Develop a robust public education program
9. Adopt a comprehensive watershed-based land use plan for the Lower Creek watershed to protect Lake Rhodhiss

Best management practices (BMPs). BMPs are essential to reduce the impacts from a number of existing land use activities. Of special concern for the Lower Creek watershed are stormwater impacts from development, sedimentation impacts from logging, and pollution and stream bank erosion from agricultural uses. This Plan lists specific BMPs to control these impacts.

Stream and wetland restoration, preservation, and stormwater BMP projects. This Plan prioritized subwatersheds were for restoration, preservation, or stormwater BMP activities based on functional integrity, degree of imperviousness, number of possible projects, and TAC recommendations. A set of 38 primary projects were identified within priority subwatersheds and include:

- 4 **Stream Preservation** sites, totaling 81,500 linear feet, or 15.4 miles
- 22 **Stream Restoration** sites, totaling 73,000 linear feet (post-construction), or 13.8 miles
- 2 **Wetland Preservation** sites, totaling 74 acres
- 3 **Wetland Restoration** sites, totaling 135 acres
- 3 combined **Wetland/Stream Restoration** sites, totaling 97 acres and 4,980 linear feet
- 4 **Stormwater BMP** sites, totaling 56 acres of BMP structures (ponds/basins; constructed wetlands; bioretention areas; permeable pavement)

These primary projects are described in detail in Appendix A, the *Project Atlas*. EEP will pursue the restoration projects to fulfill its mitigation targets; stormwater BMP and preservation projects may be pursued by EEP in the future. However, EEP cannot implement all projects (whether prioritized or not) needed to address stream degradation in the Lower Creek watershed; local groups and governmental entities are encouraged to pursue restoration, preservation, and stormwater BMP projects, as well.

2.0 INTRODUCTION

This chapter provides an overview of the Ecosystem Enhancement Program and its local watershed planning initiatives. It also provides a summary of the watershed assessment and plan development efforts conducted in the Lower Creek study area. The results of the plan development stage [Phase III] of this effort are reported in this document – the *Watershed Management Plan* (WMP). Major elements of the WMP are summarized in section 2.4 below.

2.1 MISSION OF THE ECOSYSTEM ENHANCEMENT PROGRAM

The North Carolina Ecosystem Enhancement Program (EEP) was created in July of 2003 through a Memorandum of Agreement between the NC Department of Environment & Natural Resources (DENR), the NC Department of Transportation (DOT) and the U.S. Army Corps of Engineers (USACE). The EEP essentially incorporates and expands the work of the former NC Wetlands Restoration Program, which operated from 1997 to 2003 as an in lieu fee program for the compensatory mitigation requirements associated with impacts to streams, riparian buffers and wetlands allowed under the Clean Water Act's 404/401 permitting system.

The primary mission of the Ecosystem Enhancement Program is to institute a program of *ecologically effective compensatory mitigation in advance of permitted environmental impacts* associated with transportation and other development-related projects across the state. The guiding principle behind EEP's efforts is that a *watershed planning approach* to the identification and implementation of mitigation projects – designed to *restore, enhance and protect key watershed functions* – is the most economically and ecologically effective way to achieve this mission.

2.2 EEP LOCAL WATERSHED PLANNING OBJECTIVES

Within EEP, a team of watershed planners periodically identifies high-priority local watersheds [14-digit Hydrologic Units or HUs] in which intensive watershed assessment and planning tasks will be conducted to help meet mitigation goals in certain areas of the state. The basic criteria used in selecting certain 14-digit HUs to be the focus of EEP Local Watershed Planning (LWP) initiatives include: clear evidence of degraded or impaired watershed functions (e.g., declining water quality and habitat indicators); the presence of high-quality local habitat or aquatic resources worthy of special protection measures; the opportunity to partner with local resource agency professionals, municipalities, land trusts and other local stakeholders interested in watershed restoration and protection; and projected need for compensatory mitigation efforts in the larger watershed units [8-digit Cataloging Units or CUs]. The HUs that become the focus of LWP efforts by EEP typically range in area from approximately 20 to 100 square miles, typically include at least one stream segment designated as "impaired" by the NC Division of Water Quality (DWQ), and often represent areas where road-building and development pressures are increasing rapidly.

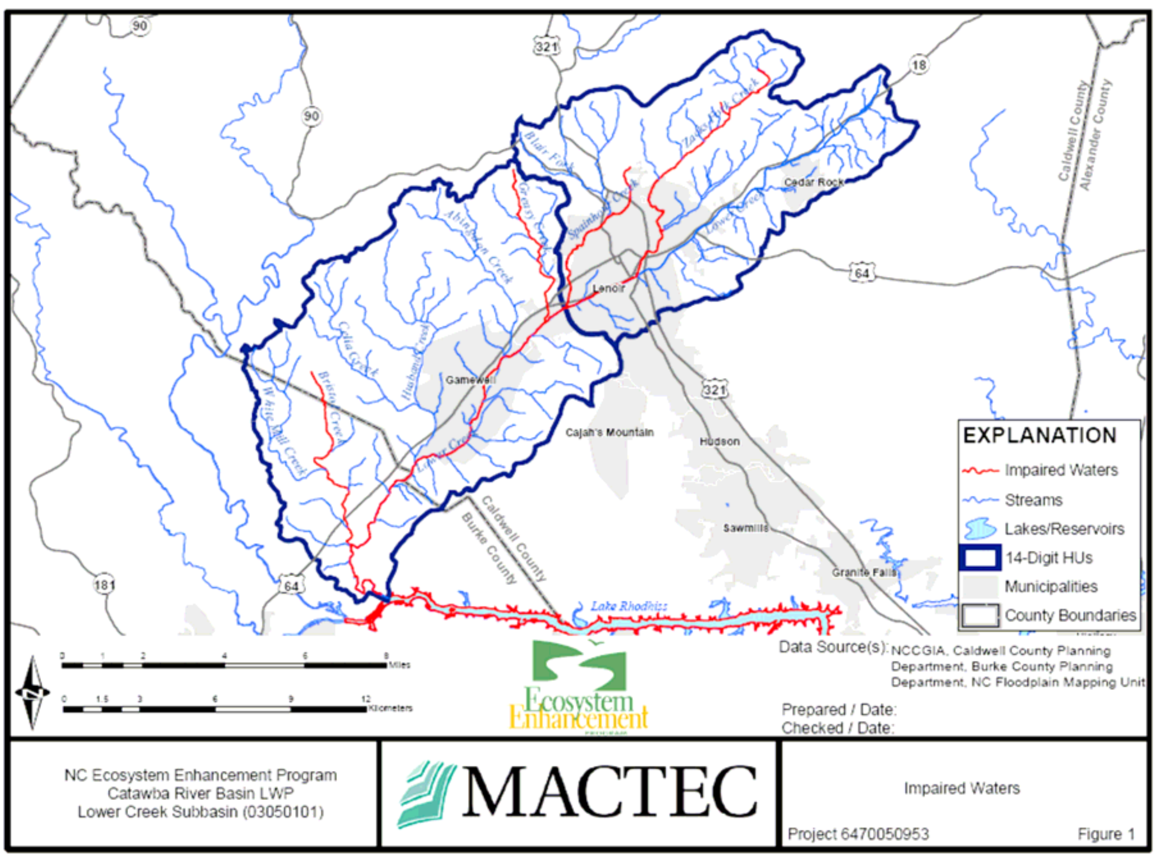
The EEP local watershed planning initiatives usually take place over an 18- to 24-month timeframe and include three major tasks (or "phases"): (1) preliminary watershed characterization based on compilation and analysis of available information & GIS data; (2) detailed assessment of field conditions at high-priority sites or reaches within representative subwatersheds; and (3) development of final local watershed planning documents, including the identification & prioritization of watershed project sites and recommendations regarding management strategies/policies for the restoration and protection of key watershed functions. Concurrent with the technical assessment of watershed conditions and development of final plan recommendations, EEP works collaboratively with a team of local watershed stakeholders (or "technical advisory committee") – consisting primarily of local resource professionals, including county and municipal stormwater and/or planning staff, staff of the Natural Resources Conservation Service (NRCS) and local Soil & Water Conservation Districts, the NC DWQ, the NC Wildlife Resources Commission, regional land trust representatives, and other interested parties – to ensure that local knowledge and local priorities are being adequately considered throughout the process.

Additional information regarding EEP's local watershed planning efforts across the state can be found at http://www.nceep.net/pages/lwplanning.htm .

2.3 BACKGROUND FOR THIS LWP PROCESS

The focus of this particular LWP effort is the Lower Creek watershed, consisting of two 14-digit hydrologic units (HUs) -- 03050101080020 (upper Lower Creek) and 03050101080010 (lower Lower Creek) -- located in Caldwell and Burke Counties, with a total drainage area of approximately 98 square miles (Figure 1). The watershed includes the communities of Lenoir, Gamewell, Cedar Rock, and a portion of Cajah's Mountain. Major tributaries in the watershed include: Zacks Fork Creek, Blair Creek, Spainhour Creek, Abingdon Creek, Husband Creek, Celia Creek, Bristol Creek, and White Mill Creek. The watershed drains into Lake Rhodhiss, the water supply source for Lenoir, Gamewell and portions of Caldwell and Burke Counties.

Figure 1: The Lower Creek Watershed



Phase I of the LWP, initiated in the summer of 2003 and completed in spring 2004, evaluated existing data regarding the hydrology, habitat and water quality functions within the watershed and identified areas for additional analysis. The Phase I tasks included a compilation and review of historical and current data related to local watershed conditions. Phase I data sources included available GIS coverages, local ordinances related to land use and watershed protection, DWQ water quality monitoring reports, interviews with local resource professionals, and an initial visual assessment of stream and riparian buffer conditions at 22 field sites. Additional activities accomplished during Phase I were the delineation and initial prioritization of subwatersheds in the study area, a general inventory of major functional stressors, and the preliminary identification of potential restoration/enhancement project opportunities. The results of the Phase I work are presented in the *Findings and Recommendations* report, completed in May 2004.

Phase II, initiated in January 2005, developed additional data related to the three major functions through GIS analyses (sinuosity, stream gradient, riparian buffer and impervious cover), field investigations of 82 sites throughout the watershed, and water quality sampling at 31 points. The location of these investigations and sampling points are shown in Figure 2 (Section 3.1). Based on these additional data, functional ratings were determined for each of the 9 tributary subwatersheds comprising the Lower Creek watershed, along with the upper and lower Lower Creek (mainstem) subwatersheds. The Phase II work culminated in the production of the *Watershed Assessment Report* (WAR) in February 2006. The Phase II detailed assessment results form the foundation for the development of this *Watershed Management Plan*, including the recommendation of specific sites for restoration, enhancement and preservation projects.

This document presents the final *Watershed Management Plan* developed for the two contiguous HUs, consisting of 29 subwatersheds comprising the Lower Creek watershed. *MACTEC Engineering & Consulting* (MACTEC), based in Raleigh, NC, was selected as the consulting firm to assist EEP in conducting the three major phases of LWP work. The *Western Piedmont Council of Governments* (WPCOG) contracted with EEP to manage the stakeholder involvement aspects of this effort, which began in January of 2004 and finished in June 2006.

The *Watershed Management Plan* represents the last of three major deliverables produced by MACTEC during this nearly 3-year effort. As noted above, the two earlier MACTEC documents are the *Findings & Recommendations* report, dated May 2004, and the *Watershed Assessment Report* (WAR), dated February 2006. All three of the Lower Creek LWP documents will be available on the EEP website by fall of 2006: http://www.nceep.net/pages/lwplanning.htm. They can be downloaded as *PDF* files.

2.4 MAJOR ELEMENTS OF THE WATERSHED MANAGEMENT PLAN

Following this introductory section, the major Sections of the document are:

- **3.0 Watershed Characterization** – summarizes the detailed assessment performed during Phase II, describing stream health, major stream stressors and overall functionality of subwatersheds;
- **4.0 Stakeholder Input** Process- provides details of the stakeholder participation strategy and meetings, as managed by WPCOG, including major points of input from the assembled advisory group and the public meeting held during the process;
- **5.0 Watershed Restoration Framework** – identifies all major stressors contributing to stream degradation within the Lower Creek watershed and summarizes the management strategies/solutions for addressing these stressors;
- **6.0 Watershed Improvement Projects** – describes the process used to prioritize subwatersheds and identify recommended ("primary") watershed improvement projects;
- **7.0 Institutional Measures –** presents recommendations related to local ordinances for land development, erosion and sedimentation control, stormwater management, and riparian buffers, in conjunction with education, in reducing and controlling watershed degradation;

8.0 Best Management Practices - describes potential technical strategies for controlling pollution associated with industrial, urban, forestry and agricultural activites;

References – presents references for all sources of data/information cited in the document.

Appendix A – contains the atlas of recommended watershed improvement projects.

Appendix B – contains a listing of potential funding sources for local watershed projects.

Appendix C – contains a listing of technical resources, with website addresses.

Appendix D – contains a map and master listing of all potential project sites identified within the Lower Creek watershed.

2.5 GLOSSARY OF KEY TERMS

The following is a glossary of key terms and acronyms used in this document.

Biological Monitoring – refers to the collection and assessment of benthic macroinvertebrates and fish by staff of the Biological Assessment Unit within DWQ's Environmental Sciences Section. Data on the number and types of taxa of benthic species are used as indicators of stream reach health per standard Bioclassification criteria [excellent; good; good/fair; fair; poor]. Fish sampling and fish tissue analyses are used to assess aquatic ecological integrity and as indicators of possible surface water and stream sediment contamination. For more information on biological monitoring efforts (and protocols), go to http://h2o.enr.state.nc.us/esb/BAU.html

Buffer – an area adjacent to a stream, wetland, or shoreline where development activities (e.g., buildings, logging) are typically restricted or prohibited; may be managed as streamside (riparian) zones where undisturbed vegetation and soils act as filters of pollutants in stormwater runoff. Buffer zone widths vary depending on state and local rules, but are typically a minimum of 25 to 50 feet on each side of perennial streams. In NC, buffer rules have been established for all, or portions of, the upper Cape Fear, lower Catawba, Neuse and Tar-Pamlico river basins.

BMPs – Best Management Practices. Any land or stormwater management practice or structure used to mitigate flooding, reduce erosion & sedimentation, or otherwise control water pollution from runoff; includes urban stormwater management BMPs and agriculture/forestry BMPs

CGIA – North Carolina's Center for Geographic Information & Analysis. Visit http://cgia.cgia.state.nc.us/cgia/

Channelization – the manmade alteration of natural stream & river channels, typically resulting in the deepening, straightening and/or realignment of natural waterways. Done historically to improve land drainage, increase agricultural production and reduce losses from flooding, channel modifications usually result in stream channel instability, increased bank erosion, altered sediment dynamics (bed degradation or aggradation), adverse effects downstream (e.g., increased incidence of flooding, channel scour), damage to riparian buffer zones and general esthetic degradation of streams, wetlands and riparian vegetation.

CWMTF – refers to North Carolina's Clean Water Management Trust Fund program, a funding agency for water quality protection & improvement projects. For additional info, go to http://www.cwmtf.net

Degradation – term usually associated with physical degradation of aquatic habitat and declining biological indicators of stream health due to various watershed stressors, e.g., channel scour from excessive storm water flows, unstable/eroding stream banks due to channel incision and/or lack of adequate riparian vegetative cover, embedded (sediment-buried) riffle zones. Not to be confused with *impairment*, which relates specifically to a decline in water quality use support ratings for a given stream or stream reach as measured by physical/chemical parameters (e.g., dissolved oxygen, metals, turbidity, fecal coliform).

Detailed Assessment – the second major phase of EEP Local Watershed Planning, which generally includes in-depth field evaluation of watershed conditions along representative stream/buffer reaches and within high-priority subwatersheds, including application of visual assessment protocols for stream habitat and riparian buffers, measurements of channel stability & bank erosion hazards indices (BEHI), collection of water quality and biological monitoring data, and (sometimes) the use of computer models to predict future hydrologic and water quality conditions under different watershed management scenarios.

DWQ – the NC Division of Water Quality, a division within NC DENR. See http://h2o.enr.state.nc.us/

EEP (or NC EEP) – NC Ecosystem Enhancement Program; created by three-agency Memorandum of Agreement (between NC DENR, NC DOT and US Army Corps of Engineers) – or "Tri-Party MOA" -- in July of 2003 to develop a comprehensive approach to watershed protection in the state, to increase the ecological effectiveness of compensatory mitigation projects, and to provide mitigation projects & strategies in advance of permitted impacts based on a watershed planning approach. The EEP program essentially absorbed and expanded the resources and staff of the former Wetlands Restoration Program, which had been established within DENR by statute in 1996, including the addition of certain compensatory mitigation & environmental analysis staff of the NC DOT. For more info, go to: http://www.nceep.net/

Floodplain – a low plain adjacent to a river that is formed chiefly of river sediment (alluvial deposits) and which is subject to periodic flooding. Floodplains perform several key functions within river and stream ecosystems, including the storage, transport and deposition of water and eroded sediments during overbank (flooding) stormflow events. A 100-year floodplain is the area along a stream or river that is normally dry, but has a one percent change of being flooded in any given year.

Functions; Functional Assessment – the major functional and ecological components of a watershed (and the focus of restoration, enhancement and protection efforts by the NC EEP) include streams, streamside (riparian) buffer zones, wetlands, and runoff-contributing uplands. The important landscape functions served by these watershed components, when they are not degraded, include: water quality protection (pollutant removal); fish & wildlife habitat; hydrologic balance (e.g., floodwater conveyance & storage); and direct human value (e.g., timber production, recreation, education). Functional assessment refers to the process whereby the status or quality of important watershed functions is determined at various scales of study/measurement.

GIS - geographic information system consisting of computer hardware, software and data designed for capturing, storing, updating, manipulating, analyzing and displaying all forms of geographically reference information; in EEP, desktop GIS is an important tool used in the assessment of various sets of watershed-related information (specific themes or coverages, e.g., land cover, property parcels, roads, municipal boundaries, streams, designated natural heritage areas, wetlands, soils, etc.) used in identifying the best locations for watershed project sites and management strategies

Hydrologic Unit (HU) – refers to the 14-digit Hydrologic Unit Codes used by the Natural Resources Conservation Service (NRCS) to identify local watersheds typically ranging from 10 to 100 square miles in total drainage area; used by NC EEP as synonymous with "local watershed"

Impairment – used by NC DWQ to describe any impairment of the use support classification of a given stream; basically, impairment indicates a stream (or stream reach) with decreased water quality to the degree that it is "not supporting" its designated uses (e.g., swimming, fishing, shellfishing, water supply, secondary recreation) because of point source or nonpoint source pollution and/or aquatic habitat degradation. For additional information about NC DWQ's use support ratings methodology, see the Appendices to any of DWQ's Basinwide Water Quality Plans; http://h2o.enr.state.nc.us/basinwide/basinwide_wq_planning.htm

Impervious Cover (IC) - a human-created or –modified surface (e.g., concrete, asphalt) that does not allow water to percolate (or infiltrate) through it; examples include parking lots, rooftops, roadways, driveways, sidewalks, compacted soils or lawns with compacted subsoils. Urbanization and development are typically associated with significant increases in the impervious cover of a given area, which result in increased rates of stormwater runoff and inputs of non-point source pollutants into local streams.

NPDES - The National Pollutant Discharge Elimination System (NPDES) is the federally established program for controlling point-source discharges of pollution. The NPDES Unit of North Carolina's Division of Water Quality (DWQ) is responsible for administering the program for the state, from which both individual and general wastewater discharge permits are issued. For additional info, visit http://h2o.enr.state.nc.us/NPDES/

NRCS – the Natural Resources Conservation Service, within the U.S. Department of Agriculture. Go to http://www.nrcs.usda.gov/

NWI – the National Wetlands Inventory, an ongoing project by the U.S. Fish and Wildlife Services to classify and map the remaining wetland areas throughout the Continental United States. For additional information, visit http://wetlandsfws.er.usgs.gov/ or http://www.nwi.fws.gov/.

Phase II stormwater rules –
From http://h2o.enr.state.nc.us/su/NPDES_Phase_II_Stormwater_Program.htm: Phase II of the NPDES Stormwater program was signed into law in December 1999. This regulation builds upon the existing Phase I program by requiring smaller communities and public entities that own and operate a municipal separate storm sewer system (MS4) to apply and obtain an NPDES permit for stormwater discharges. The program was first implemented in the State by temporary rulemaking. During the process to make permanent rules, both the temporary rules and the permanent rules were rejected by the Rules Review Commission in early 2004. In response to the legal issues surrounding Phase II implementation, the NC State Legislature passed Senate Bill 1210 in July of 2004. The Bill now provides the Environmental Management Commission (EMC) the authority and guidelines for implementing the Phase II program in NC. A summary of the Bill has been provided by NC DENR. EPA regulation (40CFR 122.34) requires permittees at a minimum to develop, implement, and enforce a stormwater program designed to reduce the discharge of pollutants from the MS4 to the maximum extent practicable. The stormwater management program must include these six minimum control measures:

1. Public education and outreach on stormwater impacts

2. Public involvement/participation

3. Illicit discharge detection and elimination

4. Construction site stormwater runoff control

5. Post-construction stormwater management in new development and redevelopment

6. Pollution prevention/good housekeeping for municipal operations

Preservation – the long term protection of an area with high habitat value (e.g., wetlands, riparian buffers, identified habitat corridors for key species), generally effected through the purchase or donation of a conservation easement by/to a government agency or non-profit group (e.g., Land Trust); such areas are left in their natural state, with minimal human disturbance or management activities. EEP-funded preservation projects may be considered as "restoration equivalents" for the mitigation of impacts within a given CU, but at a lower credit ratio than for restoration projects [i.e., 5:1 or higher].

Restoration – the re-establishment of wetlands or stream hydrology and wetlands vegetation into an area where wetland conditions (or stable streambank and stream channel conditions) have been lost; examples include: stream restoration using natural channel design methods coupled with re-vegetation of the riparian buffer; riparian wetlands restoration through the plugging of ditches, re-connection of adjacent stream channel to the floodplain, and planting of native wetland species; this type of compensatory mitigation project receives the greatest mitigation credit under the 401/404 regulatory framework

Riparian – relating to the strip of land adjacent to streams and rivers, including streambanks and adjoining floodplain area; see also *Buffer*; important streamside zones of natural vegetation that, when disturbed or removed, can have serious negative consequences for water quality in streams & rivers

SWCDs – acronym for the 96 local Soil & Water Conservation Districts in North Carolina, which operate in partnership with the federal Natural Resources Conservation Service (NRCS; formerly the Soil Conservation Service) and the Division of Soil & Water Conservation within NC DENR to protect and conserve the state's soil and water resources. For additional information, go to http://www.enr.state.nc.us/DSWC/ and/or to http://www.ncaswcd.org/

Stakeholder – any agency, organization, or individual involved in or affected by the decisions made in the development of a watershed plan; typically includes: *primary stakeholders* such as watershed residents, farmers, developers, local government or resource agency staff with a direct say in the planning process; and *secondary stakeholders* such as state or regional resource agency staff who can serve as technical resources/advisors to the local planning process

Stressor – broadly defined, a watershed stressor is any physical, chemical or biological agent or process that induces an adverse response in watershed functioning. Examples range from broad watershed processes such as stormwater runoff from areas with high impervious cover to water quality pollutants (nutrients, sediment, fecal coliform) affecting a specific stream reach. Stressors are often reflective of the cumulative effects of geographically widespread *sources* or causes of functional problems. For instance, chronically low dissolved oxygen in a stream [the stressor] may be caused by a specific activity [the source] such as poor animal waste management practices and/or unrestrained livestock access on farmland located within a specific sub-watershed.

Sub-watershed (or subwatershed) – a component drainage area within a local watershed (14-digit NRCS hydrologic unit); typically about one to 5 square miles in area, these areas are considered the most appropriate and effective geographic scale for local watershed planning & management (e.g., for detailed watershed characterizations, urban stream classification and watershed-based zoning); they are sometimes delineated as the land area draining to a point where two second-order streams combine to form a third-order stream (see definitions of *stream order* by A.N. Strahler). They may be delineated based also on the dominant land use(s) and/or zoning classifications they encompass, as determined by the controlling jurisdictions within whose boundaries they are located.

3.0 WATERSHED CHARACTERIZATION

Phase I of the Local Watershed Plan, completed in May 2004, evaluated existing data regarding the **hydrology**, **habitat**, and **water quality functions** within the watershed and identified areas for additional analyses. Phase II, initiated in January 2005, developed additional data relating to these three functions through GIS analyses, field investigations, and water quality sampling. This section of the Plan presents a summary of the findings of the more detailed assessment of Phase II, describing stream integrity, major stream stressors, and functional integrity of the 29 subwatersheds of the Lower Creek watershed.

The Lower Creek watershed is approximately 98 square miles and is comprised of two 14-digit hydrologic units—03050101080020 (upper Lower Creek) and 03050101080010 (lower Lower Creek). Lower Creek drains sections of both Caldwell and Burke Counties and empties into Lake Rhodhiss, the water supply source for Lenoir, Gamewell, and portions of Caldwell and Burke Counties. For planning purposes, the watershed was divided into 29 subwatersheds, ranging from approximately two to six square miles in size (Figure 2).

3.1 DATA SOURCES

Data gathered during the detailed assessment phase of this project include biological community data, physical/chemical water quality data, field assessment information, and GIS data.

NC Division of Water Quality Monitoring. North Carolina's draft 2006 303(d) list of impaired waterbodies includes Lake Rhodhiss and several streams in the Lower Creek watershed—Lower Creek, Spainhour Creek, Zacks Fork, and Bristol Creek (Figure 1). All of these streams are on the 303(d) list due to impaired biological integrity; Lower Creek is also listed due to high turbidity values. During the Lower Creek watershed planning effort, the NC Division of Water Quality (DWQ) primarily focused water quality monitoring efforts on these impaired streams to determine causes of impairment (Figure 2). Bristol Creek was not studied, as further analysis of the biological data leading to its 303(d) listing revealed that the biological community is likely not impaired. During 2002 and 2004-2005, DWQ staff monitored biological communities using benthic macroinvertebrates and physical/chemical water quality parameters such as nutrients, metals, and fecal coliform bacteria, and water column toxicity.

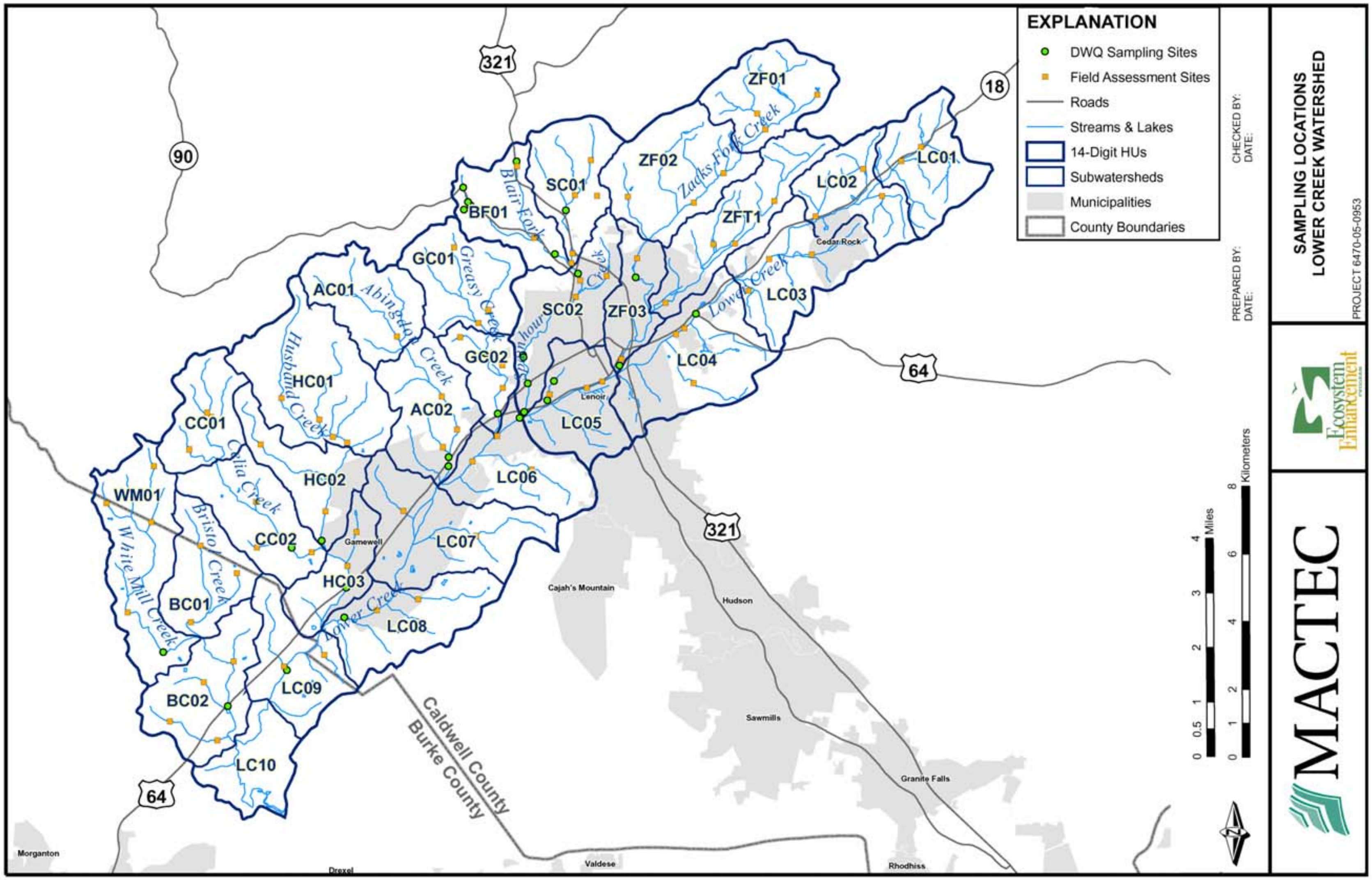
Additional Field Investigations. Additional field assessment was performed at 82 sites throughout the watershed in order to determine stream stability, habitat condition, obvious water quality problems, and pollution sources (Figure 2). Since a primary purpose of this assessment was to identify the stressors that were affecting the hydrologic, habitat, and water quality functions within the Lower Creek watershed, the site selection was biased towards degraded sites. In particular, sites were selected from stream reaches:

- having a sinuosity <1.2 – indicating a high probability of channelization; and
- lacking an adequate 30-foot forested riparian buffer – indicating potential for bank erosion and impaired habitat.

Since another objective of this project was to identify viable mitigation sites, an additional site selection criterion was to focus on stream reaches that were characterized by a few property owners, rather than many, in order to identify sites with a high potential for restoration projects.

GIS Assessment. GIS datasets were developed to identify watershed stressors, aid in assessment site choice, and to determine the best restoration and preservation project sites. Primary datasets included sinuosity, stream gradient, riparian buffer, and impervious cover.

Figure 2: Sampling and Assessment Sites



3.2 STREAM-SPECIFIC ISSUES: 303(D)-LISTED AND OTHER DEGRADED STREAMS

NC Division of Water Quality (DWQ) monitoring provided some specific information on stream integrity and stressors for 303(d) listed and other degraded streams. This section describes the biological integrity and key stresssors (causes of degradation) for four urban streams (Zacks Fork, Blair Fork, Spainhour Creek, and an unnamed tributary to Lower Creek), a largely rural stream on the edge of Lenoir (Greasy Creek), and Lower Creek, which drains both rural and urban areas.

3.2.1 Common causes of degradation and their sources

All of these streams are impacted by **habitat degradation** of three types—sedimentation, a lack of wood and leaf habitats, and a lack of riffles and pools. The sources of this habitat degradation are channelization, lack of forested riparian buffer, and sediment from stream bank erosion and upland sources.

These streams are characterized by **turbid** water during storms, with levels that exceeded the state standard. This turbidity is caused by fine sediments from streambank erosion and upland sources.

Nutrients, including nitrogen and phosphorous, were also high during storms in all of these streams. Possible nutrient sources in urban streams are fertilizers and sewer system leaks and backups. In rural streams, agricultural sources are more likely, such as livestock and fertilizers. Horticultural operations can also be sources of nutrients, and are possible sources of high nutrients in both Spainhour Creek and Greasy Creek.

Fecal coliform bacteria levels were high in both baseflows and stormflows in all streams. High baseflow levels of fecal coliform bacteria indicate a dry weather source, such as a problematic sewer system, leaking septic systems, straight-piped waste, and livestock access to streams. Sewer system leaks and overflows were observed in several locations in Lenoir.

High levels of **copper**, **zinc**, and **lead** were found in most streams during storm events. These trace metals are common in urban streams (USGS, 2001), and possible sources are numerous, including vehicle exhaust and impervious surfaces themselves (Center for Watershed Protection, 1995).

Biological Community Ratings

NC Division of Water Quality rates biological communities in order to characterize stream integrity. Biological community ratings include Excellent, Good, Good-Fair, and Not Impaired, which are all considered "not impaired" ratings, and Fair and Poor, which are "impaired" ratings.

3.2.2 Stream descriptions

Note: As noted above, habitat degradation was common to all streams described and is therefore not described below. Instead, biological condition, water quality, and stormflow scour issues are described.

Zacks Fork. 303(d) listed Zacks Fork begins in a rural watershed characterized by a mix of forest, agricultural, and residential land uses and then passes through heavily residential and commercial northeastern Lenoir at its downstream end. Benthic macroinvertebrates are severely impacted in the downstream urban portion of Zacks Fork but are much less impacted (rated Not Impaired by DWQ) in the upstream rural portion of Zacks Fork. Water quality issues in the downstream section include high nutrient, turbidity, fecal coliform bacteria, zinc, and copper concentrations. Stormflow scour is also a problem in the urban downstream section, scouring habitats and organisms from stream substrates during storm events.

Blair Fork. Blair Fork is a tributary to 303(d) listed Spainhour Creek, but is not currently on the 303(d) list. It drains an area of residential, industrial, and commercial land uses. The benthic macroinvertebrate community is extremely degraded, characterized by a set of organisms that indicate toxicity. The stream has failed multiple toxicity tests, and a likely source of toxicity is a closed unlined landfill on NC 90 (see Figure 6, Section 5.0). Fecal coliform bacteria, copper, turbidity, and nutrients were also high in Blair Fork. Stormflow scour is also a cause of degradation for Blair Fork.

Spainhour Creek. Spainhour Creek drains a large part of Lenoir, including residential, commercial, and industrial areas. The benthic macroinvertebrate community of Spainhour Creek was rated Fair (impaired), by DWQ. Spainhour Creek is impacted by high levels of fecal coliform bacteria, nutrients, turbidity, zinc, copper, and possible toxicity. Stormflow scour is also a problem for this urban stream.

Unnamed tributary to Lower Creek. This tributary drains an almost totally impervious area in the heart of Lenoir's industrial and commercial area. This stream is routed under buildings and channelized where in the open; problems with stormwater scour and lack of appropriate habitat are evident. It was also characterized by possible toxicity and carries high copper, zinc, and lead levels and organic pollutants, including heptanones, methoxy propyl acetate, chloroform, and gasoline-range petroleum hydrocarbons. It carries high levels of nutrients, turbidity, and fecal coliform bacteria. These pollutants may be entering the stream through illicit connections to the stream, the sewer system, or stormwater runoff.

Greasy Creek. This stream drains a largely rural area, characterized by forest, residential, and agricultural land uses. The benthic macroinvertebrate community was rated Fair (impaired) near its confluence with Lower Creek at NC 18, but improved to Good-Fair (not impaired) just two miles upstream, where it has a forested buffer and much better stream habitat. The downstream site was also characterized by high turbidity, nutrients, fecal coliform bacteria, copper, zinc, lead, and possible toxicity.

Lower Creek. This 23 mile stream drains both rural and urban areas, receiving impacts from its tributary streams. Benthic macroinvertebrates have been sampled at many sites on its length, and all sites are highly degraded or impaired, with the exception of the uppermost site at NC 90, which is upstream of much of the urbanized area of Lenoir. This stream suffers from stormwater scour and high concentrations of a number of pollutants, including fecal coliform bacteria, turbidity, nutrients, copper, and zinc.

3.3 FUNCTIONAL ASSESSMENT

A functional framework was used to characterize the integrity of the Lower Creek watershed as a whole. Data used include GIS datasets, biological community data, physical/chemical data, and field assessment information.

For each major functional area (hydrology, habitat, and water quality), specific parameters were selected from the Phase II data sources (GIS, field investigation, and water quality sampling) to indicate the functional integrity of streams within each subwatershed (Table 1). Values were established for each particular parameter to designate level of function and an aggregate score was developed for the groups of parameters representing a particular watershed function. This aggregate score was then used to assess whether that function was Functioning, Functioning at Risk, or Not Functioning, according to the following definitions:

- **Functioning [F]:** The subject watershed function is performing naturally, without evidence of significant degradation or a stressed condition.
- **Functioning at Risk [FR]:** The subject watershed function is currently moderately degraded, but shows evidence of stress such that, without intervention, it could over time become Not Functioning.
- **Not Functioning [NF]:** The subject watershed function is currently stressed to the level of being highly degraded.

Table 1: Parameters Used for Functional Assessment

Function	PARAMETERS				
Hydrology	Sinuosity	Impervious Cover	Stream Gradient	Site Investigations (Hydrology)	
Habitat	Riparian Buffer	Site Investigations (Habitat)			
Water Quality	Riparian Buffer	Impervious Cover	Site Investigations (Water Quality)	DWQ Phys/Chem Monitoring	DWQ Benthic Monitoring

Table 2 presents the overall results of the functional analyses of hydrology, habitat, and water quality at the subwatershed level. This information is also shown graphically on subwatershed maps for each watershed function in Figures 3, 4, and 5. Based upon this analysis, only White Mill Creek, a stream of moderate length (<10 miles) in a relatively small (<5 square mile), predominantly rural, undeveloped subwatershed and the upper portion of Abingdon Creek (AC01), a similar but slightly smaller subwatershed, are fully functional across all three watershed functions. In contrast, the lower reach of Spainhour Creek (SC02), a stream/subwatershed of similar scale to ACO1 but in a subwatershed that is highly urbanized, is not functioning for all three watershed functions. Similarly, Blair Fork (BF01), the lower reach of Greasy Creek (GC02), and the middle of Lower Creek (LC05) are not functioning on the basis of both habitat and water quality due to the urbanized nature of these subwatersheds. Overall, most of the other subwatersheds are functioning at risk, several tending toward not functioning on one or more of the three watershed functions.

Table 2: Summary of Functionality by Subwatershed

Subwatershed	Subwatershed Code	Overall Functionality			
		Hydrology	Habitat	Water Quality	
Zacks Fork 01	ZF01	FR	F	F	upper Lower Creek area
Zacks Fork 02	ZF02	FR	FR	FR	upper Lower Creek area
Zacks Fork 03	ZF03	FR	FR	NF	upper Lower Creek area
Tributary to Zacks Fork	ZFT1	FR	FR	FR	upper Lower Creek area
Spainhour Creek 01	SC01	FR	FR	FR	upper Lower Creek area
Spainhour Creek 02	SC02	NF	NF	NF	upper Lower Creek area
Blair Fork	BF01	FR	NF	NF	upper Lower Creek area
Greasy Creek 01	GC01	FR	F	FR	upper Lower Creek area
Greasy Creek 02	GC02	FR	NF	NF	upper Lower Creek area
Lower Creek 01	LC01	FR	F	F	upper Lower Creek area
Lower Creek 02	LC02	FR	FR	FR	upper Lower Creek area
Lower Creek 03	LC03	FR	FR	FR	upper Lower Creek area
Lower Creek 04	LC04	FR	FR	FR	upper Lower Creek area
Lower Creek 05	LC05	FR	NF	NF	upper Lower Creek area
Abingdon Creek 01	AC01	F	F	F	lower Lower Creek area
Abingdon Creek 02	AC02	FR	FR	FR	lower Lower Creek area
Husband Creek 01	HC01	FR	FR	FR	lower Lower Creek area
Husband Creek 02	HC02	F	F	FR	lower Lower Creek area
Husband Creek 03	HC03	FR	F	FR	lower Lower Creek area
Celia Creek 01	CC01	F	F	FR	lower Lower Creek area
Celia Creek 02	CC02	FR	NF	FR	lower Lower Creek area
Bristol Creek 01	BC01	F	FR	FR	lower Lower Creek area
Bristol Creek 02	BC02	FR	NF	FR	lower Lower Creek area
White Mill Creek	WM01	F	F	F	lower Lower Creek area
Lower Creek 06	LC06	NF	FR	FR	lower Lower Creek area
Lower Creek 07	LC07	FR	FR	FR	lower Lower Creek area
Lower Creek 08	LC08	FR	FR	F	lower Lower Creek area
Lower Creek 09	LC09	FR	NF	FR	lower Lower Creek area
Lower Creek 10	LC10	FR	F	FR	lower Lower Creek area

Figure 3: Overall Hydrology Functionality

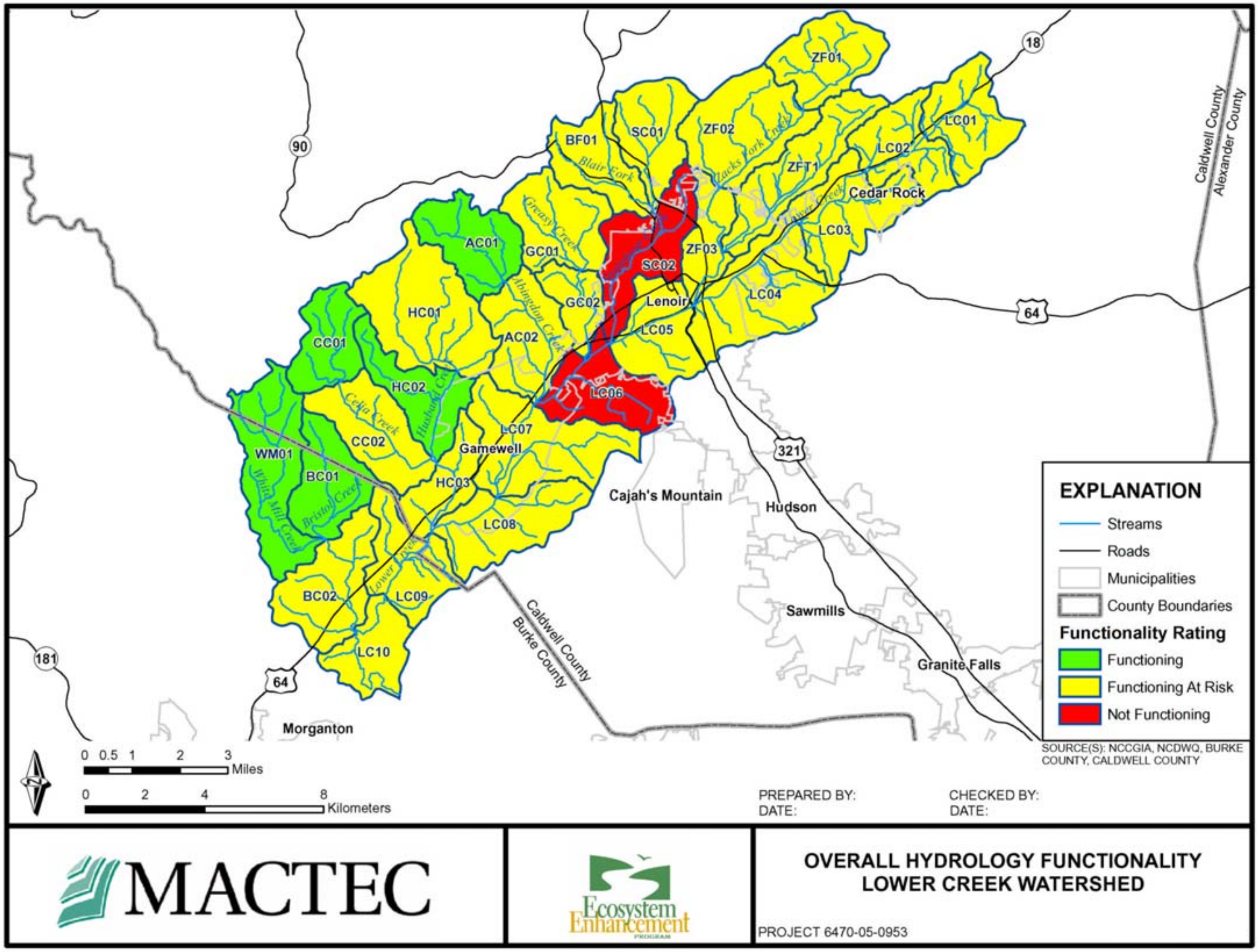


Figure 4: Overall Habitat Functionality

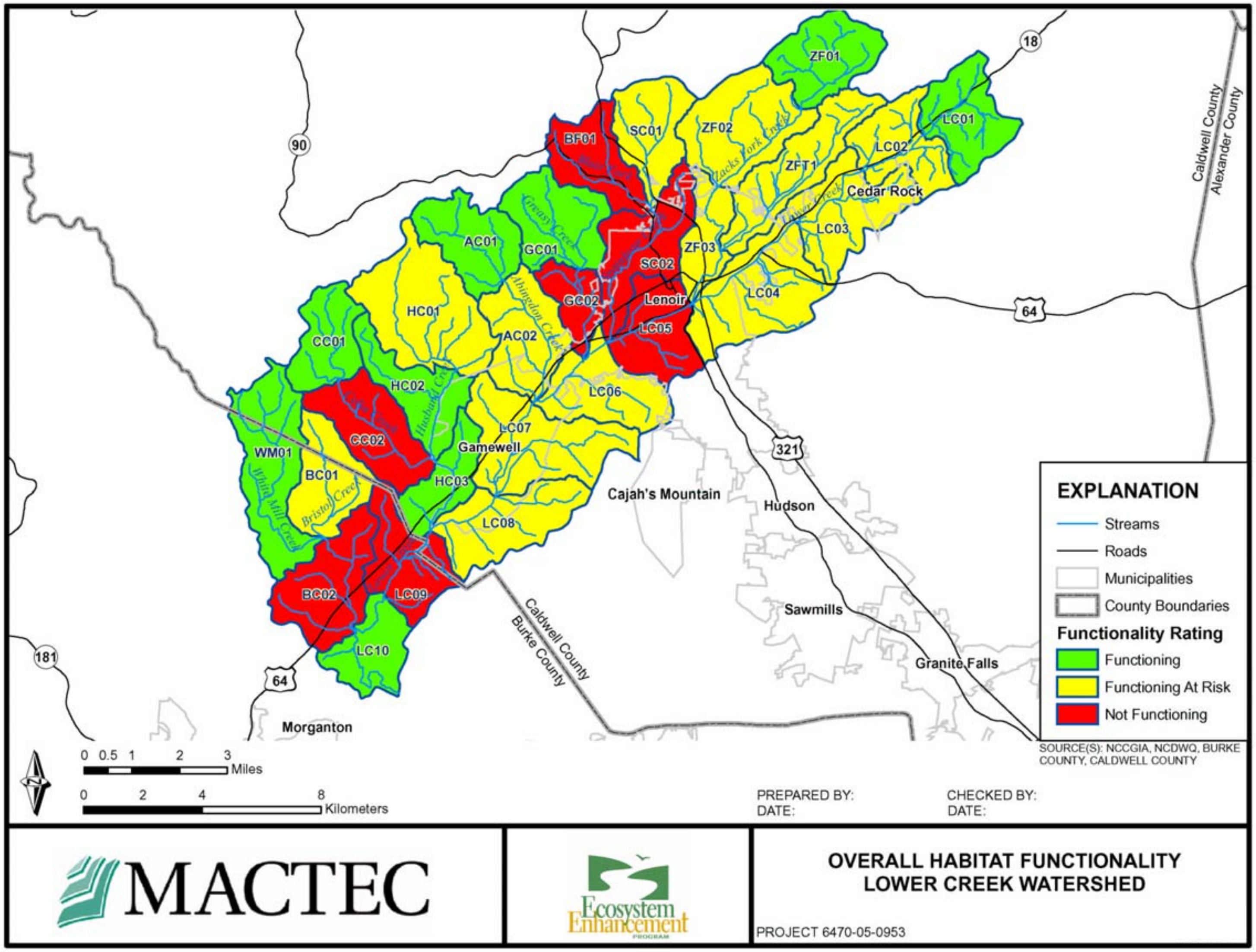
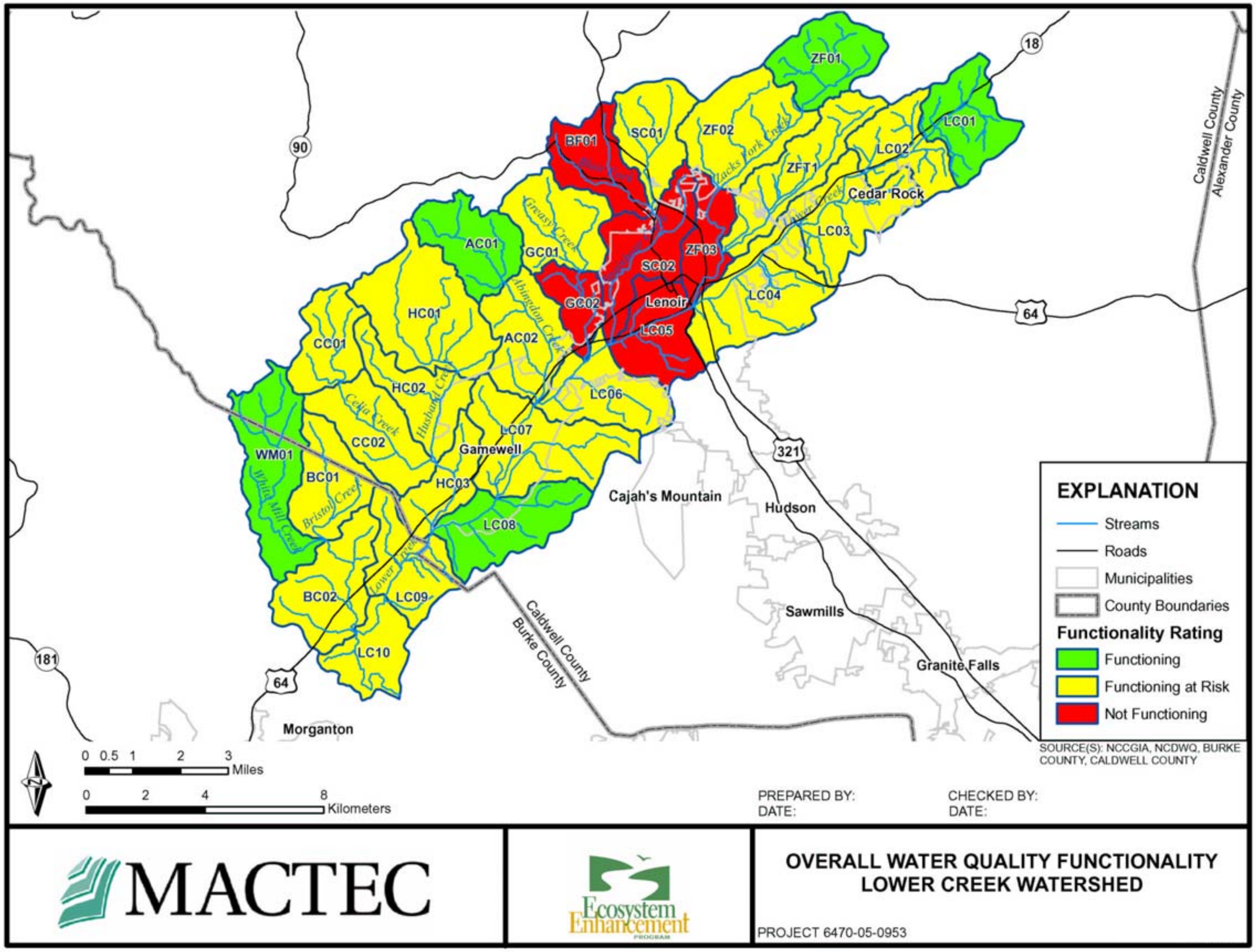


Figure 5: Overall Water Quality Functionality



3.4 WATERSHED-WIDE STRESSORS

Table 3 provides a listing of the major stressors impacting the functionality of hydrology, habitat, and water quality within the Lower Creek watershed. These contributing factors do not impact the entire watershed uniformly. Table 3 provides a partial listing of subwatersheds impacted by each stressor; only those stressors for which GIS analysis could determine problem locations are listed with affected subwatersheds. More intensive on-the-ground monitoring is needed to determine the extent of other stressors, and due to resource constraints, monitoring studies for this project did not include enough sites to fully represent all subwatersheds.

On a macro level, the Lower Creek watershed can be described as having three distinct parts:

1. A northern rural, mostly forested region, characterized by steeply sloped headwater areas with highly-erodible soils (ZF01, ZF02, ZFT1, SC01, LC01, LC02, LC03). This area also has some agricultural land use and is beginning to develop with single family homes on moderate to large lots.

   Significant stressors in this area include:
   - channelization from agricultural and development activity;
   - sediment from upland and streambank erosion;
   - inadequate forested buffer from agricultural and development activity; and
   - fecal coliform bacteria from livestock and other rural sources.

2. A central urbanized area, characterized by high percentages of impervious cover, floodplain encroachment and many industrial facilities (LC04, LC05, LC06, LC07, ZF03, SC02, BF01, GC01, GC02).

   Significant stressors in this area include:
   - channelization from development activity;
   - stormwater flow from impervious cover;
   - floodplain encroachment from development activity;
   - inadequate forested buffer from agricultural and development activity;
   - toxicity from illicit connections and old landfill;
   - fecal coliform bacteria from sewer overflows;
   - nutrients from agricultural and landscaping activities; and
   - sediment from instream mining activities, streambank erosion, and upland erosion.

3. A relatively flatter, southern rural area with a variety of agricultural activities and forested cover (LC08, LC09, LC10, AC01, AC02, HC01, HC02, HC03, CC01, CC02, BC01, BC02, WM01). This area is also beginning to develop into residential use.

   Significant stressors in this area include:
   - channelization from agricultural and development activity;
   - sediment from streambank and upland erosion;
   - inadequate forested buffer from agricultural and development activity; and
   - stormwater flow from impervious cover.

Table 3: Stressors Impacting Watershed Functions

Note: Bolded subwatersheds indicate "not functioning" for at least one function. The column "Subwatersheds Affected" is an incomplete list of subwatersheds actually affected by stressors—only those stressors for which GIS analysis could determine problem locations are listed with affected subwatersheds.

Stressor	Source	Function Impacted	Impact	Subwatersheds Affected (through GIS analysis)
Channelization	Alteration from agricultural or land development activities	Hydrology Habitat	– Flooding – Streambank erosion – Streambed scour – Loss of instream habitat – riffles, pools, edge habitat	LC01, LC02, LC03, LC04, **LCO5**, LC06, LC07, **LC08**, LC09, LC10, **ZF02**,, **ZFT1**, **SC01**, **SC02**, BF01, GC01, GC02, AC01, **AC02**, **HC01**, HC02, HC03, CC01, CC02, BC01, **BC02**, WM01
Stormwater Flow	Impervious cover	Hydrology Habitat	– Flooding from increased peak flows – Streambank erosion – Streambed scour	LC03, LC04, **LC05**, **LC06**, LC07, LC09, **ZF03**, ZFT1, SC01, **SC02**, **BF01**, GC02, AC02, HC01, HC03, CC02
Floodplain Encroachment	Land development activities	Hydrology	– Flooding – Downstream erosion	LC04, LC05, LC06, ZF03, SC02
Inadequate Forested Buffer	Agricultural and land development activities	Habitat Water Quality	– Loss of aquatic organic habitat (wood, leaves) – Loss of terrestrial habitat – Sediment from streambank erosion – Non-point source pollution	LC02, LC03, LC04, LCO5, LC06, LC07, LC09, ZF02, ZF03, ZFT1, SC01, SC02, **BF01**, GC01, GC02, HC01, HC02, CC01, CC02, BC01, BC02
Sediment	Upland erosion	Water Quality Habitat	– Suspended solids – Homogeneous and embedded substrate	not determined through GIS
Sediment	Bank erosion	Water Quality Habitat	– Suspended solids – Homogeneous and embedded substrate	not determined through GIS
Sediment	In-stream mining	Water Quality Habitat	– Suspended solids – Homogeneous and embedded substrate	not determined through GIS
Fecal Coliform Bacteria	Cattle	Water Quality	– Impacted water quality	not determined through GIS
Fecal Coliform Bacteria	Sewer overflows, illicit connections	Water Quality	– Impacted water quality	See Section 3.2
Toxicity	Illicit connections, legacy issues	Water Quality	– Loss of aquatic life – Impacted water quality	See Section 3.2
Nutrients	Agricultural activity, lawns	Water Quality	– Loss of aquatic life – Algal growth	See Section 3.2

4.0 STAKEHOLDER INPUT PROCESS

4.1 FORMATION OF STAKEHOLDER TEAM

From the beginning of the EEP project in the Lower Creek watershed, the involvement of local stakeholders was viewed as a vital part of the watershed planning process. In fact, staff from the Planning Department at the Western Piedmont Council of Governments (WPCOG) was hired to develop, in conjunction with EEP staff and MACTEC, a list of local stakeholders necessary to ensure the success of the planning process. WPCOG's awareness of key water quality and environmental stakeholders greatly assisted in developing a list of stakeholders. These individuals became the basis for the stakeholders group, in this planning process called the Technical Advisory Committee (TAC). The individual members of the TAC and the organizations they represent are listed in Table 4.

Table 4: Members of the Lower Creek Technical Advisory Committee (TAC)

Organization	***Representatives***
Burke County	Judy Francis, Planning Director Marc Collins, Interim Planning Director
Caldwell County	Bill Duquette, County Environmental Engineer Eric Woolridge, Senior Planner
City of Lenoir	Charles Beck, Utilities Director
National Resource Conservation Service, Burke and Caldwell Counties	Rusty Lyday, District Conservationist
NC Cooperative Extension	Allen Caldwell, County Director
Division of Forestry	Roger Miller, Water Quality Forester
Carolina Land & Lakes Resource Conservation & Development	Dan McClure, Executive Director
Foothills Conservancy	Tom Kenney, Land Protection Director
Duke Power	Bill Fortis, Scientist
NC Wildlife Resources Commission	Jim Borawa
Burke County Soil and Water	Jack Huss
Lenoir-Rhyne College	Marsha Fanning, Professor of Biology
NC Division of Water Quality	Dave Toms and Mary Stone
Town of Gamewell	Ron Hancock, Planner
Caldwell County Pathways/Lenoir City Council	Merlin Perry

It was important to secure the participation of persons knowledgeable about the Lower Creek watershed, aware of key local issues and any current projects that might be underway or under consideration in the watershed. Information on the progress of on-going projects was shared with the TAC as a whole near the conclusion of each TAC meeting. This provided valuable input for other TAC members and provided EEP and MACTEC a fuller awareness of community concerns about the Lower Creek watershed.

The four primary roles of the TAC were:

- Provide local perspective,
- Prioritize issues for watershed planning,
- Prioritize areas for implementation, and
- Serve as a link to the larger local community.

4.2 MAJOR ISSUES OF CONCERN IDENTIFIED BY THE LOWER CREEK TAC

4.2.1 Initial Concerns and Goals

At the opening meeting (March 2005) of the Technical Advisory Committee, members described an initial set of local concerns they would like to see addressed in the Lower Creek *Watershed Management Plan*. These 12 issues -- many of which overlap in terms of their root causes or required strategies for implementation -- became the "first cut" at developing a list of community goals for the Lower Creek watershed:

1. Obtain right-of-way easements along streams to build paths and greenways.
2. Improve water quality conditions in streams; improve conditions in Lake Rhodhiss.
3. Improve the public's understanding of the functions of floodplains; including education, erosion control measures and developing appropriate regulations.
4. Develop alternatives to impervious parking areas.
5. Manage stormwater more effectively.
6. Promote a better understanding of how cultural/historic resources relate to natural resources.
7. Provide better explanations to the public on why changes in zoning ordinances are needed; for example, what are the benefits associated with low density development along streams?
8. Maintain/protect wildlife habitat.
9. Consider effective sediment transport and deposition by local watercourses.
10. Protect public water supply.
11. Ensure the plan is transferable to other watersheds.
12. Educate the public about local watershed issues and potential solutions.

4.2.2 Additional Concerns and Goals

During discussion of the Lower Creek *Watershed Assessment Report* at the TAC meeting in December 2005, additional items and a higher degree of technical focus were added to the initial list of TAC concerns. These additional items included:

General Issues:

- Tie in projects with utility work projections
- Pursue restoration/remediation strategies for old furniture sites

Northern Lower Creek:

- Seek preservation options at headwaters in the Zacks Fork and Lower Creek subwatersheds
- Develop strategy for the old Lenoir reservoir site in the Zacks Fork 02 subwatershed
- Implement land development policies to encourage lower density development for second homes
- Address issues of stream channelization/straightening
- Prioritize headwater properties for acquisition; some are currently for sale

Central Lower Creek:

- Address water quality issues
- Develop solutions within the constraint that most urban areas are already built-out
- Work to restore/enhance or stabilize sections of Lower Creek below the city, as sewer expands southward to the airport

Southern Lower Creek:

- Address the issue of in-stream sand mining – is it likely to continue?
- Work with the Foothills Conservancy—mitigation option through partnership with County in Abingdon Creek01 subwatershed, in vicinity of "new" landfill (conservation easement)
- Within the Lower Creek 10 subwatershed —Foothills is discussing purchasing option at the mouth of Lower Creek, for wetlands preservation.

4.3 TAC MEETING MILESTONES

- ***Meeting 1: March 1, 2005***
  The initial meeting of the Technical Advisory Committee (TAC) introduced members to the Ecosystem Enhancement Program (EEP) and its goals, and described the ways the TAC can assist in developing the Lower Creek *Watershed Management Plan*. WPCOG staff reviewed a previous planning effort, and MACTEC staff summarized data collected for the Phase I Report. EEP staff emphasized the benefits of participation in this planning process for the Lower Creek watershed. Phases II and III of the watershed management planning process were described by MACTEC staff.

- ***Meeting 2: May 3, 2005***
  The second TAC meeting identified local needs in developing a Lower Creek *Watershed Management Plan*. DWQ staff helped the TAC understand the role of the Lower Creek watershed in the larger Lake Rhodhiss watershed and explained why Lake Rhodhiss was considered "impaired" by state officials. Excessive sediment in the Lower Creek watershed contributes to the poor aquatic life in those streams, as a recent Total Maximum Daily Load (TMDL) study demonstrated. A community meeting was scheduled for late June 2005 to seek input from local citizens about their concerns for the Lower Creek watershed.

- ***Meeting 3: December 13, 2005***
  The next TAC meeting included a synopsis of the recently published DWQ report ("Summary of Monitoring Results in Lower Creek Watershed and Tributaries – Catawba

River Basin: February 2004—April 2005"), which includes data on a benthic macroinvertebrate study conducted during 2002-04 and an impaired streams stressor study completed in 2005. [Details of this study are reported in the *Watershed Assessment Report* (WAR) and summarized in Section 3.0 of this Plan.]

Findings of the Lower Creek *Watershed Assessment Report*, prepared by MATEC, were another important component of this TAC meeting. MACTEC staff reported general findings for the northern, central and southern portions of the watershed, which are summarized in section 3.4 of this Plan.

- ***Meeting 4: January 10, 2006***
  The fourth TAC meeting focused on identifying potential project sites and incorporating community priorities and watershed needs into the *Watershed Management Plan* (WMP). The WMP will be composed of strategies to address both watershed-wide stressors and stream-specific stressors, including site-specific mitigation projects. The sites identified by TAC members at this meeting will also be incorporated into a Watershed *Project Atlas* [Appendix A of this Plan]. TAC members viewed maps showing 82 potential project sites and provided information about additional candidates for project consideration.

  TAC comments on specific sites and issues for broad management recommendations proposed for implementation by various local government agencies were also summarized at the meeting. Other issues identified by the TAC as needing to be addressed in the recommendations include the "legacy landfill," forming a public education workgroup within the TAC, floodplain encroachment and sand mining operations.

- ***Meeting 5: June 20, 2006***
  The fifth and final meeting of the Technical Advisory Committee centered on the completed Lower Creek *Watershed Management Plan* and reviewed the process which resulted in the recommendations proposed in the *Plan.* During the meeting EEP and MACTEC staff reviewed key watershed stressors and strategies to address them, the final projects recommended for implementation, and measures local governments can take to implement important components of the *Plan.* The TAC also discussed in detail ways to implement a "Watershed Council" to educate the public about the importance of watershed issues and to assist in implementing the recommended projects in the Lower Creek watershed. The TAC agreed to continue meeting even though its formal assignment has been accomplished.

4.4 TAC FEEDBACK AND FINAL RECOMMENDATIONS

At the January 2006 meeting, TAC members were given additional opportunities to identify projects on detailed maps provided by MACTEC and to propose their ideas for the prioritization of subwatersheds for project selection. Subwatershed prioritization facilitates the clustering of multiple projects in close proximity, thereby improving the likelihood of achieving measurable improvements to water quality, hydrology and habitat within a particular catchment. An initial classification of priority subwatersheds for preservation, restoration and stormwater BMPs was presented by MACTEC. TAC members recommended additional priority areas be designated, including Bristol Creek subwatersheds 01 and 02. The subwatershed prioritization/classification methodology was subsequently refined (the results of which are included in Section 6.0 of this Plan).

The TAC also spent some time at this meeting considering which broad land management policies local governments could use to further the implementation of recommendations in the Watershed Management Plan. The following eight institutional measures were discussed with the TAC. Specific comments offered by the TAC are included under each of these measures.

1. **Comprehensive land use planning** – Burke County's comprehensive plan was last revised in 1993. The County is using the small area planning process to update and revise its land use regulations. Caldwell County's land use plan is being revised. Lenoir's current comprehensive plan was developed in 1975, and the City has established a planning process using local citizens to make recommendations for revising the plan.
2. **Subdivision/land development ordinances** – Burke County relies heavily on the state's erosion control regulations. The County's zoning ordinance addresses development on steep slopes and erosion control but not in the Lower Creek area. Caldwell County has adopted a watershed protection ordinance based on the state's model ordinance. This ordinance only applies to a relatively small percentage of the project area. Caldwell County is planning on implementing a local sediment erosion control program. Municipalities within the County will be covered. The County will apply for grant funds from the state this December and plans to implement the program in about one year. Lenoir does not address stormwater or slopes in its current regulations. Impervious surfaces are regulated to a lesser degree.
3. **Erosion & sedimentation control ordinances**
4. **Stormwater management ordinances** – Burke County has stormwater requirements for lake-front development. Caldwell County has received a NPDES Phase II Permit from the state. The County is co-permitting with municipalities and is currently developing a stormwater ordinance.
5. **Floodplain management ordinances**
6. **Riparian buffer ordinances** – Burke County has more stringent buffer rules for development along the Catawba River than the state does. Buffers are not required along streams county-wide. Caldwell County's current draft stormwater ordinance requires buffers along perennial streams.
7. **Public education programs**
8. **Watershed stewardship programs** – Both Counties have activities that fall under this heading. Burke County has an Environmental Affairs Board that makes recommendations to the Planning Board and Board of Commissioners about environmental issues. An active advocacy group, the Lake James Environmental Association, has members living in Burke County and participates in the Volunteer Watershed Information Network (VWIN) Program. Caldwell County Cooperative Extension is active in working with a variety of partners in the County. Examples of activities include special workshops, master gardener program, stormwater stenciling by 4H members, and the use of newsletters and local TV for public education purposes. Caldwell County Pathways is an advocacy group interested in promoting trail opportunities in the County. Both Burke and Caldwell County Soil and Water Conservation Districts annually host Big Sweep, a volunteer program to pick up trash from streams.

Each of these institutional measures, and associated recommendations, are addressed in greater detail within Section 7.0 of this Plan.

4.5 ADDITIONAL OUTREACH/EDUCATION EFFORTS AND COMMUNITY INPUT

4.5.1 Publicity for the Lower Creek Watershed Project

Special efforts were made by WPCOG staff to inform the public of the Community Meeting scheduled for June 21, 2005 at the Caldwell County Public Library in Lenoir. News releases were written by WPCOG staff, distributed to the two daily newspapers in Lenoir and Morganton, as well as in the regional *Catawba Valley Neighbors* section of the *Charlotte Observer*, and published in local "event calendars." A feature story on the EEP/Lower Creek watershed project was published in the *Lenoir News Topic*.

Staff from EEP, WPCOG, MACTEC and the Caldwell County Planning Department joined together to create a special TV program focusing on the issues facing Lower Creek and its impact on Lake Rhodhiss. This special show was broadcast on the Caldwell County-owned cable TV station several times during the week before the Community meeting as part of the "Caldwell County Today" show.

4.5.2 Community Meeting – June 21, 2005

Seven local citizens met with project staff and several members of the Technical Advisory Committee to gather community opinions and concerns about Lower Creek in June 2005. Citizen-stakeholders at the community meeting joined together in a small group discussion setting and responded to the following three questions:

1. What are the **assets** of the Lower Creek watershed?
2. What **concerns** do you have regarding the Lower Creek watershed?
3. What is your long-term (10-15 year) **vision** for the Lower Creek watershed?

Following their responses to the above questions, the citizens were allocated three votes each for the "concerns" and "vision" responses. Stakeholders were instructed to vote on the statements they considered most important. Individuals could vote once for each of three separate responses or chose to vote two or three times on a single response, as long as they did not vote more than three times overall within the "concerns" and "vision" categories. Voting did not occur for statements within the "assets" category.

ASSETS (non-voting category)

1. Takes away stormwater
2. Carries a large quantity of water
3. Still largely rural
4. Provides examples of what happens when we do no exercise care
5. With land usage/impervious cover does not have time to recover
6. Presents a good opportunity for restoration
7. Large portion of usable land
8. Provides source of drinking water at relatively low cost

CONCERNS

1. Development is occurring without adequate controls (5 votes)
2. Drinking water quality (4)
3. Lack of buffer areas (3)
4. A growing amount of impervious cover (1)

5. A lot of stuff in Lower Creek that shouldn't be there…some you can see and some you can't (1)
6. Development has encroached on the creek (e.g. Lenoir Mall) (1)
7. You can tell it has rained because of the sediment (1)
8. Wildlife and insect dying/leaving due to loss of habitat (1)
9. Occasional sewage overflows into the Creek (1)
10. Chlorine put in Creek kills wildlife (1)
11. Industries located along tributaries may be stressing stream (1)
12. Erosion – road building, development (1)
13. Streambank erosion (1)
14. Effect of water quality on property value (e.g. addition to the 303(d) list) (1)
15. Nutrients (golf course, homes) (1)
16. Some (not major) cattle & horse access (1)
17. Flooding due to increased runoff (1)
18. Floodwaters are contaminated (sewage, toxins) (1)
19. Trash and debris finds it ay into creek – impedes flow (1)
20. Some "straight pipe" discharges of grey water (1)

VISION

1. Adequate enforcement of erosion and sedimentation control regulations (5 votes)
2. Comprehensive plan for watershed management with all local governments supporting (e.g. 321 overlay plan) (4)
3. Get Lower Creek and other water bodies off the impaired list (3)
4. Conservation easements/preservation of natural areas (e.g. wetlands) (2)
5. Greenway System – walking, biking, provide a buffer, attract people, source of pride (1)
6. A "Clean Stream" – no bank erosion, no trash in stream, no "spraying with Roundup" (1)
7. Commercial/Industrial property owners clean up their property around stream (1)
8. Better drainage system to control flows – reduce flooding, reduce erosion (1)
9. Area-wide understanding of the value of watershed management (1)
10. Provide recognition/incentive for participation by companies (e.g. "clean water award")
11. "Green" programs (e.g. reuse of water) (1)
12. Use of Stormwater BMP's (e.g. settling basins) (1)

Despite the low public turnout, project staff and TAC members felt the group's expressions of "concerns" and "vision" for Lower Creek focused on viable ways to remedy the current situation in Lower Creek. The input from the community meeting was valuable, staff and TAC members felt, because the public showed an understanding of options for providing remedies for water quality issues in Lower Creek.

4.5.3 Progress Reports to Local Governments

WPCOG and EEP staff met with elected boards from Caldwell and Burke Counties and from Lenoir and Gamewell in August and September 2005. These summary presentations gave local elected officials an overview of the Lower Creek watershed project and offered them the opportunity to ask questions or seek additional information about the project.

An additional progress report was also planned by WPCOG and EEP staff in late summer or fall of 2006, updating local officials from these same local governments on the recommendations proposed in the *Watershed Management Plan* and on implementation efforts. Staff stressed the importance of local commitment to implement Plan recommendations and the Technical Advisory Committee's role in developing recommendations of importance to local communities.

4.5.4 TAC Education Subcommittee

An *ad hoc* subcommittee to develop educational options to be included in the Lower Creek *Watershed Management Plan* held two meetings in March and April 2006. The group aimed to develop ways to educate citizens and local officials on the need for improving the water quality in Lower Creek. It also discussed ways that the implementation strategies described in the *Watershed Management Plan* could be put into action. A variety of existing programs for use at the state, regional and local levels were identified during the initial discussion.

At the first meeting subcommittee members identified four initial topics with education implications. During the second meeting subcommittee members decided to formally recommend three of the four ideas discussed at the first meeting:

- The Clean Water Contractor Program was recommended for inclusion in the Plan's education recommendations;
- Information on the effects of poor water quality on economic development was proposed for presentation to local officials in a detailed data sheet or brochure; and
- A recently published brochure [*The Catawba River and You: Actions You Can Take to Protect Your Drinking Water Source, the Catawba River*] is available for distribution to citizens. It outlines practical steps that folks in Caldwell and Burke Counties can take to protect water quality in the watershed. Copies of the brochure can be obtained from the WPCOG Water Quality Administrator at (828) 322-9191.
- The establishment of a local watershed council, the fourth proposal, is addressed in Section 8.5 of this Plan.

4.5.5 Lower Creek Watershed Website

A website devoted to the Lower Creek watershed project was launched by the WPCOG before the public input meeting in mid-June 2005. This site provides periodic updates on the Lower Creek Local Watershed Planning effort, highlighting meeting summaries, PowerPoint presentations and major reports as completed by DWQ staff and MACTEC. The website was designed to provide TAC members easy access to detailed reports and updates from DWQ and EEP staff and project consultants: http://204.211.224.29/lowercreek/

5.0 WATERSHED RESTORATION FRAMEWORK

This Plan attempts to address watershed stressors, or problems, identified through the watershed assessment process (described in Section 3) with a number of approaches, including stream and wetland restoration, land preservation, institutional measures such as ordinances and regulations, best management practices, and pollutant-specific strategies. These strategies are described in detail in Sections 5, 6, 7, and 8. Management strategies were developed with the input of the Lower Creek Technical Advisory Committee, which prioritized stressors, identified priority areas, and named key restoration projects (see Section 4).

Major issues/stressors contributing to stream degradation within the Lower Creek watershed and where they are addressed in this plan are listed in Table 5 and below.

Table 5: Watershed Stressors and Management Strategies

Stressor	Management Strategy	Strategy Location
Stream bank erosion	Stream restoration, riparian buffers, livestock exclusion, sand dredging BMPs	Sections 5, 6.4, 7.4, 8.4
Lack of adequate forested buffer	Stream restoration, riparian buffers	Sections 5, 6.4, 7.4
Stream channelization	Stream restoration	Section 6.4
Impervious cover	Stormwater BMPs, stormwater ordinance, low impact development	Sections 6.4, 7.2, 7.3, 8.2
Upland erosion	Ag & forestry BMPs, erosion and sedimentation control ordinance, subdivision ordinance modifications, steep slope ordinance, public education	Sections 7.2, 7.3, 7.5, 7.7, 8.3, 8.4
Livestock access to streams	Livestock exclusion	Section 8.4
Floodplain development	Floodplain development ordinance	Section 7.6
Urban toxicants	Illicit discharge program, landfill strategy, watershed education program, stormwater BMPs	Sections 5, 7.2, 7.7, 8.2
Nutrients	Illicit discharge program, ag BMPs, riparian buffers, watershed education program, stormwater BMPs, additional studies	Sections 5, 7.2, 7.4, 7.7, 8.4
Fecal coliform bacteria	Retrofit wastewater collection system, ag BMPs, illicit discharge program, watershed education program, stormwater BMPs	Sections 5, 7.2, 7.8, 8.2, 8.4

1. Stream bank erosion

Impact: Habitat degradation (sedimentation), turbidity

Management strategy: stream restoration or enhancement, riparian buffer planting, livestock exclusion from streams

Strategy location: Sections 5 (this section), 6.4, 7.4, 8.4

Eroding stream banks are found throughout the watershed and are a primary source of sediment in watershed streams and Lake Rhodhiss. Strategies to address stream bank erosion depend on site-specific issues, such as the magnitude of degradation, stream size, watershed character, and causative factors. Small-scale bank stabilization projects can be done to address localized stream bank failures, but full-scale **stream restoration** projects are required to restore stable stream morphology where streams have become highly channelized and/or incised. Some streams simply need livestock fenced out and/or a buffer planted.

Section 6 identifies the most feasible stream restoration projects in priority subwatersheds of the Lower Creek watershed. These projects were identified using EEP's feasibility criteria, which include project size (e.g., stream length), drainage area size, and number of landowners. There are many other areas in the Lower Creek watershed that have eroding stream banks; of special note is Lower Creek itself, which is characterized by severe erosion in many areas, especially along its downstream half. Some of these areas can be addressed through other programs, such as NRCS and SWCD.

Lower Creek has one permitted **sand dredging** operation, and there are pending permits for three more operations. Lower Creek Technical Advisory Committee members have noted that this activity can cause systematic and local channel instability as well as turbidity. These operations are allowed through general permits assigned by the NC Division of Water Quality (DWQ), and they do not fall under Clean Water Act Section 401/404 permitting as dredging activities. DWQ can specify best management practices (BMPs) that minimize the impacts of sand dredging in its general permits; DWQ should monitor present activities and their impacts and determine a set of BMPs that are applicable to these operations.

2. Lack of adequate forested riparian buffer

Impact: Habitat degradation (lack of wood and leaf habitats), stream bank erosion
Management strategy: stream restoration or enhancement, riparian buffer planting
Strategy location: Sections 5, 6.4, 7.4

Many streams in the Lower Creek watershed lack an adequate forested buffer, which is essential to stream bank stability, aquatic habitat, canopy cover to maintain cool temperatures needed by aquatic organisms, and a filter for pollutants that run off adjacent lands. The Mountain Stream Buffer Technical Advisory Committee to the Upper Catawba River Basin Buffer Advisory Committee (2000) recommended at least 30 to 50 ft of woody vegetation along streams to maintain many buffer functions. For streams that are relatively stable, planting an adequate buffer can be sufficient to improve stream function; however, where streams are unstable, stream bank stabilization activities should also be implemented in addition to buffer planting.

3. Stream channelization

Impact: habitat degradation, increase in stormflow discharge rates and flow velocities, flooding, streambed scour, stream bank erosion
Management strategy: stream restoration or enhancement
Strategy location: Section 6.4

Lower Creek and many of its tributaries have been channelized, or straightened, in the past. This causes channel instability and consequent erosion and reduces stream habitat quality. It can also increase stream flow velocity, which during storms can scour stream habitats, cause more stream bank erosion, and increase flooding. Channelization can be corrected with stream restoration.

4. Impervious cover resulting from development activity

Impact: increase in stormflow discharge rates and flow velocities, flooding, streambed scour, stream bank erosion, pollutants

Management strategy: stormwater best management practice (BMP) retrofits, stormwater management ordinance, low impact development

Strategy location: Sections 6.4, 7.2, 7.3, 8.2

Impervious cover, such as parking lots, roads, and buildings, is a significant cause of degradation in the developed portions of the Lower Creek watershed. It increases the amount of runoff during storm events, carrying pollutants and increasing stream flow volume and velocity. As with channelization, this increase in flow can scour stream habitats, cause more stream bank erosion, and increase flooding. These impacts can be reduced with stormwater BMPs. Existing impervious cover can be retrofitted with stormwater BMPs, although this may be cost-prohibitive to perform on many existing areas. Future development should be encouraged to apply building and site design practices that minimize impervious surfaces and their impacts to streams (e.g., low impact development).

5. Upland erosion

Impact: Habitat degradation (sedimentation), turbidity

Management strategy: agriculture and forestry BMPs, erosion and sedimentation control measures, stormwater management ordinances, modifications in subdivision ordinances, public education, steep slope ordinance

Strategy location: Sections 7.2, 7.3, 7.5, 7.7, 8.3, 8.4

Erosion from unstabilized development sites, unvegetated slopes on residential and commercial land, and unpaved roads and driveways are sources of sediment for streams. Agricultural and forestry BMPs should be encouraged, and the public should be educated on upland erosion and measures to minimize its impacts. Sediment from development can be controlled with the development and/or enforcement of appropriate ordinances. Subdivision ordinances should be modified to protect steep slopes from development and/or a steep slope ordinance should be adopted.

6. Livestock access to streams

Impact: Bank erosion, habitat degradation (sedimentation), nutrient and fecal bacteria inputs

Management strategy: Fence out livestock and provide alternative watering

Strategy location: Section 8.4

Livestock operations exist throughout the rural portions of the Lower Creek watershed. Some of these allow livestock access to streams for watering, damaging stream banks and buffer vegetation and increasing nutrient and fecal coliform bacteria levels. Livestock should be fenced out of streams and provided alternative watering sources.

7. Floodplain development

Impact: Reduction in stream and floodplain capacity to transport flow, flooding

Management strategy: Floodplain development ordinance

Strategy location: Section 7.6

Development in floodplains reduces the capacity of floodplains to store and transport flood waters, increasing flooding downstream. A floodplain development ordinance should be enacted and enforced by local and county governments to restrict development in the floodplain.

8. Urban toxicants—metals, organic pollutants
Impact: Toxicity to aquatic organisms
Mangement strategy: Illicit discharge detection and elimination program, plan to address landfill pollutants, watershed education program, stormwater BMPs
Strategy location: Sections 5, 7.2, 7.7, 8.2

Evidence of toxicity was found in a number of streams that drain Lenoir. Toxicants detected included lead, copper, zinc, and organic pollutants (petroleum-based hydrocarbons). These toxicants can be carried to streams from impervious surfaces during storms and can be directly input via illicit or unknown connections to the stormwater system. Better education of watershed residents and businesses on reducing sources is needed. In addition, an illicit detection and elimination program, proposed in Caldwell County's Phase II stormwater permit, should be effective in reducing sources

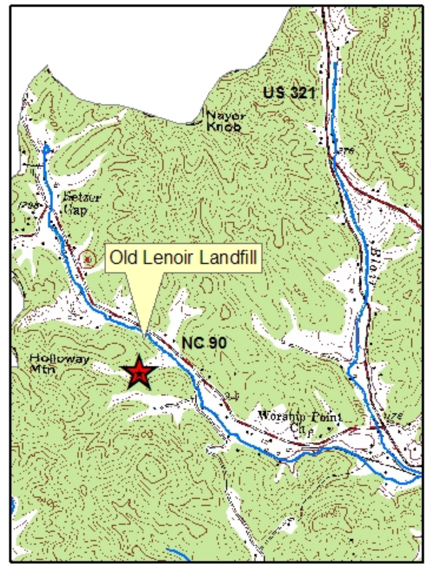


Figure 6: Landfill on Blair Fork

Of special note is toxicity in Blair Fork, which is likely due, at least in part, to a closed **unlined landfill** off NC 90. NC Division of Waste Management and NC Division of Water Quality should coordinate to perform further testing on impacts from the landfill and determine a strategy to mitigate impacts.

9. Nutrients
Impact: Impacts to aquatic organisms, increased algal activity in Lake Rhodhiss
Management strategy: Illicit discharge detection and elimination program, agricultural best management practices, riparian buffers, watershed education program, stormwater BMPs additional studies
Strategy location: Sections 5, 7.2, 7.4, 7.7, 8.2, 8.4

High nutrient levels were found in most streams sampled (including Lower Creek, an urban unnamed tributary to Lower Creek, Zacks Fork, Spainhour Creek, Blair Fork, and Greasy Creek); elevated nutrients are of special concern in Lake Rhodhiss, which is on the draft 2006 303(d) list. A combination of watershed education for residents, farmers, and business owners, agricultural BMPs for livestock, horticulture, and crop growers, and an illicit discharge detection and elimination program is needed.

The Lenoir wastewater treatment plant is also a significant source of nitrogen and phosphorus in Lower Creek and Lake Rhodhiss (USGS, 1997).

Further study is needed to quantify nutrient impacts and sources for Lake Rhodhiss. Duke Energy is in the process of renewing its license from the Federal Energy Regulatory Commission to operate its dams on the Catawba River, one of which forms Lake Rhodhiss. Plans to monitor nutrient inputs to Lake Rhodhiss are outlined in the draft relicensing agreement. The Division of Water Quality awarded a 319 grant to the Carolina Land and Lakes Resource Conservation and Development Council to monitor tributaries to the lake and develop a Lake

Rhodhiss Watershed Restoration Plan. Both of these efforts may be incorporated into TMDL monitoring and modeling efforts DWQ may perform to address impairment in the lake.

10. Fecal coliform bacteria

Impact: Increased health risk with wading, swimming, fishing
Management strategy: Retrofit public wastewater collection system, livestock best management practices, illicit discharge detection and elimination program, watershed education program, stormwater BMPs
Strategy location: Sections 5, 7.2, 7.8, 8.2, 8.4

High concentrations of fecal coliform bacteria were found throughout the watershed, and inputs have a diverse set of sources. The City of Lenoir's **wastewater collection system** has had problems with sewer overflows and leaks. To address this, it is upgrading a large section of its main sewer interceptor along NC 18, which has had chronic issues with overflows. To comply with its sewer system permit, which was issued in 2004, Lenoir will perform extensive inspections, maintenance, and rehabilitation on its sewer lines. It is expected that these actions will result in quantifiable improvement in sewer line function (Jim Reid, NC Division of Water Quality, personal communication).

Straight pipes and malfunctioning septic systems are also possible sources of fecal inputs; these can be pinpointed through an illicit detection and elimination program and their incidence decreased through watershed education. Livestock inputs of fecal waste can be eliminated by fencing cattle out of streams, locating concentrated feeding areas away from streams, and maintaining an adequate forested buffer.

6.0 WATERSHED IMPROVEMENT PROJECTS

This Section includes

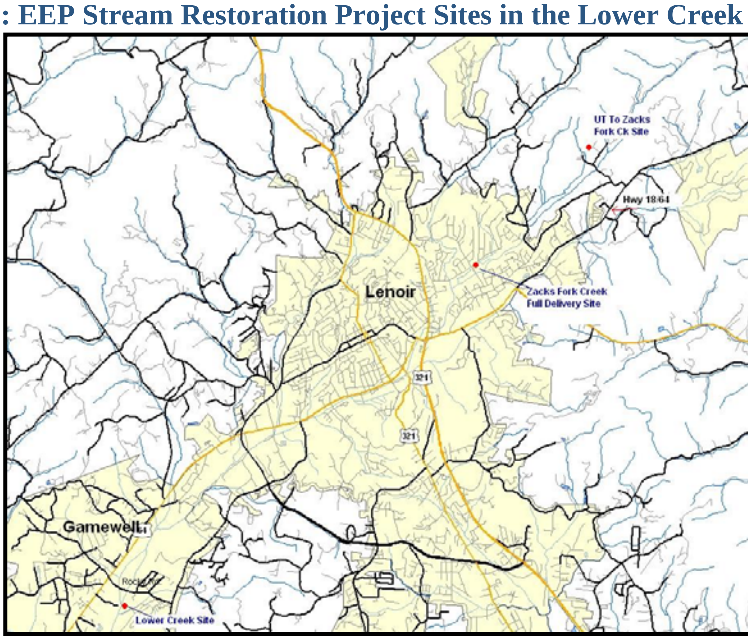
- A summary of current EEP restoration projects within the Lower Creek watershed (section 6.1);
- An overview of the general strategy for "project synergy" recommended to maximize functional restoration at the subwatershed scale (section 6.2);
- A description of the subwatershed classification and prioritization methodology used to identify the best project types and locations for addressing the major functional problems in individual subwatersheds (section 6.3); and
- A summary of the primary project sites (38 total) recommended to address the major functional problems identified across the LWP study area, and how they were selected (section 6.4).

Appendix A of the WMP presents the Project Atlas for the 38 primary project sites recommended for implementation, including a detailed site map, a summary of major functional issues addressed by the project, and cost estimates for each project. **Appendix D** provides a master list and map of all 187 potential project sites identified from the Phase II GIS screening exercise and from local stakeholder recommendations (see Section 6.4 below).

6.1 CURRENT PROJECTS IN THE WATERSHED

EEP is currently working on three projects within the Lower Creek watershed (see Figure 7 below). These include a recently completed stream restoration project [approx. 3,900 linear feet] on Zacks Fork Creek near the soccer complex in subwatershed ZF03, implemented as part of EEP's Full Delivery program. A second project, currently being designed, is located on Lower Creek on the Cardwell and Kincaid Furniture parcels on Rocky Road (LC07) and will involve approximately 3,000 feet of streambank stabilization and installation of stormwater management BMPs. A third site is currently being assessed as a potential stream restoration project (approximately 1,500 linear feet) on an unnamed tributary to Zacks Fork Creek in subwatershed ZFT1.

Figure 7: EEP Stream Restoration Project Sites in the Lower Creek Watershed



In addition to these EEP projects, the NRCS has worked with several horticultural and livestock operations on the implementation of agricultural BMPs and streambank stabilization on their farms. The Foothills Conservancy (FC) has submitted an application to the CWMTF for the acquisition of a tract of Crescent Resources land that covers the downstream portions of Lower Creek, Bristol Creek, and the Johns River near Lake Rhodhiss. This project would protect all streams in subwatershed LC10. The FC is also working with Caldwell County on a preservation project near the county's active landfill in AC01 (upper Abingdon Creek) to mitigate for landfill impacts.

6.2 PROJECT SYNERGY OBJECTIVES

The Lower Creek watershed contains approximately 208 total miles of stream channel. Given the size of the Lower Creek watershed, the best approach to influencing or producing a positive effect on the hydrology, habitat, and water quality of the watershed is the clustering of restoration projects at the subwatershed scale. By implementing multiple projects in close proximity to one another (within the same subwatershed), a cumulative benefit will theoretically be gained for the most important functional indicators. This clustering (or "project synergy") strategy is encouraged by EEP's Watershed Needs Assessment Team in their report to the Mitigation Coordination Group (October 2003) – see http://www.nceep.net/news/reports/WNAT%20Mit%20Group%20Final.pdf.

The EEP Monitoring and Research section is presently engaged in research designed to (1) determine the optimal scale and proximity of project clusters to achieve functional benefit; and (2) identify the functional indicators (monitoring parameters) and values most appropriate for long-term project success criteria.

The practical recommendation that follows from this general goal of project synergy is simply to implement multiple projects in close proximity to each other within high-priority subwatersheds whenever possible.

6.3 SUBWATERSHED PRIORITIZATION

This Section describes the subwatershed classification and prioritization process employed by MACTEC within the Lower Creek watershed. The 29 subwatersheds have been classified utilizing GIS analysis in conjunction with the subwatershed's functional rating (see Section 3.3) and stakeholder input.

Four subwatersheds were initially omitted from the subwatershed prioritization due to large channel dimensions, minor functional benefit, or poor water quality from an associated landfill (Table 6). The remaining twenty-five subwatersheds that comprise the Lower Creek watershed were grouped into three general categories of mitigation potential: **preservation, restoration and stormwater BMPs** (Figure 8) In general, subwatersheds in more rural areas with relatively low values for impervious cover (IC) and high values for riparian cover were considered to be better suited for preservation. Subwatersheds situated in areas with large tracts of cleared land with past or present agricultural production are often ideal candidates for restoration. Subwatersheds in urbanized areas with relatively high values for impervious cover and low values for riparian cover were considered to be better suited for stormwater BMP measures.

Figure 8: Subwatershed Prioritization Flowchart

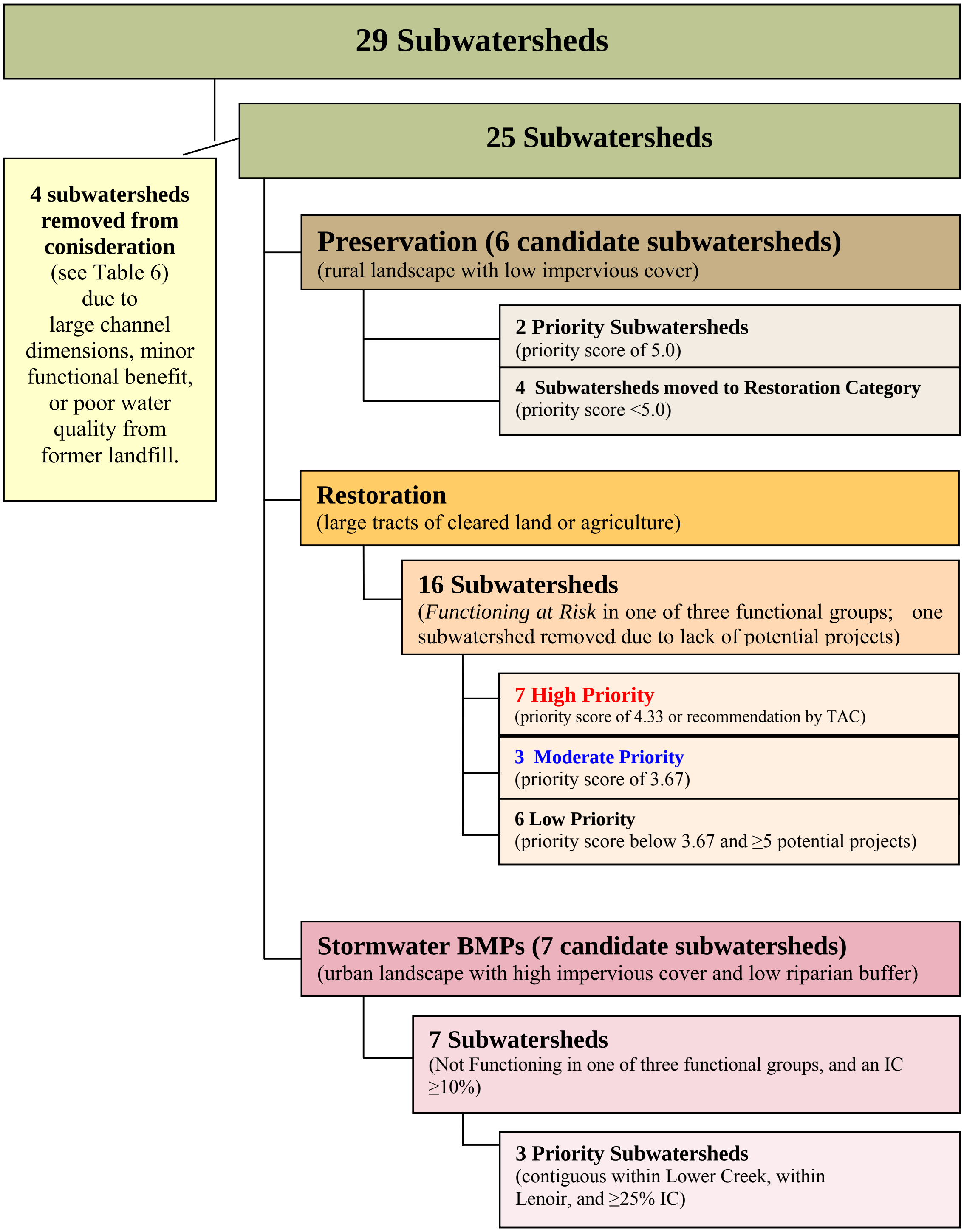


Table 6: Subwatersheds Omitted From Prioritization

NAME		JUSTIFICATION
BF01 (Blair Fork)		Poor water quality due to leachate from former landfill
LC08	lower reaches of Lower Creek mainstem	Lower Creek channel dimensions too large
LC09		Lower Creek channel dimensions too large
LC10		Intact riparian buffers; all streams already slated for protection by Foothills Conservancy (CWMTF acquisition): the Lower Creek-Johns River-Lake Rhodhiss tract.

In the *Watershed Assessment Report* (WAR) each subwatershed received a functionality rating for habitat, hydrology, and water quality (see page 24 of the WAR, *Overall Functionality Scoring* and Section 3.3 of this Plan). A rating of ***Functioning*** was assigned to the subwatershed function provided the function was performing naturally, without evidence of significant degradation or a stressed condition. A rating of ***Functioning at Risk*** was assigned to the subwatershed function if the function was moderately degraded and showed evidence of stress such that, without intervention, it could over time become not functioning. A rating of ***Not Functioning*** was assigned to the subwatershed function if the function was stressed to the level of being highly degraded. Based on these functional ratings, the following rationale was used to develop a subwatershed priority rating: a subwatershed function with a rating of *Functioning* should maintain its functionality through the mitigation strategy of preservation; a subwatershed function with a rating of *Functioning at Risk* could see the functionality rating improved through restoration strategies; a subwatershed function with a rating of *Not Functioning* most likely would not respond to preservation or restoration strategies; however, the function may respond positively to management opportunities over time.

Given the aforementioned rationale, prioritization commenced by assigning a priority score to each subwatershed based on its associated functionality rating for habitat, hydrology, and water quality (as presented in the WAR). Subwatershed ratings of *Functioning*, *Functioning at Risk*, and *Not Functioning* were assigned a value of 5, 3 and 0, respectively. A **composite priority score** for each subwatershed was calculated based on the average score of these three parameters (water quality; hydrology; habitat).

6.3.1 Preservation Subwatersheds

A subwatershed was selected for **preservation** strategies if it had been assigned a functional rating of *Functioning* for at least two out of three functionality parameters (habitat, hydrology, and water quality) and had not been assigned any functionality rating of *Not Functioning*. Table 7 below provides a summary of the six subwatersheds that fit these criteria. Subwatersheds **AC01** and **WM01** (bolded in table) were selected as the two priority subwatersheds for preservation strategies because both were assigned the highest priority scores (5.00) of all Lower Creek subwatersheds. The remaining four subwatersheds in Table 7 below were then considered for **restoration** strategies, as they each have a *Functioning at Risk* component that could benefit from restoration/enhancement efforts.

Table 7: Subwatersheds Selected For Preservation Strategies
[Bold indicates selection as a priority subwatershed for this mitigation category]

Name	Habitat	Hydrology	Water Quality	Priority Score
AC01	**F**	**F**	**F**	**5.00**
CC01	F	F	FR	4.33
HC02	F	F	FR	4.33
LC01	F	FR	F	4.33
WM01	**F**	**F**	**F**	**5.00**
ZF01	F	FR	F	4.33

6.3.2 Restoration Subwatersheds

A subwatershed was selected for **restoration** strategies if it had been assigned a functional rating of *Functioning at Risk* for at least one out of three functionality parameters (habitat, hydrology and water quality) and had not been assigned a functionality rating of *Not Functioning*. Table 8 below provides a summary of the 17 subwatersheds that fit these criteria. [Note: the upper half of ZF03 was also selected for restoration strategies–despite an overall subwatershed rating of NF in water quality–because of a relatively high percentage of wooded riparian buffers and recommendations from the Lower Creek TAC.]

Subwatersheds considered for **restoration** strategies were *further* classified into three priority groups based on their functional priority score and the total number of existing and potential mitigation project sites identified within their boundaries. In Table 8, "MACTEC projects" are those potential project sites that were identified through GIS analysis by MACTEC. "Stakeholder projects" are potential projects sites recommended by stakeholders participating in the Lower Creek Local Watershed Planning process. "Existing/past projects" are watershed improvement projects that have been or are currently being funded by the Clean Water Management Trust Fund, or mitigation projects that have been or are currently being funded by the Ecosystem Enhancement Program.

Subwatersheds designated for High Priority restoration (highlighted in red in Table 8) were those that received a priority score of 4.33 or were recommended by the Lower Creek TAC. The TAC recommended that subwatersheds LC01, ZF01, ZF02 and ZFT1 be given top consideration for restoration projects due to the predominance of agricultural land uses and farm properties that could benefit from stream restoration efforts and/or agricultural BMPs. Subwatersheds that were designated as Moderate Priority for restoration (highlighted in blue in Table 8) were those that received a priority score of 3.67. Lastly, subwatersheds that received a score below 3.67 (yet had at least five existing or potential projects) were designated as Low Priority for restoration. Subwatershed LC02 (upper Lower Creek) was omitted from consideration due to fewer than five potential projects within its boundaries. This left 16 subwatersheds remaining as priority subwatersheds for restoration projects.

Table 8: Subwatersheds Selected For Restoration Strategies

[Asterisks indicate subwatersheds recommended as priorities for restoration projects by the Lower Creek Technical Advisory Committee (TAC), regardless of their functional priority scores.]

Name	Habitat	Hydrology	Water Quality	Priority Score	Projects (MACTEC)	Project (Stake-Holders)	Projects (Existing/ Past)	Project (Total)
AC02	FR	FR	FR	3	4	1	0	5
BC01	FR	F	FR	3.67	3	1	0	4
CC01	F	F	FR	4.33	3	1	0	4
GC01	F	FR	FR	3.67	4	2	0	6
HC01	FR	FR	FR	3	5	0	0	5
HC02	F	F	FR	4.33	5	0	0	5
HC03	F	FR	FR	3.67	2	0	0	2
LC01*	F	FR	F	4.33	4	2	0	6
LC02	FR	FR	FR	3	3	0	0	3
LC03	FR	FR	FR	3	4	1	0	5
LC04	FR	FR	FR	3	5	3	0	8
LC07	FR	FR	FR	3	9	2	0	11
SC01	FR	FR	FR	3	4	1	0	5
ZF01*	F	FR	F	4.33	4	3	0	7
ZF02*	FR	FR	FR	3	4	1	0	5
ZF03 (upper)	FR	FR	NF	2	2	2	1	5
ZFT1*	FR	FR	FR	3	4	0	2	6

6.3.3 Stormwater BMP Subwatersheds

A subwatershed was selected for **stormwater BMP** strategies if it had been assigned a functional rating of *Not Functioning* for at least one out of three functionality parameters (habitat, hydrology, and water quality) and had an impervious cover (IC) value ≥10%. Table 9 below provides a summary of the seven subwatersheds that fit these criteria. **LC05**, **SC02** and the lower half of **ZF03** (bolded) were selected as the highest priority subwatersheds for stormwater BMP strategies because they had IC values ≥25%, were situated within the urbanized Lenoir municipal area, and were contiguous within the Lower Creek watershed (allowing maximum potential for functional improvement through project synergy).

Table 9: Subwatersheds Selected For Stormwater BMP Strategies
[Bold indicates selection as a priority subwatershed for this mitigation category]

Name	Habitat	Hydrology	Water Quality	Priority Score	% IC
BC02	NF	FR	FR	2.00	10.1
CC02	NF	FR	FR	2.00	10.8
GC02	NF	FR	NF	1.00	14.2
LC05	**NF**	**FR**	**NF**	**1.00**	**28.7**
LC06	FR	NF	FR	2.00	19
SC02	**NF**	**NF**	**NF**	**0.00**	**28**
ZF03 (lower half)	**FR**	**FR**	**NF**	**2.00**	**29.6**

6.4 IDENTIFIED PROJECTS

MACTEC reviewed the 153 stream reach sites that had been identified through GIS analysis during the watershed assessment (Phase II) and an additional 34 sites suggested by the Lower Creek TAC for the purpose of identifying potential stream and wetland improvement project for the Lower Creek watershed. The list of all 187 sites reviewed (the master site data set) and site location map are presented in Appendix D. This master site data set was reviewed for potential stream and wetland **restoration**, and stream and wetland **preservation** sites. Candidate sites for **stormwater BMP projects** are also identified as potential mitigation sites in this section of the *Watershed Management Plan*.

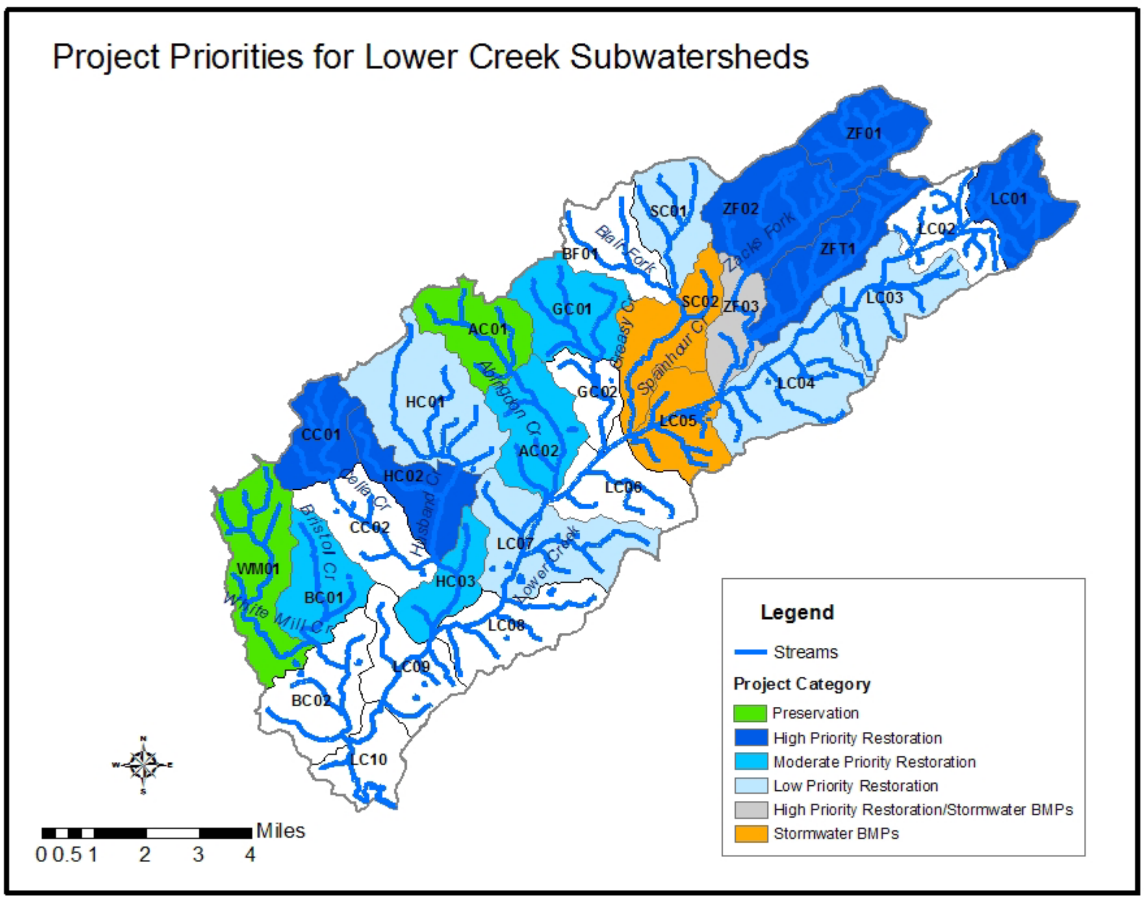
Figure 10 in this section presents an overview of the site screening and selection process used to identify the highest priority (or **primary**) project sites recommended in three major mitigation categories: stream restoration, stream preservation and wetlands restoration/preservation.

Table 10: Final Priority Subwatersheds & Mitigation Categories

NAME	MITIGATION CATEGORY
AC01	Preservation
WM01	Preservation
ZF02	Restoration (High Priority)
ZF03 (upper)	Restoration (High Priority)
ZFT1	Restoration (High Priority)
CC01	Restoration (High Priority)
HC02	Restoration (High Priority)
LC01	Restoration (High Priority)
ZF01	Restoration (High Priority)
BC01	Restoration (Moderate Priority)
GC01	Restoration (Moderate Priority)

NAME	MITIGATION CATEGORY
HC03	Restoration (Moderate Priority)
AC02	Restoration (Moderate Priority)
HC01	Restoration (Low Priority)
LC03	Restoration (Low Priority)
LC04	Restoration (Low Priority)
LC07	Restoration (Low Priority)
SC01	Restoration (Low Priority)
ZF03 (lower)	Stormwater BMP
LC05	Stormwater BMP
SC02	Stormwater BMP

Figure 9: Project Priorities for Lower Creek Subwatersheds



6.4.1 Stream Restoration

The minimum stream length that is generally considered cost-effective for EEP restoration projects is 2,000 linear feet (ln ft). Using an assumed post-restoration sinuosity factor of 1.2, the minimum stream length for a channelized stream has to be approximately 1,650 ln ft. Therefore, initial stream restoration site selection was based on a site having a sinuosity of less than 1.2 and a minimum length of ≥1,650 linear feet (ln ft). This initial screening resulted in 43 stream restoration sites being identified based on the criteria listed above (Figure 10).

The 43 potential stream restoration sites were then reviewed to determine their locations relative to the prioritized subwatersheds (Section 6.3 above) and the number of land owners associated with proposed project parcels. Twenty-two of the 43 candidate stream sites are deemed to be ***primary*** sites for restoration because they are located in a priority subwatershed and have two or fewer land owners (Table 11). Locations of the primary stream restoration sites are included in Figures 11 through 13. Specific site information and a color digital aerial photography view for each of the 22 primary sites are in Appendix A.

The 21 sites (of the 43 that met basic project screening criteria) not selected as primary sites are listed in Table 14 and should be considered ***secondary*** stream sites worthy of project implementation only if the primary sites fail to be acquired.

Figure 10: Site Selection Flowchart

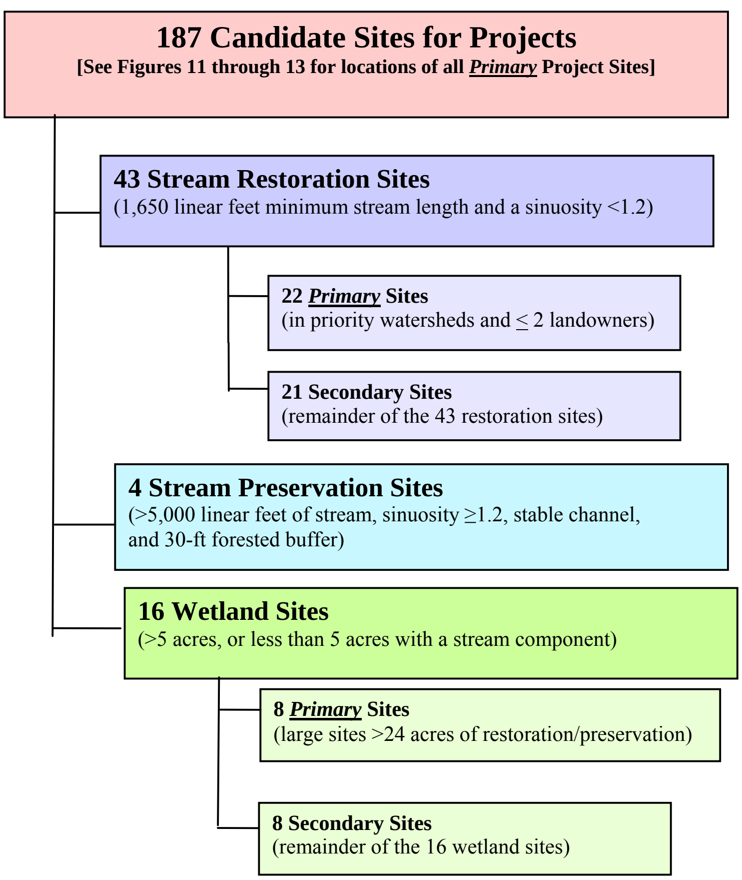


Table 11: *Primary* Sites Recommended for Mitigation Projects
[See Figures 11 through 13 for Site Locations]

Site Name	Site ID Code	Landowner Name	Existing Stream Length (ft)	Mitigated Stream Length (ft)	Wetland Acreage	Project Type
Beach Tract	SR-15	Horace Beach Heirs	3,230	3,876	NA	Stream Restoration
Harper Morganton #108	SR-16	Lenoir Golf Club Inc. Caldwell Community College	2,575	3,090	NA	Stream Restoration
K&B Farms Tract	SR-17	K & B Famrs Partnership	2,990	3,588	NA	Stream Restoration
Lenoir Aviation #78	SR-18	Lenoir Aviation Club Inc.	1,755	2,106	NA	Stream Restoration
North Wilkesboro #21	SR-19	Jane C Broyhill	4,010	4,812	NA	Stream Restoration
North Wilkesboro #22	SR-20	Fred L And Ethel Price	2,000	2,400	NA	Stream Restoration
Poteet #115	SR-21	Jack R And Emily J Poteet	3,350	4,020	NA	Stream Restoration
Powell #67	SR-22	City Of Lenoir	4,420	5,304	NA	Stream Restoration
Storey Frances #75	SR-23	Frances Mabe Story	3,115	3,738	NA	Stream Restoration
Truesdale #51	SR-24	D James D Miller	2,505	3,006	NA	Stream Restoration
Zacks Fork #403	SR-25	Maurice Grady Barlowe	2,675	3,210	NA	Stream Restoration
Crisp Tract	SR-26	Crisp, A B Bolick Toy Thurston & Troy Crisp Howard E & Shirley	2,070	2,484	NA	Stream Restoration
Lyndsey #328	SR-27	William W Jr. and Judy Mikeal	1,580	1,896	NA	Stream Restoration
Old Farmhouse Rd #329	SR-28	Barney D And Myrtle Laws Ray Loranzy Laws	2,780	3,336	NA	Stream Restoration
Throneburg Tract	SR-29	C H Throneburg	3,665	4,398	NA	Stream Restoration
Bumgarner Tract	SR-30	Dorothy Bumgarner	2,275	2,730	NA	Stream Restoration
Cedar #209	SR-31	Hibriten Development Crop	3,790	4,548	NA	Stream Restoration
Lenoir Golf Club Tract	SR-32	Lenoir Golf Club Inc.	3,585	4,302	NA	Stream Restoration
Lenoir Golf Course Tract	SR-33	Lenoir Golf Club Inc Landowner Unknown	2,010	2,412	NA	Stream Restoration
R Cardwell Tract	SR-34	Ranson M & Reba Cardwell	2,980	3,576	NA	Stream Restoration
Rocky Road #40	SR-35	Moore, Hazel A Jones, Ola Mae E	1,830	2,196	NA	Stream Restoration

Site Name	Site ID Code	Landowner Name	Existing Stream Length (ft)	Mitigated Stream Length (ft)	Wetland Acreage	Project Type
Rocky Road #401	SR-36	Beaver-Helton Prop Inc.	1,900	2,280	NA	Stream Restoration
Rader #336	SP-12	Carolina Center (Crescent) Burke County	18,910	18,910	NA	Stream Preservation
Watson Tract	SP-14	Watson, Tony D & Pamela H Landowner Unknown	5,280	5,280	NA	Stream Preservation
Dimmette #62	SP-11	Bullek Croporation Of NC Jetts Investment Llc	10,560	10,560	NA	Stream Preservation
Timber #400	SP-13	Rocky Road Inc. Landowner Unknown	47,220	47,220	NA	Stream Preservation
B&C Griffin Tract	WP-37	Ben & Clay Bollinger Griffin	3,985	4,782	46	Wetland Preservation
Hallyburton Tracts	WP-38	Hallyburton Geo	3,220	3,864	28	Wetland Preservation
Cardwell KH Tract	WR-39	Kathleen H Cardwell	1,000	1,200	42	Wetland Restoration
Cardwell KH2W Tract	WR-40	Cardwell, Kathleen H	NA	NA	38	Wetland Restoration
W&J Clay Tract	WR-41	William E & Johnnie R Clay	2,350	2,820	55	Wetland Restoration
Aldridge Tract	WR-42	Aldridge & Sons Nursery	1,250	1,500	25	Wetland/Stream Restoration
B&J Griffin Tract	WR-43	Ben D & Jackie Griffin	1,450	1,740	48	Wetland/Stream Restoration
Gragg Tract	WR-44	Jeffery & Sherry Gragg	1,450	1,740	24	Wetland/Stream Restoration
Brownfield Site (Bernhardt Furniture)	BMP-45	Bernhardt Furniture Company	NA	NA	NA	Stormwater BMP
Industrial Site (below Broyhill Furniture)	BMP-46	Bentley Larkin Cowles	NA	NA	NA	Stormwater BMP
Mall Site (former Lenoir Mall)	BMP-47	Tri City Inc.	NA	NA	NA	Stormwater BMP
Middle School (Hibriten HS)	BMP-48	Caldwell County	NA	NA	NA	Stormwater BMP

6.4.2 Stream Preservation

In order to identify feasible and cost-effective EEP Project sites for stream preservation, the following criteria were applied: a stream reach ≥5,000 ln ft with a sinuosity of ≥1.2, stable channel form, and a minimum 30-ft forested buffer along both banks of the stream. Four sites from the master data set were identified based on these criteria and are included in the Table 11 list of Primary sites recommended as mitigation projects. None of these sites are located within preservation priority subwatersheds (Section

6.3.1); however the sites range in size from 5,280 to 33,000 ln ft and their size alone makes them worthy of consideration as priority (primary) preservation sites. In addition, three of the four sites are located in restoration priority subwatersheds. Locations of these primary preservation sites are included in Figures 11 through 13. Specific site information and a color digital aerial photography view for each of these four preservation sites are provided in Appendix A, the Lower Creek Project Atlas.

Regardless of whether a subwatershed is prioritized for restoration or preservation, it may contain sites worthy of protection (preservation). However, some of the potential preservation sites may fall below the basic EEP screening criteria noted above. Such sites may be still good candidates for consideration by a land conservancy group such as the Foothills Conservancy. Table 12 shows four examples of stream preservation sites suitable for acquisition by a land conservancy.

Table 12: Potential Land Conservancy Projects

Site Name	Landowner Name	Subwatershed Location	Existing Stream Length (ft)	Project Type
P&P Holdings	P & P Holdings, LLC	WM01	3,800	Stream Preservation
Simmons	Simmons, Gregory & Rita H	ZF02	1,710	Stream Preservation
Church M&B	Church, Mark & Bruce & Bruce	ZF02	2,305	Stream Preservation
Shaw H	Shaw, Howard C E	WM01	1,210	Stream Preservation

6.4.3 Wetlands Restoration and Preservation

Locating potential wetland restoration and preservation sites in the upper Piedmont physiographic province of North Carolina is difficult**.** Therefore, the entire Lower Creek watershed was screened for wetlands mitigation sites without regard to subwatershed prioritization. For a site to be considered as a potential wetland restoration/enhancement/preservation project in the upper Piedmont, EEP generally uses five acres (ac) as the minimum cost-effective area. If a wetland site is less than five acres in size, then the site has to have a contiguous stream reach that meets the stream restoration criteria. Sixteen sites were selected based on these criteria. Only two of the sites had multiple land owners, with the 14 remaining sites having a single landowner. The size of the wetland sites range from six to 55 ac. The eight largest sites (greater than or equal to 24 acres) were selected as **primary** sites for wetland projects (Table 11). Note that the 8 wetland sites include two preservation, three restoration and three combined stream/wetland restoration sites.

Locations of the eight primary wetland sites are shown in Figures 11 through 13. Specific site information and a color digital aerial photography view for each of these sites are detailed in Appendix A. The remaining eight potential wetland sites range in size from 6 to 16 ac and are listed in Table 14 as Secondary project sites.

6.4.4 Stormwater BMP Candidate Sites

As stated in Section 6.3, subwatersheds ZF03, LC05, and SC02 were selected as the priority subwatersheds for stormwater BMP strategies because they had IC values ≥25%, were situated within the urbanized Lenoir municipal area, and were contiguous within the Lower Creek watershed. Traditional stream improvement projects within such highly urbanized (high IC) subwatersheds have limited potential for significant stream quality improvement, as other issues, such as stormflow scour and storm-carried pollutants can limit biological communites. Projects designed to hold and treat stormwater runoff or which allow stormwater to diffuse through buffers prior to entering a water body offer the greatest potential benefits.

Although many potential locations for stormwater BMP projects exist within these subwatersheds, four projects were chosen to exemplify the type of sites where stormwater BMPs can be best implemented. Each project should be taken as an example of how and where stormwater BMPs can be used in an urban setting to reduce flooding potential and improve water quality, often in concert with other objectives. These four projects are listed in Table 13, along with the rationale for their choice. Locations of the BMP sites are included in Figure 12. Detailed descriptions, along with color aerial photographs of their locations, can be found in Appendix A.

Table 13: Example Stormwater BMP Projects

Site Name	Landowner Name	Subwatershed	Reason for Selection
Brownfield Site	Bernhardt Furniture	LC05	Existing industrial building providing the potential for redevelopment and the opportunity to reduce impervious cover and eliminate illicit discharge connections
Mall Site	Multiple owners	LC05	Large paved parking lot to serve of shopping center & office complex. Current status of the property provides the potential to eliminate significant expanses of paving and redirect runoff to BMPs prior to discharging into the adjacent Lower Creek
Industrial Site	Broyhill Furniture and others	LC05	Existing operating industrial building at headwaters to stream, providing potential for BMPs to treat stormwater prior to entering the stream channel as well as the opportunity to identify and eliminate direct drainage connections from industrial activities
School Site	Caldwell County Board of Education	LC04	Large, publicly owned property with plans for Middle School providing the opportunity for greenfield stormwater BMP techniques

Figure 11: Priority Mitigation Sites – Upper Lower Creek Watershed

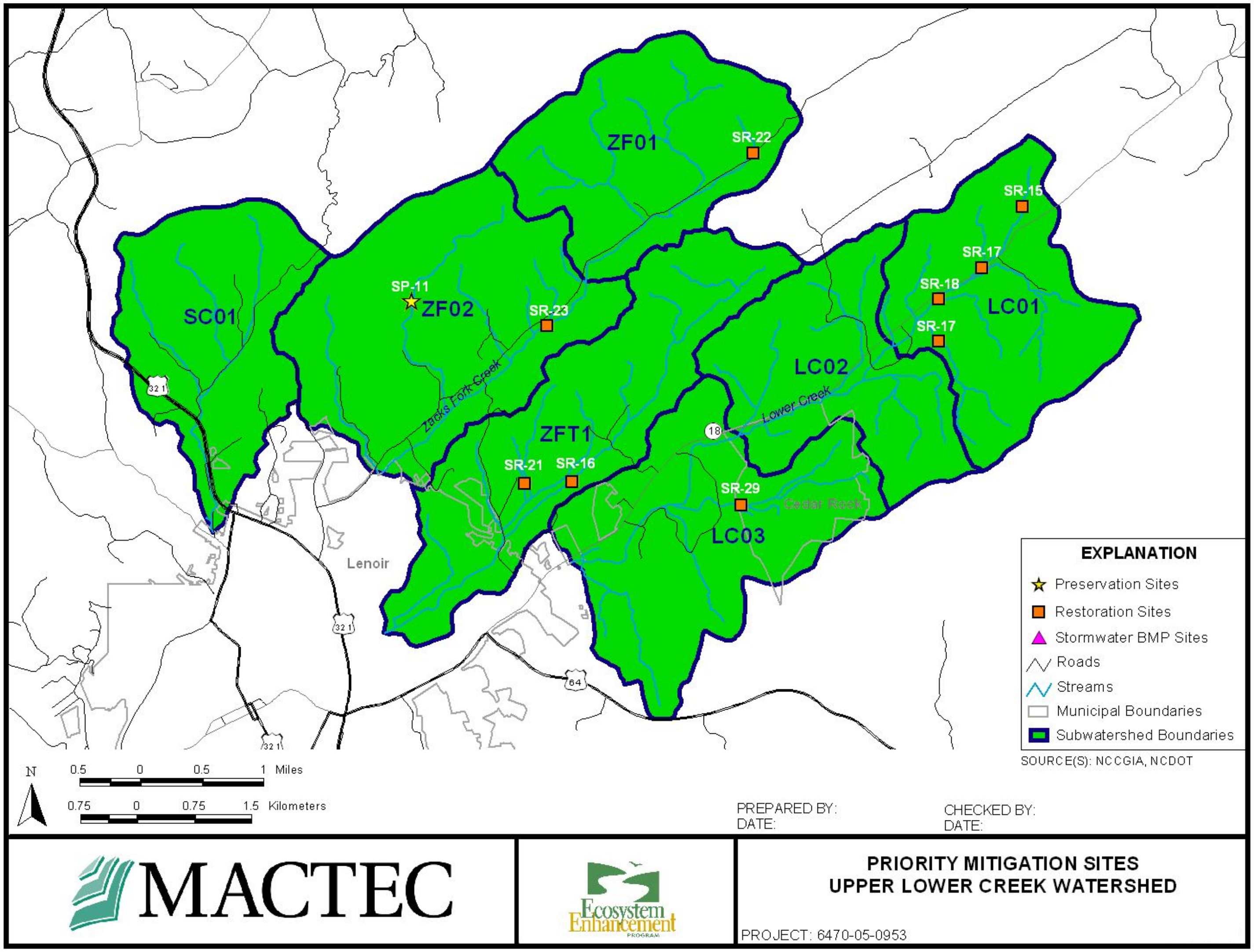


Figure 12: Priority Mitigation Sites – Middle Lower Creek Watershed

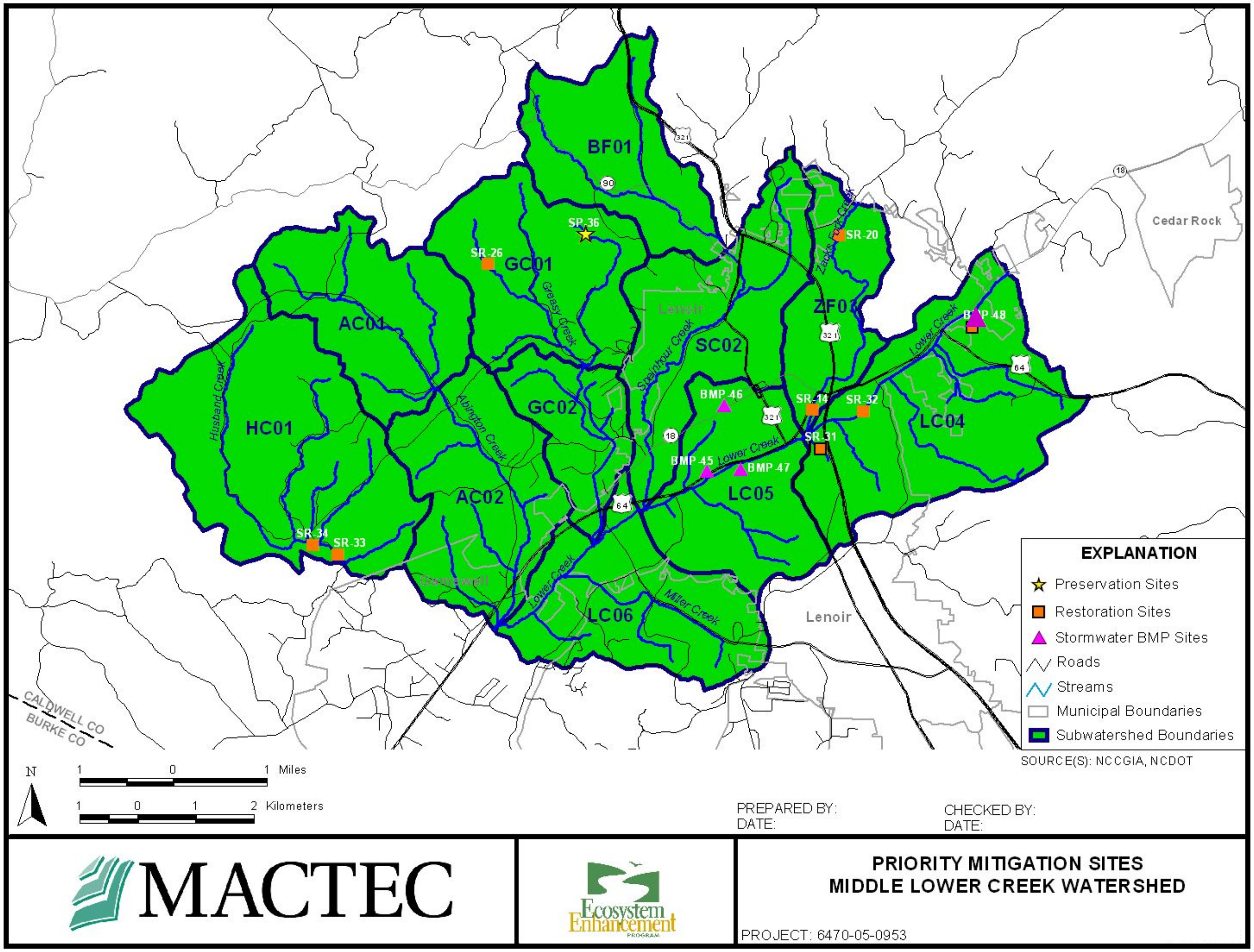


Figure 13: Priority Mitigation Sites – Lower Lower Creek Watershed

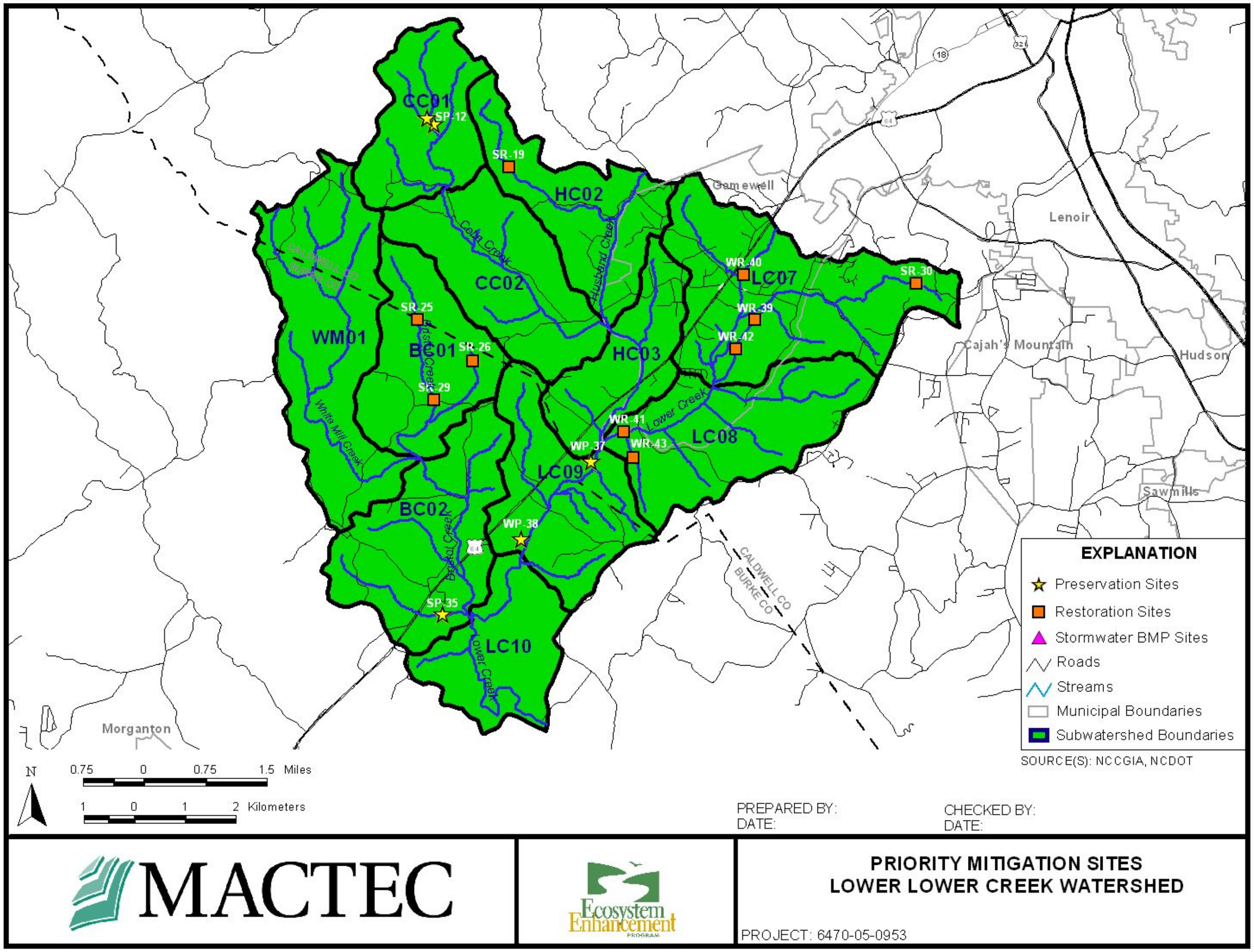


Table 14: Secondary Project Sites

Site Name	Landowner Name	PIN	Existing Stream Length (ft)	Mitigated Stream Length (ft)	Wetland Acreage	Potential Project Type
Barlowe Tract	Barlowe, Richard & Marshall &	2862228937	4,800	4,800	NA	Stream Restoration/ Preservation
Broyhill Timber	Broyhill Timber Resources Inc	2881228768	3,220	3,220	NA	Stream Restoration/ Preservation
Carolina Center	Carolina Center	271500252294	4,425	4,425	NA	Stream Restoration/ Preservation
Broyhill Furniture #14	Landowner Unknown	2738895056	2,680	3,216	NA	Stream Restoration
Cassavaugh Tract	Cassavaugh, John H And Jessie	2737611913	4,335	5,202	NA	Stream Restoration
Celia Creek #106	Landowner Unknown	2718529282	2,056	2,467	NA	Stream Restoration
City of Lenoir #1	Landowner Unknown	2738679061	1,770	2,124	NA	Stream Restoration
Craig Mountain #306	Corpening, Mary Ellen Et Al	2737126828	4,610	5,532	NA	Stream Restoration
Curtis	Landowner Unknown	270700430864	3,200	3,840	NA	Stream Restoration
Denton	Denton Ronald C	Unknown	1,625	1,950	NA	Stream Restoration
Dirt Tract	Caroway, Rickie	271600246792	1,695	2,034	NA	Stream Restoration
Hartland #104	Tuttle, Catherine P	2727163377	1,980	2,376	NA	Stream Restoration
Helton Farms #213	Moore, John H II & Amy	2871728200	4,445	5,334	NA	Stream Restoration
Keyes	Keyes Joseph R Estate Miller Joan K	2841647391 2841647775	1,735	2,082	NA	Stream Restoration
Powell Brickyard #224	Shatley Markus Wayne & Georgi	2739585408	1,665	1,998	NA	Stream Restoration
Racetrack #300	Foothills Promotions LLC	2726274552	1,770	2,124	NA	Stream Restoration
Smith	Smith, Viola A	2841212655	2,000	2,400	NA	Stream Restoration
Spencer	Spencer, Lillie H	2739752928	2,000	2,400	NA	Stream Restoration
Virginia Street #18	Landowner Unknown	2749421165	1,995	2,394	NA	Stream Restoration
SE Watson	Watson Stuart Edward & Eu	2820226497	2,300	2,760	NA	Stream Restoration
Wilkie	Wilkie, Dean E	2871026344	3,510	4,212	NA	Stream Restoration
Caldwell County Board of Education	Caldwell County Board of Education	2860019971	NA	NA	6	Wetland Restoration
Crump	Crump Dewey Vergil & Grace	2728834854	NA	NA	14	Wetland Restoration
Jensen	Jensen Donald D	286450000	NA	NA	6	Wetland Restoration
Kent	Kent Horatio M Sr & Mary M	286456051	NA	NA	9	Wetland Restoration
Mikeal	Mikeal Anthony Paul & Theresa	286458199	NA	NA	15	Wetland Restoration
Hoffman	Hoffman James David & Martha	2840376554	1,100	1,320	15	Wetland/Stream Restoration
Kingston #37	Taylor Dean & Ruby Phipps Joe Xenifea III & Alisa	2728033976 2728211198	880	1,056	16	Wetland/Stream Restoration
Macguire	Macguire Osborne R & Mary	2871160535	1,595	1,914	13	Wetland/Stream Restoration

7.0 INSTITUTIONAL MEASURES

Institutional measures include ordinances, codes, regulations, and other instruments adopted by political jurisdictions in order to minimize the negative impacts that developmental activities have upon hydrology, water quality, and aquatic habitat, or which serve to protect or even improve these attributes within the watershed.

Gamewell, the City of Lenoir and both Burke and Caldwell Counties are developing or revising their comprehensive land use plans. In addition, Caldwell County is developing its stormwater management ordinance in response to EPA's Phase II Stormwater Management Permit requirements. It is therefore an opportune time to reexamine the institutional measures regulating land development aspects that have an impact on stream health.

Caldwell County is revising their 1995 comprehensive plan, with a draft due in the fall of 2006. This plan will describe guidelines for the entire County as well as special guidelines for five small planning areas. Only small portions of the Lower Creek watershed overlap with these small planning areas. Burke County revised its strategic plan in 2002, which calls for the development of nine small area plans over time. These small area plans will serve as comprehensive plans, incorporating guidelines and regulations for many planning issues. A small area plan has not yet been developed for the Lower Creek watershed area, which falls in the Chesterfield small planning area; currently, most of this area is zoned as "rural mixed use", which allows for most commercial, industrial, and residential uses. Lenoir is developing a new comprehensive plan, and a draft is scheduled to be complete by December, 2006. Various topics are being examined by committees, including land use, transportation, natural resources and open space, and more. Gamewell is developing their first land use plan, which should be approved in the fall of 2006.

The following recommended actions, if implemented by local governments within the watershed, can have a positive effect upon the preservation or enhancement of this watershed's vital functions.

7.1 LENOIR AND GAMEWELL AND COUNTIES OF BURKE AND CALDWELL SHOULD CONSIDER FORMAL ADOPTION OF THE LOWER CREEK WATERSHED MANAGEMENT PLAN AS A SUPPLEMENT TO THEIR RESPECTIVE COMPREHENSIVE PLANS.

This watershed management plan is based upon a relatively comprehensive study of the hydrology, water quality and aquatic habitat within the Lower Creek Local Watershed. This study – comprised of a *Findings and Recommendations Report*, the *Watershed Assessment Report* and this final *Watershed Management Plan* (WMP) – identifies the most important local watershed functions and functional deficits, and makes recommendations to alleviate or mitigate these problems. As such, the recommendations of the WMP are complementary to and have impact upon the Comprehensive Plans of each of the constituent political jurisdictions.

7.2 DEVELOP COMPREHENSIVE STORMWATER MANAGEMENT ORDINANCES TO LIMIT THE IMPACT OF DEVELOPMENT UPON DOWNSTREAM HYDROLOGY, WATER QUALITY, AND HABITAT.

Effective stormwater management is essential for the protection of streams and Lake Rhodhiss. The City of Lenoir has been highly developed both commercially and industrially over many decades. As the surrounding area continues to experience growth, some of the agricultural and forested areas in the Lower Creek watershed will be developed over the next several decades.

Caldwell County is developing a stormwater management ordinance to comply with the Environmental Protection Agency's NPDES Phase II Stormwater regulations (EPA, 1999). This ordinance will apply to all areas of the County, including Lenoir and Gamewell, and its adoption is planned for October, 2006. These Phase II regulations specify six minimum elements for a stormwater management program:

1. Public education and outreach on stormwater impacts
2. Public involvement/participation
3. Illicit discharge detection and elimination
4. Construction site stormwater runoff control
5. Post-construction stormwater management in new development and redevelopment
6. Pollution prevention/good housekeeping for municipal operations

Caldwell County's draft stormwater ordinance combines elements of the North Carolina's model ordinance (http://h2o.enr.state.nc.us/su/phase_2_mod_ord.htm) and its Environmental Assessment for the Upper Yadkin reservoir. The ordinance specifies post-construction stormwater management measures and an illicit discharge detection and elimination program, according to Phase II specifications. It also requires the protection of 50 ft buffers along perennial streams and 30 ft buffers along intermittent streams for development or redevelopment. Developers are not required, however, to *establish* vegetated buffers if there are none on site; Caldwell County should require the establishment of vegetated buffers in these cases.

Burke County is currently not pursuing a county-wide stormwater ordinance. As stormwater management is essential to the protection of aquatic resources, including Lake Rhodhiss, the County should develop a stormwater management program that addresses the six elements listed above. Part of this program should be an ordinance which addresses post-construction stormwater management and illicit discharges. North Carolina's model stormwater ordinance is an excellent resource.

BMPs that increase stormwater retention time, promote infiltration and provide filtration should all be incorporated into the compliance strategy for post-construction stormwater management regulations. Site plan review for new developments should address storm water quality as well as storm water quantity issues.

7.3 AMEND SUBDIVISION ORDINANCES TO PROMOTE LOW IMPACT DEVELOPMENT AND OTHER MEASURES THAT LIMIT DEVELOPMENT IMPACTS

Developmental activities that minimize impervious cover, reduce the utilization of closed stormwater conveyance systems and incorporate stormwater management BMPs have less impact upon the natural environment and are referred to as "Low Impact Development" (LID) measures. LID measures are designed to more closely replicate the natural hydrologic system, including infiltration, storage, recharge, and evapotranspiration, thereby allowing development while minimizing the impact upon hydrology, water quality, and aquatic habitat.

LID measures have been successfully implemented in areas undergoing rapid urbanization such as Prince George's County, MD, Boston, MA and the Puget Sound Region, WA (see technical resources on LID in

Appendix C). In addition to utilizing techniques such as cluster development to maximize open spaces, LID incorporates stormwater management measures like grassed swales, bio-retention cells, and permeable pavement to control and/or treat the runoff produced by urbanization. Given the amount of rural area currently within the Lower Creek watershed and the current pace of development, the incorporation of LID measures in this development can appreciably mitigate the impact upon resources within the watershed.

Many LID measures – such as narrower pavement width on subdivision streets and the use of grass swales, rather than traditional curb and gutter – conflict with current subdivision standards (NCDOT, 2000), requiring some changes in ordinances to accommodate this type of development. In addition, since the incorporation of LID measures often results in greater development expense (either in construction cost, fewer lots per acre, or both) many jurisdictions have utilized incentives (such as greater overall density allowances) to promote this type of development. Other jurisdictions have mandated that LID measures be utilized in the development of particularly sensitive areas. Since LID can result minimize impacts to hydrology, water quality, and habitat, the cost of promoting these measures is justified by their environmental benefits (EPA, 2004).

Local and county governments should also examine current regulations to insure that they do not encourage impervious cover. For example, development regulations sometimes specify a large amount of parking lot for commercial and residential facilities that can be minimized with creative methods, such as shared parking.

Both Caldwell and Burke Counties promote the protection of environmentally sensitive in certain instances, such as in the Lake James small planning area in Burke County and any area submitted as a "planned unit development" in Caldwell County. Both counties should amend their subdivision ordinances to specify LID and to require open space, setting aside sensitive areas, including floodplains and steep slopes, from development.

7.4 ADOPT AND ENFORCE MORE COMPREHENSIVE RIPARIAN BUFFER ORDINANCES.

Riparian buffers have been shown to improve water quality and protect stream banks from erosion. The State of North Carolina has adopted Riparian Buffer Rules (15A NCAC 02B.0243) which require a 50 foot vegetated buffer along the Catawba River (below Lake James) and along the mainstem lakes within the Catawba River Basin, which includes Lake Rhodhiss. Burke County has adopted a buffer ordinance that requires all woody vegetation within 65 feet of Lake Rhodhiss be protected. Caldwell County's draft stormwater management ordinance specifies the preservation of 50 ft buffers on perennial streams and 30 ft buffers on intermittent stream for land under development.

As areas of agricultural usage are developed, it is important that attention be given to the preservation or re-establishment of vegetated buffer areas. In the interim, while agricultural activities continue to be significant in these areas, agricultural best management practices (BMP's) should be encouraged (See Section 8.4).

Significant threats to both water quality and aquatic habitat were identified in the *Watershed Assessment Report*. These threats can be mitigated, in part, through the extension of the requirement for vegetated buffer strips along perennial and intermittent streams within the watershed. It is recommended that each of the local governments having jurisdiction over the Lower Creek local watershed adopt and enforce ordinances that extend the protection of 50-foot vegetative buffers to the perennial and intermittent streams that comprise the watershed.

7.5 AGGRESSIVELY MONITOR COMPLIANCE WITH AND ENFORCEMENT OF EROSION AND SEDIMENTATION CONTROL ORDINANCES AND DEVELOP A STEEP SLOPE ORDINANCE.

Caldwell County has developed a draft local sediment and erosion control ordinance in compliance with the State's Sedimentation Pollution Control Act of 1973 (SPCA) and intends to assume responsibility for implementation of the requirements of the SPCA within all of Caldwell County by October 2007. Currently, Burke County has no intention on assuming a local sediment and erosion control program and depends on the State's Division of Land Resources program to enforce state regulations.

These programs provide legal basis for the regulation of construction activities to ensure that sedimentation and erosion is minimized. However, this regulatory control is only as effective as is the associated monitoring of construction and enforcement of the ordinance. The challenge faced by many local governments, particularly those experiencing rapid development, is providing an adequate level of construction monitoring with a modest staff of erosion and sediment control (E&SC) inspectors. In fact, during the field investigations conducted as part of this planning process, numerous examples of sediment-laden waters downstream of construction activities were observed.

Some local governments have increased development review and processing fees to fund additional field resources for E&SC monitoring. In addition, when the public becomes aware of the cause and effect of construction-related erosion and sedimentation problems (see Recommendation 7.8.), they will be more likely to become involved in identifying construction sites that are the source of such problems, thus enforcement actions may be taken. It is recommended that each jurisdiction establishes an E&SC "hot-line" where calls can be taken from the public. In this way, the monitoring resources of the state and local jurisdictions can be more effectively leveraged into action.

Development on steep slopes is of particular concern in Caldwell and Burke Counties. Counties should consider a steep slope ordinance, which would prohibit or limit development on steep slopes. Boone is considering a steep slope ordinance, and can serve as an example for the Counties.

7.6 AMEND ORDINANCES TO PROHIBIT DEVELOPMENT IN THE FLOODPLAIN.

Throughout the Lower Creek watershed, the floodplain has been filled to accommodate industrial or commercial development. This filling of the floodplain, even where conduits are placed to allow passage of floodwaters, generally results in hydraulic restrictions that produce upstream flooding during severe rain events (i.e., impairment of the hydrologic function). Anecdotal evidence of such flooding was presented at several of the TAC meetings and individual discussions with the local resource professionals and governmental officials. City of Lenoir and Burke and Caldwell Counties have adopted floodplain management ordinances, but restrictions of the floodplain are permitted as long as structures are constructed at a specified level above the flood elevation.

Revised floodplain maps from the Federal Emergency Management Agency are being developed with new remote sensing imagery. County and municipal jurisdictions should reevaluate floodplain areas based on these new maps and allow no development or filling in the 100 year floodplain.

7.7 DEVELOP AND IMPLEMENT A ROBUST PUBLIC EDUCATION PROGRAM ON WATERSHED ISSUES.

Public Education and Outreach on Stormwater Impacts
You must implement a public education program to distribute educational materials to the community or conduct equivalent outreach activities about the impacts of storm water discharges on water bodies and the steps that the public can take to reduce pollutants in storm water runoff.

[40CFR 122.34 (b)(1)(i)]

As part of the EPA's NPDES Phase II Stormwater Regulations (EPA, 1999), a public education and outreach program is required that will help citizens understand the impact their actions (and the actions of others, such as developers and contractors) have upon the watershed (see text box). The EPA recommends that such a program inform individuals and groups how to become involved in local stream restoration activities and give guidelines for minimum measures to accomplish this requirement (EPA, 2000).

A defined public education program is essential to the development of a responsible public attitude toward watershed management. As citizens understand the importance of hydrology, water quality, and aquatic habitat to their quality of life, as well as the consequences of their actions upon these attributes, they will pay greater attention to activities that might have detrimental consequences. Many of the major municipalities in NC (e.g. City of Charlotte, Town of Chapel Hill, and Town of Cary) have established successful stormwater public education programs and can be contacted regarding the details of their programs. In addition, the Land-of-Sky Regional Council has developed a series of stormwater fact sheets under contract to the NC Division of Water Quality (NCDENR, 2002c). Links to these and other resources can be found in the technical resources provided in Appendix C.

There are two new efforts that will educate the public on watershed impacts and solutions. As part of its Phase II stormwater program, Caldwell County will implement a public education effort on stormwater impacts and steps that citizens can take to reduce their own impacts. A public education effort is also part of the 319 grant awarded to the Carolina Land and Lakes Resource Conservation and Development Council to develop a Lake Rhodhiss Watershed Restoration Plan. These two efforts should be built upon to develop a more comprehensive watershed education program.

The Lower Creek Technical Advisory Committee recommends that a public education program include the following elements:

1. Establish a Clear Water Contractor Program

Clear Water Contractor programs have been applied to a number of areas in western North Carolina. RiverLink (http://www.riverlink.org/), a watershed group that seeks to revitalize the French Broad River watershed, provides Clear Water Contractor workshops to contractors on appropriate sedimentation and erosion control measures to apply during site preparation and development.. Caldwell and Burke Counties should establish its own Clear Water Contractor program. Once Caldwell County has assumed an erosion and sedimentation control program, it could offer developers reduced erosion control permit fees if their staff attended the training. Burke County could offer incentives for participation, providing quicker review of development plans (e.g., subdivision plats) for those who take the course.

2. Identify and quantify the economic effects of poor water quality in the watershed.

Economic effects of of poor water quality should be quantified and shared with decision-makers and citizen groups. The Western Piedmont Council of Government (WPCOG) has developed slides that cover drinking water, wastewater, property loss/degradation and other costs.

3. Develop a brochure outlining steps citizens can take to protect water quality in the watershed.

The WPCOG has developed a brochure that will be used by local governments in Burke and Caldwell Counties for assisting them with meeting the new NPDES Phase II stormwater requirements. The emphasis of the brochure focuses on steps citizens can take to protect Lake Rhodhiss as a drinking water source. This should be shared with area citizens.

4. Establish a local watershed council.

A watershed council could serve as a local voice for issues affecting the Lower Creek watershed. However, this will only be effective if it is staffed and developed with local citizens. Local government or resource agency staff could potentially play a vital role in supporting such a council from a technical standpoint once a citizen-based group with leader is established. This council could oversee a watershed stewardship program, which can be a very effective tool for gaining stakeholder consensus, engaging interested parties to keep "watch" over activities affecting the stream, and identifying a champion for various watershed improvement projects. The NCDENR supports such an organized watershed stewardship approach through its Stream Watch program as stated below:

> NC General Statutes § 143-215.74F. *The Department of Environment, Health, and Natural Resources may establish a Stream Watch Program to recognize and assist civic, environmental, educational, and other volunteer groups interested in good water resources management and protection. The goals of the Stream Watch Program are to encourage volunteer groups to adopt streams and other water bodies and to work toward their good management and protection; to increase public awareness of and involvement in water resources management; and to promote cooperative activities among volunteer groups, local government, industry, the Department of Environment, Health, and Natural Resources, and other agencies and entities for improved protection and management of water resources.*

A Lower Creek watershed council could, in addition to keeping watch over current activities within the watershed, serve as the catalyst for ensuring that the recommendations made in this *Watershed Management Plan* are followed through and serve as an essential part of a coordinated watershed management strategy—see Section 8.5. Contact information for several good examples of viable stream watch programs are given in the technical resources in Appendix C.

7.8 ADOPT A COMPREHENSIVE WATERSHED-BASED LAND USE PLAN FOR THE LOWER CREEK WATERSHED IN ORDER TO PROTECT LAKE RHODHISS (A WATER SUPPLY RESERVOIR) FROM CONTAMINATION.

Because of the importance of the Lower Creek watershed to water supply from Lake Rhodhiss and the agricultural, industrial and commercial activities occurring within this watershed, the development of a comprehensive land plan for this area – a plan which prioritizes wise management of the quantity and quality of local water resources – is an essential tool for preserving drinking water quality. The EPA includes watershed-based zoning in its guidance on Post-Construction Storm Water Management (EPA, 2003). In that guidance material, Watershed-Based Zoning is defined to include a mixture of land use and zoning options with the following nine steps:

1. Conduct a comprehensive stream inventory.
2. Measure current levels of impervious cover.
3. Verify impervious cover/stream quality relationships.
4. Project future levels of impervious cover.
5. Classify subwatersheds based on stream management "templates" and current impervious cover.
6. Modify master plans/zoning to correspond to subwatershed impervious cover targets and other management strategies identified in Subwatershed Management Templates.
7. Incorporate management priorities from larger watershed management units such as river basins or larger watersheds.
8. Adopt specific watershed protection strategies for each subwatershed.
9. Conduct long-term monitoring over a prescribed cycle to assess watershed status.

Most of the work in the first five steps has been completed as a part of this planning process. GIS files have been established with attributes such as impervious cover, land use, and zoning layers for each of the 29 subwatersheds that comprise the Lower Creek watershed (WAR, 2005). Steps 6 through 8 could be spearheaded by a local stakeholder group including representatives from the planning departments of Caldwell and Burke Counties and the towns of Lenoir and Gamewell. Monitoring of development within the watershed (step 9) is vital to keeping the plan up-to-date and relevant.

8.0 BEST MANAGEMENT PRACTICES

A best management practice (BMP) is a practice or combination of practices providing the most effective and practicable (including technological, economic, and institutional considerations) means of controlling point or non-point source pollutants at levels compatible with environmental quality goals. A stormwater BMP is a technique, measure, or structural control used to manage the quantity and improve the quality of stormwater runoff in the most cost-effective manner. These stormwater BMPs may provide flow control, pollutant removal or pollution source reduction, either individually or in combination. The following sections address recommendations related to five basic categories of watershed management practices: general land use and development, stormwater, floodplains, forestry, and agricultural activities. Appendix C includes website links where additional technical and cost information about these management practices may be found.

8.1 LAND MANAGEMENT

Land management BMPs impact both the quantity of stormwater runoff and the amount of pollution entering water bodies as a result of land development activities. Improvements in land management are necessary to reduce the delivery of pollutants to water resources and prevent flooding and stress of channels downstream of the development. In general, these practices serve to promote infiltration of rainwater, slow runoff velocities and filter out particulate matter and other pollutants in stormwater runoff. Minimization of impervious surfaces and the protection of natural riparian buffers are two core strategies within this category of management practices.

A. Low-Impact Development (LID)

As already mentioned in Section 7.3, developmental activities that minimize impervious cover, reduce the utilization of closed stormwater conveyance systems, and incorporate stormwater management BMPs have less impact upon the natural environment and are referred to as "Low Impact Development" (LID) measures. LID measures are designed to more closely replicate the natural hydrologic system, including infiltration, storage, recharge, and evapotranspiration, thereby allowing development while minimizing the impact upon hydrology, water quality, and aquatic habitat.

B. General Considerations for Water Resources Protection

In the EPA's January 2001 report *Our Built and Natural Environments*, habitat loss and fragmentation as well as water quality degradation, primarily due to stormwater, were identified as the two most significant consequences of land development. This report goes on to identify planning techniques, such as infill and cluster development that can mitigate these negative impacts, while accommodating growth. In its 2004 publication *Protecting Water Resources with SMART GROWTH*, the EPA makes 75 policy recommendations (46 at the watershed or regional level, 29 at the individual development level) which are designed to facilitate growth and development in a manner that preserves and even enhances the water resources critical to supporting this growth. [In November 2004, the EPA recognized the Town of Davidson, NC with its 2004 Award for Overall Excellence in Smart Growth for its approach to land planning (EPA, 2004b). For additional information, see http://www.epa.gov/livability/sg_awards_publication_2004.htm and http://www.smartgrowth.org/pdf/cs_006_DavidsonNC.pdf .]

Two conclusions can be drawn from this background material:

1. Development without specific guidance/boundaries around water resources will almost certainly result in negative impact upon hydrology, water quality, and aquatic habitat; and
2. Protection of water resources and growth are not necessarily mutually exclusive.

Consequently, a successful strategy for future land use and watershed management should include the following elements:

- A public education program which stresses the value of water resources and their sensitivity to developmental activities;
- Comprehensive regional planning which identifies and preserves sensitive areas, while encouraging growth in areas with infrastructure and resources to support it;
- The encouragement of planning techniques such as Low Impact Development and Smart Growth to minimize the impact of growth upon hydrology, water quality and aquatic habitat;
- Preservation of sensitive areas such as high-quality wetlands and water supply sources to ensure they continue to function in a manner that will sustain future growth;
- Planning and management of stormwater on a watershed-wide basis, considering the impact of development upon the overall watershed;
- The adoption of Stormwater Management BMPs, such as grassed swales, bio-retention areas and porous pavement into subdivision codes;
- Incorporation of a comprehensive review of the impact that all proposed developments will have upon hydrology, water quality, and aquatic habitat within the watershed; and
- Assessment of the incremental cost of water resources management (including comprehensive site plan review) to the entity that stands to gain economically from the development.

C. Other Tools for Watershed Protection

An excellent resource for information on the various tools available for land use planning and watershed protection is the Center for Watershed Protection. The following website highlights eight major tools for watershed protection: http://www.cwp.org/tools_protection.htm .

8.2 STORMWATER MANAGEMENT

An urban stormwater management BMP is designed to limit the hydrologic (increased runoff) and water quality impacts of changed land uses, primarily from residential or commercial development. These practices utilize measures such as detention, settling, infiltration, and filtration to decrease the peak stormwater flow rate (thereby reducing downstream erosion and flooding) and remove pollutants (e.g. oil and grease, metals, nutrients, sediment) from the stormwater.

A. A. Wet Detention Ponds

Stormwater detention ponds excavated below the normal groundwater table contain water at nearly all times. Storage area is available above this normal water level where, during storm events, stormwater is temporarily detained and released downstream at controlled rates to limit downstream flow. The detention time within the wet pond facilitates the settling of sediments (along with other pollutants that attach to these sediments). Such facilities are 70%

or more effective in the removal of suspended solids (NC Cooperative Extension Service, 1999). Larger, more regional, ponds are generally more effective and maintainable than small ponds designed to handle stormwater from small (<20 acre) sites.

B. Bio-Retention Areas

Bio-retention areas combine stormwater management with landscaping to retain stormwater (particularly from small, more frequent rain events) in order to enable infiltration and evapotranspiration by plants within the area. These types of facilities are well-suited to parking lots, where traditionally drainage is collected in a closed system and conveyed offsite. Utilization of a bio-retention area provides a means to control runoff to pre-development levels by retaining runoff from impervious areas in a facility designed to replace the function of the vegetation and soil areas that have been rendered impervious through development.

C. Reinforced Grass Swales

The historic function of drainage design was to collect and convey stormwater runoff downstream as quickly as possible, resulting in both increased flow rates and velocities, and reduced infiltration and evapotranspiration of runoff. Historically, drainage systems minimized the amount of overland flow, quickly channeled runoff into closed systems for conveyance away from the site and were dominated by curbs, gutters, inlets and piped systems. The utilization of grassed swales for the collection and conveyance of stormwater runoff enables overland flow to enter the swale along its entire length, promotes infiltration through the channel walls and provides a degree of filtration through the grass media, removing sediments and other pollutants. Turf Reinforcement Matting (TRM) enables the grass to become established and protects the channel walls from erosion. From the standpoint of managing both stormwater quality and quantity, open channels are superior to a closed system.

D. Level Spreaders in conjunction with Riparian Buffers

Forested or grassed vegetated buffers along streams provide a combination of filtration, depression storage, infiltration, and evapotranspiration, which both reduces the quantity of runoff (as compared to a closed channelized system) and removes many pollutants, including sediments and nutrients. Care must be exercised in grading these buffer areas to maintain overland (sheet) flow of runoff and minimize the potential for runoff to become channelized. Channelized flow is prone to develop erosive velocities and minimizes the filtering effect provided by sheet flow through the buffer area. Maintaining slopes of 2% or less and ensuring that an established bed of ground vegetation is maintained will serve to prevent such channelization within buffer areas.

E. Constructed Wetlands

Constructed stormwater wetlands are designed for temporarily storing stormwater runoff in shallow pools that create growing conditions suitable for emergent and riparian wetland plants. The runoff storage, complex microtopography and emergent plants in the constructed wetland together form an ideal matrix for the removal of urban pollutants. In North Carolina, constructed stormwater wetlands include two basic designs: extended detention wetlands; and, for smaller sites and in combination with other BMPs, pocket wetlands. When designed and constructed to the NC DENR guidelines (NC DENR, 1999), these structural BMPs are assumed to achieve 85% removal of total suspended solids (TSS).

These five stormwater management practices are examples of BMPs that have general application throughout the areas of this local watershed undergoing development, as well as in those areas where redevelopment is occurring. More detail on these BMPs can be found in the technical resources listed in Appendix C, including the NC DENR *Stormwater BMPs Manual* (April, 1999). A good starting point for additional information on urban stormwater BMPs is the website of Dr. Bill Hunt (N.C. State University, Stormwater Engineering Group): http://www.bae.ncsu.edu/people/faculty/hunt/ . For information on the Phase II stormwater rules for local government, visit http://www.ncphase2sw.org/. Stormwater-related fact sheets and other useful links can be found at http://h2o.enr.state.nc.us/su/Manuals_Factsheets.htm.

8.3 FORESTRY PRACTICES

8.3.1 Forestry BMPS

Controlling sediment export from forestry operations is very important. The relative infrequency of harvesting operations (25 or 50 year rotations for pine pulpwood or sawtimber, 60- to 80-year rotations for hardwood sawtimber) makes sediment export from this activity less of an immediate concern in terms of overall functional degradation factors, but when harvesting does occur it can be a significant source of sediment. The often large extent of the area affected can require an extensive network of roads and skid trails, which are the most significant source of sediment from timber harvesting operations. There is the potential for large amounts of sediment from these sites to enter streams, especially when the *Forest Practices Guidelines*, as promulgated in 15A NCAC II.0100-.0209, are not followed.

Sediment is the most common pollutant produced from timber harvests. Harvesting equipment and trees are dragged over the ground, which loosens the soil, and the equipment may also spill gas and oil on the ground. Canopy cover is reduced from timber harvesting, increasing the amount of rainfall reaching the ground surface and in turn increasing runoff. Several common BMPs that help minimize sediment yield from forest harvesting operations are listed below. Details on these and other forestry BMPs can be obtained from the NC Division of Forest Resources (NCDFR) *Best Management Practices Manual* (NCDENR,1989) and the NCDFR website: http://www.dfr.state.nc.us/water_quality/wq_bmpmenu.htm .

- **Streamside management zones** maintain or enhance a forested corridor along a stream channel so that it acts as a filter for sediment and nutrients released from upslope harvested areas.
- **Water bars or diversions**, **turnouts, and timely seeding of critical cuts and fills** control sediment yield from forest roads.
- **Stream crossing stabilization** is accomplished by orienting the crossing perpendicular to the stream. The use of stone, erosion control fabric, or other materials further stabilize stream banks and bed at sites that are frequently crossed with heavy equipment. The use of portable bridges (bridgemats) is the preferred method of crossing most streams.

Removing the furthest timber first, using water bars on trails, establishing trails on the contour, avoiding wet weather logging, and reshaping and vegetating trails after use are other practices that, if used appropriately and extensively, can minimize sediment yield from silviculture operations. An established program, administered by the NCDFR, is in place to provide assistance to landowners in the use of these BMPs. The NCDFR is responsible for enforcing the *Forest Practice Guidelines* (http://www.dfr.state.nc.us/water_quality/pdf/fpg.pdf), which are necessary to maintain the forestry exemption from state sediment and erosion control regulations.

8.3.2 Sustainable Forestry

Landowners who want to more actively manage their forestlands while still meeting some conservation objectives can practice sustainable forestry management. Appalachian Voices in Boone, NC has produced a sustainable forestry guidebook, well-respected by a variety of forestry professionals, entitled *Managing Your Woodlands, A Guide for Southern Appalachian Landowners* (Goslee, 2004).

The NC Division of Forest Resources (NCDFR) provides on-site forestry planning and consultation, free of charge, to forestland owners. The NCDFR administers the non-binding *Forest Stewardship Program* to provide landowners with cost-effective resource management planning. Participants in this program are eligible for cost-share assistance from NCDFR that can help with reforestation and timber stand improvements. Participants also receive recognition with a sign to post on their forestland. Resource management advice given through this program often can help boost long-term economic returns for the landowner. NCDFR also maintains a list of consulting foresters who can help woodland landowners with forest management plans and road and access designs to minimize impact on streams and riparian areas (http://www.dfr.state.nc.us/tending/tending_consulting.htm). The private consulting foresters charge for their services.

8.4 AGRICULTURAL MANAGEMENT

Livestock with direct access to streams were observed at several locations in rural portions of the Lower Creek watershed. Runoff containing sediment, chemicals and excess nutrients from crop fields may also contribute to the degradation of water quality and habitat. Agricultural BMPs that have proven effective in addressing such problems are promoted by the Natural Resources Conservation Service (see technical resources in Appendix C), which provides technical advice as well as limited financial assistance. Applicable BMPs include:

A. Controlled Livestock Watering

Direct contact of pastured animals with surface water results in direct deposition of animal waste, stream bank erosion, and re-suspension of sediments and associated nutrients held in streambeds. The most effective means to separate livestock from contact with the stream is to utilize a combination of fencing off the riparian area and the provision of alternate watering locations (troughs or tanks) at least 100 feet away from the riparian area to provide a buffer between waste deposition and the watercourse.

B. Grazing Controls

Allowing livestock to graze up to the edge of stream banks promotes stream bank erosion, with attendant sedimentation. In addition, the proximity of livestock to the streambed opens the watercourse to pollution from nearby animal waste. As in the case of controlled watering, the most effective means to control grazing is through the installation of fencing along the riparian area, creating a vegetated buffer of at least 20 feet between the fence and the stream bank.

C. Stream bank Stabilization

Where stream banks have been eroded due to livestock activity, generally they can be stabilized to prevent further erosion utilizing bioengineering techniques, such as turf reinforcement matting and live staking. Where inadequate space is available to allow the stream bank slope to be reduced, "hard" measures utilizing rip-rap may be necessary. "Spot" repairs of eroded stream bank within agricultural areas should be recognized as a temporary fix to stop erosion and not as a substitute for a more comprehensive stream restoration in which aquatic habitat is also re-established.

D. Residue and Tillage Management, No Till/Strip Till/Direct Seed

Minimal cultivation of the soil leads to increased stubble and plant residue on the soil surface. No-till promotes a greater soil water-holding capacity, more efficient use of water by crops, and reduced loss of water from runoff and evaporation. It can be very effective in reducing loss of soil and nutrients from the field, which may reduce the amount of sediment and nutrients entering a stream.

E. Drip Irrigation

Conventional irrigation practices can cause high amounts of soil, carrying nutrients and other pollutants, to erode from fields and be transported into stream networks. Drip irrigation provides a more efficient use of water by reducing runoff, evaporation, and deep percolation. Drip irrigation may also reduce nitrogen loss from leaching.

F. Nutrient Management

Nutrient leaching through soil and the subsequent runoff of excess nutrients is an issue at many agricultural operations, including horticulture, row crops, and grasslands. The most significant BMP to address agricultural nutrient loss to streams is Nutrient Management – managing the amount, source, placement, form, and timing of nutrient application. Supporting practices vary by land use and include adequate ground cover from cover crops, conservation cover, residue and tillage management, and pasture/hayland planting; adequate filtration of surface water runoff from filter strips and forested riparian buffers; and irrigation water management.

G. BMPs for Pesticides/Herbicides

The improper storage, handling, application and disposal of agricultural chemicals (pesticides, herbicides, fungicides) has the potential to contaminate groundwater, wetlands, ponds, lakes and streams within a local watershed setting. Water quality impairment and toxic impacts to aquatic habitat can be prevented, or at least minimized, through the use of well-established BMPs for agrichemicals, or through the adoption of Integrated Pest Management (IPM) methods. For additional information, visit the following websites: http://www.ces.ncsu.edu/copubs/env/water/023/ and http://ipm.ncsu.edu/getsubs2.cfm?TopicID=9 .

H. Ornamental Plant Production

General recommendations for ornamental plant production include:

- Conservation Cover – permanent plant cover of the soil surface for the length of the crop cycle.
- Filter Strip – a strip of grass (that can include trees) between the crop and any surface water source.
- Nutrient Management - managing the amount, source, placement, form, and timing of nutrient application
- Pest Management – utilizing environmentally sensitive prevention, avoidance, monitoring and suppression strategies to manage weeds, insects, diseases and other organisms.
- Critical Area Planting – establishment of plant cover on any severely eroding site, including ditch banks, access roads shoulders and banks, loading areas, etc.

Many other conservation practices or BMPs can be used to address site specific needs

8.5 COORDINATED WATERSHED MANAGEMENT STRATEGY

The Center for Watershed Protection's (www.cwp.org) manual entitled *An Integrated Framework to Restore Small Urban Watersheds* (March 2004) provides an excellent blueprint for restoration of small watersheds like Lower Creek. The need for a coordinated strategy is stressed in this manual, which states that: "aligning the efforts and resources of stakeholders towards common goals is critical to the adoption and implementation of any restoration plan." An overarching, coordinated strategy is critical to both the correction of existing problems and the prevention of further degradation of hydrology, water quality, and aquatic habitat. This strategy should include the following elements:

A. An active Stakeholder Group (e.g., *Stream Watch* group, "creek-keepers" group, Local Watershed Advisory Group, etc.) with representation from each local government to provide coordinated, consensus-based management for the process;

B. Incorporation of this *Watershed Management Plan* into the comprehensive planning initiatives of each local government;

C. Establishment of annual quantifiable watershed improvement goals by the Stakeholder Group;

D. Prioritization of projects, based upon the annual watershed improvement goals; and

E. Identification of a "Champion" (lead agency and/or small team of local resource professionals) who will take responsibility for overseeing the implementation of each priority project, or for interfacing with the Ecosystem Enhancement Program's Implementation and Property Acquisition staff as they attempt to recruit willing landowners for permanent easements and begin design/construction of some of the watershed improvement projects identified in this plan.

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Findings and Recommendations

For Lower Creek

Ecosystem Enhancement Program

Catawba River Basin

Local Watershed Planning (Phase I)

MACTEC

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FINDINGS AND RECOMMENDATIONS

CATAWBA RIVER BASIN LOCAL WATERSHED PLANNING
LOWER CREEK, NORTH CAROLINA

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TABLE OF CONTENTS

Page

LIST OF APPENDICES

LIST OF TABLES

LIST OF FIGURES

1.0 INTRODUCTION

The North Carolina Ecosystem Enhancement Program (NCEEP) has initiated comprehensive watershed planning efforts in certain high-priority local watersheds in order to meet the following primary objectives:

1. Assessment of historical and current watershed conditions;
2. Identification of major causes and sources of watershed degradation (including water quality impairment, aquatic habitat degradation, and flooding problems);
3. Involvement of local stakeholder groups in determining major watershed issues and high-priority focus areas;
4. Prediction of future watershed conditions under alternative land use and watershed management scenarios;
5. Development of a package of watershed restoration and protection recommendations, including:
   b) Identification of restoration, enhancement, and preservation opportunities in order to assist the North Carolina Department of Transportation (NCDOT) in meeting future compensatory mitigation needs for stream, riparian buffer, and wetland impacts;
   c) Identification of non-traditional mitigation projects (e.g., stormwater best management practices [BMPs], urban retrofits, agricultural practices) for targeted sites or subwatersheds; and
   d) Identification of a long-term follow-up strategy to assist localities in implementation of specific watershed protection recommendations developed during the planning process.

The NCEEP generally selects areas for watershed planning due to three primary factors:

1. Documented water quality and aquatic habitat problems in selected stream segments;
2. The opportunity to partner with local agencies and municipalities that have already initiated watershed protection or restoration efforts; and
3. Ongoing threats to local watershed health attributable to agricultural activities, urban/suburban development, planned highway construction projects, clearing of riparian buffers, and/or other non-point sources.

The NCEEP Local Watershed Planning (LWP) efforts are moving toward a watershed assessment approach that emphasizes lost or impacted (and restorable) functions of key watershed components (streams, riparian buffers, wetlands, and contributing uplands) – within the context of an integrated landscape or ecosystem approach. These functions generally fall into three primary categories:

- Water quality protection;
- Habitat; and
- Floodwater storage.

These three functional areas are often the focus of watershed assessment and restoration efforts associated with the LWP process.

Whereas the NCEEP has funding to implement specific restoration, enhancement, and preservation projects that may receive compensatory mitigation credit, the primary responsibility for watershed-based 'non-traditional' mitigation projects (e.g., stormwater management practices) will rest with local government entities. As part of the development of Local Watershed Plans, the NCEEP and its consultants will work with local stakeholder groups to recommend politically and financially feasible watershed solutions, including assistance in identifying possible funding sources for the recommended solutions.

The NCEEP has retained MACTEC Engineering and Consulting, Inc. (MACTEC) to conduct a technical assessment of watershed conditions within the Lower Creek Watershed, including hydrologic unit (HU) 03050101080010 and HU 03050101080020. MACTEC's support services to the NCEEP began in July 2003 and were substantially completed in December 2003. The tasks for MACTEC's watershed characterization effort are outlined below:

Task 1.2.1 - Compilation and Review of Existing Data and Information
Task 1.2.2 - Initial Visual Assessment of the Watershed
Task 1.2.3 - Subwatershed Delineation (and Modeling)
Task 1.2.4 - Findings and Recommendations Report

The purpose of this Findings and Recommendations Report is to summarize the results of these tasks and provide vital information regarding the Lower Creek Watershed (including both 14-digit HU's). This report compiles and summarizes key local watershed characterization findings (including technical memoranda, geographic information system [GIS] products, and tables) and presents collected information pertaining to the condition of wetlands, streams, riparian buffers, contributing uplands, and water quality within the local watersheds. Specifically, this report includes local watershed summaries for the following categories:

- Data Summary
- Physical Features of the Local Watershed
  - Hydrology and Subwatershed Delineation
  - Geology and Soils
  - Land Use and Land Cover
- Functional Assessment
  - Water Quality and Aquatic Habitat
  - Local Watershed Functions
- Local Water Quality Initiatives

- Threats to Local Watershed Functions

Preliminary watershed characterizations were developed based on the information collected and are summarized below. These characterizations provide essential data needed to successfully conduct future detailed assessment of representative subwatersheds and preliminary identification of local watershed improvement projects.

2.0 PRELIMINARY WATERSHED CHARACTERIZATION

The preliminary watershed characterization of Lower Creek includes a description of local physiographic features, a functional assessment based on currently available information, and statements regarding primary threats and areas in need of more detailed assessment.

The Lower Creek Watershed is predominantly located within the Northern Inner Piedmont Physiographic Region (North Carolina Department of Environment and Natural Resources [NCDENR], 2003a). Low to high hills and ridges characterize this ecoregion, along with low to moderate-gradient streams with cobble, gravel, and sandy substrates. The underlying geology consists of igneous and metamorphic rocks, specifically granite and gneiss. Chewacla, Masada, and Congaree series soils are common along Lower Creek. Cecil, Pacolet, and Rion series soils are common in upland areas of the watershed. Local soil survey data generally characterize the prevailing topography as gently rolling land with moderately steep slopes along drainageways (USDA, 1989 and USDA, 2002).

The Lower Creek Watershed includes both HU 03050101080010 (Upper Lower Creek) and HU 03050101080020 (Lower Lower Creek). For purposes of this LWP process, the Lower Creek Watershed was divided into subwatersheds according to hydrology, land use, and topography (Appendix C, Figure C-1). Each subwatershed is approximately one to five square miles in size, and was delineated to facilitate the characterization of specific drainage areas within the watershed and to help identify potential problems and/or opportunities at the catchment level. Regarding subwatershed designations, the prefix 'UL' refers to Upper Lower Creek, while the prefix 'LL' refers to Lower Lower Creek.

Previous studies by the United States Geologic Survey (USGS), the North Carolina Department of Environment and Natural Resources (NCDENR), and the Western Piedmont Council of Governments (WPCOG) have indicated that water quality, aquatic habitat, and hydrologic processes within the Lower Creek Watershed been degraded by stormwater runoff, non-point source (NPS) pollutants, channel alteration, and riparian buffer impacts. Recent visual observation of conditions in the watershed (by the NCEEP, the DWQ, and MACTEC) has revealed the presence of eroding streambanks, incised channels, in-stream sedimentation, an absence of riparian buffers, and evidence of previous channelization.

2.1 PHYSICAL FEATURES

According to the North Carolina Center for Geographic Information and Analysis (NCCGIA), the Lower Creek Watershed is approximately 98.2 square miles in extent, including HU 80010 (approximately 40.6 square miles) and HU 80020 (approximately 57.6 square miles). Within this watershed are the City of Lenoir, the Town of Cedar Rock, the Town of Gamewell, and a portion of the Cajah's Mountain community (Figure 1). The Lower Creek Watershed is located in the Catawba River basin, and extends from northeastern headwaters in Caldwell County to a southwestern terminus at Rhodhiss Lake (in Burke County). United States Geological Survey (USGS) stream gauge data are not available for this watershed. Lower Creek is the third largest drainage area for Rhodhiss Lake (second only to the Catawba River and the Johns River (WPCOG, 1998).

2.1.1 Hydrology and Subwatershed Delineation

Total stream length in the watershed (NCCGIA, 1996) is approximately 208.3 miles (1,099,824 linear feet [lf]) for the 98.2-square-mile drainage area, resulting in a density of approximately 2.1 stream miles/square miles. In order to assess conditions in the study area, MACTEC divided the Lower Creek Watershed into 29 subwatersheds, differentiated by their presence in either the Upper Lower Creek HU 80010 (subwatersheds UL01 through UL13) or the Lower Lower Creek HU 80020 (subwatersheds LL01 through LL16) (see Appendix C, Figure C-1). General subwatershed characteristics are summarized in Table 1 and are discussed in subsequent sections of this document.

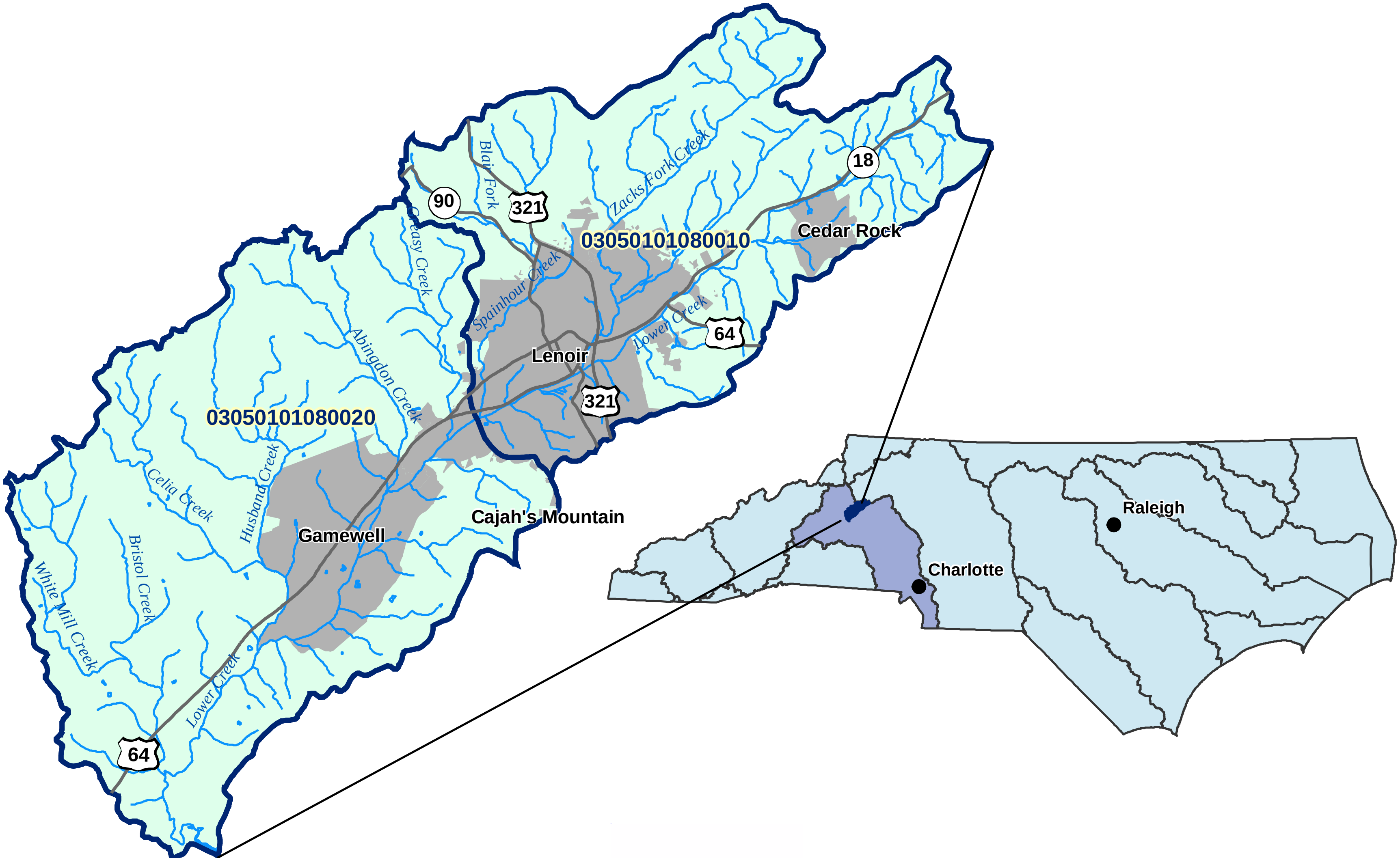
Table 1: Lower Creek Watershed Characteristics

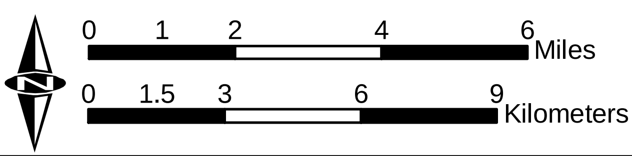
SUB-WATERSHED	APPROXIMATE AREA (square miles)	IMPERVIOUS COVER	AGRICULTURAL LAND USE	FORESTED LAND USE	URBAN LAND USE	FLOODPLAIN ENCROACH-MENT	WETLAND AREA	POTENTIAL WETLAND LOSS	NPDES DISCHARGERS	NCNHP OCCURRENCES
UL01	3.12	<1.0%	11%	89%	0%	<1.0%	0.3%	7.1%	0	0
UL02	2.83	<1.0%	25%	75%	0%	<1.0%	0.2%	10.6%	0	0
UL03	3.83	1.1%	23%	76%	1%	<1.0%	0.3%	12.0%	1	0
UL04	2.94	<1.0%	13%	87%	0%	<1.0%	0.1%	9.3%	0	0
UL05	3.15	<1.0%	1%	99%	0%	<1.0%	0.2%	4.7%	0	0
UL06	4.50	<1.0%	10%	90%	0%	<1.0%	0.3%	7.3%	1	0
UL07	1.85	24.9%	20%	55%	25%	2.1%	0.1%	10.7%	0	0
UL08	3.52	9.4%	13%	77%	10%	1.7%	0.3%	8.7%	0	1
UL09	2.44	30.6%	23%	47%	31%	4.9%	0.4%	15.1%	0	1
UL10	3.00	43.8%	10%	46%	44%	6.9%	0.8%	5.3%	0	0
UL11	3.66	38.2%	18%	43%	38%	4.6%	0.6%	6.4%	0	0
UL12	2.95	1.4%	5%	94%	1%	<1.0%	0%	4.0%	0	0
UL13	2.81	<1.0%	4%	95%	1%	<1.0%	0.1%	11.4%	1	0

SUB-WATERSHED	APPROXIMATE AREA (square miles)	IMPERVIOUS COVER	AGRICULTURAL LAND USE	FORESTED LAND USE	URBAN LAND USE	FLOODPLAIN ENCROACH-MENT	WETLAND AREA	POTENTIAL WETLAND LOSS	NPDES DISCHARGERS	NCNHP OCCURRENCES
LL01	3.42	<1.0%	5%	94%	1%	<1.0%	0%	9.2%	1	0
LL02	4.29	13.9%	23%	63%	14%	1.9%	0.5%	7.8%	0	0
LL03	1.96	7.1%	26%	67%	7%	<1.0%	0.9%	2.3%	1	1
LL04	5.33	1.1%	9%	90%	1%	<1.0%	0.1%	6.5%	0	0
LL05	5.67	<1.0%	9%	91%	0%	<1.0%	0.3%	8.6%	0	0
LL06	2.90	1.8%	29%	69%	2%	<1.0%	0%	11.3%	0	0
LL07	5.07	8.0%	29%	63%	8%	<1.0%	1.0%	2.1%	0	0
LL08	3.71	1.3%	28%	71%	1%	<1.0%	0.1%	<1.0%	0	0
LL09	2.15	1.0%	20%	79%	1%	<1.0%	1.9%	7.1%	0	0
LL10	3.44	<1.0%	19%	80%	0%	<1.0%	0.3%	3.9%	0	0
LL11	2.51	<1.0%	6%	94%	0%	<1.0%	0.4%	4.9%	0	0
LL12	4.76	<1.0%	6%	93%	0%	<1.0%	0.4%	0.9%	0	0
LL13	2.99	<1.0%	8%	91%	0%	<1.0%	0.8%	ND	0	0
LL14	3.11	<1.0%	21%	78%	1%	<1.0%	7.4%	<1.0%	1	0
LL15	4.62	<1.0%	18%	81%	1%	<1.0%	4.3%	ND	0	0
LL16	1.66	<1.0%	1%	99%	0%	<1.0%	5.6%	ND	0	0

Note: As indicated, percentages are based on percent of subwatershed area.

Land use decisions often affect hydrologic processes (e.g., by influencing stormwater runoff patterns and infiltration), water quality (e.g., by creating conditions that may either contribute or filter potential pollutants), and habitat (e.g., by influencing terrestrial and/or aquatic habitat structure). To better understand and anticipate such effects, MACTEC derived estimates of percent impervious cover (IC), percent agricultural land (including rural residential land), percent forested land, and percent urban land for each subwatershed. The estimates shown in Table 1 were developed using 1996 NCCGIA land use/land cover data, and indicate the approximate percentage of subwatershed area in each land use category. Impervious cover estimates were derived from NCCGIA land use/land cover data (1996) by defining impervious land as those features with Low Intensity Developed or High Intensity Developed attributes (in EarthSat land cover data, see Appendix A, Figure A-2). Percent impervious cover was then calculated by dividing the area of impervious land by total area of each subwatershed. Using NCCGIA data, Agricultural Land Use was defined as the ‘cultivated’ and ‘managed herbaceous cover’ categories. In contrast, Forested Land Use was defined as including: ‘evergreen shrubland,’ ‘deciduous shrubland,’ ‘mixed hardwoods/conifers,’ ‘mixed shrubland,’ ‘mixed upland hardwoods,’ ‘mountain conifers,’ ‘southern yellow pine,’ and ‘unmanaged herbaceous cover.’ Urban Land Use includes both ‘high intensity developed’ and ‘low intensity developed.’ The following categories were excluded from these classifications: ‘unconsolidated sediments,’ ‘exposed rock,’ ‘water bodies,’ and ‘not within state land cover databases.’





Data Source(s): NCCGIA

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Lower Creek Subbasin (03050101)

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Project Study Area Location

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Figure 1

Since discussions with local stakeholders have indicated concerns regarding previous floodplain filling in the watershed, approximate extents of floodplain encroachment were also estimated. Percent floodplain encroachment was calculated by creating an arithmetic overlay utilizing Federal Emergency Management Agency (FEMA) Q3 Flood Data and NCCGIA land cover data. Q3 Flood Data are digital representations of Flood Insurance Rate Map (FIRM) information intended for use with GIS technology. However, FEMA data does not include all floodplain areas, and may exclude floodplains along some small first-order streams. Wetland information was derived from U.S. Fish and Wildlife Service (USFWS) National Wetlands Inventory (NWI) coverages (Appendix A, Figure A-5). In order to identify subwatersheds with wetland losses (and therefore potential wetland restoration opportunities), percent wetland loss was derived from an overlay operation comparing NWI wetland extents and Natural Resources Conservation Service (NRCS) hydric soil extents (Appendix A, Figure A-3). Limitations of this approach include potential NWI underestimation of wetland extents (i.e., NWI coverages may not include all small wetland areas), and potential overestimation of NRCS hydric soil extents (i.e., NRCS data includes both hydric soils and hydric inclusion soils). National Pollutant Discharge Elimination System (NPDES) dischargers and N.C. Natural Heritage Program (NCNHP) element occurrences were derived from 1996 NCCGIA and 2003 NCNHP data.

2.1.2 Geology and Soils

The Lower Creek Watershed is characterized by Inner Piedmont Belt geology (North Carolina Geological Survey [NCGS], 2003). Major rock types described by the NCGS include two intrusive formations, OCgm – Migmatitic Granitic Gneiss (foliated to massive, granitic to quartz dioritic; biotite gneiss and amphibolite common) and OCg – Metamorphosed Granitic Rock (equigranular to megacrystic, foliated to massive; includes Toluca Granite). Two metamorphic formations are prevalent in the Lower Creek Watershed, CZbg – Biotite Gneiss and Schist (inequigranular, locally abundant potassic feldspar and garnet; inter-layered and gradational with calc-silicate rock, sillimanite-mica schist, mica schist, and amphibolite; contains small masses of granitic rock) and CZms – Mica Schist (garnet, staurolite, kyanite, and sillimanite occur locally; lenses and layers of quartz schist, micaceous quartzite, calc-silicate rock, biotite gneiss, amphibolite, and phyllite) (NCGS, 2003).

The Caldwell County Soil Survey (USDA, 1989) describes the following soil mapping units within the Lower Creek Watershed: Chewacla-Masada-Congaree (along floodplains), Cecil-Pacolet-Rion, and Evard-Hayesville-Saluda (in headwaters/uplands areas). Chewacla-Masada-Congaree soils are nearly level to strongly sloping, somewhat poorly drained to well-drained soils that have a loamy or clayey subsoil or loamy underlying material and have been formed in recent or old alluvium. These soils are used mostly for row crops, hay, or pasture. Seasonal wetness is the main limitation, and occasional flooding is a hazard. Cecil-Pacolet-Rion soils are gently sloping to steep, well-drained soils that have clayey or loamy subsoil and have been formed in residium from igneous and metamorphic rock. Uses of these soils include row crops, woodlands, and urban development. Slope steepness is the main limitation to development, and erosion is a concern in these areas. Evard-Hayesville-Saluda soils are moderately sloping to very steep, well-drained soils that have loamy subsoil and have been formed in residium from granite gneiss. Most areas of this soil are forested. These areas are usually not used for cropland, building site development, or recreational facilities because of steep slopes. Unpublished Burke County soil survey data (USDA, 2002) describes the following soil mapping units in the watershed: Arkaqua-Banister-Colvard (along floodplains and stream terraces) and Fairview (in headwaters/uplands areas).

According to the USDA (USDA, 1991), hydric soils in Caldwell County include Roanoke Loam (Ro) and frequently flooded Wehadkee loam (Wk). The following hydric inclusion soils are also found in Caldwell County: Chewacla loam (Cm [4]), Dogue fine sandy loam (DoB [54B]), and Tate fine sandy loam (TaB [10C] and TaD). In Burke County, the USDA (1993) lists the following hydric soils: Nikwasi loam (40A), Roanoke loam (89A), Tate-Nikwasi complex (105B), Wehadkee silt loam (86A), and Worsham fine sandy loam (80A). Only one hydric inclusion soil was noted in Burke County: occasionally-flooded Wehadkee (15A).

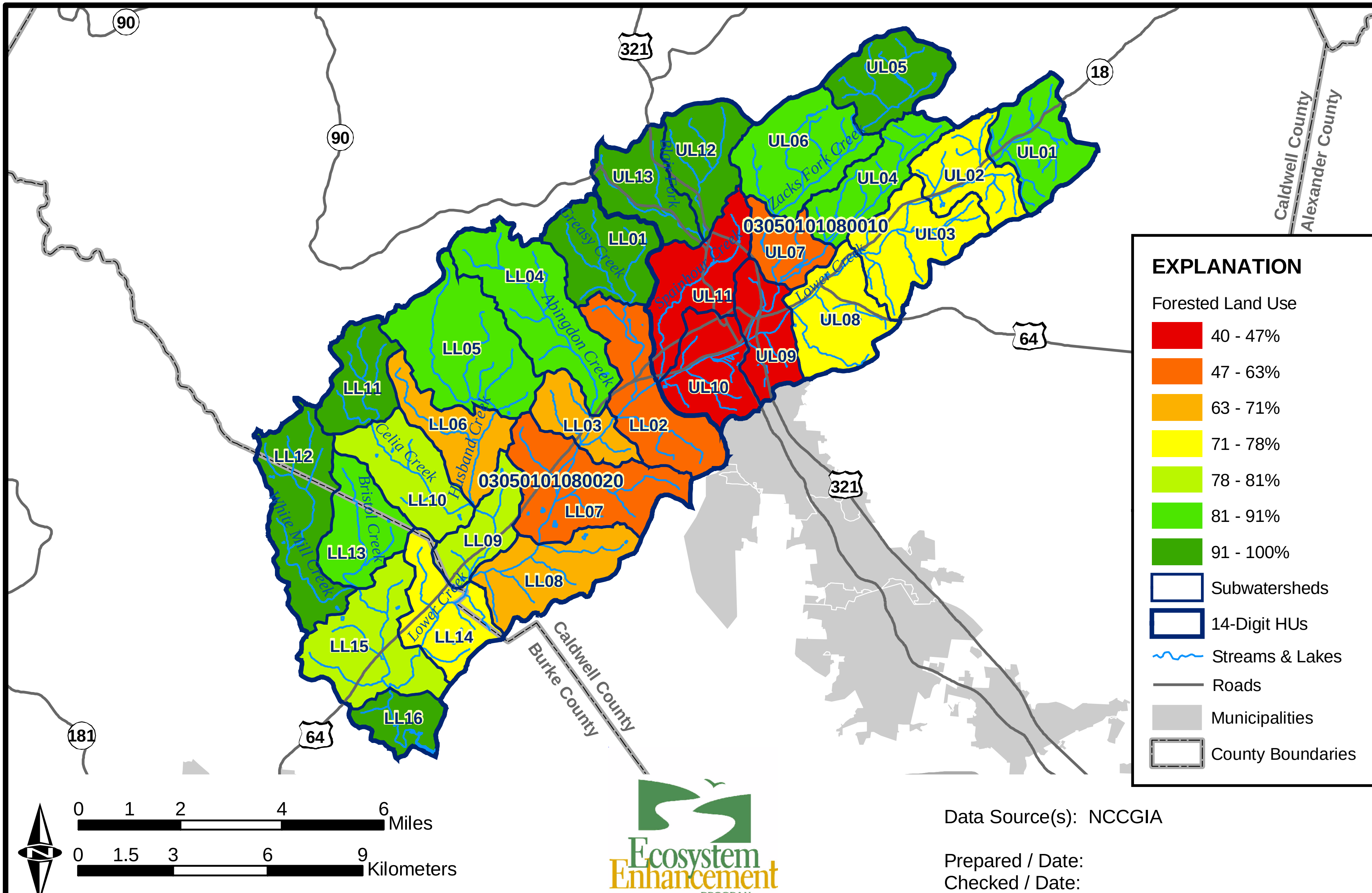
The soil erodibility characteristics of a watershed are often depicted by K factor (Appendix A, Figure A-4). K factors are a component in the Universal Soil Loss Equation (USLE) and represent the susceptibility of soil to sheet and rill erosion. Soils high in clay content have low K factor values (approximately 0.05 to 0.15) because they resist detachment. Coarse soils (e.g., sandy soils) have low K factor values (approximately 0.05 to 0.2) because they produce minimal runoff. Medium textured soils (e.g., silt loam) have moderate K factor values (approximately 0.25 to 0.4) because they are moderately susceptible to detachment and runoff. Soils with high silt content are the most erodible and tend to have K factor values greater than 0.4 (Institute of Water Research [IWR], 2002). K factors are primarily based on percentage of silt, sand, and organic matter (up to four percent), and on soil structure and permeability (USDA, 1989). Unfortunately, county soil surveys do not always consistently apply K factors to given soil types. Despite this inconsistency, a K factor analysis is useful for a general characterization of soil erodibility. Soil erodibility (K-factor) within the Lower Creek Watershed ranges from 0.10 to 0.38, while soil erodibility throughout Caldwell County ranges from 0.02 to 0.69. Erodible soils (i.e., K factor values >0.4) within the Lower Creek Watershed are primarily concentrated along the mainstem of Lower Creek (see Appendix A, Figure A-4), indicating that stream banks may be relatively susceptible to erosion in these areas. Burke County was not included in this analysis as digital soils data are not currently available.

2.1.3 Land Use and Land Cover

The NCEEP frequently evaluates land use and land cover data to help identify potential stream and wetland restoration opportunities. NCGIA data (1996) indicates land use within the watershed to be approximately 75% forest, 14% agricultural (cultivated row crops and pasture), and 11% urban (Figure 2, Figure 3, and Figure 4). Additional land use and land cover analyses were used to estimate impervious cover for individual subwatersheds using available 1996 NCCGIA land cover data (Figure 5). The highest levels of impervious cover in this largely rural watershed are located in the City of Lenoir, the Town of Cedar Rock, and the Town of Gamewell. In addition, MACTEC also utilized available information regarding soils and wetlands to facilitate the identification of potential target subwatersheds.

2.2 FUNCTIONAL ASSESSMENT

Watershed functions are intimately linked by the downgradient flow of water, sediment, and other materials from upland areas. Alterations to wetlands, streams, and riparian buffers (as well as impervious cover and land use changes) can alter the ability of a watershed to perform functions related to hydrology, water quality, and habitat. Preliminary identification of impacts to hydrology, water quality, and habitat functions in the Lower Creek Watershed was achieved by compiling and analyzing existing data, conducting GIS analyses, and performing preliminary field reconnaissance. Initial efforts focused on the condition of wetlands, streams, riparian buffers, contributing uplands, and water quality within the watershed. In particular, impacts related to impervious cover and land use change along riparian corridors were noted during field reconnaissance efforts. A summary of potentially impacted functions follows.



Data Source(s): NCCGIA

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Ecosystem Enhancement PROGRAM

NC Ecosystem Enhancement Program
Catawba River Basin LWP
Lower Creek Subbasin (03050101)

MACTEC

Forested Land Use

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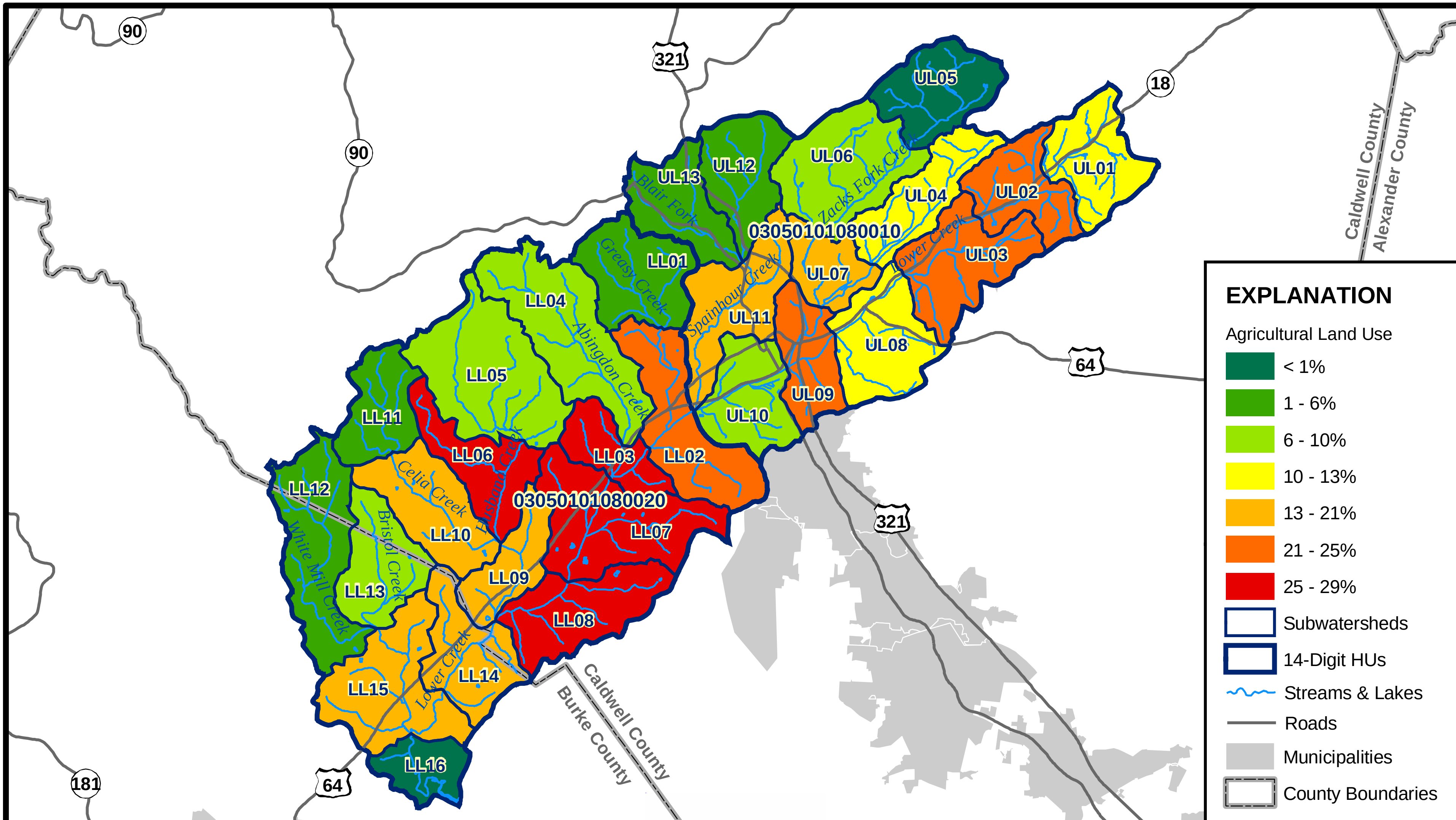
Figure 2



0 1 2 4 6 Miles

0 1.5 3 6 9 Kilometers

Ecosystem Enhancement PROGRAM

Data Source(s): NCCGIA

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NC Ecosystem Enhancement Program
Catawba River Basin LWP
Lower Creek Subbasin (03050101)

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Agricultural Land Use

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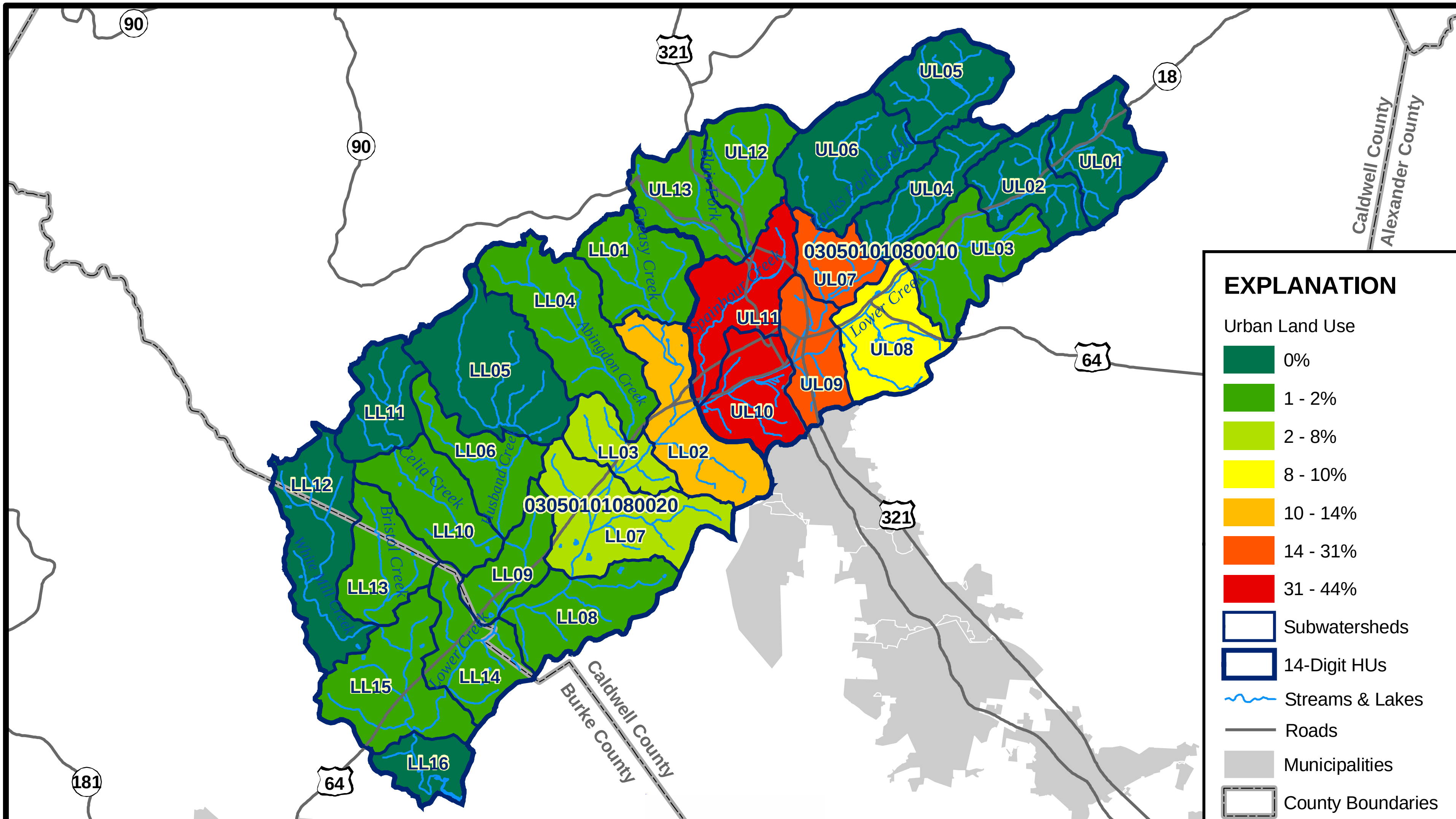
Figure 3



0 1 2 4 6 Miles

0 1.5 3 6 9 Kilometers

Data Source(s): NCCGIA

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NC Ecosystem Enhancement Program
Catawba River Basin LWP
Lower Creek Subbasin (03050101)

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Urban Land Use

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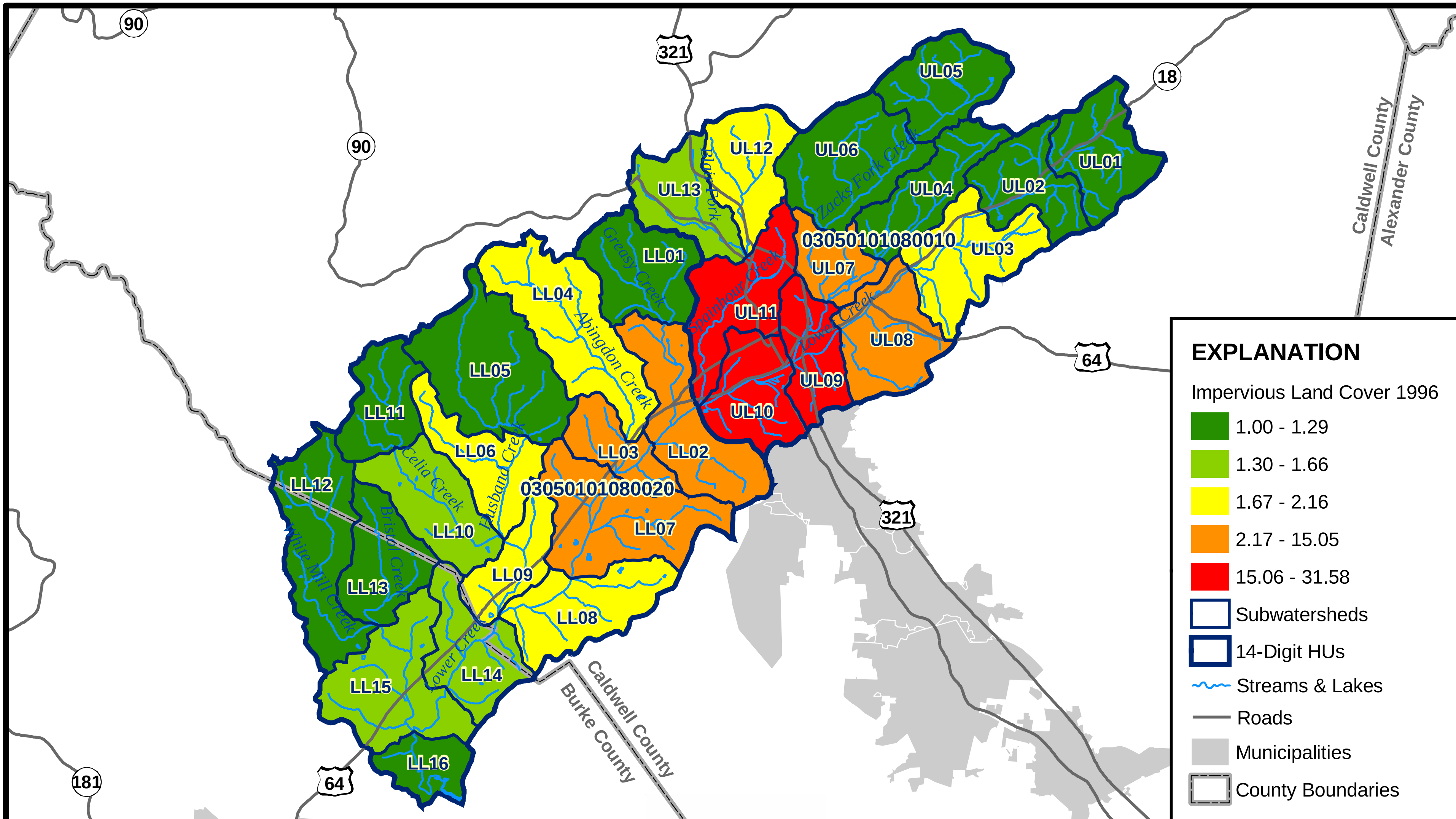
Figure 4



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0 1 2 4 6 Miles

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Data Source(s): NCCGIA

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NC Ecosystem Enhancement Program
Catawba River Basin LWP
Lower Creek Subbasin (03050101)

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Impervious Cover

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Figure 5

2.2.1 Hydrology

Hydrologic functions in the Lower Creek Watershed are closely associated with rural land use patterns and decisions. Many first-order streams in this watershed originate in northern forested areas currently managed primarily for silvicultural purposes. In contrast, many second-order and third-order streams are located in the central, lower elevation valleys, areas dominated by agricultural croplands, pastures, and rural residential land use. It is in many of these larger central valleys that the presence of ornamental nursery operations is particularly evident. While urbanized areas like Lenoir, Cedar Rock, and Gamewell also influence local watershed hydrology, these impacts are generally most clearly evidenced within the towns themselves and in the channels immediately downstream of these urbanized areas. Consideration of the entire watershed area reveals that the majority of land in the study area has not yet become urbanized.

Since the majority of the Lower Creek Watershed is rural in character (0-5% impervious cover), most impervious cover impacts are concentrated around the existing urbanized areas of Lenoir (subwatersheds UL07, UL09, UL10, and UL11, at 15-45% impervious cover) and Gamewell (subwatersheds LL02, LL03, and LL07, with 5-15% impervious cover). Although the relationship between impervious cover and increased stormwater runoff is well documented, other factors (e.g., slope, soils, and conveyance system types) also play a role in the hydrologic response of a watershed to stormwater runoff. Despite continued debate regarding the impact of specific levels of imperviousness and influence on hydrological function, watersheds with impervious cover greater than 10% consistently exhibit evidence of reduced/impacted hydrologic function (CWP, 2003). Watersheds with riparian corridors that have experienced more than a 20% increase in urban land use have also been identified as suffering from reduced/impacted/lost hydrologic function (CWP, 2003).

During field reconnaissance efforts, stream channel incision (Figure 6) and widening processes (Figure 7) were observed throughout the watershed. These processes were primarily noted along streams that lacked riparian buffers (i.e., minimal root mass stabilization) and along channels in urbanized areas (e.g., stormwater conveyances). Evidence of significant streambank erosion and downstream sedimentation (aggradation) was also observed at various locations in the watershed. Impacts from construction activities, agriculture, and new development (e.g., residential and commercial) may be contributing to this hydrologic impairment (Figure 8).

Figure 6: Stream down-cutting (incision) along Lower Creek at golf course, 07/31/03 (UL09)

Figure 7: Streambank erosion along Lower Creek, 07/31/03 (LL07)

Figure 8: Construction activities along Zacks Fork at soccer complex, 09/04/03 (UL07)

Additional hydrologic impacts in the watershed have resulted from channel modifications and alteration of natural stream channel plan, dimension, and profile at various locations. Many streams were likely previously channelized (via straightening and relocation) in local agricultural areas, to maximize available cropland (Figure 9). More recently, other streams appear to have been piped or diverted for residential, commercial, and industrial development. In undisturbed stream channels, such alterations often disturb a natural state of dynamic equilibrium, and may create further instability in the downstream channel network. As each stream adjusts to such alterations, the processes of streambank erosion, lateral migration, channel incision, and/or streambed aggradation may be initiated. When alterations are implemented along streams that have already been previously impacted, these modifications may exacerbate such existing problems (e.g., streambank erosion, channel incision) and may prevent the streams from recovering to a naturalized state of quasi-equilibrium. For example, channelized streams lined with riprap (Figure 10) were observed throughout the Blair Fork (UL13) subwatershed, along with channels in close proximity to adjacent roadways (e.g., stream channels within approximately ten feet of Indian Grave Road and Valway Road).

Figure 9: Streambank Channelized Husband Creek tributary at tree farm, 09/19/03 (LL06)

Figure 10: Channelized Blair Fork along Valway Road tributary, 09/19/03 (UL13)

Preliminary observations indicate that many streams within the Lower Creek Watershed are incised, are characterized by actively-eroding streambanks, or are being impacted by in-stream sediment accumulation (sedimentation). While stormwater runoff from urbanized areas may be a contributing factor to this impairment in many areas (e.g., Lower Creek and Zacks Fork in/downstream of Lenoir), the presence of such problems in rural portions of the watershed may indicate other processes at work, including the theoretical process of historic valley filling/incision. It has been suggested that poor erosion and sediment control practices in eastern North America during the 19th century may have accelerated natural erosion rates and subsequently led to the 'filling' of some valley areas with an overburden of deposited sediment. This theory suggests that such valley areas may have then become stabilized over time with vegetation, and that recent channel incision (degradation) may represent an effort by the stream channels to reach their historic streambed elevations. This theory and its potential applicability to the Lower Creek Watershed should be discussed with knowledgeable local geomorphologists during future phases of the project.

2.2.2 Water Quality

Since water quality data for the Lower Creek Watershed are somewhat limited (one NCDENR Division of Water Quality [DWQ] station on Lower Creek, and DWQ biological monitoring stations on other tributaries, NCDENR 2003b), it is difficult to establish identifiable trends, extents of pollution, and potential sources of water quality impairment (due largely to spatial and temporal variability). Based on available water quality data, NPS pollutants (e.g., sediment, nutrients, and coliform bacteria) are likely are likely impacting water quality in the study area. In 2003, the DWQ summarized water quality and biological monitoring data for Lower Creek as follows (NCDENR, 2003b):

"The entire length of Lower Creek below the junction of Zacks Fork (approximately 12.7 miles) is listed on North Carolina's 2002 303(d) impaired stream list as partially supporting. Causes of impairment noted on the 2002 303(d) list are habitat degradation and turbidity; and urban runoff, non-urban development, and municipal point sources were noted as potential sources of impairment. Several major tributaries to Lower Creek (Zacks Fork , Spainhour Creek, Greasy Creek, and Bristol Creek) are also listed as partially supporting on the 303(d) list. Nonpoint sources of pollution such as agriculture, urban runoff, and non-urban development are listed as potential sources of impairment. The upper reach of Lower Creek is currently listed as fully supporting. Stream quality data for the Lower Creek watershed include DWQ benthic, fish, and habitat assessments and DWQ ambient data. In addition, the USGS collected a limited amount of data in 1993-1994 on nutrients and fecal coliform bacteria in Lower Creek (Giorgino and Bales, 1997), which are not summarized here.

Historic Monitoring 1984-1992

Benthic macroinvertebrates were collected in 1984, 1987, 1990, and 1992 in Lower Creek in or downstream of Lenoir. All samples were rated Fair. Zacks Fork Creek was sampled in 1987 and rated Fair.

1997 Watershed Study

“[The] DWQ conducted a watershed survey in 1997 in response to a request from the Western Piedmont Council of Governments [WPCOG] ([NCDENR] DWQ, 1997). Among the four monitoring sites on Lower Creek, the three downstream sites located in or downstream of Lenoir were rated Fair. A site at NC 90, which was upstream of Lenoir, was rated Good-Fair. The greatest stress in Lower Creek was at SR 1142, which was located below the densest urban development, Lenoir’s wastewater treatment plant (WWTP), and three major tributaries, each of which had Fair bioclassifications. Five tributaries of Lower Creek were also sampled--Zacks Fork Creek, Spainhour Creek, Greasy Creek, Husband Creek, and Bristol Creek. All streams but Husband Creek (rated Good-Fair) were rated Fair. Analysis of benthic community composition of each site did not indicate impacts from severe nutrient or organic enrichment or toxic conditions. A lack of protective buffers and many potential non-point sources of pollution were noted in the watershed. Potential pollution sources noted included a golf course, industries, agriculture (livestock), commercial areas, and residential developments. Impacts from urban and sub-urban development in and around Lenoir were pinpointed as major factors in biological community degradation. The study did not detect additional impacts to Lower Creek from Lenoir’s WWTP, but this may have been masked by the water quality problems above the discharge.

2002 Watershed Study

“Each stream sampled in 1997 was sampled again in 2002, and a number of sites were added to determine differences in benthic communities of urban and non-urban streams. Degraded benthic communities characterized all sites in the Lower Creek watershed ([NCDENR] DWQ, 2003f). As in 1997, none of the communities sampled in 2002 indicated severe nutrient or organic enrichment, or toxic conditions. Many sites had severe streambank erosion with little protection by a riparian buffer zone. Sandy substrates provided poor habitat, limiting benthic diversity. Poor habitat coupled with urban impacts from Lenoir produced the most stressed benthic communities as demonstrated in Lower Creek, lower Zacks Fork Creek, and lower Spainhour Creek. Tributaries, such as Abingdon Creek, upper Husband Creek, Bristol Creek, and the unnamed tributary (UT) to Spainhour Creek that did not drain urban areas, supported more diverse or intolerant benthic communities. Runoff from agriculture (cropland and livestock) and residences located in tributary catchments likely affected the benthic communities in these streams, but not as severely as urban runoff from Lenoir. The UT to Spainhour Creek and the Bristol Creek watershed (including White Mill Creek) were the only systems that supported benthic communities with long-lived stoneflies and philopotamid caddisflies.

Lower Creek

"All of the Lower Creek sites had impaired benthic communities, rated Fair or Poor. The Lower Creek sites retained their Fair ratings (SR 1303, SR 1142, and SR 1501) or declined (NC 90) from 1997. Contrary to 1997, the most upstream location on Lower Creek (NC 90) received the lowest rating (Poor) of the four mainstem Lower Creek sites. The most downstream site at SR 1501 appeared to recover slightly from the upstream sites. Lenoir's WWTP effluent did not appear to further impact the benthic fauna, although the dissolved oxygen value of 5.6 mg/L3 may be an indication of a dissolved oxygen sag from the WWTP. This was the only Lower Creek site in 2002 where stoneflies were collected, although neither of the two stonefly taxa were abundant.

Zacks Fork Creek

"An upper Zacks Fork Creek site was sampled and rated Not Impaired, supporting a more diverse benthic community (EPT richness of 19) than the lower Zacks Fork Creek site (EPT richness of 6). The upstream habitat was much better than that downstream (total habitat score of 55 vs. 26), and the upper site was above the urban influences of Lenoir. Of particular concern at the lower Zacks Fork Creek site was an elevated conductivity reading of 1000 umhos/cm. The site was located just downstream of a golf course and within Lenoir. The 2002 lower Zacks Fork Creek benthic community was much less diverse than that of 1997; EPT richness dropped from 18 to 6.

Spainhour Creek Watershed

"The small UT to Spainhour Creek supported the most intolerant benthic community (biotic index of 4.66) in the Spainhour Creek watershed, but the stream's small size likely limited diversity (EPT richness of 13). In comparison, the benthic community from urban-influenced Blair Fork was severely impacted (EPT richness of 5, biotic index of 6.42). Spainhour Creek itself was much more tolerant than UT to Spainhour, with a biotic index of 6.46. There was little change in the benthic community between 1997 and 2002 in Spainhour Creek, although that of 2002 was slightly more tolerant. Cumulative water quality impacts and habitat degradation that occurs as Spainhour flows southwest through the City of Lenoir likely contribute to the declining benthic fauna at the downstream Spainhour site.

Greasy Creek

"An upstream site was sampled on Greasy Creek in 2002 to differentiate between benthic communities and habitat in the upper portion of this watershed versus downstream, which was sampled in 1997 and 2002. Although habitat was better at the upstream site (more in-stream structure and less sand and silt), there were no notable differences in the benthic communities at the upstream and downstream sites. EPT scores were low at both sites. There was little change in the benthic community of the downstream Greasy Creek site between 1997 and in 2002.

Abingdon Creek

"Abingdon Creek was characterized by a benthic community with the second highest EPT richness (20) in the Lower Creek watershed; it was rated Not Impaired. The Abingdon Creek watershed is less urban and appears to be one of the less impacted catchments in the Lower Creek, although there are potential sources of impact, including timber operations, agricultural fields and minimal riparian zones.

Husband Creek Watershed

"An upper site on Husband Creek was sampled in 2002 and supported a much more diverse benthic community than the lower Husband Creek site (EPT richess of 24 vs. 14). This upper site had the highest EPT taxa richness of all sites sampled in the Lower Creek watershed. Between 1997 and 2002, a drop in EPT richness from 20 to 14 occurred for the downstream site; however, based on upon community composition analysis and consideration of seasonal variation, this drop does not reflect a true decline in community health. A sample was also collected in Celia Creek, which is a tributary to Husband Creek. This site was characterized by low EPT taxa richness (10), but many taxa collected were intolerant. The small drainage area may limit diversity in this stream. Considering drainage area, the taxa collected, and EPT richness, Celia Creek appears to be minimally to moderately impacted.

Bristol Creek Watershed

"Rural Bristol Creek and its tributary, White Mill Creek, were characterized by fairly limited EPT richness (12 and 14, respectively), but intolerant and long-lived taxa were present. The small sizes of both streams may limit benthic diversity and abundance.

Comparison Sites

"Smoky Creek and Gunpowder Creek, located in watersheds adjacent to the Lower Creek watershed, were sampled as part of the basinwide assessment program in August 2002 and are used for comparison to sites in the Lower Creek watershed. Unlike Lower Creek and many of its tributaries sampled during this study, Smoky Creek and Gunpowder Creek drain rural catchments. Gunpowder Creek was dominated by sand and was a comparison for Lower Creek. It was rated Good-Fair, characterized by a more diverse and intolerant community than any site on Lower Creek sampled in 2002. Smoky Creek was a smaller creek and provides a comparison for sites like Abingdon Creek, UT to Spainhour, and upper Husband Creek, which have like mixes of cobble, gravel, and sand substrates. Smoky Creek was rated Good-Fair and had a higher EPT richness and lower biotic index than any site in the Lower Creek watershed.

Ambient Monitoring Data, N.C. Division of Water Quality

"[The] DWQ has monitored chemical/physical parameters on Lower Creek at SR-1501 since 1973. This site is located below the Town of Lenoir WWTP discharge. For the period of 1998-2002, nutrients were relatively high, with a median total nitrogen (TKN+NO_2/NO_3) concentration of 1.2 mg/L and median total phosphorus of 0.1 mg/L. Twenty percent of samples were above NC's action level for copper of 7 µg/L. Fecal coliform bacteria levels were high, with the geometric mean of 277 colonies/100 mL for 55 samples (N.C. standard is 200 colonies/100 mL for 5 samples collected in 30 days).

NPDES Facilities

"There were six wastewater treatment plants permitted through the NPDES program in the Lower Creek watershed during the period of 2001 to 2003; however, three of these are either no longer operating or now send their waste to Lenoir's WWTP. A record review indicates that no facility has consistent problems, although the City of Lenoir has exceeded its permitted limits for total suspended solids and biochemical oxygen demand twice in the past two and a half years."

As noted by the DWQ, riparian buffers are absent along many streams in the Lower Creek Watershed. Without such forested buffers, there is only limited filtering of stormwater/NPS pollutants before they reach adjacent stream channels. Forested riparian buffers provide a vegetated transition zone between surface waters and human land uses. During visual assessment efforts in the Lower Creek Watershed, riparian buffers were typically found to be either sparse or entirely absent along many stream channels. This was particularly evident along Zacks Fork, Lower Creek, and an unnamed tributary to Husband Creek (Figure 11 and Figure 12).

Figure 11: Lack of riparian buffer on Husband Creek at golf course, 09/04/03 (LL05)

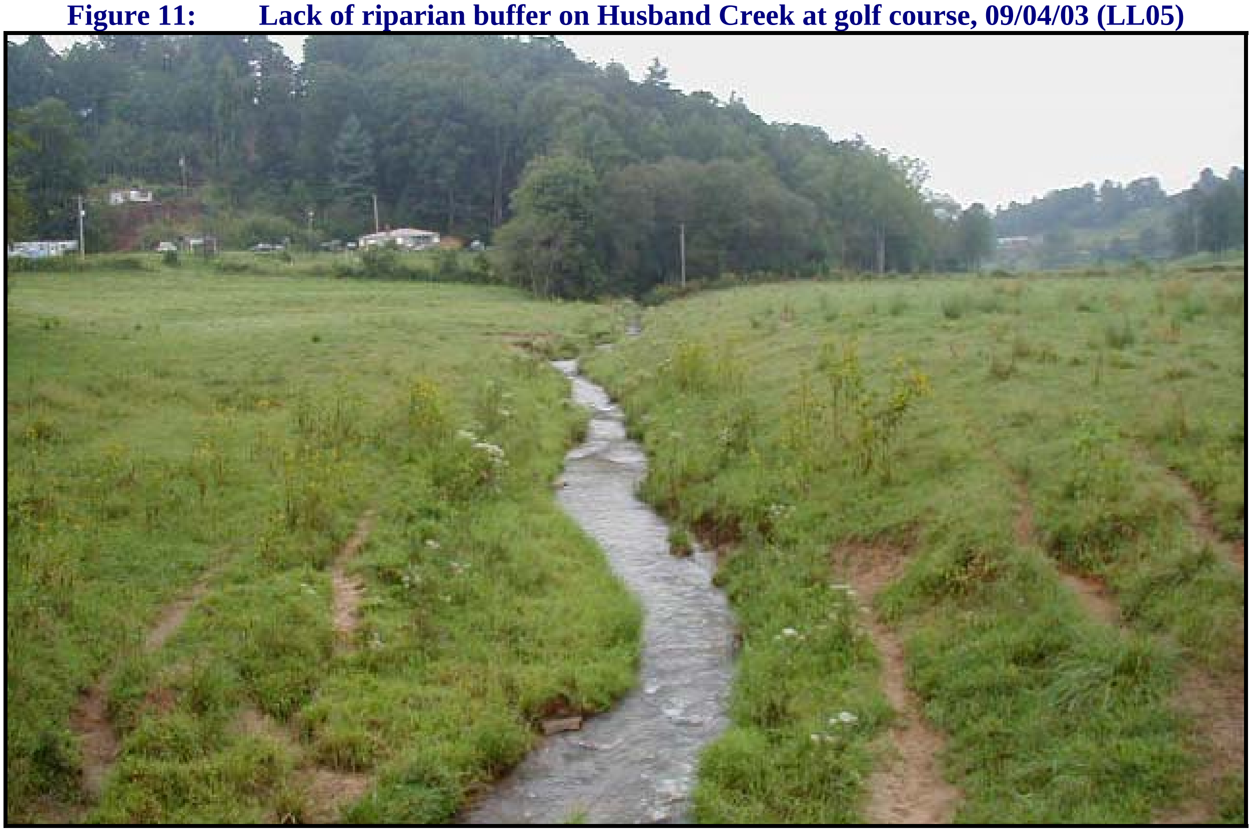


Figure 12: Lack of riparian buffer on Tributary to Zacks Fork, 09/04/03 (UL06)

While the majority of stream channels in the Lower Creek Watershed are Class C surface waters, Lower Creek is listed as WS-IV/CA downstream of Bristol Creek (See Appendix A, Figure A-6 for classifications. See Appendix A, Figure A-7 for use-support ratings). The WS-IV classification indicates that the downstream-most portion of Lower Creek and five of its tributaries are in a Water Supply Watershed. The WS-IV designation is generally applied to surface waters that are utilized for drinking water, culinary, or food processing purposes, and is typically used when a WS-I, WS-II, or WS-III classification is not feasible (usually in moderately-developed or highly-developed watersheds). The WS-IV classification involves no categorical restrictions on discharges, though the additional Critical Area (CA) classification of Lower Creek (applied downstream of Bristol Creek and around Rhodhiss Lake) does require no new landfills, specified agricultural BMPs, and regulated residential development (using either a Low Density Option of 24% built-upon area [two dwelling units per acre] or a High Density Option of 24-50% built-upon area).

According to the DWQ (NCDENR, 2002b and NCDENR, 2003b), data collected at the Lower Creek/SR-1501 monitoring station [C17500000]) also indicate consistently high concentrations of fecal coliform (3,000 colonies (c) per 100 mL, 2,000 c/100mL, and 8,400 c/100mL). For the DWQ sampling period from 1998-2002, the geometric mean was 277 c/100mL for 55 samples. The North Carolina standard is 200 c/100mL for five samples collected in 30 days (NCDENR, 2003b). Elevated fecal coliform levels may be indicative of failing septic systems, land development, urban runoff, and/or agricultural/rural residential inputs. The DWQ also noted high nutrient concentrations during some sampling efforts (NCDENR, 2003b). Nutrient inputs may be produced by a variety of sources, including fertilizer runoff (from agricultural and/or residential areas), treated wastewater effluent, urban stormwater runoff, failing septic systems, animal concentrations (e.g., concentrated animal feeding operations [CAFO] or migratory waterfowl), atmospheric aerosols, and detergents. High coliform levels and nutrient loadings have the potential to affect downstream water quality in Rhodhiss Lake (a local water supply), as elevated nutrient levels may increase the risk of eutrophication.

2.2.3 Habitat

Aquatic habitat in the Lower Creek Watershed includes both high-gradient headwater streams (to the north and northwest), lower-gradient channels in forested and agricultural areas (in the central and southern portions of the local watershed), and incised urban conveyances (in Lenoir, Cedar Rock, and Gamewell). These various environments provide equally variable aquatic habitat resources. Forested subwatersheds (and associated first and second-order tributaries) to the northeast likely contain the greatest diversity and abundance of aquatic macroinvertebrate assemblages (due to available habitat diversity, high water quality, and low predation pressure), while fish abundance and diversity may be highest in the second and third order channels adjacent to Lower Creek (due to perennial stream flow and a greater abundance of prey). In contrast, urban channels in and around Lenoir may be dominated by pollution-tolerant organisms. Studies by the USGS (Giorgino and Bales, 1997), the NCDENR (1997, 2002b, and 2003b), the WPCOG (1998 and 2003), and MACTEC field reconnaissance efforts indicate that elevated urban stormwater discharges may be impacting physical aquatic habitat structure, may be contributing to water quality degradation (e.g., urban pollutants, including toxins, hydrocarbons, oils, grease, and fuels), and may be transporting high sediment loads (which can smother or bury interstitial spaces in riffles, important as 'resting' and 'feeding' areas for the aquatic larvae of many species). However, such degradation is not limited only to urban channels, as rural streams in the Lower Creek Watershed have also been affected by sedimentation and habitat structure impacts related to NPS pollutants, channel alteration, and riparian buffer impacts. The DWQ has summarized overall habitat observations in the local watershed as follows (NCDENR, 2003b):

"Habitat evaluations at the 17 benthos sites sampled in 2002 in the Lower Creek drainage resulted in a range of scores between 26 and 70 out of a possible 100 points. The highest scores (70 and 55) were found at the upper Greasy Creek site and at the upper Zacks Fork Creek site. As with benthic community metrics, generally the highest habitat scores were recorded at upstream sites on tributaries and in catchments that were located southwest of Lenoir. Habitat scores declined from the upper sites to the lower sites on Zacks Fork (55 to 26) and Greasy Creek (70 to 42). Lower Creek mainstem sites had the lowest habitat scores due to the sandy substrates, severe erosion, absence of riffles, and small riparian zones. Comparison sites on Gunpowder Creek and Smoky Creek also had limited habitat scores (48 and 62, respectively), but were still rated Good-Fair. Like Lower Creek, comparison site Gunpowder Creek was dominated by sand and had high embeddedness and a moderate amount of in-stream structure. Habitat likely plays a role in impairment of sites in the Lower Creek watershed, but it is not the only factor in benthic degradation. For more detailed discussion, see the Catawba basinwide assessment report ([NCDENR] DWQ, 2003f), the 2003 Lower Creek study memo ([NCDENR] DWQ 2003e) and the 1997 Lower Creek watershed assessment memo ([NCDENR] DWQ, 1997).

"Fish community samples were collected in Lower Creek at SR 1501 in 1997 and 2002. The fish community was rated Good-Fair in 2002 and 1997 (NCIBI = 42 and 44, respectively). More species, total fish, species of suckers, and piscivores were collected in 2002 than in 1997. In 1997, only 49 fish were collected (the fewest fish of any site monitored that year) in contrast to 211 collected in 2002. However, these "gains" were offset in 2002 by an absence of intolerant species, fewer insectivores, and a higher percentage of diseased fish. In 1997, two species (redbreast sunfish and bluegill sunfish) dominated the community; this contrasted to five species (tessellated darter, bluehead chub, redbreast sunfish, bluegill sunfish, and yellow perch), which constituted 73 percent of all the fish collected in 2002. In 1993, Lower Creek at SR 1142 was sampled. This received a similar NCIBI score of 44 and rated Good-Fair. For more detailed discussion, see the Catawba basinwide assessment report ([NCDENR] DWQ, 2003f)."

The low impervious cover levels (<10%) found in 15 of the 16 Lower Lower Creek subwatersheds suggest that stormwater runoff impacts to habitat are minimal in this portion of the study area. In fact, all but one of these subwatersheds has less than 10% impervious cover, the threshold frequently associated with physical habitat degradation (CWP, 2003). In support of this conclusion, field observations revealed the presence of aquatic habitat resources (e.g., large woody debris, variable stream depths, riffles/pools, and undercut streambanks) in some areas (Figure 13 and Figure 14). It is estimated then that observed impacts may be more the result of commercial, agricultural, and rural residential land use decisions than IC extent (and urban stormwater runoff) in this portion of the study area.

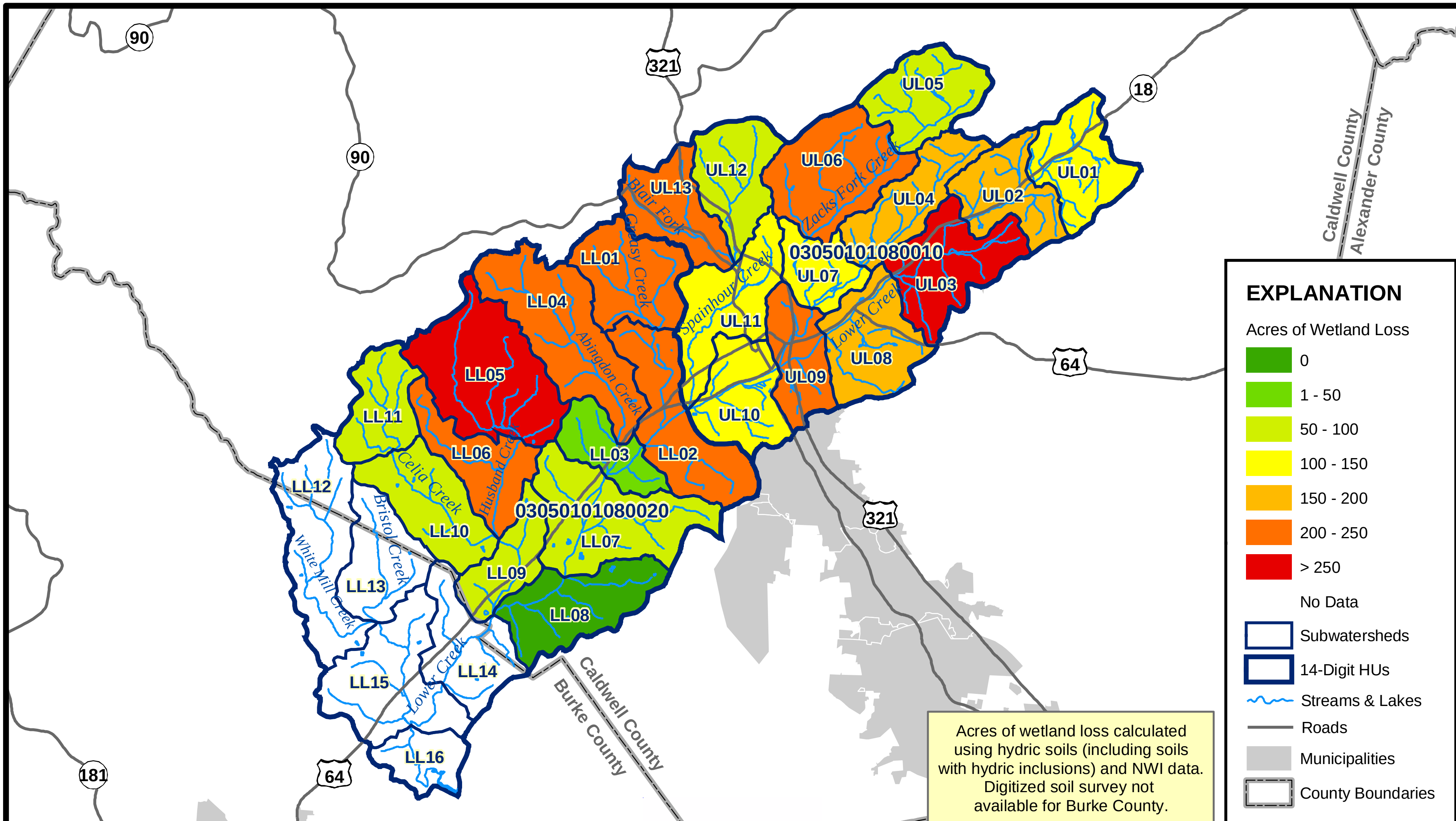
Figure 13: White Mill Creek, 09/04/03 (LL12)

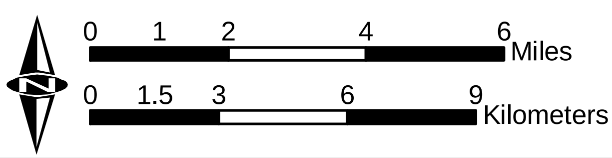
Figure 14: Lower Creek, 09/19/03 (LL08)

In general, the watershed's stream channels have been impacted by a variety of factors, including land use activities, stormwater runoff, NPS pollutants, channel alteration, riparian buffer impacts. These stressors have likely contributed to the channel incision (down-cutting), streambank erosion, and sedimentation observed in many of the study area's subwatersheds.

Within the Lower Creek Watershed, MACTEC identified potentially significant wetland habitats by using 1999 NWI data (USFWS, 2003) and county hydric soil lists (USDA, 1991 and USDA, 1993). Subwatersheds were evaluated for potential wetland loss by comparing hydric soil extents (see Appendix A, Figure A-3) with current NWI wetland extent data (see Appendix A, Figure A-5). The difference between hydric soil extent (potential wetland area) and NWI wetland extent was identified as potentially 'lost' wetland area (Figure 15). This estimated potential wetland loss was the calculated for each subwatershed. This assessment assumes that hydric soil areas would have historically been dominated by wetlands, and that human land use decisions have reduced actual wetland extents in hydric soil areas over time. Limitations of this approach include potential NWI underestimation of wetland extents (i.e., NWI coverages may not include all small wetland areas), and potential overestimation of NRCS hydric soil extents (i.e., NRCS data includes both hydric soils and hydric inclusion soils). As a result, data presented in Figure 15 may represent an over-estimation of potential wetland losses.

However, using this approach does provide a useful method of comparing 'potential' wetland losses between subwatersheds. It is anticipated that subwatersheds with high estimated wetland losses may provide the greatest potential for NCEEP wetland restoration opportunities. Available soils and NWI data indicate that the greatest historic wetland losses have likely occurred near the Town of Cedar Rock (subwatersheds UL02 and UL03), near the City of Lenoir (subwatersheds UL07 and UL09), near the Town of Gamewell (subwatersheds LL01, LL02, LL06, and LL09), and in two subwatersheds in the northwestern portion of the Lower Creek Watershed (subwatersheds UL06 and UL13). These subwatersheds may therefore provide opportunities to restore historic wetlands both in urban areas (UL02, UL03, UL07, UL09, LL01, LL02, LL06, and LL09) and in rural areas (UL06 and UL13).





Ecosystem Enhancement PROGRAM

Data Source(s): NCCGIA, USFWS, NRCS

Prepared / Date:
Checked / Date:

NC Ecosystem Enhancement Program
Catawba River Basin LWP
Lower Creek Subbasin (03050101)

MACTEC

Potential Wetland Loss

Project 6470030275

Figure 15

The geographic positions of Caldwell County and Burke County (between the Piedmont and Mountain physiographic provinces) provide a wide variety of habitat for both terrestrial and aquatic organisms, including many rare species. In the Lower Creek Watershed (subwatersheds UL08, UL09, and LL03 [NCNHP, 2003]), the NCNHP lists three element occurrences of dragonfly species listed as State Significantly Rare, including the Edmund's Snaketail (*Ophiogomphus edmundo*), the Maine Snaketail (*Ophiogomphus mainensis*), and the Mountain River Cruiser (*Macromia margarita*). See Appendix A, Figure A-13 for NCNHP Element Occurrences. NCNHP element occurrences are locations of rare and endangered species, important natural ecosystems (terrestrial or aquatic), and animal habitats. In the element occurrence database, the NCNHP also includes sites with particular biodiversity significance (attributable to rare species, rare or high quality natural communities, or other ecological features).

According to DWQ records from September 9, 2002 through 11, 2002, *Ophiogomphus* spp. were observed at sites ZFK1 (subwatershed UL07), SPH (subwatershed UL11), UTSPH (subwatershed UL12), GCR2 (subwatershed LL02), ABCR (subwatershed LL03), CCR (subwatershed LL10) and BCR (subwatershed LL15), and abundant at GCR1 (subwatershed LL02) and WMCR (subwatershed LL12). *Macromia* spp. were also observed at sites LC2 (subwatershed UL08) and LC3 (subwatershed LL08), and were abundant at site LC4 (subwatershed LL14). While these two genera were observed, it is unknown whether these observations were of the previously-mentioned rare species. Since these areas may provide habitat for rare species, preservation and enhancement opportunities should be considered in the noted subwatersheds. However, urbanization near some of the noted observation areas may limit both opportunities for preservation and actual habitat quality.

While the noted genera have been observed in these specific subwatersheds, other rare species observed elsewhere in Caldwell County and Burke County may also reside in the Lower Creek Watershed (but have not yet been observed). These include both federal and state-listed species, and many that utilize aquatic and riparian habitat resources for a portion of their life cycles (see Appendix A, TABLE ?).

2.3 LOCAL WATER QUALITY INITIATIVES

Notable local water quality initiatives currently being implemented within the Lower Creek Watershed include:

- Land use zoning in both Caldwell County and Burke County
- Caldwell County Flood Damage Prevention Ordinance
- Caldwell County Watershed Protection Ordinance
- Burke County Watershed Protection Ordinance

- Lenoir NPDES Phase II plan
- Caldwell County proposed local erosion and sediment control (ESC) permitting program
- DWQ preparation of a calibrated TMDL model for Lower Creek
- Construction of the Lenoir Greenway system
- WPCOG Study – Lower Creek Watershed Project (WPCOG, 1998)
- USGS Study – Hydrologic, Water-Quality, and Meteorologic Data from Selected Sites in the Upper Catawba Basin, North Carolina, January 1993 Through March 1994 (Jaynes, 1994)
- USGS Study – Rhodhiss Lake, North Carolina: Analysis of Ambient Conditions and Simulation of Hydrodynamics, Constituent Transport, and Water-Quality Characteristics, 1993-94 (Giorgino and Bales, 1997)
- WPCOG Study – A Comprehensive-Based Modeling Approach for Predicting Sediment and Nutrient Loads in the Rhodhiss Lake Watershed (WPCOG, 2003)

2.3.1 Local Ordinances

In addition to countywide zoning, Caldwell County has adopted a Flood Damage Prevention Ordinance and a Watershed Protection Ordinance. Burke County also has countywide zoning, and has enacted a Watershed Protection Ordinance. These ordinances are primarily intended to minimize floodplain filling and limit development in water supply watershed areas in each county.

In 1993, Caldwell County adopted a Flood Damage Prevention Ordinance (amended in 2000) that restricts development and floodplain encroachment within areas of special flood hazard (as defined by the Federal Emergency Management Agency [FEMA] for Caldwell County in 1988). This ordinance appointed the County Planning Director to administer and implement the policies, established a penalty process, and stipulated required details to be indicated on proposed development plans. The ordinance also noted specific standards for residential construction, non-residential construction, manufactured homes, recreation vehicles, elevated buildings, temporary structures, and accessory structures. Within floodways, restrictions include no encroachment, fill, or development (unless no demonstrated flood level increase would result), as well as no new manufactured homes (except in existing manufactured home parks and subdivisions). Along streams without established base flood elevations and/or floodways, no encroachment is allowed within 20 feet of the streambanks (or five times the width of the stream, whichever is greater), unless no demonstrated flood level increase would result. According to the ordinance, a no-rise certification is required for commercial or industrial development within a flood hazard area, although a single-family residential landowner is permitted to fill up to 10,000 square feet. This ordinance affects FEMA floodways mapped within the NCEEP Lower Creek watershed, primarily in the vicinity of Lenoir.

In 1996, Caldwell County also adopted a Watershed Protection Ordinance for DWQ WS-IV Water Supply Watersheds. This ordinance establishes development restrictions for a Critical Area (CA) that extends 0.5 mile from a drinking water point of intake, and for a Protected Area (PA) that extends five miles from a drinking water point of intake. Restrictions for Critical Areas (WS-IV-CA) include: a maximum of two dwelling units per acre (residential), a maximum of 24% built-upon area (non-residential), no new landfills or sludge application sites, a minimum ten-foot vegetative buffer along USGS perennial streams (for agricultural activities after 1993), BMP use requirements (for agricultural operations with more than 100 animals), and no hazardous material storage without an implemented spill containment plan. Restrictions for Protected Areas (WS-IV-PA) include: a maximum of two dwelling units per acre (residential, *with* curb and gutter systems) or three dwelling units per acre (residential, *without* curb and gutter systems), a maximum of 24% built-upon area (non-residential, *with* curb and gutter systems) or 36% built-upon area (non-residential, *without* curb and gutter systems), BMP use, a requirement to direct stormwater away from surface waters, and no hazardous material storage without an implemented spill containment plan. Within Protected Areas, non-residential development may occupy up to 10% of the remaining watershed with a maximum of 70% built-upon area (when approved as a Special Intensity Allocation [SIA]). Cluster development is allowed in all watershed areas (except WS-1), subject to zoning. The ordinance notes that 30-foot vegetative buffers along all USGS perennial streams are required for new low-density development, while 100-foot buffers are required for new development in excess of the low-density option. New development within these buffers is allowed for water-dependant structures and public projects when no practicable alternative exists. The ordinance applies to projects that require a state-approved erosion/sedimentation control plan, designates the County Planning Director as the Watershed Administrator, establishes the County Planning Board as the Watershed Review Board (for variance appeals), establishes a Watershed Protection Permitting process, provides options for stormwater management measures, and establishes a violation/fine program. This ordinance primarily affects the southwestern portion of the NCEEP Lower Creek watershed.

In 1994, Burke County adopted a Watershed Protection Ordinance to protect Public Water Supply Watersheds in the county (as defined by the N.C. Environmental Management Commission [EMC]). The ordinance establishes a Watershed Review Board, a Watershed Administrator position, a schedule for application review (typically 45 days after initial consideration), development densities, and minimum lot sizes. This ordinance divides the county into six watershed protection regions, as follows: WS-I, WS-III-CA (Critical Area), WS-III-BW (Balance of Watershed), WS-IV-CA (Critical Area), WS-IV-PA (Protected Area), and WS-BC (Balance of the County). Cluster development is allowed in all watershed areas (except WS-I). "A minimum one hundred (100) foot vegetative buffer is required for all new development activities that exceed the low-density option; otherwise, a minimum thirty (30) foot vegetative buffer for development activities is required along all perennial waters indicated on the most recent versions of USGS…topographic maps" Burke County, 1994). Some exceptions were allowed for existing land uses prior to 1994, and minor variance authority allows for cases that will not be contrary to the public interests. High-density development is allowed in WS-IV-CA and WS-IV-PA watershed areas. In WS-IV-CA watershed areas, if a sedimentation and erosion control plan is required, and development "exceeds 24% built-upon area, then engineered stormwater controls shall be used to control runoff from the first inch of rainfall and development shall not exceed 50% built-upon area" (Burke County, 1994). In WS-IV-PA watershed areas, if a sedimentation and erosion control plan is required, and development "exceeds 24% built-upon area or 36% built-upon area for non-single family residential projects without curb and gutter street system, engineered stormwater controls shall be used to control runoff from the first inch of rainfall and development shall not exceed 70% built-upon area" (Burke County, 1994).

Additionally, "all stormwater controls shall use wet detention ponds as a primary treatment system unless alternative stormwater management measures…are used" (Burke County, 1994). "Wet detention ponds shall be designed to remove 85% of total suspended solids in the permanent pool and storage runoff from a one inch rainfall from the site above the permanent pool" (Burke County, 1994). "The discharge rate from these systems following the one inch rainfall design storm shall be such that the runoff does not draw down to the permanent pool level in less than two (2) days and that the pond is drawn down to the permanent pool level within five (5) days" (Burke County, 1994). "The mean permanent pool depth shall be a minimum of three (3) feet" (Burke County, 1994). Vegetative filters are to be constructed for the overflow and discharge of all stormwater, are to be at least thirty feet in length, and are to accommodate the 10-year, 24-hour storm with a 10-year, 1-hour intensity, with a slope of five percent or less. Salient items from the Burke County Watershed Protection Ordinance are summarized in Table 2.

Table 2: Burke County Watershed Protection Ordinance

WATER-SHED	WS-I	WS-III-CA	WS-III-BW	WS-IV-CA	WS-IV-PA	WS-BC
Land Use Intensity	Low	Low-Moderate	Low-Moderate	Moderate-High	Moderate-High	Not Indicated
Residential Land Use	No	Yes (1 dwelling unit/acre)	Yes (2 dwelling units/acre)	Yes (2 dwelling units/acre)	Yes (2 dwelling units/acre)	Yes (2 dwelling u-nits/acre)
Agricultural Land Use	Yes (10-ft buffers and BMP' s [if >100 animals])	Yes (10-ft buffers and BMP' s [if >100 animals])	Yes	Yes (10-ft buffers and BMP' s [if >100 animals])	Yes	If allowed under zoning and LUMO regulations
Silvicultural Land Use	Yes	Yes	Yes	Yes	Yes	Yes
Non-residential Land Use	No	Yes (12% built-upon area)	Yes (24% built-upon area)	Yes (24% built-upon area)	Yes (24% built-upon area)	If allowed under zoning and LUMO regulations
Residential Density	N/A	12%	24%	24%	24% (up to 36% if no curb and gutter)	As allowed under zoning and LUMO regulations
Non-residential Density	N/A	12%	24% (10% of watershed may be developed at up to 70% built upon area)	24%	24% (up to 36% if no curb and gutter)	As allowed under zoning and LUMO regulations
Other	Allowed - Water withdrawal, treatment, and distribution; restricted road access; power transmission	No toxic or hazardous material storage (unless spill containment plan is implemented)	No toxic or hazardous material storage (unless spill containment plan is implemented)	Development requiring state erosion control plan is subject to ordinance	Developme nt requiring state erosion control plan is subject to ordinance	Watershed Permit required for new developme nt
Landfills	No	No	No	No	No Dischargin g Landfills	If allowed by zoning

Source: Burke County (1994)

The ordinance requires that subdivision applicants provide a description of "storm water drainage facilities" or a drainage system that "diverts stormwater runoff away from surface waters and incorporates best management practices to minimize water quality impacts" (Burke County, 1994). Penalties for violations are considered to be misdemeanors, and an appeal process is available. This Burke County ordinance primarily affects water supply watershed areas in the southwestern portion of the NCEEP Lower Creek watershed.

The City of Lenoir is currently a NPDES Phase II community. The city has contracted with AMEC Earth and Environmental (AMEC) to help develop proposed regulations and an implementation plan, and anticipates the formation of a stormwater utility in the future, along with a local fee schedule to fund this utility. This Phase II effort is being coordinated by the City of Lenoir's Public Works director and the Caldwell County Planning Director. Public education components of Lenoir's Phase II plan are currently being prepared by the WPCOG. More details of this effort should be available once the Phase II plan has been completed by AMEC. This effort will primarily affect NCEEP Lower Creek subwatersheds in the vicinity of Lenoir (UL07, UL09, UL10, UL11, and LL02).

Caldwell County's anticipated adoption of local ESC ordinances has been previously pursued, but was subsequently delayed due to funding issues. There is local governmental interest in such a program, along with concerns regarding what is perceived as inconsistent enforcement of state ESC regulations at present. At present, this proposal is temporarily on hold. If implemented in the future, this program will primarily affect NCEEP subwatersheds in Caldwell County (all subwatersheds except those portions of LL12, LL13, LL14, LL15, and LL16 that are located in Burke County).

The DWQ is currently preparing a calibrated model for 1997 flows in the Lower Creek watershed. It is anticipated that this effort will lead to the development of a Total Maximum Daily Loading (TMDL) for sediment (as well as a greater understanding of total suspended solids [TSS]). Input from DWQ personnel developing this model will likely be incorporated into revised recommendations during Phase II of the Lower Creek LWP effort. It is anticipated that DWQ data and conclusions will help determine sediment inputs from upland sources and streambank erosion. This should be significant, as stormwater runoff and associated streambank erosion may be a primary contributor of in-stream sediment loads (both as bedload and suspended load). Once completed, this effort should provide greater understanding of sediment loads throughout the NCEEP Lower Creek Watershed.

Lenoir's proposed greenway system will eventually include approximately 4.9 miles of trails along local stream channels (notably Zacks Fork). In 2003, approximately 2.0 miles of greenway were constructed. In the next one to two years, the city anticipates completion of the remaining 2.9 miles. Of note, field observations have indicated the potential for stream and/or wetland restoration efforts along portions of the existing and proposed greenway. The City of Lenoir has previously received funding through the

North Carolina Clean Water Management Trust Fund (CWMTF) for greenway acquisition (see Appendix A, Figure A-8). This greenway system primarily affects urban subwatersheds within the City of Lenoir.

Previous Lower Creek Studies

Previous research efforts by the Western Piedmont Council of Governments (WPCOG, 1998), the USGS, and the NCDENR have been conducted in the Lower Creek watershed. The results of these studies indicate that stormwater, NPS pollutants, and riparian buffer impacts have likely contributed to water quality degradation in the watershed.

In 1996, the WPCOG was awarded a water quality planning grant from the NCDENR. The WPCOG used this funding to develop a watershed management plan for Lower Creek (the Lower Creek Watershed Project). In this effort, the WPCOG conducted stakeholder meetings, located municipal stormwater outfalls, delineated 'subbasins', reviewed DWQ water quality and macroinvertebrate data, evaluated land use/land cover, identified local zoning ordinances, projected future population change, described soils, and prioritized subbasins (high, medium, and low priority) for future NPS controls and sediment management BMP's (WPCOG, 1998). Recommendations from this report were categorized as either 'watershed protection recommendations' or 'urban stormwater recommendations.' Watershed Protection recommendations included: 1) establishment of 50-foot buffers along perennial streams in the Lower Creek watershed, 2) identification of landowners in priority subbasins that would be interested in NPS control demonstration projects, 3) development of a public education strategy to highlight Lower Creek pollution sources, 4) encouragement of bioengineering streambank stabilization in the watershed, 5) establishment of a Lower Creek Non-Point Source Team to implement recommendations and evaluate progress. Urban Stormwater recommendations included: 1) adoption of strategies and regulations to minimize additional impervious cover in the watershed (e.g., limit parking areas, limit street widths, limit cul-de-sac pavement), 2) avoidance of curb-and-gutter stormwater systems, 3) encouragement of cluster development (or open space zoning) near perennial streams, 4) treatment of potential pollutant 'hot spots,' 5) storm drain labeling, 6) local government participation in regional stormwater discussions (WPCOG, 1998).

Observations from this study (WPCOG, 1998) include:

Wastewater discharges – The Lenoir WWTP discharge volume was approximately 4.08 million gallons per day (MGD) in 1997.

Stakeholder involvement – A total of six stakeholder meetings were held. More public involvement was observed in initial meetings than in latter meetings (which were predominately attended by agency personnel). One local group (The Healthy Caldwellians) was active in many discussions. Local issues of concern raised during the initial public meeting (March 18, 1997) included financial costs, science-based decisions, vegetation removal, drainage, pesticide usage, underground storage tanks (UST's), mega stores/malls, legal responsibility of clean-up efforts, and education. Issues discussed by the Stakeholders Group in subsequent meetings included identification of polluters, identification of enforcement agencies, increased awareness of NPS pollutants, poor land management decisions, solutions to similar problems elsewhere, mandatory animal waste plans, landowners interested in BMP's, potential funding sources, and environmental publications. Newspaper articles regarding Lower Creek and water quality were published in the Caldwell News (March 12, 1997) and the Charlotte Observer (March 16, 1997).

Stormwater outfalls – Stormwater outfalls along Lower Creek were located with GPS along approximately 3.5 miles of channel, between N.C. Highway 90 and the N.C. Highway 18/Southwestern Loop intersection. Collected data included pipe diameter and composition/material.

Bacteria – The WPCOG collected a total of 13 samples at the Antioch Road crossing of Lower Creek (between April 28, 1997 and June 26, 1997). This sampling effort revealed uniformly high fecal coliform bacteria counts throughout Lower Creek (arithmetic mean: 2,119 colonies per 100 ml of water, geometric mean: 722 colonies per 100 ml of water). The WPCOG subsequently collected fecal coliform data at ten DWQ sites in the Lower Creek watershed on June 12, 1997. The results of this sampling effort also indicated high fecal coliform concentrations throughout the watershed, "with values ranging from 340 to 5,400 colonies per 100 ml" (WPCOG, 1998). Finally, the WPCOG collected more water samples at twelve locations (six on Lower Creek) on August 18, 1997. These samples also revealed elevated bacteria levels, with the lowest measurement being 700 colonies per 100 ml of water. The North Carolina state water quality standard is 200 colonies per 100 mL of water (geometric mean).

Subbasins – The WPCOG delineated approximately 15 'subbasins,' as follows: Abingdon Creek (AB), Bristol Creek (BR), Greasy Creek (GR), Husband Creek (HU), Lower Creek #1 (LC1), Lower Creek #2 (LC2), Lower Creek #3 (LC3), Lower Creek #4 (LC4), Spainhour Creek (SP), Unnamed #1 (UN1), Unnamed #2 (UN2), Unnamed #3 (UN3), Unnamed #4 (UN4), Unnamed #5 (UN5), and Zacks Fork (ZF). The WPCOG subbasins were delineated on the basis of named streams (rather than by drainage area) and generally contain one to six NCEEP subwatersheds as summarized in Table 3, following:

Table 3: Subbasin/Subwatershed Comparison

STREAM NAME	WPCOG SUBBASIN	APPROXIMATE NCEEP SUBWATERSHED(S)
Abingdon Creek	AB	LL04
Bristol Creek	BR	LL12, LL13, and LL15
Greasy Creek	GR	LL01 and Northwestern LL02
Husband Creek	HU	LL04, LL05, LL06, LL09, LL10, and LL11
Lower Creek #1	LC1	UL01, UL02, UL03, and Northern UL08
Lower Creek #2	LC2	Southeastern UL08, UL09, and UL10
Lower Creek #3	LC3	Southeastern LL02, LL03, LL07, and LL08
Lower Creek #4	LC4	Southeastern LL14, LL15, and LL16
Spainhour Creek	SP	UL11, UL12, and UL13
Unnamed #1	UN1	Northwestern LL03
Unnamed #2	UN2	Northwestern LL07
Unnamed #3	UN3	Northwestern LL14
Unnamed #4	UN4	Western LL16
Unnamed #5	UN5	Southern LL16
Zacks Fork	ZF	UL04, UL05, UL06, UL07, and Northern UL09

Water quality improvements – Water quality in Lower Creek has generally improved since the 1960's, when "concentrations of toxic compounds such as phenols and cyanide were present in waters below the outfalls of furniture industries, and dyes from textile plants frequently discolored streams within the watershed" (WPCOG, 1998, p7). Additionally during the 1960's, fecal coliform bacteria concentrations occasionally numbered in excess of one million colonies per 100 ml of water (WPCOG, 1998). This study attributes water quality improvements partly to Clean Water Act (CWA) implementation, a North Carolina phosphate detergent ban in the 1980's, and a reduction in the number of private outfalls (and permitted dischargers) in the watershed.

Land use – The WPCOG estimated that over 80% of the land area in each subbasin was dominated by residential and residential/agricultural land use, and that approximately 65.4% of the total watershed area was characterized by residential and agricultural land uses. This study also noted that the majority of industrial and commercial land use (approximately 5.7% of watershed land use) was concentrated along Lower Creek and Spainhour Creek, and that the 1990 WPCOG *Catawba River Non-Point Source Study* had previously estimated commercial/industrial land use in the watershed to be approximately 4% (from aerial photograph interpretation). Three WPCOG subbasins evidenced high levels (>7%) of industrial/commercial land use, including Lower Creek #2 (7.4%), Lower Creek #3 (8.1%), and Spainhour Creek (14.3%).

Zoning – "Except for the recently incorporated Village of Cedar Rock, all local governments in the Lower Creek watershed have zoning and subdivision regulations. Like many western North Carolina counties, however, Burke and Caldwell Counties have only recently adopted [countywide] zoning" (WPCOG, 1998, p10). This study notes that Burke County had only adopted zoning in selected portions of the county by 1997, and that no county erosion control regulations were in place at that time (WPCOG, 1998, p10). Features of local land use regulations are summarized in Table 4.

Table 4: Local Land Use Regulations

LOCAL GOVERNMENT	INCORP-ORATED	ZONING	SUBDIVISION REGULATIONS	WATERSHED ORDINANCE
Burke County	1777	Yes (1997)	Yes (1998)	Yes (1994)
Caldwell County	1841	Yes (1986)	Yes (1969)	Yes (1994)
Cedar Rock	1997	No	No	No
Gamewell	1981	Yes (1990)	Yes (1990)	Yes (1993)
Lenoir	1851	Yes (1962)	Yes (1977)	No

Source: WPCOG (1998)

Land cover – "Land cover within the watershed is dominated by two forest categories, mixed hardwoods/conifers and mixed upland hardwoods, collectively comprising over 64% of the region" (WPCOG, 1998, p10), particularly in the northern and eastern portions of the watershed. This study also noted that "managed herbaceous cover was the third most prevalent class and includes pastures, hay, and golf courses. This land use class is common along streams throughout the watershed indicating that many natural riparian buffers have been altered or destroyed" (WPCOG, 1998, p10). Additional land cover types included mountain conifers in the southwestern portion of the watershed (12.5%), high-intensity development with >80% man-made surfaces (3.6%), and low-intensity development with 50-80% man-made surfaces (2.4%). Low-intensity development and high-intensity development were most prevalent in Lenoir and along the N.C. Highway 18 corridor. Four WPCOG subbasins "had developed (high and low intensity classes combined) areas comprising 10% or more of their total land area: Spainhour, UN1, LC2, and UN2. The cultivated class which includes row crops such as corn as well as non-row crops like wheat and oats, comprised only 0.3% of the watershed. This class may also include first year trees raised in nurseries." (WPCOG, 1998)

Population – Population estimates were derived by calculating the Caldwell County incorporated area population (1996 N.C. Office of State Planning data) and dividing by the total incorporated land area, resulting in an estimated population density of approximately 0.15 persons/acre (WPCOG, 1998). After extrapolating this approach and adding municipal populations, the WPCOG estimated the overall Lower Creek watershed population to be approximately 24,079 residents. Projected future population growth in Burke and Caldwell Counties is anticipated to be low (0.5% - 1.0% annually), with lower population growth rates in rural areas than in urban areas (WPCOG, 1998). Local planners anticipate that the greatest future population growth will likely occur in subbasins Lower Creek #1, Lower Creek#2, and Lower Creek#3 within the next 10-20 years (WPCOG, 1998).

Soils – The majority of the Lower Creek watershed is dominated by well-drained Cecil and Pacolet soils along Piedmont upland sideslopes. Poorly-drained Chewacla and Wehadkee soils were commonly noted along floodplains within the watershed.

Priority subbasins – In addition to providing general recommendations for the Lower Creek watershed, the WPCOG also prioritized the delineated subbasins for future NPS controls and sediment management BMP's (WPCOG, 1998), as follows:

High priority subbasins – Lower Creek #2 (industrialized corridor, minimal or absent riparian buffers, stormwater discharges, channel alterations), Spainhour (greatest extent of high-intensity and low-intensity development [>21% combined], extensive commercial and industrial development), Lower Creek #1 (greatest extent of cultivated cropland in watershed, one gravel quarry and two golf courses along Lower Creek, proposed residential subdivisions).

Medium priority subbasins – Zacks Fork (cattle access, southern portion of subbasin is urbanized, planed Lenoir greenway corridor), Husband Creek (largest subbasin in the watershed, golf course and large dairy farm, proposed industrial park in southern portion of subbasin, high DWQ bioclassification scores, impacted riparian areas, severe streambank erosion), Greasy Creek, Lower Creek #3 (severe streambank erosion, proposed residential development), Unnamed #1 (moderately high percentage of low-intensity and high-intensity development (15.1%), Unnamed #2 (>50% of land area classified as managed herbaceous), Bristol Creek (second largest subbasin in watershed, DWQ observations of in-stream silt accumulations, large cattle operation in southwestern portion of subbasin, largest wetland area in Lower Creek watershed), and Lower Creek #4 (severe streambank erosion).

Low priority subbasins – Unnamed #3 and Unnamed #4 (rural, minimal commercial/industrial development, minimal projected population growth).

In 1994, the USGS published a report in cooperation with the WPCOG that summarized water quality data, hydrologic data, and meteorologic data collected at selected sites in the upper Catawba River basin between January 1993 and March 1994. This data was collected from Rhodhiss Lake, Lake Hickory, and three tributaries (including Lower Creek), for the purposes of characterizing water quality and calibrating hydrodynamic models for the two reservoirs. This data was subsequently analyzed and published by the USGS in 1997 (Giorgino and Bales, 1997).

In 1997, the USGS published a research report in cooperation with the WPCOG in an effort to "describe ambient hydrologic and water-quality conditions, to estimate loadings of nutrients and suspended solids from selected tributaries and point sources, and to simulate hydraulic circulation and water-quality characteristics in Rhodhiss Lake using a hydrodynamic computer model" (Giorgino and Bales, 1997). The report summarized Rhodhiss Lake data collected between 1993 and 1994, and involved use of the USACE CE-QUAL-W2 model.

Results of this study (Giorgino and Bales, 1997) included:

"Rhodhiss Lake was constructed in 1925 to supply hydroelectric power for a growing population and textile industry. Today, in addition to power generation, the reservoir is used for drinking- and industrial-water supply [City of Lenoir], recreation, waste assimilation, and habitat for fish and wildlife" (Giorgino and Bales, 1997). "Based on nutrient concentrations, Rhodhiss Lake is classified eutrophic. However, nuisance levels of phytoplankton were rarely observed, possibly because short residence time and mixing patterns suppressed algal growth" (Giorgino and Bales, 1997).

USGS records from 1967 indicated "that concentrations of nitrate, phosphate, and chloride in Lower Creek were elevated compared to levels in undisturbed streams" (Giorgino and Bales, 1997 and Wilder and Slack, 1971). USGS records from the 1970's also indicated that concentrations and yields of suspended sediment in Lower Creek were comparable to those in other streams affected by urban construction in the Catawba River Basin, and were higher than those streams in forested or agricultural watersheds nearby" (Giorgino and Bales, 1997 and Simmons, 1993). NCDENR records from 1994 suggested that Lower Creek water quality degradation was likely due to high concentrations of sediment and fecal coliform bacteria, and that these impacts were from both point and non-point sources.

The City of Lenoir wastewater treatment plant discharged an average of 0.097 m^3/s [1993-94] into Lower Creek. During drier months, point-source discharges along Lower Creek accounted for a greater proportion of streamflow, and specific conductance measurements were higher.

Nutrient levels in Lower Creek were generally higher than those in Rhodhiss Lake and in two tributaries of Lake Hickory. "Elevated concentrations [of nitrogen] in Lower Creek reflected inputs from numerous domestic and industrial discharges and from nonpoint sources including urban and agricultural runoff" (Giorgino and Bales, 1997, p15). Elevated total phosphorus (TP) concentrations may be the result of inputs from both nonpoint sources and resuspension of streambed sediments. "Dissolved inorganic forms of nitrogen – NO_2+NO_3 and NH_4 – accounted for approximately…54 percent [of the total nitrogen load] at Lower Creek site 53. Loadings of PO_4 accounted for…11 percent [of the total phosphorus load] in

Lower Creek" (Giorgino and Bales, 1997). While the majority of suspended solids and nutrients may have originated from nonpoint sources, "point sources contributed significant amounts of nitrogen and phosphorus. For example, although the Lenoir-Lower Creek WWTP accounted for less than 1 percent of the TSS load measured at Lower Creek site 53, it accounted for 34 and 25 percent of the TN [total nitrogen] and TP loads, respectively" (Giorgino and Bales, 1997).

"Lower Creek had high specific conductance, high concentrations of total suspended solids, and was nutrient enriched. Fecal coliform concentrations exceeded 200 cols/100 ml in 76 percent of the samples. The two highest values occurred when streamflow was elevated, but values in excess of 200 cols/100 ml were observed across a wide range of flow conditions" (Giorgino and Bales, 1997).

"Results indicated that almost all the suspended solids and the majority of the nitrogen and phosphorus entering the headwaters of the reservoir originated from nonpoint sources…Nonetheless, point sources contributed significant amounts of nutrients" (Giorgino and Bales, 1997).

2.3.2 Assessment of Local Water Quality Initiatives

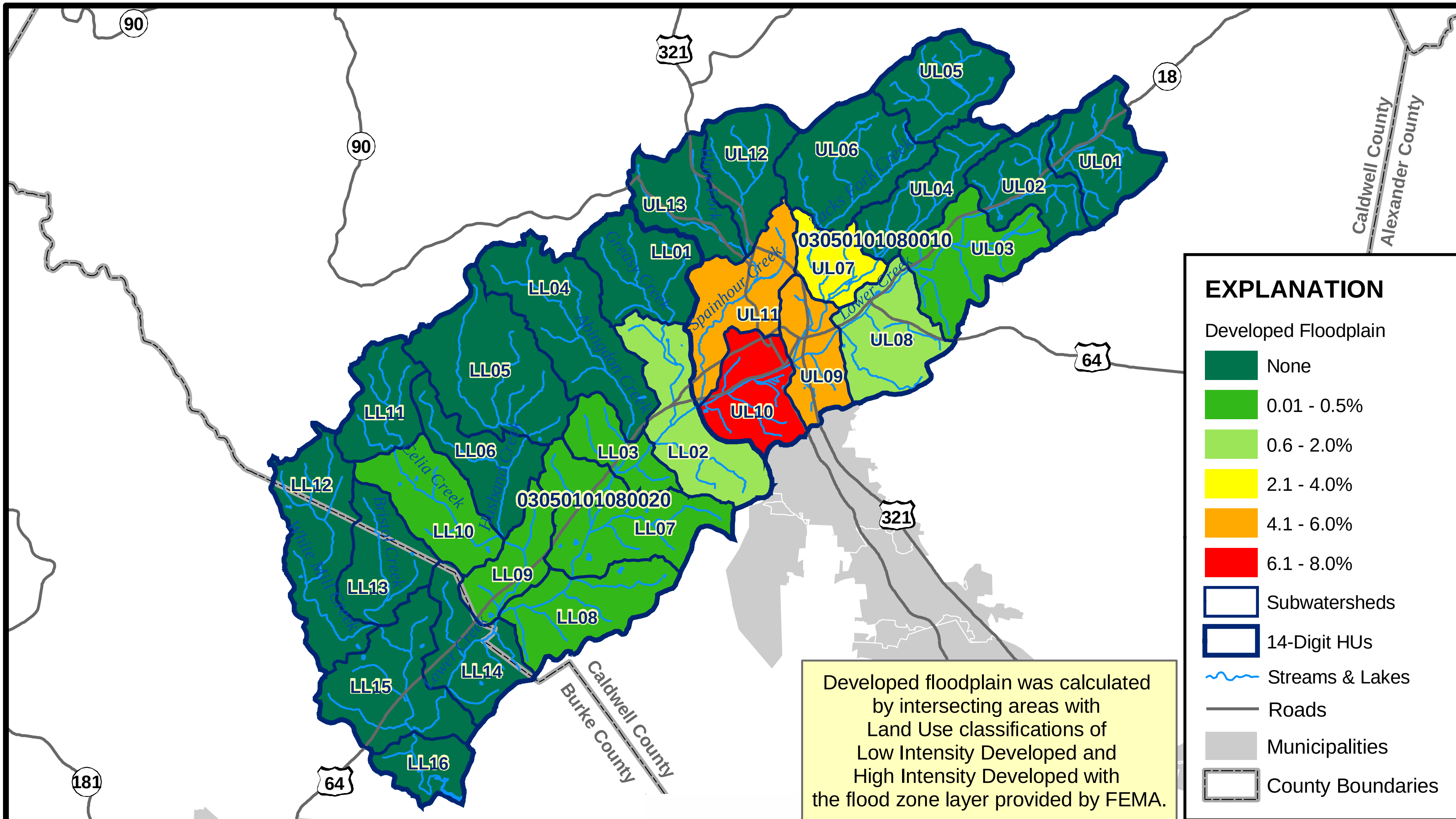
The noted local water quality initiatives (ordinances and studies) provide valuable insights regarding the condition of Lower Creek and its tributaries, and these efforts support continued research in the watershed. Results of these previous research efforts indicate that water quality and habitat have been primarily impacted by stormwater runoff, NPS pollutants, and bacteria. The WPCOG's focus on prioritization of subbasins, as well as recommendations for public policy changes (e.g., 50-foot buffers along perennial streams) and practical implementation projects (e.g., demonstration projects) are consistent with NCEEP goals for the Lower Creek Watershed.

2.4 THREATS TO LOCAL WATERSHED FUNCTIONS

In September 2003, MACTEC conducted field observations in the local watershed to assess possible lost functions of streams, wetlands, and adjacent riparian areas (Appendix B). Observations and potential threats to Lower Creek Watershed functions are summarized in Table 5, with Figure 16 providing a assessment of floodplain encroachment. Note that these data only include conditions observed during preliminary reconnaissance efforts. It is likely that additional impacts may be occurring along unobserved stream channels (e.g., channel alteration and aggradation/degradation), and in subwatersheds with minimal roadway networks (e.g., predominantly forested subwatersheds). The stressors most likely responsible for the greatest degradation of water quality, aquatic habitat, and hydrology are indicated in bold font.

Table 5: Potential Threats to Lower Creek Watershed Functions

SUSPECTED STRESSOR	PRELIMINARY INDICATOR(S)	SUSPECTED SOURCE(S)	SUSPECTED CAUSE(S)
Stormwater Runoff	Degraded water quality, channel instability (streambed scour), IC>5%	Commercial, industrial, and residential development, construction, urban runoff	Insufficient stormwater quantity management
NPS Pollutants	Degraded water quality, previous research data	Agricultural, residential, and urbanized areas, livestock in/adjacent to streams	Stormwater runoff pollutants, streambank erosion, fecal coliform bacteria, inadequate ESC practices
Channel Alteration	Channel instability (streambank erosion), degraded aquatic habitat	Previous agricultural and commercial development	Channel straightening, piping, channel excavation
Riparian Buffer Impacts	Channel instability (streambank erosion), degraded aquatic habitat, disturbed riparian buffer	Residential/commercial development, agriculture	Clearing for development and agriculture
Floodplain Encroachment	Evidence of floodplain encroachment (>1%)	Residential/commercial development	Development and filling within floodplain areas
Metals	Elevated levels of: aluminum, copper, iron, or manganese	Excess sedimentation in streams	Insufficient stormwater quality management, inadequate ESC practices
Wetland Loss	Estimated wetland loss >5%	Commercial, industrial, and residential construction, agriculture	Wetland fill for residential/commercial development and agriculture



Data Source(s): NCCGIA, FEMA

Prepared / Date:
Checked / Date:

NC Ecosystem Enhancement Program
Catawba River Basin LWP
Lower Creek Subbasin (03050101)

Floodplain Encroachment

Project 6470030275

Figure 16

3.0 DETAILED ASSESSMENT SCOPING

The next phase of this study will address missing data, preliminary targeted subwatersheds, and recommended indicators and methods (related to hydrology, water quality, and habitat).

3.1 MISSING DATA

Missing data and resources are summarized in Appendix A. Missing data include information related to culverts, greenway areas, utility lines, cleared riparian buffers, infrared images, local topography, and concentrated animal feeding operations (CAFO). For many analyses in this study, MACTEC used 1996 NCCGIA land cover information (Appendix A, Figure A-2). While this data provided sufficient accuracy and detail for most assessment efforts, recent (e.g., 2000-2002) data would have been preferred. In future phases of this project, tax parcel data may be assessed for its value in better identifying (and quantifying) current land use patterns. MACTEC will pursue this and other alternative data sources during subsequent phases of the project.

3.2 PRELIMINARY TARGETED SUBWATERSHEDS

Criteria used to develop subwatershed scores (for the purpose of identifying preliminary targeted subwatersheds for detailed field review) are summarized in Table 6. Data used in the scoring were obtained from previous reports, historical documentation, existing GIS coverages, previous GIS analyses, and preliminary field investigations. Data are generally summarized in Table 1 through Table 9 of this report.

A number (1-29) was first assigned to each subwatershed for each parameter/characteristic being compared, based upon the subwatershed's relative rank within the 29 overall Lower Creek subwatersheds. For example, the subwatershed with the highest percent impervious cover (subwatershed UL10) was given a rank of 29, while the subwatersheds with lowest percent impervious cover (subwatersheds UL01, UL02, UL05, UL06, LL11, and LL16 with 0.00% IC) were given a rank of 1. In general, subwatersheds were ranked so that the highest ranks (e.g., 20-29) indicate either the greatest degree of degradation or the greatest need for restorative action (to address hydrology, water quality, and/or habitat issues). Rankings were then multiplied by a weighting factor to establish the final (weighted) score.

Table 6: Subwatershed Ranks and Scores

SUBWATERSHED	APPROXIMATE AREA (SQUARE MILES)	IMPERVIOUS COVER	Rank	AGRICULTURAL LAND USE	Rank	FORESTED LAND USE	Rank	URBAN LAND USE	Rank	FLOODPLAIN ENCROACHMENT	Rank	WETLAND AREA	Rank	POTENTIAL WETLAND LOSS	Rank	DWQ BIOTIC INDEX	Rank	DWQ QUALITATIVE RANK	SCORE
UL01	3.12	<1.0%	0	11%	13	89%	18	0%	0	<1.0%	1	0.30%	5	7.10%	13	0	NR	NR	14
UL02	2.83	<1.0%	0	25%	25	75%	10	0%	0	<1.0%	1	0.20%	5	10.60%	21	0	NR	NR	29
UL03	3.83	1.10%	1	23%	22	76%	11	1%	1	<1.0%	1	0.30%	5	12.00%	25	0	NR	NR	196
UL04	2.94	<1.0%	0	13%	15	87%	17	0%	0	<1.0%	1	0.10%	5	9.30%	20	0	NR	NR	59
UL05	3.15	<1.0%	0	1%	1	99%	28	0%	0	<1.0%	1	0.20%	5	4.70%	8	0	NR	1	13
UL06	4.50	<1.0%	0	10%	12	90%	20	0%	0	<1.0%	1	0.30%	5	7.30%	15	0	NR	1	15
UL07	1.85	24.90%	16	20%	20	55%	4	25%	19	2.10%	20	0.10%	5	10.70%	22	0	NR	1	249
UL08	3.52	9.40%	7	13%	14	77%	12	10%	10	1.70%	10	0.30%	5	8.70%	18	6.46	15	20	277
UL09	2.44	30.60%	22	23%	24	47%	3	31%	22	4.90%	20	0.40%	5	15.10%	26	6.77	20	20	304
UL10	3.00	43.80%	28	10%	11	46%	2	44%	28	6.90%	25	0.80%	10	5.30%	10	6.67	20	20	282
UL11	3.66	38.20%	25	18%	16	43%	1	38%	25	4.60%	20	0.60%	10	6.40%	11	6.46	15	20	282
UL12	2.95	1.40%	1	5%	4	94%	24	1%	1	<1.0%	1	0.00%	0	4.00%	7	4.66	1	5	170
UL13	2.81	<1.0%	0	4%	3	95%	27	1%	1	<1.0%	1	0.10%	5	11.40%	24	6.42	15	20	184
LL01	3.42	<1.0%	0	5%	5	94%	26	1%	1	<1.0%	1	0.00%	0	9.20%	19	5.28	5	20	147
LL02	4.29	13.90%	10	23%	23	63%	6	14%	10	1.90%	10	0.50%	5	7.80%	16	5.28	5	20	271
LL03	1.96	7.10%	7	26%	26	67%	7	7%	7	<1.0%	1	0.90%	10	2.30%	5	6.52	20	20	247
LL04	5.33	1.10%	1	9%	9	90%	19	1%	1	<1.0%	1	0.10%	5	6.50%	12	5.60	10	1	137
LL05	5.67	<1.0%	0	9%	10	91%	21	0%	0	<1.0%	1	0.30%	5	8.60%	17	5.48	5	1	105
LL06	2.90	1.80%	1	29%	28	69%	8	2%	4	<1.0%	1	0.00%	0	11.30%	23	5.48	5	1	152
LL07	5.07	8.00%	7	29%	29	63%	5	8%	7	<1.0%	1	1.00%	10	2.10%	4	6.10	15	20	243
LL08	3.71	1.30%	1	28%	27	71%	9	1%	1	<1.0%	1	0.10%	5	<1.0%	2	6.52	20	20	205
LL09	2.15	1.00%	1	20%	19	79%	14	1%	1	<1.0%	1	1.90%	15	7.10%	14	5.24	5	20	197
LL10	3.44	<1.0%	0	19%	18	80%	15	0%	0	<1.0%	1	0.30%	5	3.90%	6	5.78	10	5	155
LL11	2.51	<1.0%	0	6%	6	94%	25	0%	0	<1.0%	1	0.40%	5	4.90%	9	5.78	10	5	24
LL12	4.76	<1.0%	0	6%	7	93%	23	0%	0	<1.0%	1	0.40%	5	0.90%	3	4.87	1	5	81
LL13	2.99	<1.0%	0	8%	8	91%	22	0%	0	<1.0%	1	0.80%	10	NR	0	5.56	10	5	55
LL14	3.11	<1.0%	0	21%	21	78%	13	1%	1	<1.0%	1	7.40%	29	<1.0%	1	6.14	15	20	133
LL15	4.62	<1.0%	0	18%	17	81%	16	1%	1	<1.0%	1	4.30%	25	NR	0	5.56	10	5	110
LL16	1.66	<1.0%	0	1%	2	99%	29	0%	0	<1.0%	1	5.60%	29	NR	0	0	NR	NR	-18

Since IC and 'urban land use' distributions in subwatersheds are generally biased toward lower estimates (i.e., 15 subwatersheds with <1% impervious cover vs. only four subwatersheds with >20% impervious cover), relative ranks were assigned to individual subwatersheds as follows: <1%=rank of 0, 1%-2%=rank of 1, 2%-5%=rank of 4, 5%-10%=rank of 7, 10%-15%=rank of 10, 15%-20%=rank of 13, 20%-25%=rank of 16, 25%-30%=rank of 19, 30%-35%=rank of 22, 35%-40%=rank of 25, and >40%=rank of 28. Additionally, since floodplain encroachment values range only from <1% to 6.9%, relative ranks were assigned to individual subwatersheds as follows: <1%=rank of 1, 1%-2%=rank of 10, 2%-5%=rank of 20, 5%-10%=rank of 25. Estimated wetland areas in the Lower Creek subwatersheds range from 0.0% to 7.4% of subwatershed areas. As a result, wetland area ranks are as follows: 0%=rank of 0, 0.0%-0.5%=rank of 5, 0.5%-1.0%=rank of 10, 1.0%-2.0%=rank of 15, 2%-4%=rank of 20, 4%-6%=rank of 25, and >6%=rank of 29. Wetland losses were ranked on the basis of estimated wetland loss as a percentage of subwatershed area. Biotic Index estimates included in Table 6 reflect DWQ data collected September 9-11, 2002 (NCDENR, 2004b). DWQ water quality data provided for Table 6 included Biotic Index scores and qualitative assessments of water quality/habitat quality (based on EPT Richness, EPT Biotic Index scores, Biotic Index scores, and BioClassifications). Biotic Index ranks were assigned as follows: 4.5-5.0=rank of 1, 5.0-5.5=rank of 5, 5.5-6.0=rank of 10, 6.0-6.5=rank of 15, >6.5=rank of 20. DWQ qualitative assessments were ranked as follows: "Not impaired"=rank of 1, "Not rated, but sensitive species present"=rank of 5, "Impaired (fair or poor), or indications of a severely impacted community"=rank of 20. In Table 6, the designation 'NR' indicates that a subwatershed was 'Not Ranked' on the basis of the specific characteristic noted.

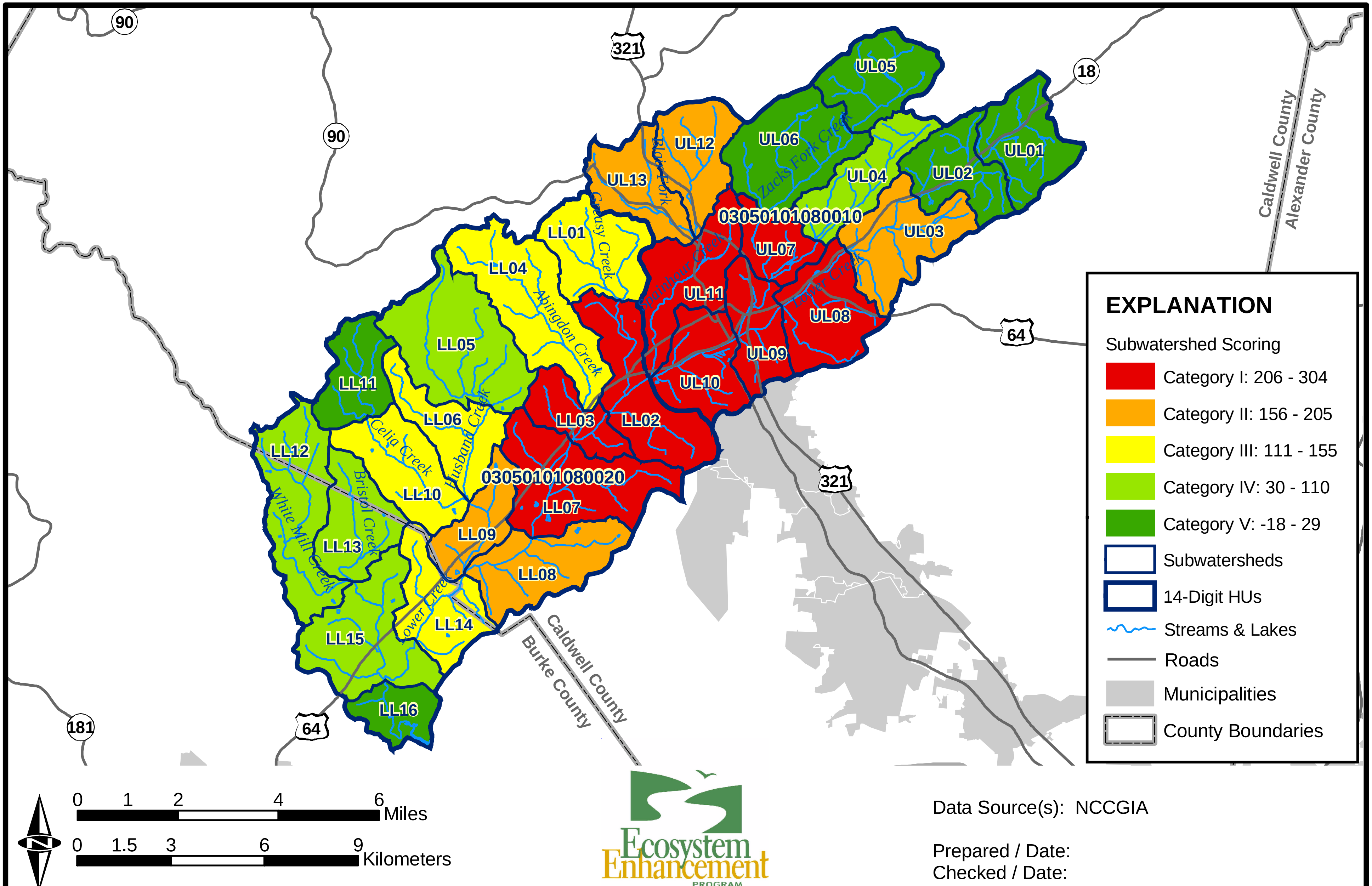
Weighting factors of +10, +5, +2, +1, and -1 were assigned based upon the estimated impact of the criterion to hydrology, water quality and/or habitat, as well as the expected utility of the data. For example, impervious cover received a relatively high weighting factor of +5 due to relatively well-established impacts to hydrology, water quality, and habitat associated with impervious cover (CWP, 2003). Larger absolute factors (e.g., +10) were used for criteria with characteristically low raw scores (e.g., number of major NPDES dischargers). Other criteria (e.g., percent wetland) received lower weighting factors (i.e., -1) due to potential inaccuracies associated with the data. For example, the source material used to produce NWI data is derived from high altitude aerial photography, and may exclude some small wetlands (see Appendix A, Figure A-5). Total scores were established according to the following formula:

$$
\begin{aligned}
\textit{Total Score} = \; & +5 \times \textit{Impervious Cover Rank} \\
& -1 \times \textit{Forested Land Use Rank} \\
& +1 \times \textit{Agricultural Land Use Rank} \\
& +2 \times \textit{Urban Land Use Rank} \\
& +2 \times \textit{Floodplain Encroachment Rank} \\
& -1 \times \textit{Wetland Area Rank} \\
& +1 \times \textit{Wetland Loss Rank} \\
& +10 \times \textit{Number of Major NPDES Dischargers} \\
& +10 \times \textit{Number of Minor NPDES Dischargers} \\
& +2 \times \textit{DWQ Biotic Index Rank} \\
& +2 \times \textit{DWQ Qualitative Assessment Rank}
\end{aligned}
$$

Subwatershed scores are presented in Table 7 and on Figure 17. High scores indicate evidence of potential degradation of hydrology, water quality, and habitat, while low scores indicate fewer impacts to subwatershed integrity. Note that the highest scores typically correspond to urban/developed subwatersheds.

Table 7: Subwatershed Categorization

CATEGORY	SCORE RANGE	SUBWATERSHED
I	206 - 304	UL07, **UL08**, **UL09**, **UL10**, **UL11**, LL02, LL03, LL07
II	156 - 205	**UL03**, UL12, UL13, **LL08**, **LL09**
III	111 - 155	**LL01**, LL04, **LL06**, **LL10**, LL14
IV	30 - 110	UL04, **LL05**, LL12, LL13, **LL15**
V	-18 - 29	UL01, **UL02**, UL05, **UL06**, **LL11**, LL16



Data Source(s): NCCGIA

Prepared / Date:
Checked / Date:

NC Ecosystem Enhancement Program
Catawba River Basin LWP
Lower Creek Subbasin (03050101)

Subwatershed Scores

Project 6470030275

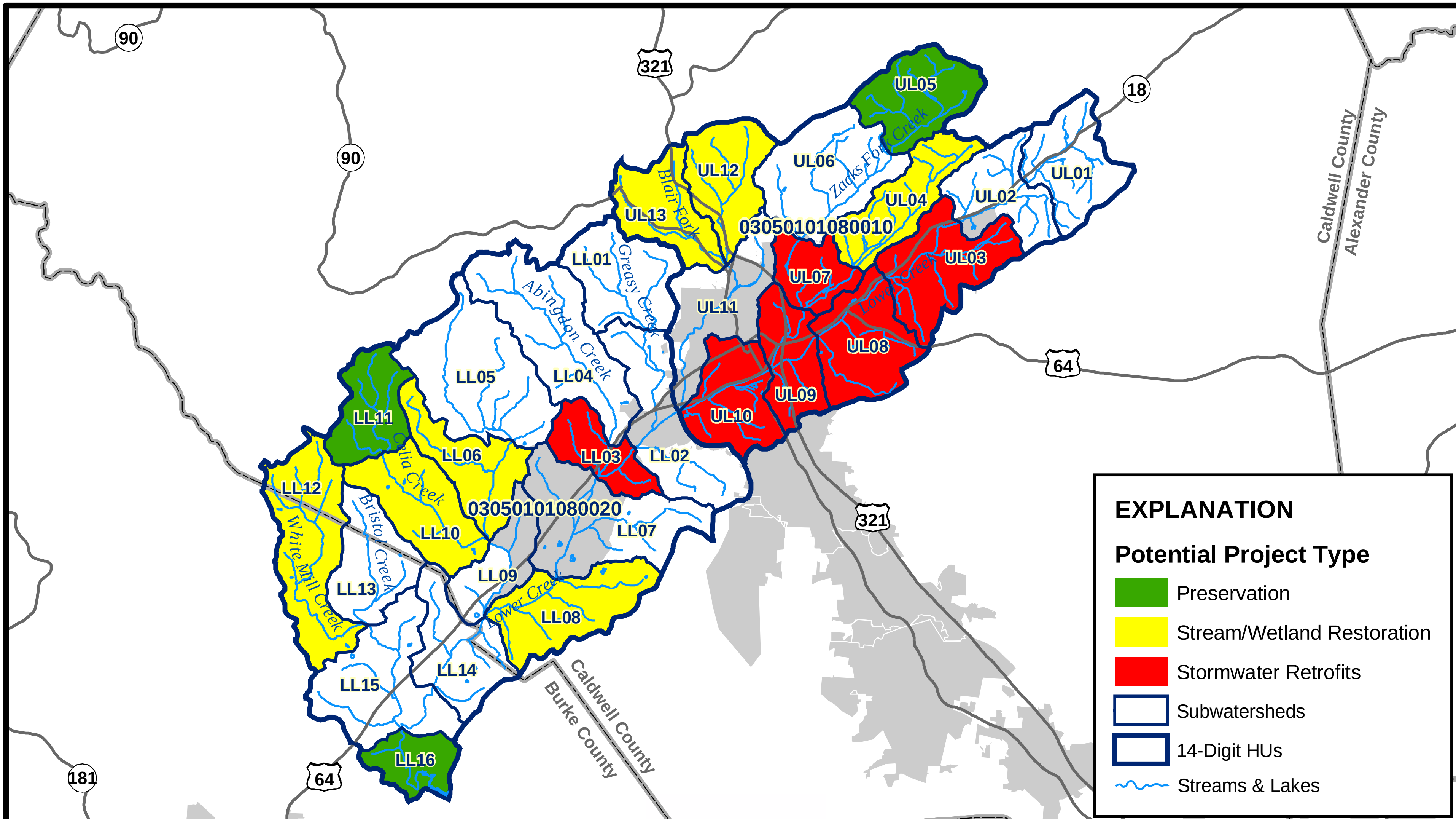
Figure 17

Following subwatershed score tabulation, MACTEC used the optimal method (i.e., 'natural breaks' in ArcView®) to group similar values together and determine the appropriate number of categories. This statistical analysis established five categories (I through V) of subwatershed scores (see Table 7). These five categories are representative of conditions encountered throughout the study area: highly-impacted (Category I), moderately-impacted (Categories II through IV), and minimally-impacted (Category V). The establishment of representative categories of subwatersheds helps ensure that a range of habitats and potential mitigation opportunities will be reviewed. For example, highly developed/impacted subwatersheds (Category I) may present more stormwater retrofit opportunities while moderately impacted subwatersheds (Categories II through IV) may present more traditional stream and/or wetland restoration opportunities. Similarly, less impacted subwatersheds (Category V) may provide potential examples reference (or baseline) conditions for comparison to impacted subwatersheds. However, it is anticipated that a variety of mitigation opportunities (e.g., stormwater retrofits, enhancement, restoration, preservation, etc.) may exist within most subwatersheds, regardless of score or classification.

MACTEC identified specific targeted subwatersheds for additional assessment by selecting the highest-scoring subwatersheds in Categories I though V. Selection of these target subwatersheds should help focus future site identification efforts on those subwatersheds with the greatest need for restorative action/improvement. This approach should also help ensure efficient use of resources (e.g., time and personnel) in future mitigation site identification efforts. In this initial assessment, MACTEC selected approximately the highest-scoring 50% of subwatersheds in Categories I through V (see Table 7, Table 8, and Figure 18). This approach produced a total of 15 targeted subwatersheds. If future efforts reveal that site identification can be better accomplished with a smaller number of target subwatersheds, the NCEEP may alternatively select the six highest-scoring 25% of subwatersheds in each category (UL02, UL08, UL09, LL08, LL10, and LL15), instead of the highest-scoring 50% of subwatersheds. See Figure 18 for geographic distribution of categories and subwatershed scores.

Table 8: Targeted Subwatersheds

HYDROLOGIC UNIT	TARGETED SUBWATERSHED(S)
80010 (Upper Lower Creek)	UL02, UL03, UL06, UL08, UL09, UL10, UL11
80020 (Lower Lower Creek)	LL01, LL05, LL06, LL08, LL09, LL10, LL11, LL15



0 1 2 4 6 Miles

0 1.5 3 6 9 Kilometers

Ecosystem Enhancement PROGRAM

Data Source(s): NCCGIA

Prepared / Date:
Checked / Date:

NC Ecosystem Enhancement Program
Catawba River Basin LWP
Lower Creek Subbasin (03050101)

MACTEC

Preliminary Targeted Subwatersheds

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Figure 18

3.3 RECOMMENDED INDICATORS AND METHODS

Four significant stressors in the Lower Creek watershed will be assessed during subsequent Phase 2 assessment efforts. These include stormwater runoff, NPS pollutants, channel alteration, and riparian buffer impacts. Since impacts from these stressors are often interconnected, each stressor will be investigated on the basis of both individual and cumulative effects. Indicators of stressor impacts include degraded water quality, channel instability (streambed scour and streambank erosion), aquatic habitat degradation, IC>5%, disturbed riparian buffers, and data from previous research efforts. It is anticipated that the majority of water quality impacts, hydrologic instability, and habitat degradation in the watershed are related to these four issues.

3.3.1 Stormwater Runoff

Impacts - *Water quality* impacts associated with stormwater runoff typically include suspended sediment loads and nonpoint source pollutants, while *hydrology* impacts may be most obvious in streambank erosion and streambed scour (channel incision) processes. Stormwater runoff may impact (degrade) aquatic *habitat* by disturbing interstitial spaces in streambed substrates, promoting habitat simplification via sedimentation of riffles and pools, as well as removal of in-stream habitat (e.g., woody debris) via channel/streambed scour.

Study Methods – In order to document the effects of stormwater runoff, Phase 2 efforts will include DWQ pollutant 'hot spot' investigations and MACTEC stream channel surveying. DWQ will investigate potential pollutant 'hot spots' during field reconnaissance efforts throughout the Lower Creek Watershed, and will analyze water quality in streams that seem suspect (e.g., have high specific conductance, smell of volatile organics, etc.). DWQ will utilize previously-collected MACTEC subwatershed reconnaissance data to initially identify potential hot spots. In each of the eight subwatersheds with >5% IC (UL07, UL08, UL09, UL10, UL11, LL02, LL03, and LL07) and along at least one reference stream, MACTEC will survey permanent stream channel cross-sections. A threshold of 5% has been selected in order to assess anticipated impacts in subwatersheds with >10% IC, and to also document the potential for stormwater runoff impacts associated with lower IC extents (i.e., 5%-10%). In order to quantify the estimated physical affects of stormwater discharge volumes on channel morphology, this effort will document bank erosion hazard index (BEHI) score, bankfull cross-sectional area, bank/height ratio, entrenchment ratio (ER), width/depth (W/D) ratio, and Rosgen stream classification. Following two precipitation events of at least two inches within 24 hours, these permanent cross-sections will be re-surveyed and will be compared to the initial cross-sections. This effort will help document the rates at which streambank erosion may be occurring over a short timeframe (i.e., months), and will allow future surveying of these same cross-sections to document streambank erosion occurring over a longer timeframe (i.e., years).

Application Areas – DWQ 'hot spot' investigation sites will be determined in the field by DWQ personnel. MACTEC channel surveying will be implemented at representative locations in the eight subwatersheds with greater than 5% IC (UL07, UL08, UL09, UL10, UL11, LL02, LL03, and LL07).

Goals – DWQ monitoring efforts should identify potential urban pollutant 'hot spots' that may require additional study and/or BMP consideration, while MACTEC surveying efforts should a) provide a record of channel evolution over time (as compared to the reference reach), b) allow comparison between urban channels throughout the Lower Creek Watershed, c) help quantify urban streambank erosion rates, and d) help provide actual streambank erosion rates associated with BEHI scores. Surveyed cross-sections may also be compared to regional curves and to reference reach data, in order to assess the sampled channels in relation to background/baseline conditions. The eventual goals of these efforts will be to identify potential stormwater BMP's to reduce the noted the noted impacts, to identify specific urban stormwater runoff issues that are significantly affecting water quality (e.g., pollutant sources, streambank erosion areas, and elevated stormwater discharge catchments), and to locate subwatersheds that should be considered for future actions (e.g., further monitoring and/or BMP implementation).

INDICATOR	METHODS	APPLICATION AREAS	GOALS
Degraded water quality, channel instability (streambed scour), IC>5%	DWQ urban hot spot investigations; MACTEC channel surveying	Urbanized areas, DWQ sampling locations, subwatersheds with >5% IC (UL07, UL08, UL09, UL10, UL11, LL02, LL03, and LL07)	To detect pollutant hot spots, identify urban stressor pollutants, document channel morphology impacts (stormwater runoff volume), identify potential stormwater management BMP opportunities

3.3.2 NPS Pollutants

Impacts - NPS pollutants may include stormwater pollutants from urban areas (e.g., toxins, metals, petroleum products, hydrocarbons, etc.), suspended sediment from areas of disturbed soil (e.g., eroding streambanks, construction sites, active croplands, etc.), nutrients (e.g., nitrates and phosphates) from residential, agricultural, and commercial areas, and fecal coliform bacteria (animal access to surface waters). *Water quality* impacts associated with NPS pollutants typically include elevated concentrations of nutrients, hydrocarbons, and metals, along with increased turbidity (suspended sediment) and sedimentation. *Hydrologic* impacts of NPS pollutants are primarily related to excess sedimentation, which may alter the balance between sediment bedload and streamflow discharge. This alteration may then initiate a process of accelerated stream channel aggradation, excessive lateral channel movement, and subsequent streambank erosion. NPS pollutants affect aquatic *habitat* primarily by increasing stresses upon aquatic organisms (e.g., toxins), by reducing food accessibility (i.e., turbidity reduces visibility for 'sight' predators), and by eliminating streambed interstitial spaces available for spawning/resting habitat (due to sedimentation).

Study Methods – In order to identify and characterize NPS pollutants, DWQ will conduct water quality monitoring of stormflow at five sampling locations in the Lower Creek Watershed (NPS pollutant concentrations are typically high in stormwater runoff). Stormflow water quality (metals, nutrients, semi-volatile organics, solids, turbidity) will be assessed in the following urban tributaries: Zacks Fork, Spainhour Creek, Blair Fork, and a small unnamed urban tributary in an industrial area of Lenoir. Greasy Creek, which drains a rural and residential area, will also be sampled as a 'rural' reference stream. DWQ anticipates that five samples will be collected at each sampling location. Additionally, DWQ plans to characterize baseflows (10 samples anticipated) and stormflows (five samples anticipated) at the existing DWQ ambient monitoring site on Lower Creek. In order to characterize the extent of sedimentation impacts, MACTEC will conduct substrate composition assessments (using Wolman pebble counts) at each DWQ monitoring site, and at a representative location in each of the targeted subwatersheds. These pebble counts will include both pavement (larger-diameter, erosion-resistant surface substrate) and subpavement (smaller-diameter, erosion-prone subsurface substrate) sampling. It is anticipated that pebble counts in the targeted Category IV and V subwatersheds may provide insights regarding 'reference' substrate composition (i.e., 'background/baseline' conditions), while pebble counts in the targeted Category I, II, and III subwatersheds may reveal substrate characteristics more typically encountered in degraded subwatersheds.

Application Areas – DWQ will conduct stormflow sampling along Zacks Fork (which includes subwatersheds UL04, UL05, UL06, UL07, and UL09), Spainhour Creek (subwatershed UL11), Blair Fork (which includes subwatersheds UL12 and UL13), an unnamed urban tributary in Lenoir, and Greasy Creek (which includes subwatersheds LL01 and LL02). DWQ will also collect and differentiate stormflow and baseflow samples at the existing DWQ Lower Creek ambient water quality monitoring station (subwatershed LL14). MACTEC will conduct substrate assessments at the five DWQ monitoring locations, and along representative stream reaches in the targeted subwatersheds (UL02, UL03, UL06, UL08, UL09, UL10, LL05, LL06, LL08, LL09, LL10, LL11, and LL15).

Goals – These monitoring efforts should provide greater insights regarding NPS baseflow/stormflow pollutant characteristics (and concentrations) within the Lower Creek Watershed. Collected data should allow comparisons between individual subwatersheds, while 'reference' stream data should provide insights regarding extent of degradation (from baseline/undisturbed conditions). With the greater insights provided by these efforts, it is anticipated that specific NPS pollutants (e.g., suspended sediment, nutrients, fecal coliform bacteria) can be better targeted as stressors by future restoration and BMP implementation efforts.

INDICATOR	METHODS	APPLICATION AREAS	GOALS
Degraded water quality, previous research data	Baseflow/stormflow water quality monitoring, substrate composition assessment	Water quality monitoring along Zacks Fork, Spainhour Creek, Blair Fork, Greasy Creek, unnamed Lenoir tributary, and DWQ ambient station; substrate assessment in subwatersheds UL02, UL03, UL06, UL08, UL09, UL10, LL05, LL06, LL08, LL09, LL10, LL11, and LL15.	To identify (and characterize) specific baseflow/stormflow pollutants and characterize sedimentation

3.3.3 Channel Alteration

Impacts - Field reconnaissance observations indicate that many stream channels within the Lower Creek Watershed may have been previously channelized. *Hydrologic* impacts of channelization often include channel incision (resulting from steeper gradient streams), initiation of channel instability, and disruption of sediment/discharge relationships. Channelization and subsequent incision may also impact *water quality*, since streambank instability and erosion may result in increased downstream turbidity and sedimentation. When channelization does accelerate incision, tributaries may also become incised, and the deposition of eroded streambed/streambank material downstream may lead to subsequent lateral channel movement and further streambank erosion. In addition to the immediate physical impacts of channelization (e.g., excavation), this type of channel alteration may impact *habitat* by reducing the abundance of riffles and pools, by removing woody debris (that provides cover), and by increasing downstream sedimentation (thereby smothering important interstitial habitat. Once channelized, streams may require many years to reach a subsequent state of quasi-equilibrium and become naturalized again. During that time period, water quality, hydrologic processes, and aquatic habitat may be extensively altered and degraded.

Study Methods – In order to identify potentially channelized streams within the Lower Creek Watershed, MACTEC will use historic NRCS aerial photography, along with 1996 NCCGIA data. Stream channel centerlines indicated on historic NRCS aerials will be digitized and overlaid with the more-recent NCCGIA hydrography layers. Representative channelized stream reaches will be visually identified on these overlays, and will then be ground-truthed in the field (and photographed) by MACTEC and DWQ personnel. DWQ will collect information on aquatic habitat, bank stability, buffer status, benthic community health, sources of pollution, and potential future stream restoration sites. This combined effort should provide valuable insights regarding potential 'limiting' effects of aquatic habitat on biological communities, and should help identify and characterize channelized stream reaches.

Application Areas – Aerial photography analysis will be conducted for the Category I, II, and III targeted subwatersheds.

Goals – It is anticipated that this effort will help characterize the effects of channelization in the lower Creek Watershed. Collected data should help explain whether the existing degradation noted along many stream reaches is the result of previous channelization, should identify whether channelization was/is a potential cause of upstream/downstream degradation, and should aid in the identification of potential future stream restoration sites.

INDICATOR	METHODS	APPLICATION AREAS	GOALS
Channel instability, degraded aquatic habitat	GIS analysis, field verification	Category I, II, and III targeted subwatersheds	To characterize the extent of channelization and identify potential restoration sites

3.3.4 Riparian Buffer Impacts

Impacts - Forested riparian buffers are an integral component of many aquatic ecosystems. These buffers provide root mass stabilization of streambanks, produce coarse particulate organic matter (CPOM) as a food source for aquatic organisms, reduce water temperatures, provide cover for aquatic organisms, and help maintain habitat connectivity. Previous studies and field reconnaissance efforts have revealed that forested riparian buffers are either narrow or completely absent along many stream channels within the Lower Creek Watershed. These buffers are often cleared for development (residential and commercial), silviculture (tree/shrub nurseries), and/or agriculture (crop/pasture lands). Clearing of buffers often affects *habitat* by reducing stream shading (thereby increasing water temperature), by eliminating in-stream cover (as provided by logs and woody debris), and by reducing the natural connectivity between uplands, riparian areas, and aquatic ecosystems). *Water quality* impacts associated with riparian buffer clearing generally include reduced pollutant removal from runoff and reduced root mass stabilization of streambanks (and subsequent streambank erosion/downstream sedimentation). Removal of forested buffers may also affect *hydrologic* relationships by eliminating precipitation absorption by organic matter on the forest floor (thereby increasing the volume of runoff directly entering a stream channel).

Study Methods – In order to assess the extent of riparian buffer impacts in the targeted subwatersheds, MACTEC will use infrared orthophotos and/or 1993 black and white aerial photos to calculate the length of stream channel with absent/minimal forested riparian buffers, the length of stream channel with forested riparian buffers (>50 feet in width), and the length of stream with forested riparian buffer (>50 feet in width) along only one streambank. Field verification of buffer estimates will be conducted by MACTEC at representative locations, and will be photo-documented. DWQ qualitative assessments of riparian buffer structure and quality may also be integrated with this effort, in order to develop a description of 'typical' buffer characteristics associated with buffer width.

Application Areas – Riparian buffer assessment efforts will be implemented in the targeted subwatersheds (UL02, UL03, UL06, UL08, UL09, UL10, LL05, LL06, LL08, LL09, LL10, LL11, and LL15). Depending upon the value and insight provided by these initial evaluations, riparian buffer assessments may then be implemented for the entire Lower Creek Watershed.

Goals – The goals of this effort are to document riparian buffer extents in the targeted subwatersheds, and to identify potential opportunities for restoration. Since existing vegetation may disguise areas that were historically affected by previous buffer impacts (>20 years ago), initial buffer assessment efforts will be evaluated to determine whether assessment efforts should be extended to the entire Lower Creek Watershed.

INDICATOR	METHODS	APPLICATION AREAS	GOALS
Channel instability, disturbed riparian buffers	GIS analysis, field verification	Targeted subwatersheds	To document buffer extents and identify potential opportunities for restoration

4.0 POTENTIAL IMPLEMENTATION OPPORTUNITIES

During Phase 2 efforts, MACTEC will rank potential restoration opportunities identified within the Lower Creek Watershed, in coordination with the NCEEP and local stakeholders. The result of this effort will be a ranking of potential projects for individual subwatersheds. Estimated costs and benefits (quantified for analysis) can then be developed for the highest-priority opportunities, in order to assist the NCEEP in deciding on the optimal combination of projects. In addition to recommending conventional opportunities (e.g., stream restoration and wetland enhancement), non-conventional mitigation approaches (e.g., stormwater BMPs and/or retrofits) will be considered.

MACTEC will utilize the data and maps collected to develop map products for identifying:

- Potential wetland and stream restoration projects, to meet compensatory mitigation requirements;
- Non-conventional mitigation projects (including BMPs, open space preservation, riparian corridor connectors, enhancement sites, and stormwater retrofits).

This information will be presented by prioritized subwatershed and catchment (using GIS, photo-documentation, GPS location information, and written site descriptions). This approach will include a discussion of how the recommended mitigation alternative(s) at each site should help address the specific cause(s) of degradation in that subwatershed. These recommendations may also discuss relative benefits of site-specific actions versus local policy changes. In general, site recommendations will be based on the following:

- Specific functional impairment to be addressed
- Anticipated cost effectiveness, constructability, site constraints, and functional benefits of mitigation alternatives
- Input from the NCEEP, the landowner, and local stakeholders
- Maximization of potential mitigation credits at each site
- Overall watershed benefits of the mitigation alternatives
- Aesthetic value of the proposed restorative actions/alternatives

The various attributes of each potential mitigation alternative will be summarized in a comparative mitigation table that will include a brief narrative for each site (to aid decision-making). Overall, a variety of beneficial opportunities may be available in the Lower Creek Watershed. Implementation of both conventional and non-conventional mitigation approaches may serve to locally improve and protect water quality, hydrologic stability, and habitat resources. However, due to the extent of NPS impairment, dramatic gains in water quality may be challenging to attain. A combination of site-specific restorative actions and local policy changes (e.g., increased erosion and sediment control regulation enforcement) may provide the greatest hope for significant progress.

During initial watershed reconnaissance efforts, a variety of potential opportunities were visually identified (Table 9), based on observed conditions and/or evidence of impairment. It is anticipated that identification of specific watershed improvement sites will be conducted in subsequent efforts.

Table 9: Preliminary Potential Opportunities

SUB-WATERSHED	SITE ID	STREAM	APPROXIMATE LOCATION	POTENTIAL OPPORTUNITY
UL01	1	Lower Creek	Farm road off NC 18	Stream/buffer restoration, streambank stabilization
UL09	2	Zacks Fork and Lower Creek	Lenoir Golf Club	Stream/buffer restoration, livestock exclusion, stormwater management
UL07	4	Zacks Fork	Relic pond site	Stream/wetland restoration
UL11/ UL12	5	Blair Fork Creek	Valway Rd. (at Blair Fork Baptist Church)	Stream/buffer restoration, water quality monitoring site
UL06	6	UT to Zacks Fork	Cottrell Hill Rd. bridge	Stream/buffer restoration, livestock exclusion
UL07	7	Zacks Fork	Lenoir Rotary Soccer Complex	Buffer restoration
UL12	8	UT to Blair Fork Cr.	Indian Grave Rd.	Stream restoration
UL13	9	Blair Fork	Valway Rd.	Buffer restoration
UL08	17	UT to Lower Creek	Haigler Rd.	Stream restoration
UL08	23	Lower Creek	DWQ site/station LC1	Urban stream restoration
LL07	3	Lower Creek	Rocky Rd bridge	Stream restoration, livestock exclusion, erosion control BMPs
LL02	10	Greasy Creek	Abingdon Rd bridge	Buffer restoration
LL02	22	Miller Creek	Miller Hill Rd.	Water quality monitoring site
LL04	11	Abingdon Creek	Deerbrook Rd.	Buffer restoration
LL05	12	UT to Husband Creek	Country Acres Golf Course	Buffer restoration
LL10	13	Celia Creek	Hartland Rd.	Water quality monitoring site
LL12	14	White Mill Creek	Piney Rd.	Stream preservation
LL14	24	Lower Creek	DWQ monitoring station C1750000	Stream restoration, stormwater BMPs
LL15	15	Bristol Creek	Hartland Rd.	Stream/buffer restoration, streambank stabilization
LL14	16	Lower Creek	Antioch Rd.	Stream restoration, streambank stabilization, turbidity reduction BMPs (u/s NPDES discharge)
LL06	18	Husband Creek	Tree farm on Fleming Chapel Church Rd.	Stream restoration
LL15	19	UT to Lower Creek	Cattle farm on Jay Clark Rd.	Stream restoration, livestock exclusion, invasive species control
LL07	21	UT to Lower Creek	Craigs Mountain Rd.	Buffer restoration

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APPENDIX A

COMPILATION AND REVIEW OF EXISTING DATA AND INFORMATION

TECHNICAL MEMORANDUM

DATE: August 18, 2003
TO: Project File
FROM: Ben Leatherland; Greta Hawkins
THROUGH: Richard Darling
SUBJECT: Catawba – Lower Creek Local Watershed Planning (Phase 1) GIS and Data Collection
COPIES: Kristin Cozza

The North Carolina Wetland Restoration Program (NCWRP) has contracted with MACTEC Engineering and Consulting, Inc. (MACTEC) to conduct comprehensive technical watershed assessments within the Catawba (03050101) Lower Creek Basin (62,833.1 acres, 98.2 square miles) located in Caldwell and Burke Counties, North Carolina (see attached project location map). Consistent with Catawba River basinwide water quality management planning, this watershed assessment is intended to:

- identify and compile existing data and information that relates to water quality and habitat for the targeted local watershed;
- develop Geographic Information System (GIS) data layers;
- provide sampling recommendations and field analysis, where appropriate;
- identify areas for potential wetland, stream, and/or riparian buffer restoration projects for compensatory mitigation as well as similar water quality improvement projects [Best Management Practices (BMPs)];
- develop or apply modeling tools to predict the impact of various restoration projects or management strategies, when applicable;
- involve local stakeholders in identifying local watershed concerns, high-priority sub-watersheds, and specific management and project recommendations;
- develop management plans for two local watersheds listed as follows:
  - Upper Lower Creek (HU 80010) 25,979.09 acres (40.59 square miles)
  - Lower Lower Creek (HU 80020) 36,853.96 acres (57.58 square miles)

This technical memorandum summarizes the data collection efforts undertaken by MACTEC as part of Phase 1 Catawba River Basin Local Watershed Planning. While the majority of the data sources in the watersheds have been compiled, additional data may be collected during the remaining phases of the project.

Data has been collected (and/or ordered) from a variety of sources, including Caldwell County, Burke County, the City of Lenoir, the Natural Resources Conservation Service (NRCS), the N.C. Department of Environment and Natural Resources (NCDENR), the N.C. Department of Transportation (NCDOT), the U.S. Fish and Wildlife Service (USFWS), and the U.S. Geological Survey (USGS). See attached GIS Data Collection Matrix for details regarding acquired data.

During the course of data collection efforts, various data "gaps" have been identified (unavailable data, or data of a quality/resolution that would limit future usefulness). The following "gaps" have been identified, and are in the process of being resolved:

1) Color infrared orthophotographs for Lenoir, NC and Colletsville, NC
2) Burke County Soil Survey *(no published soil survey at present, general soils data for watershed have been requested from NRCS)*
3) Historic aerial photography for Caldwell County and Burke County

During the data collection process, some challenges have been encountered. These have included variable data layer resolution, inconsistent data accuracy, and insufficient data layer extents (coverage) (see attached GIS Data Collection Matrix). MACTEC personnel are continuing to obtain GIS data, in order to resolve these challenges.

Attachments: Project Location Map
List of Contacted Stakeholders
GIS Data Collection Matrix

Contacted Stakeholders

First Name	Last Name	Agency	Address	City	State	Zip Code	E-Mail	Phone Number
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Jim	Reid	NCDENR Division of Water Quality	59 Woodfin Place	Asheville	NC	28801	Jim.Reid@ncmail.net	828-251-6208
Jocelyn	Elliott	North Carolina Wetlands Restoration Program	1619 Mail Service Center	Raleigh	NC	27699	jocelyn.elliott@ncmail.net	919-716-1921
Brian	Jacobson	DWQ-Modeling Branch	1617 Mail Service Center	Raleigh	NC	27699	Brian.Jacobson@ncmail.net	919-733-5083, ext. 552
Cecil	Haynes	NRCS Caldwell County	120 Hospital Ave., NE, Suite 2	Lenoir	NC	28645		828-758-1111
Russell	Lyday	NRCS Burke County	130 Ammons Dr., Suite 3	Morganton	NC	28655		828-439-9727, ext.3

GIS Data Collection Matrix

Layer	File Ext.	Description	Geographic Area	Location in E:/GIS Data Layers	Source/ Delivery Media	Origination Date	Projection	Datum	Units of Measure	Notes
Burke County										
dotlrsnode.shp	shp	endpoints of primary and secondary roads.	Burke County	E://GIS Data Layers/Burke County/DOT Layers/Burke dot	NC DOT	2003	NC Stateplane		meters	
dotsecroads.shp	shp	secondary roads.	Burke County	E://GIS Data Layers/Burke County/DOT Layers/Burke dot	NC DOT	2003	NC Stateplane		meters	
dotroads.shp	shp	all roads.	Burke County	E://GIS Data Layers/Burke County/DOT Layers/Burke dot	NC DOT	2003	NC Stateplane		meters	
dotrailrds.shp	shp	railroad lines.	Burke County	E://GIS Data Layers/Burke County/DOT Layers/Burke dot	NC DOT	2003	NC Stateplane		meters	
dotprimrds.shp	shp	primary roads.	Burke County	E://GIS Data Layers/Burke County/DOT Layers/Burke dot	NC DOT	2003	NC Stateplane		meters	
dotlrsrtrts.shp	shp	looks like combination of dot primary roads and dot secondary roads.	Burke County	E://GIS Data Layers/Burke County/DOT Layers/Burke dot	NC DOT	2003	NC Stateplane		meters	
dotlrsrt.shp	shp	looks like combination of dot primary roads and dot secondary roads.	Burke County	E://GIS Data Layers/Burke County/DOT Layers/Burke dot	NC DOT	2003	NC Stateplane		meters	
dotgovbdry.shp	shp		Burke County	E://GIS Data Layers/Burke County/DOT Layers/Burke dot	NC DOT	2003	NC Stateplane		meters	
dotcntybdry.shp	shp	county boundary	Burke County	E://GIS Data Layers/Burke County/DOT Layers/Burke dot	NC DOT	2003	NC Stateplane		meters	
dotcitybdry.shp	shp	municipal boundaries.	Burke County	E://GIS Data Layers/Burke County/DOT Layers/Burke dot	NC DOT	2003	NC Stateplane		meters	
dotairport.shp	shp	airport runways	Burke County	E://GIS Data Layers/Burke County/DOT Layers/Burke dot	NC DOT	2003	NC Stateplane		meters	
topo20.shp	shp	20-foot countours from NCDOT GIS division	Burke County	BURKE COUNTY\Burke County CD	Burke County GIS; CD	2003			feet	
topo.shp	shp	5-foot countours from NCDOT GIS division	Burke County	BURKE COUNTY\Burke County CD	Burke County GIS; CD	2003			feet	
streams.shp	shp	1:100,000 scale USGS stream data	Burke County	BURKE COUNTY\Burke County CD	Burke County GIS; CD	2003			feet	
roads.shp	shp	street centerlines with E911 road names	Burke County	BURKE COUNTY\Burke County CD	Burke County GIS; CD	2003			feet	
railroad.shp	shp	centerlines of rail lines	Burke County	BURKE COUNTY\Burke County CD	Burke County GIS; CD	2003			feet	
zone.shp	shp	county zoning	Burke County	BURKE COUNTY\Burke County CD	Burke County GIS; CD	2003			feet	
vote.shp	shp	voter precincts	Burke County	BURKE COUNTY\Burke County CD	Burke County GIS; CD	2003			feet	
valdzone.shp	shp	Valdese zoning	Burke County	BURKE COUNTY\Burke County CD	Burke County GIS; CD	2003			feet	
twp.shp	shp	township boundaries	Burke County	BURKE COUNTY\Burke County CD	Burke County GIS; CD	2003			feet	
school.shp	shp	Elementry, middle, and high school districts	Burke County	BURKE COUNTY\Burke County CD	Burke County GIS; CD	2003			feet	

Layer	File Ext.	Description	Geographic Area	Location in E:/GIS Data Layers	Source/ Delivery Media	Origination Date	Projection	Datum	Units of Measure	Notes
parcel.shp	shp	Cadastral polygons, tax parcels	Burke County	BURKE COUNTY\Burke County CD	Burke County GIS; CD	2003			feet	
morgzone.shp	shp	Morganton zoning	Burke County	BURKE COUNTY\Burke County CD	Burke County GIS; CD	2003			feet	
lakerivr.shp	shp	lakes and rivers	Burke County	BURKE COUNTY\Burke County CD	Burke County GIS; CD	2003			feet	
flood.shp	shp	FEMA floodplain boundaries	Burke County	BURKE COUNTY\Burke County CD	Burke County GIS; CD	2003			feet	
fire.shp	shp	fire districts	Burke County	BURKE COUNTY\Burke County CD	Burke County GIS; CD	2003			feet	
etj.shp	shp	Extra-territorial jurisdiction.	Burke County	BURKE COUNTY\Burke County CD	Burke County GIS; CD	2003			feet	
county.shp	shp	County boundaries.	Burke County	BURKE COUNTY\Burke County CD	Burke County GIS; CD	2003			feet	
city.shp	shp	city limits	Burke County	BURKE COUNTY\Burke County CD	Burke County GIS; CD	2003			feet	
burkewsw.shp	shp	water supply watersheds	Burke County	BURKE COUNTY\Burke County CD	Burke County GIS; CD	2003			feet	
Town of Lenoir										
regecity_line.shp	shp	regional city extra-territorial jurisdictional boundaries.	Lenoir region	CALDWELL COUNTY\Town of Lenoir	Town of Lenoir; CD	July 2003			feet	
centerlines_7_03.shp	shp	road centerlines for Town of Lenoir.	Lenoir	CALDWELL COUNTY\Town of Lenoir	Town of Lenoir; CD	July 2003			feet	
municzonee00_polygon.shp	shp	Lenoir zoning.	Lenoir	CALDWELL COUNTY\Town of Lenoir	Town of Lenoir; CD	July 2003			feet	
Caldwell County										
dotlrsnode.shp	shp	endpoints of primary and secondary roads.	Caldwell County	CALDWELL COUNTY\DOT Layers\Caldwell dot.av	DOT	April 2003	NC Stateplane	NAD 83	meters	origination date unclear
dotsecroads.shp	shp	secondary roads.	Caldwell County	CALDWELL COUNTY\DOT Layers\Caldwell dot.av	DOT	April 2003	NC Stateplane	NAD 83	meters	origination date unclear
dotroads.shp	shp	all roads.	Caldwell County	CALDWELL COUNTY\DOT Layers\Caldwell dot.av	DOT	April 2003	NC Stateplane	NAD 83	meters	origination date unclear
dotrailrds.shp	shp	railroad lines.	Caldwell County	CALDWELL COUNTY\DOT Layers\Caldwell dot.av	DOT	April 2003	NC Stateplane	NAD 83	meters	origination date unclear
dotprimrds.shp	shp	primary roads.	Caldwell County	CALDWELL COUNTY\DOT Layers\Caldwell dot.av	DOT	April 2003	NC Stateplane	NAD 83	meters	origination date unclear
dotlrsrtrts.shp	shp	looks like combination of dot primary raods and dot secondary roads.	Caldwell County	CALDWELL COUNTY\DOT Layers\Caldwell dot.av	DOT	April 2003	NC Stateplane	NAD 83	meters	origination date unclear

Layer	File Ext.	Description	Geographic Area	Location in E:/GIS Data Layers	Source/ Delivery Media	Origination Date	Projection	Datum	Units of Measure	Notes
dotlrsrt.shp	shp	looks like combination of dot primary raods and dot secondary roads.	Caldwell County	CALDWELL COUNTY\DOT Layers\Caldwell dot.av	DOT	April 2003	NC Stateplane	NAD 83	meters	origination date unclear
dotgovbdry.shp	shp		Caldwell County	CALDWELL COUNTY\DOT Layers\Caldwell dot.av	DOT	April 2003	NC Stateplane	NAD 83	meters	origination date unclear
dotcntybdry.shp	shp	county boundary	Caldwell County	CALDWELL COUNTY\DOT Layers\Caldwell dot.av	DOT	April 2003	NC Stateplane	NAD 83	meters	origination date unclear
dotcitybdry.shp	shp	municipal boundaries.	Caldwell County	CALDWELL COUNTY\DOT Layers\Caldwell dot.av	DOT	April 2003	NC Stateplane	NAD 83	meters	origination date unclear
dotairport.shp	shp	airport runways	Caldwell County	CALDWELL COUNTY\DOT Layers\Caldwell dot.av	DOT	April 2003	NC Stateplane	NAD 83	meters	origination date unclear
caldwellb.shp	shp	base soil survey	Caldwell County	E:\Catawba\soil survey	USDA NRCS		NC Stateplane	NAD 83	meters	origination date unclear
caldwellt.shp	shp	taxonomy soil survey	Caldwell County	E:\Catawba\soil survey	USDA NRCS		NC Stateplane	NAD 83	meters	origination date unclear
Other										
lenhydro	sdts	hydrography	Lenoir quad	E:\usgsdlg	USGS; http://edc.usgs.gov/geodata					
lenmtrans	sdts	miscellaneous transportation	Lenoir quad	E:\usgsdlg	USGS; http://edc.usgs.gov/geodata					
lenrail	sdts	railroads	Lenoir quad	E:\usgsdlg	USGS; http://edc.usgs.gov/geodata					
lenroad	sdts	roads	Lenoir quad	E:\usgsdlg	USGS; http://edc.usgs.gov/geodata					
kchydro	sdts	hydrography	Kings Creek quad	E:\usgsdlg	USGS; http://edc.usgs.gov/geodata					
kcmtrans	sdts	miscellaneous transportation	Kings Creek quad	E:\usgsdlg	USGS; http://edc.usgs.gov/geodata					
kcrail	sdts	railroads	Kings Creek quad	E:\usgsdlg	USGS; http://edc.usgs.gov/geodata					
kcroad	sdts	roads	Kings Creek quad	E:\usgsdlg	USGS; http://edc.usgs.gov/geodata					

Layer	File Ext.	Description	Geographic Area	Location in E:/GIS Data Layers	Source/ Delivery Media	Origination Date	Projection	Datum	Units of Measure	Notes
drexhydro	sdts	hydrography	Drexel quad	E:\usgsdlg	USGS; http://edc.usgs.gov/geodata					
drexmtrans	sdts	miscellaneous transportation	Drexel quad	E:\usgsdlg	USGS; http://edc.usgs.gov/geodata					
drexrail	sdts	railroads	Drexel quad	E:\usgsdlg	USGS; http://edc.usgs.gov/geodata					
drexroad	sdts	roads	Drexel quad	E:\usgsdlg	USGS; http://edc.usgs.gov/geodata					
morgnhydro	sdts	hydrography	Morganton North quad	E:\usgsdlg	USGS; http://edc.usgs.gov/geodata					
morgnmtrans	sdts	miscellaneous transportation	Morganton North quad	E:\usgsdlg	USGS; http://edc.usgs.gov/geodata					
morgnrail	sdts	railroads	Morganton North quad	E:\usgsdlg	USGS; http://edc.usgs.gov/geodata					
morgnroad	sdts	roads	Morganton North quad	E:\usgsdlg	USGS; http://edc.usgs.gov/geodata					
collhydro	sdts	hydrography	Collettsville quad	E:\usgsdlg	USGS; http://edc.usgs.gov/geodata					
collmtrans	sdts	miscellaneous transportation	Collettsville quad	E:\usgsdlg	USGS; http://edc.usgs.gov/geodata					
collrail	sdts	railroads	Collettsville quad	E:\usgsdlg	USGS; http://edc.usgs.gov/geodata					
collroad	sdts	roads	Collettsville quad	E:\usgsdlg	USGS; http://edc.usgs.gov/geodata					
lenoir_l	shp	NWI line (streams)	Lenoir quad	E:\NWI	National Wetlands Inventory; http//www.nwi.fws.gov/downloads.htm		UTM	NAD 83		
lenoir_p	shp	NWI polygons (wetlands, lakes)	Lenoir quad	E:\NWI	National Wetlands Inventory; http//www.nwi.fws.gov/downloads.htm		UTM	NAD 83		
kingsc_l	shp	NWI line (streams)	Kings Creek quad	E:\NWI	National Wetlands Inventory; http//www.nwi.fws.gov/downloads.htm		UTM	NAD 83		
kingsc_p	shp	NWI polygons (wetlands, lakes)	Kings Creek quad	E:\NWI	National Wetlands Inventory; http//www.nwi.fws.gov/downloads.htm		UTM	NAD 83		
drexel_l	shp	NWI line (streams)	Drexel quad	E:\NWI	National Wetlands Inventory; http//www.nwi.fws.gov/downloads.htm		UTM	NAD 83		

Layer	File Ext.	Description	Geographic Area	Location in E:/GIS Data Layers	Source/ Delivery Media	Origination Date	Projection	Datum	Units of Measure	Notes
drexel_p	shp	NWI polygons (wetlands, lakes)	Drexel quad	E:\NWI	National Wetlands Inventory; http//www.nwi.fws.gov/downloads.htm		UTM	NAD 83		
morgno_l	shp	NWI line (streams)	Morganton North quad	E:\NWI	National Wetlands Inventory; http//www.nwi.fws.gov/downloads.htm		UTM	NAD 83		
morgno_p	shp	NWI polygons (wetlands, lakes)	Morganton North quad	E:\NWI	National Wetlands Inventory; http//www.nwi.fws.gov/downloads.htm		UTM	NAD 83		
collet_l	shp	NWI line (streams)	Collettsville quad	E:\NWI	National Wetlands Inventory; http//www.nwi.fws.gov/downloads.htm		UTM	NAD 83		
collet_p	shp	NWI polygons (wetlands, lakes)	Collettsville quad	E:\NWI	National Wetlands Inventory; http//www.nwi.fws.gov/downloads.htm		UTM	NAD 83		
kingck1	sid	color infrared DOQQ	Kings Creek quad	E:\Catawba	NC DENR; ftp://gis.enr.state.nc.us/doqq98	1998				unprojected
kingck2	sid	color infrared DOQQ	Kings Creek quad	E:\Catawba	NC DENR; ftp://gis.enr.state.nc.us/doqq98	1998				unprojected
kingck3	sid	color infrared DOQQ	Kings Creek quad	E:\Catawba	NC DENR; ftp://gis.enr.state.nc.us/doqq98	1998				unprojected
kingck4	sid	color infrared DOQQ	Kings Creek quad	E:\Catawba	NC DENR; ftp://gis.enr.state.nc.us/doqq98	1998				unprojected
drexel1	sid	color infrared DOQQ	Drexel quad	E:\Catawba	NC DENR; ftp://gis.enr.state.nc.us/doqq98	1998				unprojected
drexel2	sid	color infrared DOQQ	Drexel quad	E:\Catawba	NC DENR; ftp://gis.enr.state.nc.us/doqq98	1998				unprojected
drexel3	sid	color infrared DOQQ	Drexel quad	E:\Catawba	NC DENR; ftp://gis.enr.state.nc.us/doqq98	1998				unprojected
drexel4	sid	color infrared DOQQ	Drexel quad	E:\Catawba	NC DENR; ftp://gis.enr.state.nc.us/doqq98	1998				unprojected

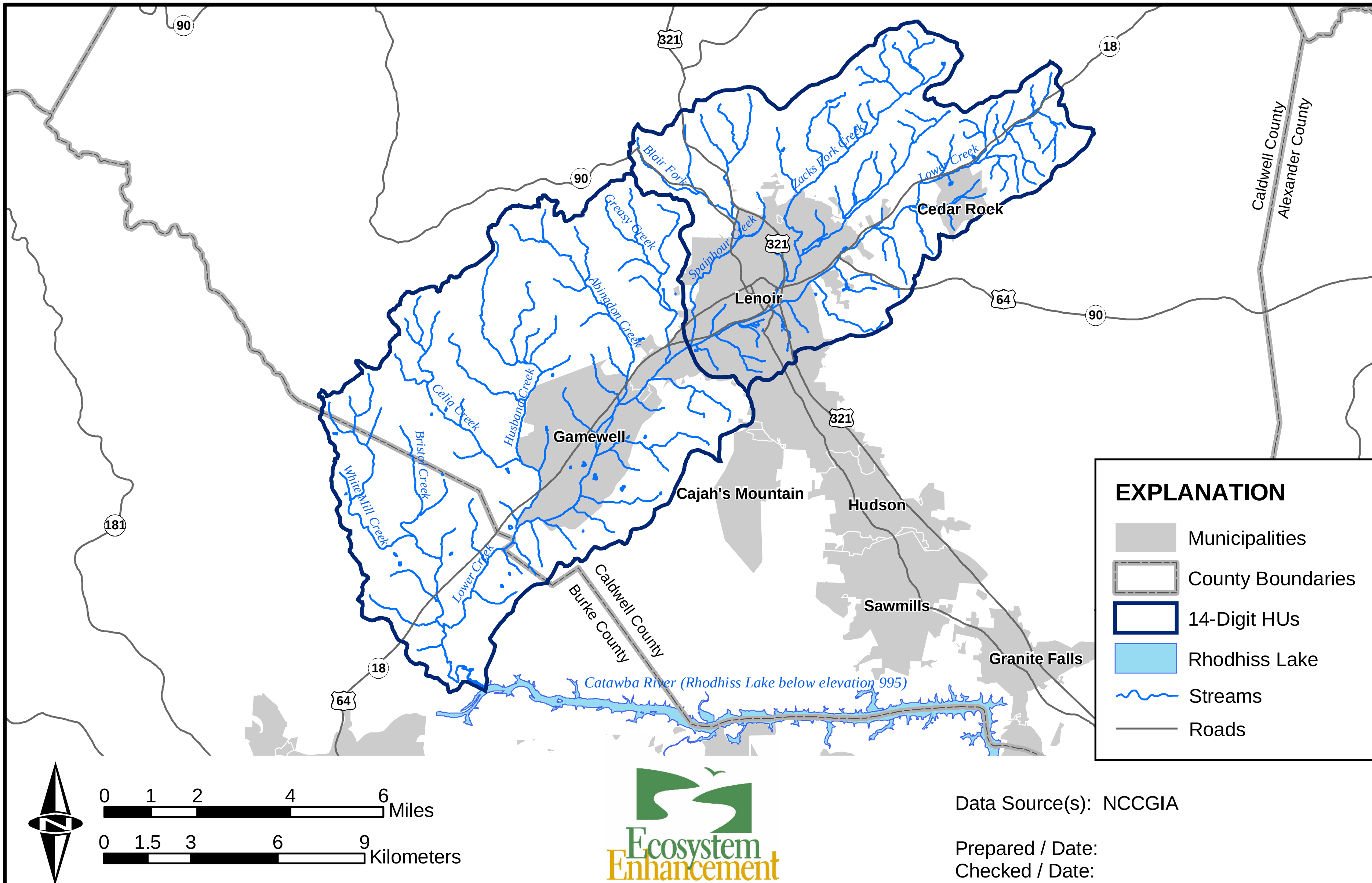
Layer	File Ext.	Description	Geographic Area	Location in E:/GIS Data Layers	Source/ Delivery Media	Origination Date	Projection	Datum	Units of Measure	Notes
morgan1	sid	color infrared DOQQ	Morganton North quad	E:\Catawba	NC DENR; ftp://gis.enr.state.nc.us/doqq98	1998				unprojected
morgan2	sid	color infrared DOQQ	Morganton North quad	E:\Catawba	NC DENR; ftp://gis.enr.state.nc.us/doqq98	1998				unprojected
morgan3	sid	color infrared DOQQ	Morganton North quad	E:\Catawba	NC DENR; ftp://gis.enr.state.nc.us/doqq98	1998				unprojected
morgan4	sid	color infrared DOQQ	Morganton North quad	E:\Catawba	NC DENR; ftp://gis.enr.state.nc.us/doqq98	1998				unprojected
collvl1	jpg	black & white DOQQ	Collettsville quad	E:\Catawba\DOQQs\1993	NC DENR; ftp://gis.enr.state.nc.us/doqq93/	1993				
collvl2	jpg	black & white DOQQ	Collettsville quad	E:\Catawba\DOQQs\1993	NC DENR; ftp://gis.enr.state.nc.us/doqq93/	1993				
collvl3	jpg	black & white DOQQ	Collettsville quad	E:\Catawba\DOQQs\1993	NC DENR; ftp://gis.enr.state.nc.us/doqq93/	1993				
collvl4	jpg	black & white DOQQ	Collettsville quad	E:\Catawba\DOQQs\1993	NC DENR; ftp://gis.enr.state.nc.us/doqq93/	1993				
drexel1	jpg	black & white DOQQ	Drexel quad	E:\Catawba\DOQQs\1993	NC DENR; ftp://gis.enr.state.nc.us/doqq93/	1993				
drexel2	jpg	black & white DOQQ	Drexel quad	E:\Catawba\DOQQs\1993	NC DENR; ftp://gis.enr.state.nc.us/doqq93/	1993				
drexel3	jpg	black & white DOQQ	Drexel quad	E:\Catawba\DOQQs\1993	NC DENR; ftp://gis.enr.state.nc.us/doqq93/	1993				
drexel4	jpg	black & white DOQQ	Drexel quad	E:\Catawba\DOQQs\1993	NC DENR; ftp://gis.enr.state.nc.us/doqq93/	1993				
kingck1	jpg	black & white DOQQ	Kings Creek quad	E:\Catawba\DOQQs\1993	NC DENR; ftp://gis.enr.state.nc.us/doqq93/	1993				

Layer	File Ext.	Description	Geographic Area	Location in E:/GIS Data Layers	Source/ Delivery Media	Origination Date	Projection	Datum	Units of Measure	Notes
kingck2	jpg	black & white DOQQ	Kings Creek quad	E:\Catawba\DOQQs\1993	NC DENR; ftp://gis.enr.state.nc.us/doqq93/	1993				
kingck3	jpg	black & white DOQQ	Kings Creek quad	E:\Catawba\DOQQs\1993	NC DENR; ftp://gis.enr.state.nc.us/doqq93/	1993				
kingck4	jpg	black & white DOQQ	Kings Creek quad	E:\Catawba\DOQQs\1993	NC DENR; ftp://gis.enr.state.nc.us/doqq93/	1993				
lenoir1	jpg	black & white DOQQ	Lenoir quad	E:\Catawba\DOQQs\1993	NC DENR; ftp://gis.enr.state.nc.us/doqq93/	1993				
lenoir2	jpg	black & white DOQQ	Lenoir quad	E:\Catawba\DOQQs\1993	NC DENR; ftp://gis.enr.state.nc.us/doqq93/	1993				
lenoir3	jpg	black & white DOQQ	Lenoir quad	E:\Catawba\DOQQs\1993	NC DENR; ftp://gis.enr.state.nc.us/doqq93/	1993				
lenoir4	jpg	black & white DOQQ	Lenoir quad	E:\Catawba\DOQQs\1993	NC DENR; ftp://gis.enr.state.nc.us/doqq93/	1993				
morgan1	jpg	black & white DOQQ	Morganton North quad	E:\Catawba\DOQQs\1993	NC DENR; ftp://gis.enr.state.nc.us/doqq93/	1993				
morgan2	jpg	black & white DOQQ	Morganton North quad	E:\Catawba\DOQQs\1993	NC DENR; ftp://gis.enr.state.nc.us/doqq93/	1993				
morgan3	jpg	black & white DOQQ	Morganton North quad	E:\Catawba\DOQQs\1993	NC DENR; ftp://gis.enr.state.nc.us/doqq93/	1993				
morgan4	jpg	black & white DOQQ	Morganton North quad	E:\Catawba\DOQQs\1993	NCDENR; ftp://gis.enr.state.nc.us/doqq93	1993				
collvl	tif	DRG	Collettsville quad	E:\Catawba\DRG	NC DENR; ftp://gis.enr.state.nc.us/drg/	1998?				not sure of date
drexel	tif	DRG	Drexel quad	E:\Catawba\DRG	NC DENR; ftp://gis.enr.state.nc.us/drg/	1998?				not sure of date
kingck	tif	DRG	Kings Creek quad	E:\Catawba\DRG	NC DENR; ftp://gis.enr.state.nc.us/drg/	1998?				not sure of date

Layer	File Ext.	Description	Geographic Area	Location in E:/GIS Data Layers	Source/ Delivery Media	Origination Date	Projection	Datum	Units of Measure	Notes
lenoir	tif	DRG	Lenoir quad	E:\Catawba\DRG	NC DENR; ftp://gis.enr.state.nc.us/drg/	1998?				not sure of date
morgan	tif	DRG	Morganton North quad	E:\Catawba\DRG	NC DENR; ftp://gis.enr.state.nc.us/drg/	1998?				not sure of date
primary_roads	shp	primary roads	NC	E:\Catawba\basinpro	BasinPro3 CDs					
hunc	shp	14 digit hydrologic units	NC	E:\Catawba\basinpro	BasinPro3 CDs					
municipalbnd	shp	municipal boundaries	NC	E:\Catawba\basinpro	BasinPro3 CDs					
countybnd	shp	county boundaries	NC	E:\Catawba\basinpro	BasinPro3 CDs					

Watershed data										
monitoring stations		ambient water quality monitoring stations	Catawba river basin	http://www.esb.enr.state.nc.us/stations/ctbsta.asp	NC DWQ	varied				
assessment report	pdf	basinwide assessment report	Catawba river basin	P:\30141 natural resources\2003\0275 - NCWRP Catawba	NC DWQ; http://www.esb.enr.state.nc.us/bar.html					
water quality plan	pdf	basinwide water quality plan	Catawba river basin	http://h2o.enr.state.nc.us/basinwide/catawba/catawba_wq_management_plan.htm	NC DWQ					
biological assessment	doc	TMDL study	Lower Creek/Spainhour Creek	P:\30141 natural resources\2003\0275 - NCWRP Catawba	NC DWQ					
macrobenthic	xls	macrobenthic summary reports	Lower Creek	P:\30141 natural resources\2003\0275 - NCWRP Catawba	NC DWQ					

Transportation Improvement Program										
TIP data		DOT TIP data	NC	ftp://ftp.doh.dot.state.nc.us/TIPDATA/	NC DOT					



Data Source(s): NCCGIA

Prepared / Date:
Checked / Date:

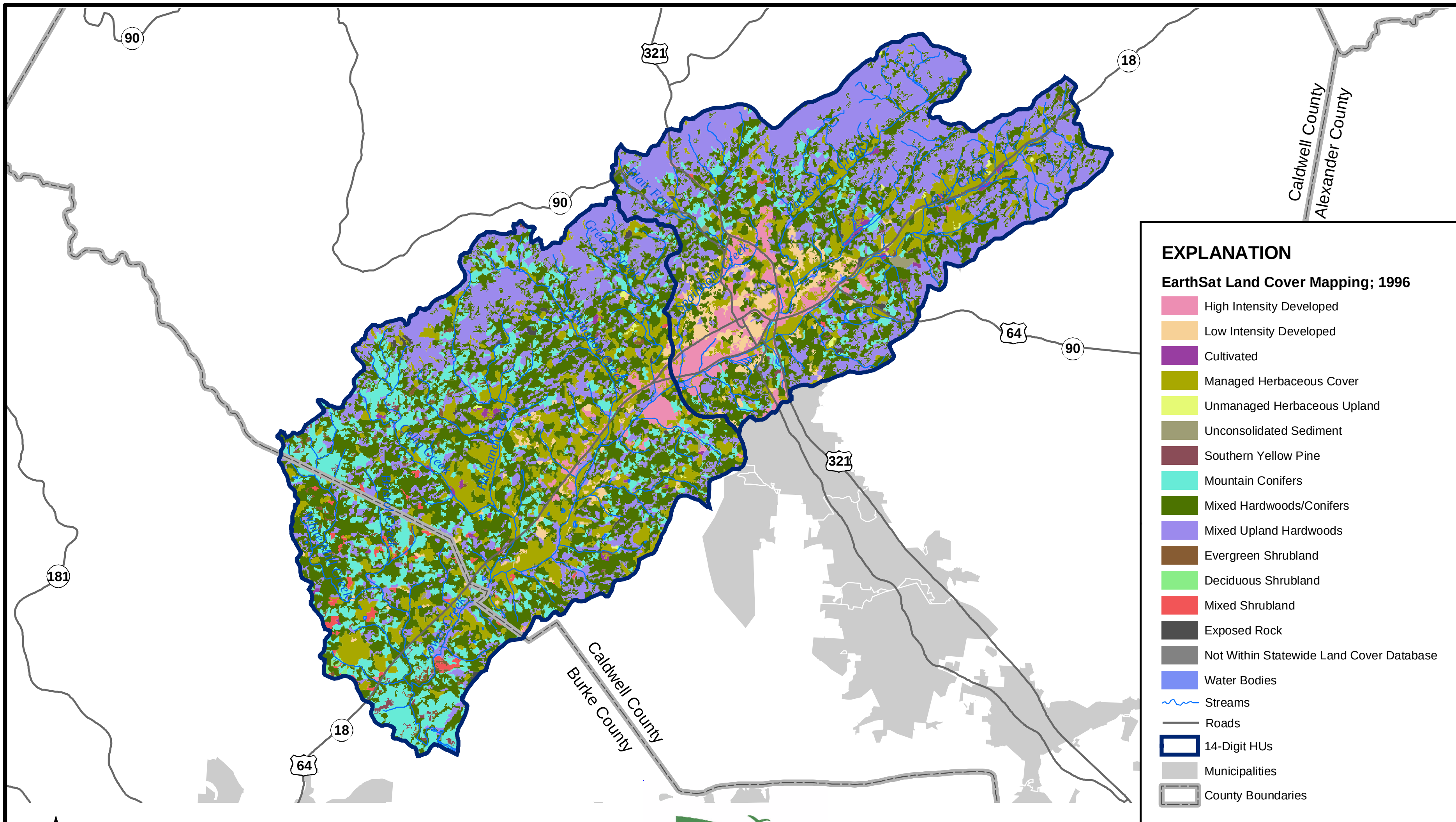
NC Ecosystem Enhancement Program
Catawba River Basin LWP
Lower Creek Subbasin (03050101)

MACTEC

Project Area Location

Project 6470030275

Figure A-1



0 1 2 4 6 Miles

0 1.5 3 6 9 Kilometers

Data Source(s): NCCGIA

Prepared / Date:

Checked / Date:

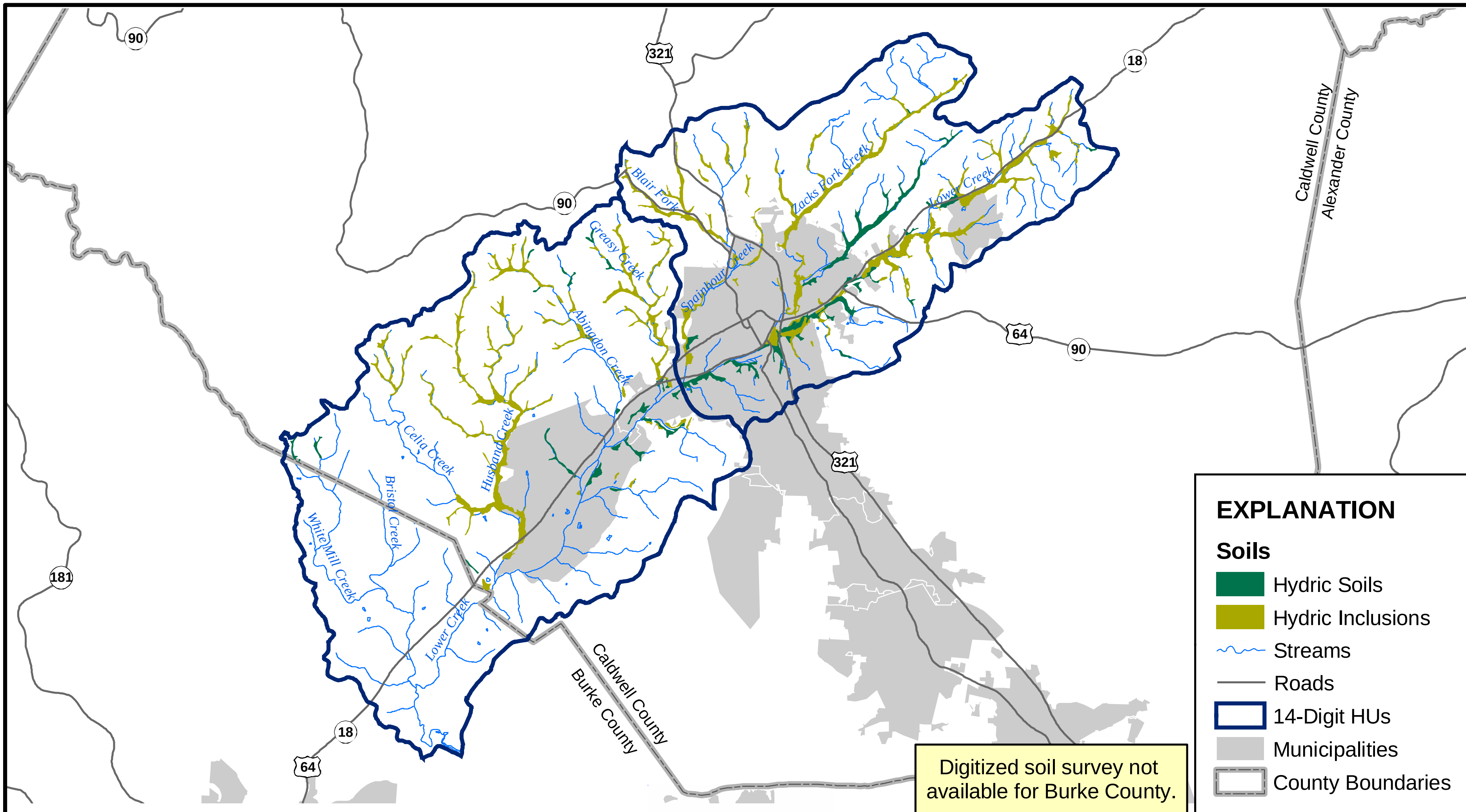
NC Ecosystem Enhancement Program
Catawba River Basin LWP
Lower Creek Subbasin (03050101)

MACTEC

EarthSat Land Cover

Project 6470030275

Figure A-2



0 1 2 4 6 Miles

0 1.5 3 6 9 Kilometers

Data Source(s): NCCGIA, NRCS

Prepared / Date:

Checked / Date:

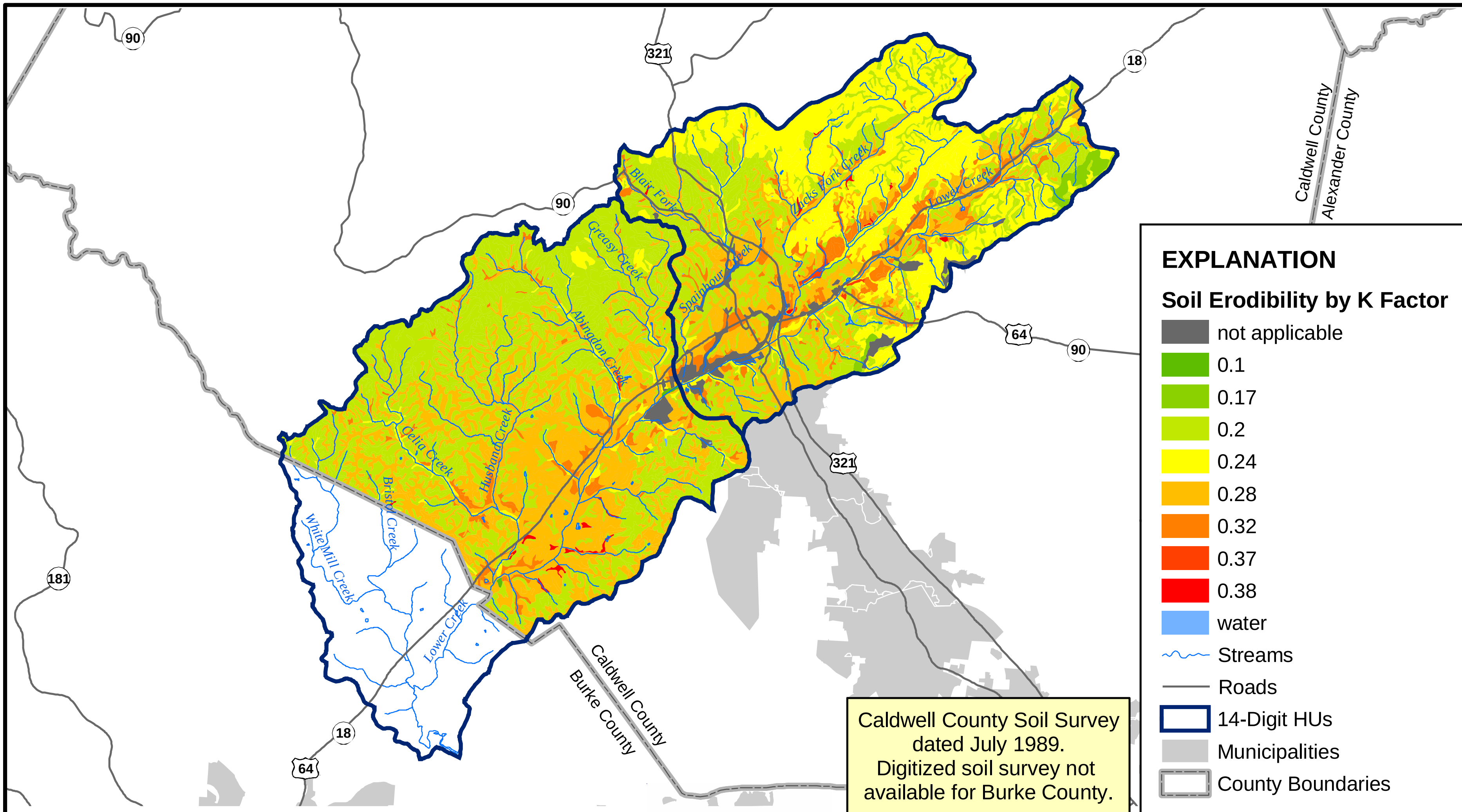
NC Ecosystem Enhancement Program
Catawba River Basin LWP
Lower Creek Subbasin (03050101)

MACTEC

NRCS Hydric Soils

Project 6470030275

Figure A-3



0 1 2 4 6 Miles

0 1.5 3 6 9 Kilometers

Ecosystem Enhancement PROGRAM

Data Source(s): NCCGIA, NRCS

Prepared / Date:

Checked / Date:

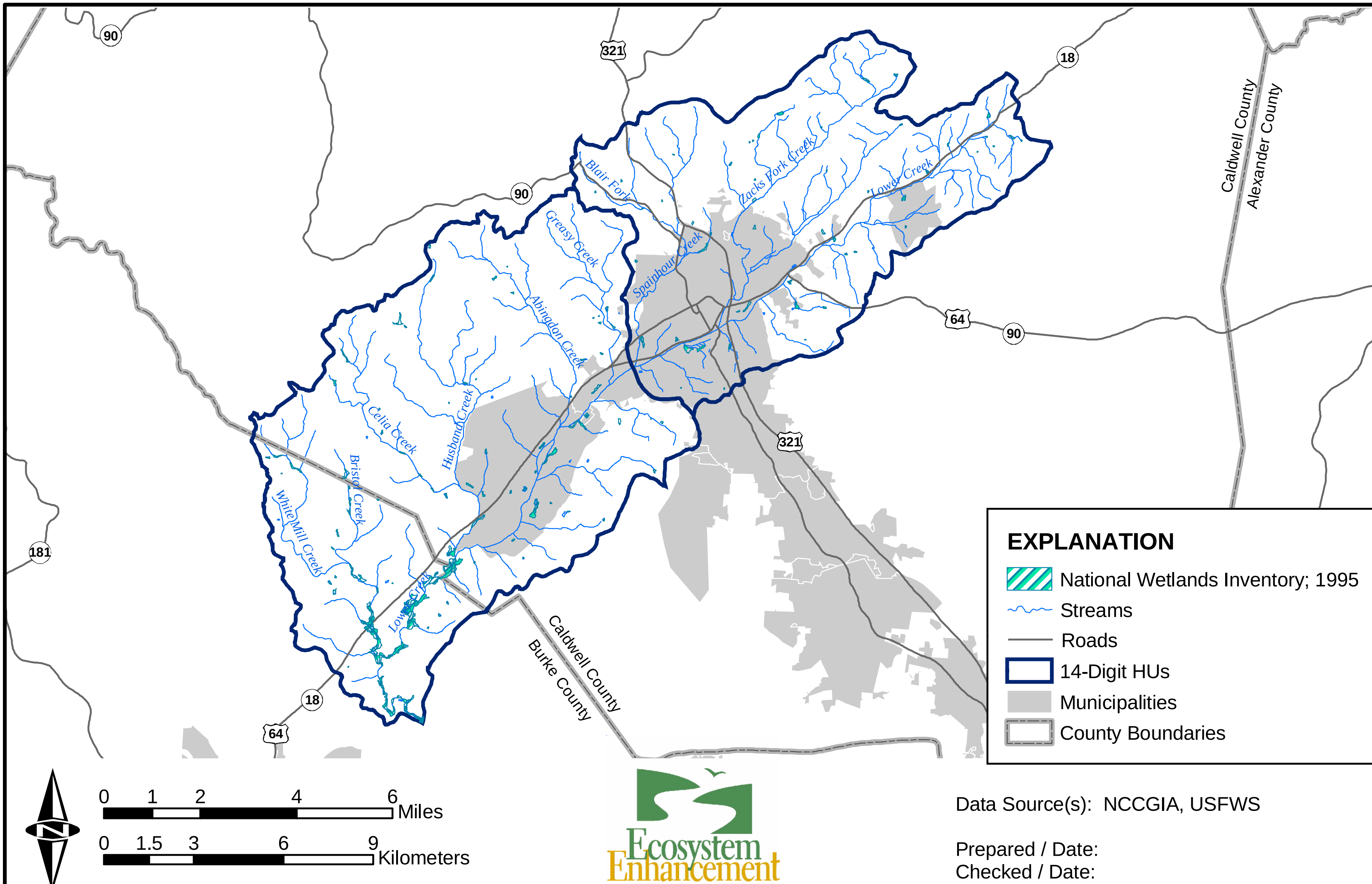
NC Ecosystem Enhancement Program
Catawba River Basin LWP
Lower Creek Subbasin (03050101)

MACTEC

NRCS Soil Erodibility

Project 6470030275

Figure A-4



Data Source(s): NCCGIA, USFWS

Prepared / Date:
Checked / Date:

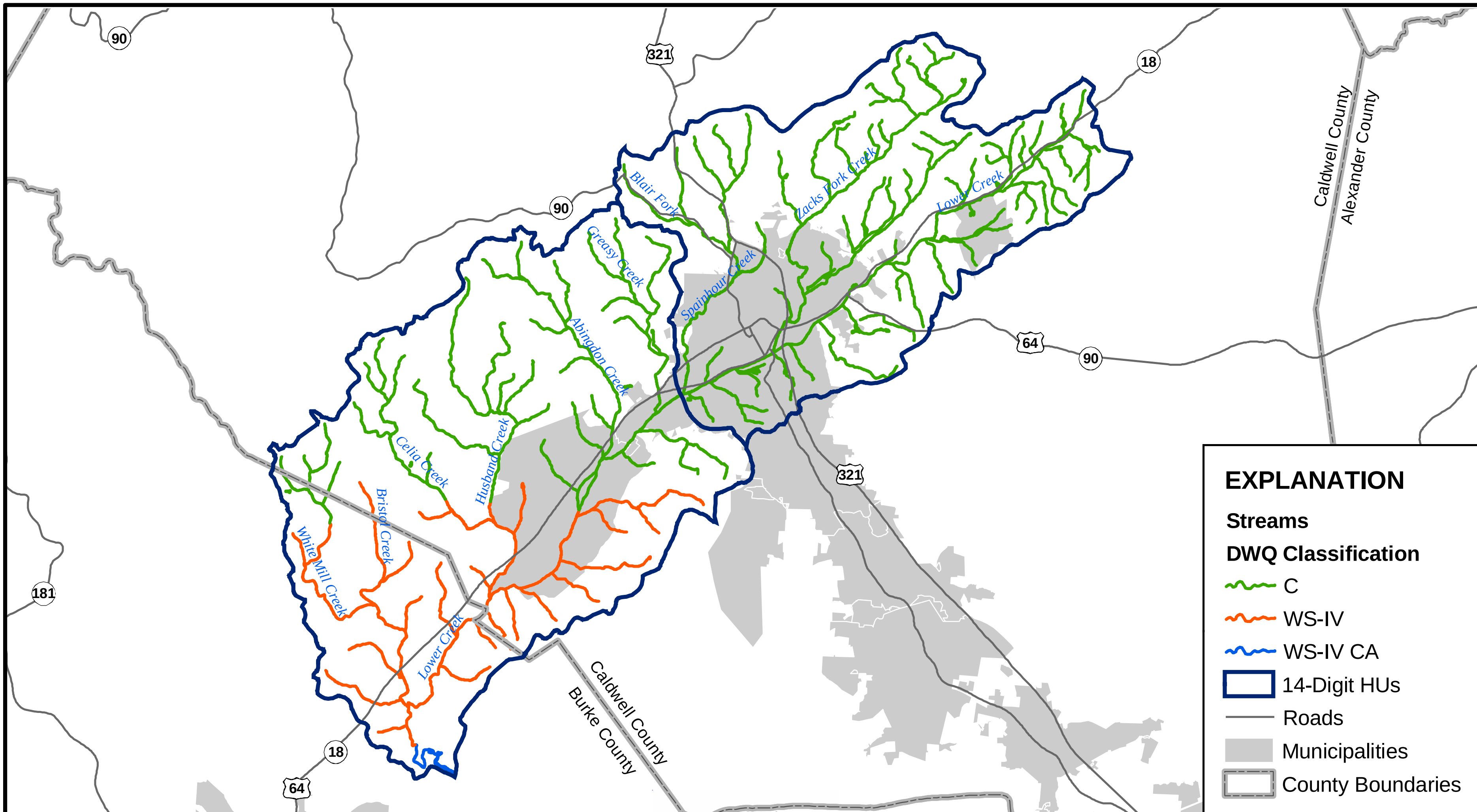
NC Ecosystem Enhancement Program
Catawba River Basin LWP
Lower Creek Subbasin (03050101)

MACTEC

NWI Wetlands

Project 6470030275

Figure A-5



0 1 2 4 6 Miles

0 1.5 3 6 9 Kilometers

Data Source(s): NCCGIA, NCDWQ

Prepared / Date:
Checked / Date:

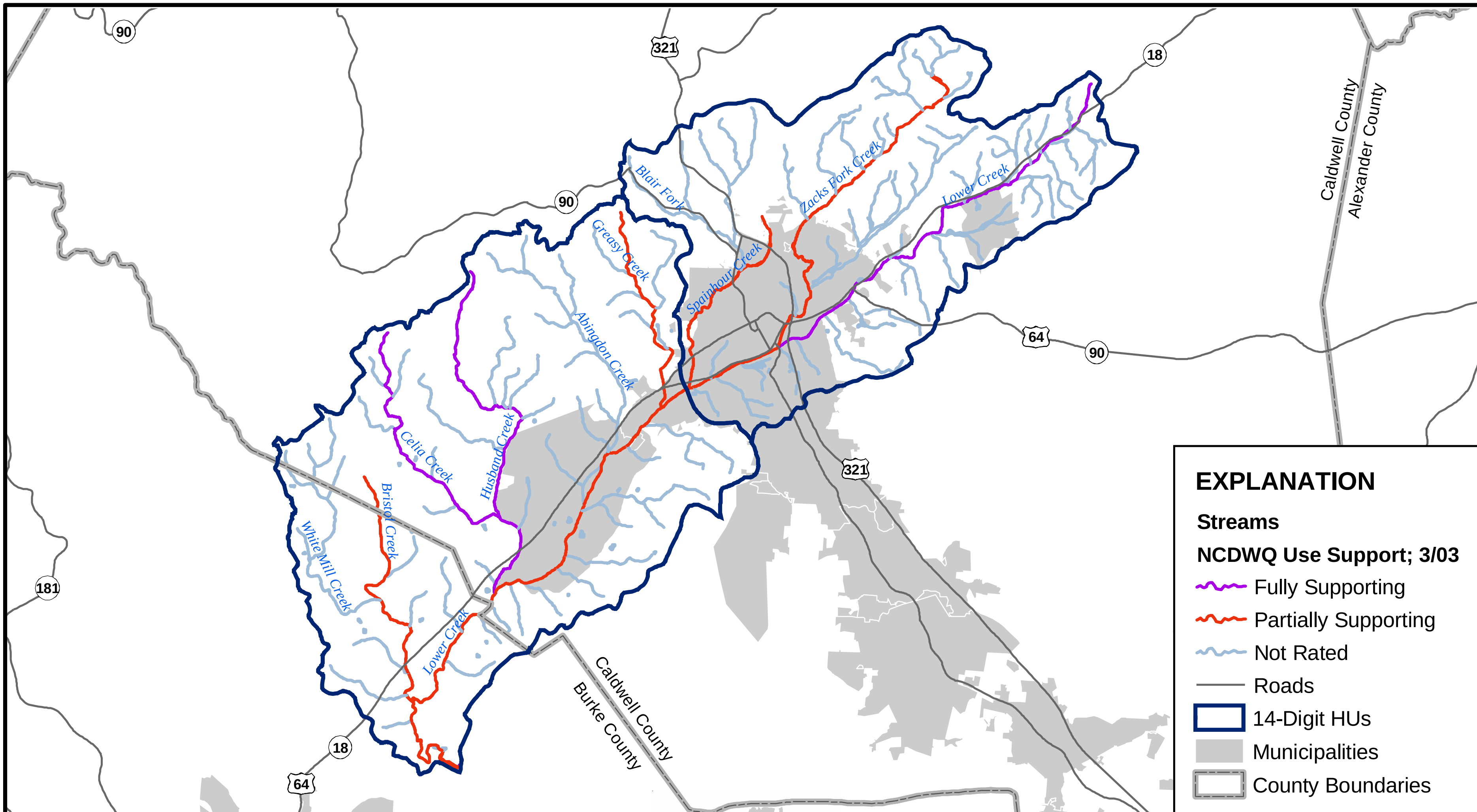
NC Ecosystem Enhancement Program
Catawba River Basin LWP
Lower Creek Subbasin (03050101)

MACTEC

NCDWQ Stream Classification

Project 6470030275

Figure A-6



0 1 2 4 6 Miles
0 1.5 3 6 9 Kilometers

Ecosystem Enhancement PROGRAM

Data Source(s): NCCGIA, NCDWQ

Prepared / Date:
Checked / Date:

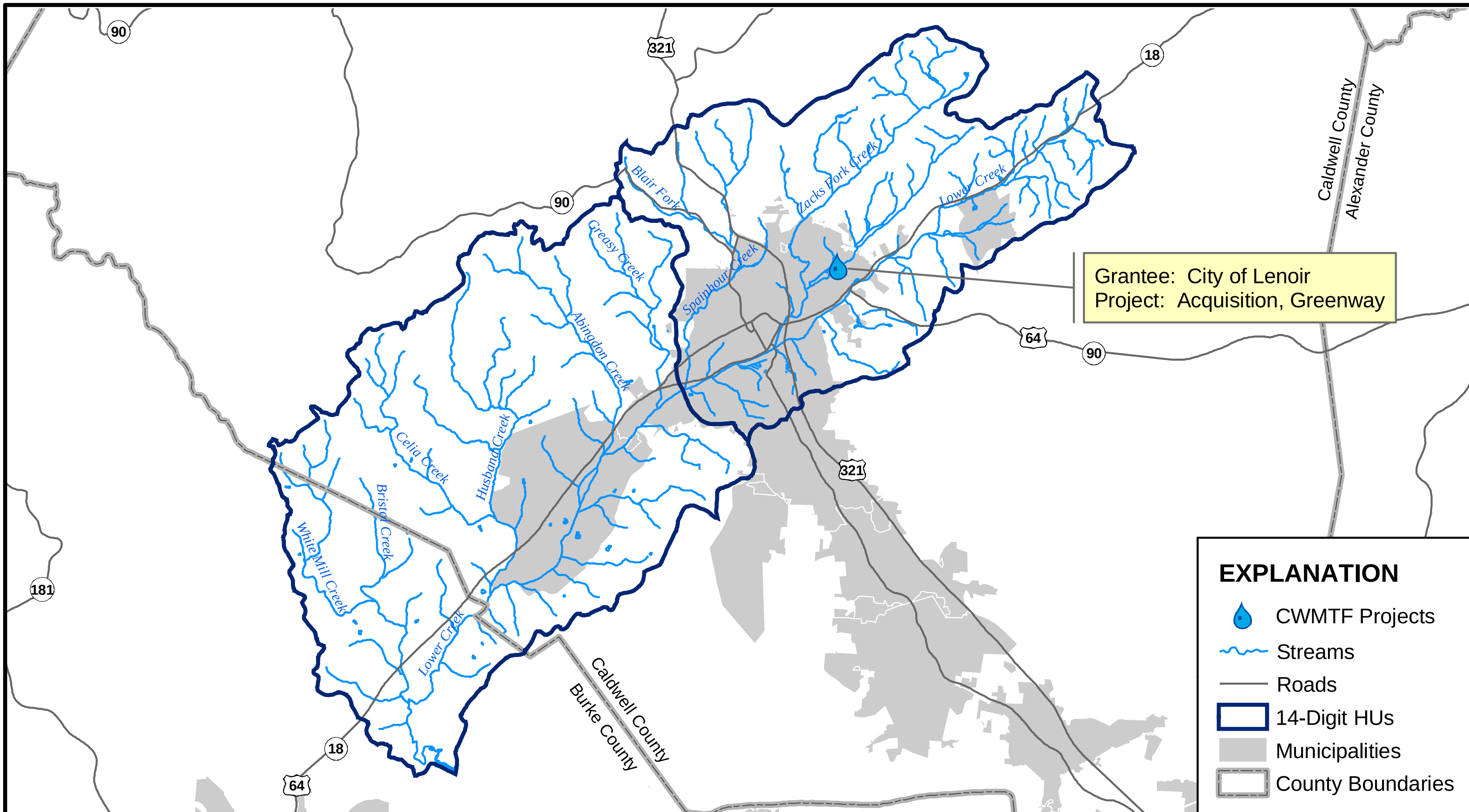
NC Ecosystem Enhancement Program
Catawba River Basin LWP
Lower Creek Subbasin (03050101)

MACTEC

NCDWQ Use Support

Project 6470030275

Figure A-7



0 1 2 4 6 Miles

0 1.5 3 6 9 Kilometers

Data Source(s): NCCGIA, NCCWMTF

Prepared / Date:
Checked / Date:

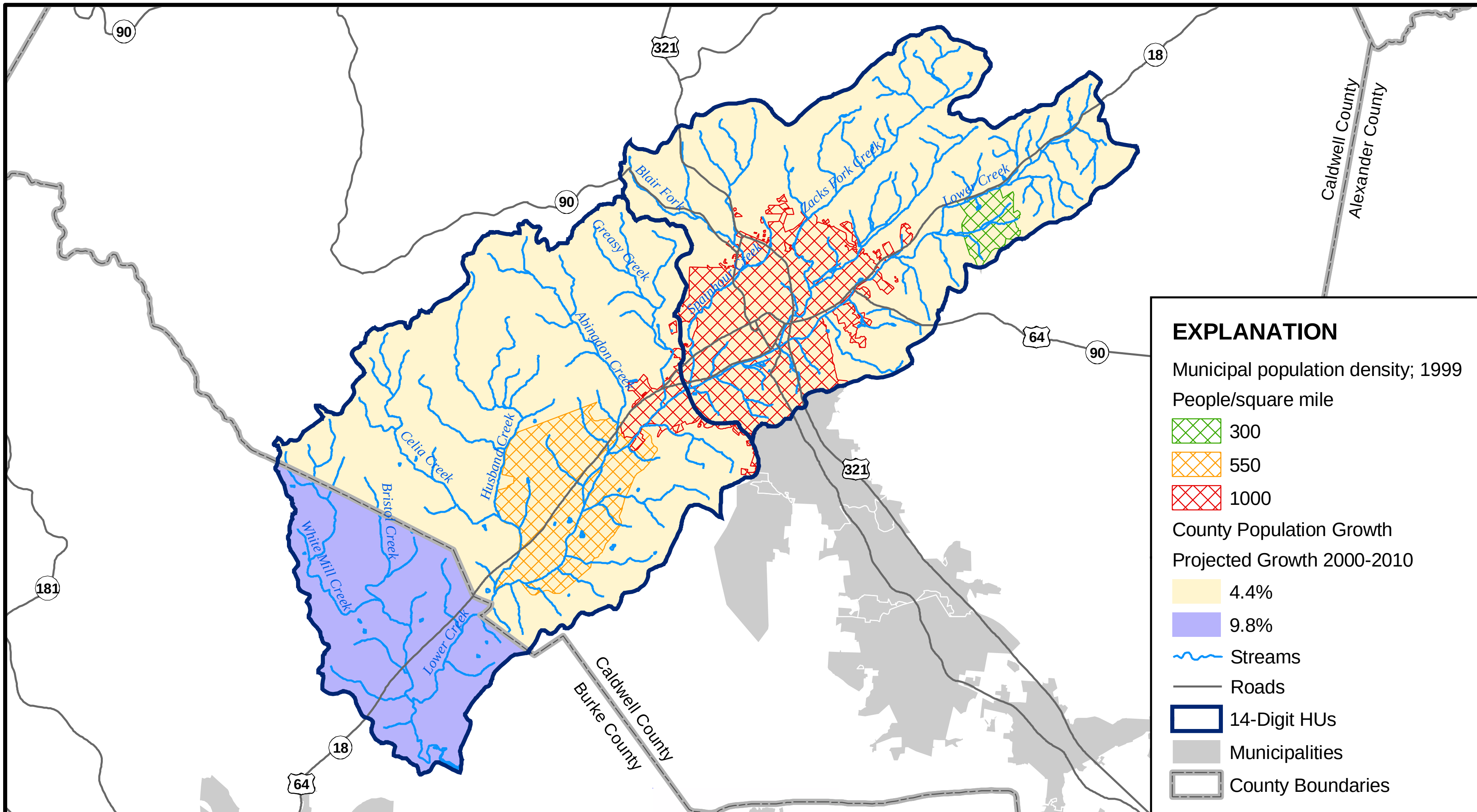
NC Ecosystem Enhancement Program
Catawba River Basin LWP
Lower Creek Subbasin (03050101)

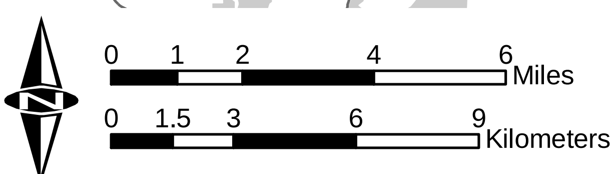
MACTEC

BasinPro CWMTF Projects

Project 6470030275

Figure A-8





Data Source(s): NCCGIA,
Office of State Planning

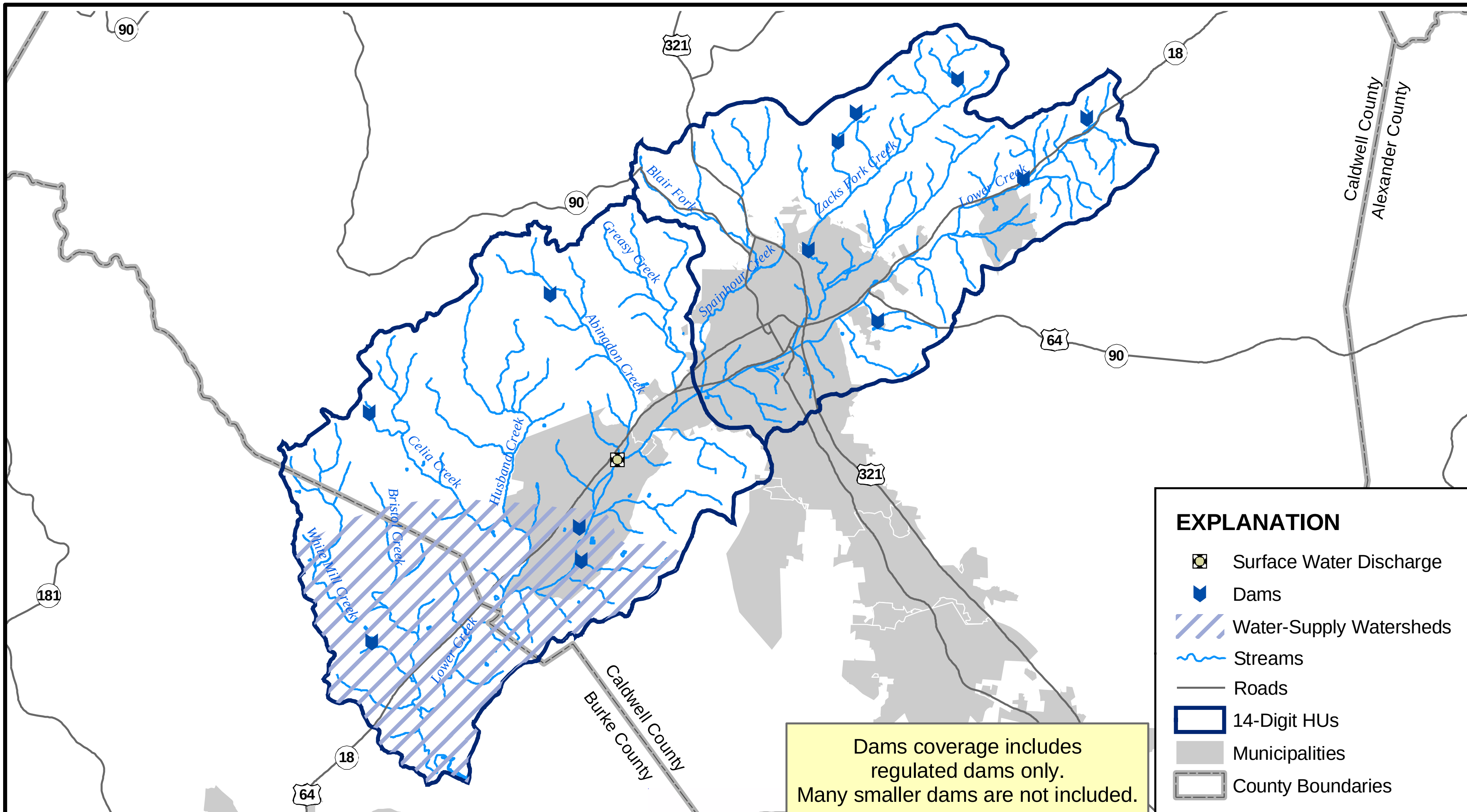
Prepared / Date:
Checked / Date:

NC Ecosystem Enhancement Program
Catawba River Basin LWP
Lower Creek Subbasin (03050101)

BasinPro Demographics

Project 6470030275

Figure A-9



0 1 2 4 6 Miles

0 1.5 3 6 9 Kilometers

Data Source(s): NCCGIA,
NC Dam Safety Program

Prepared / Date:
Checked / Date:

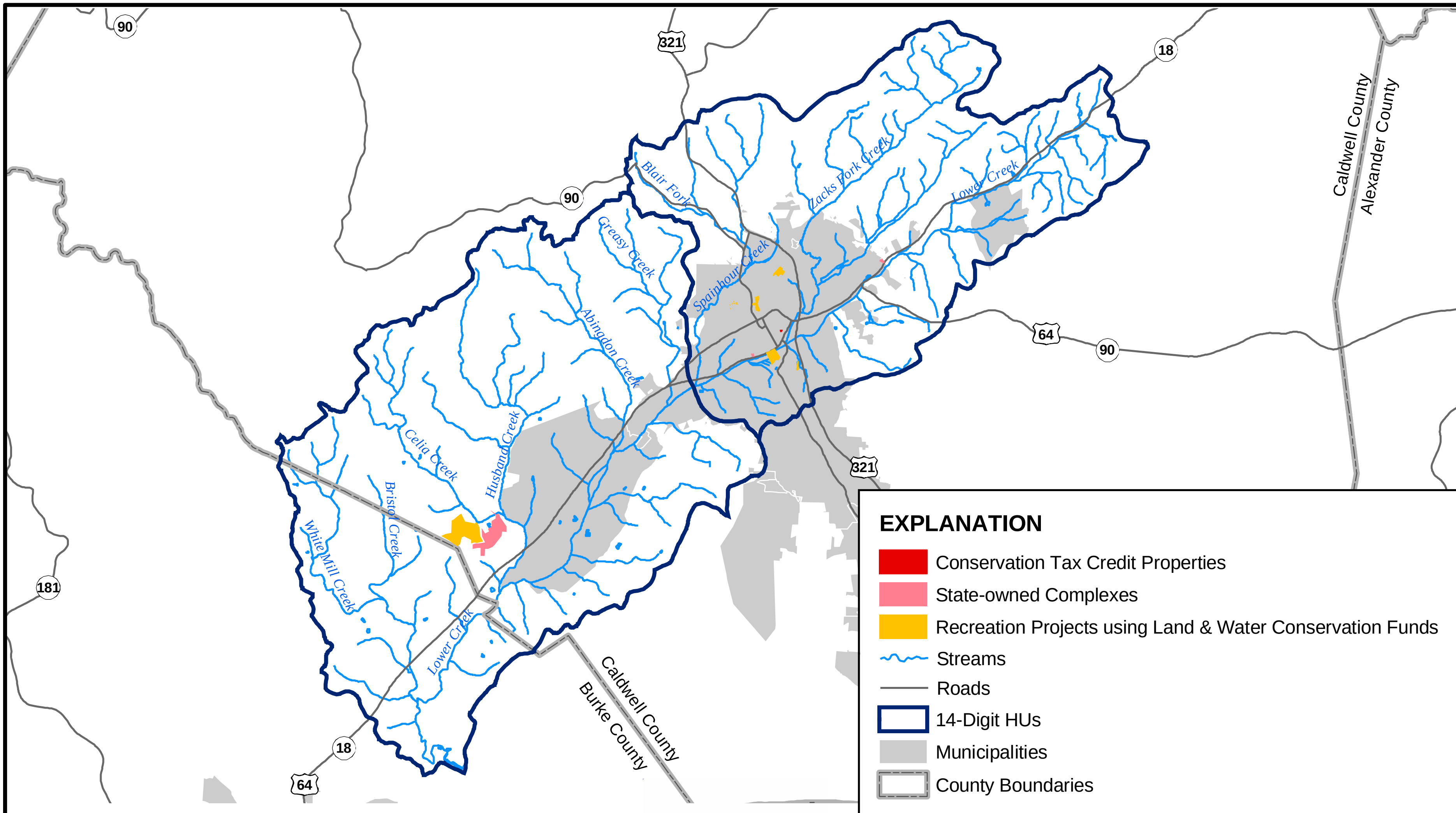
NC Ecosystem Enhancement Program
Catawba River Basin LWP
Lower Creek Subbasin (03050101)

MACTEC

BasinPro Infrastructure

Project 6470030275

Figure A-10



0 1 2 4 6 Miles

0 1.5 3 6 9 Kilometers

Ecosystem Enhancement PROGRAM

Data Source(s): NCCGIA, Caldwell County

Prepared / Date:

Checked / Date:

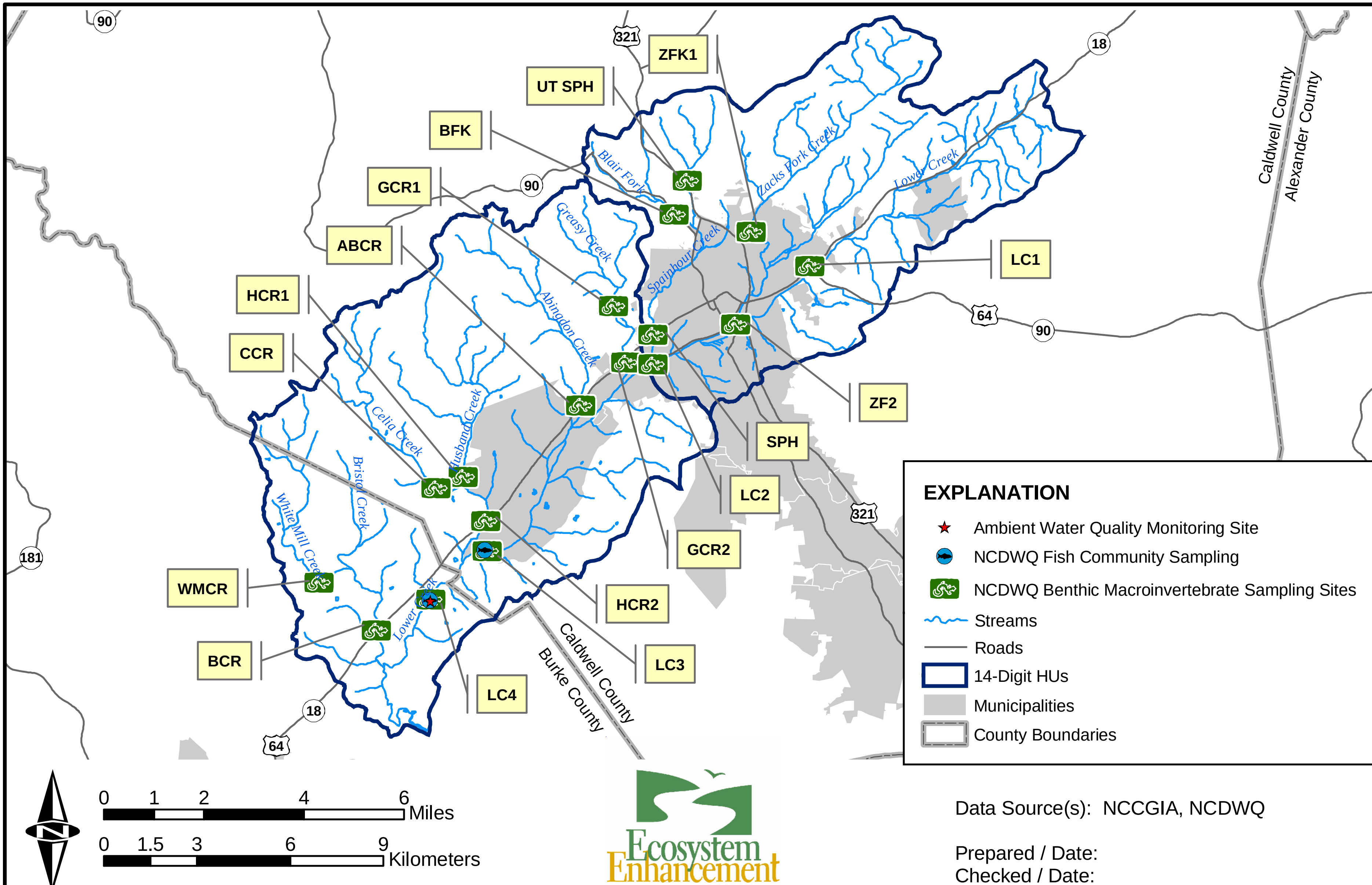
NC Ecosystem Enhancement Program
Catawba River Basin LWP
Lower Creek Subbasin (03050101)

MACTEC

BasinPro Managed Lands

Project 6470030275

Figure A-11



Data Source(s): NCCGIA, NCDWQ

Prepared / Date:
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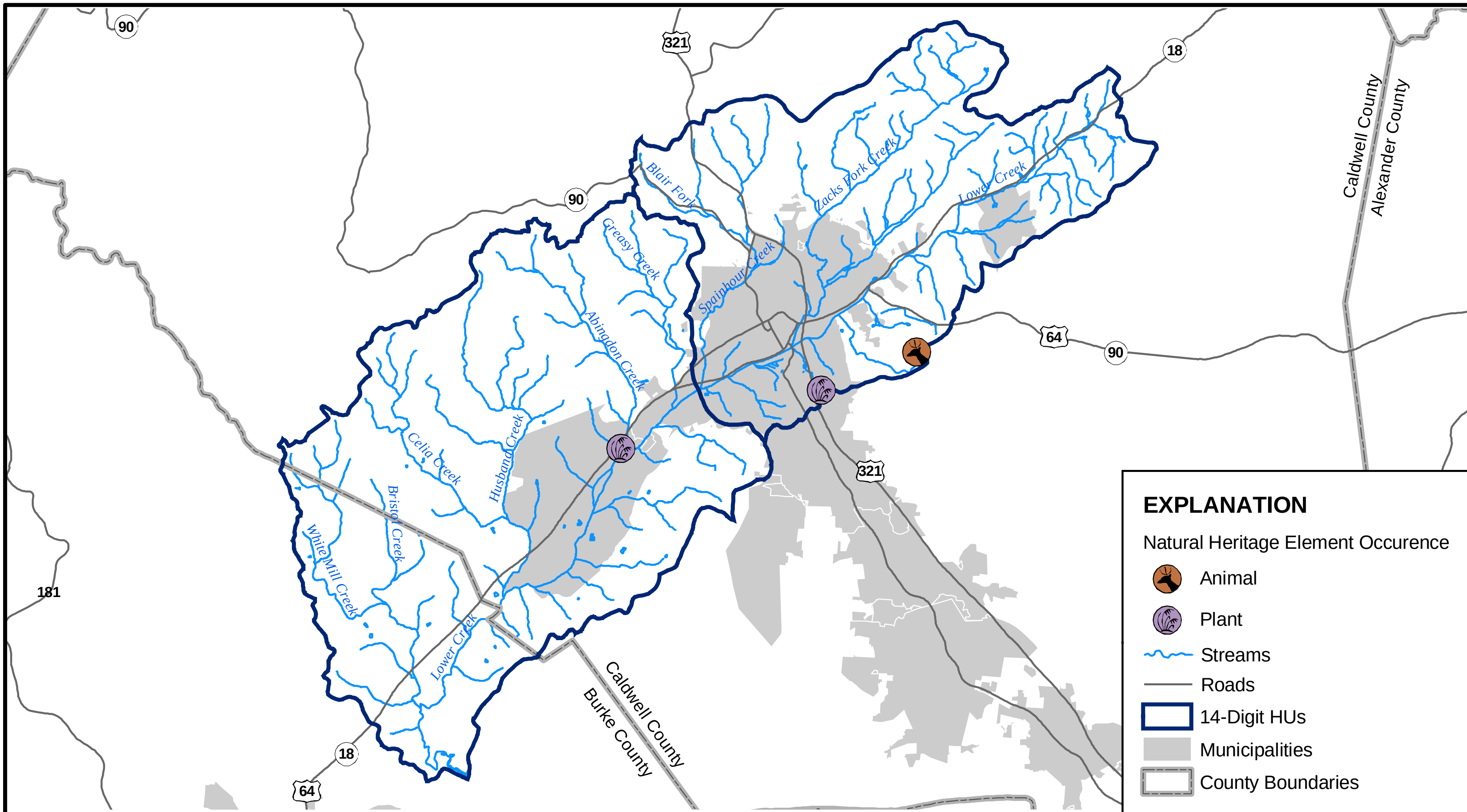
NC Ecosystem Enhancement Program
Catawba River Basin LWP
Lower Creek Subbasin (03050101)

MACTEC

NCDWQ Monitoring Sites

Project 6470030275

Figure A-12



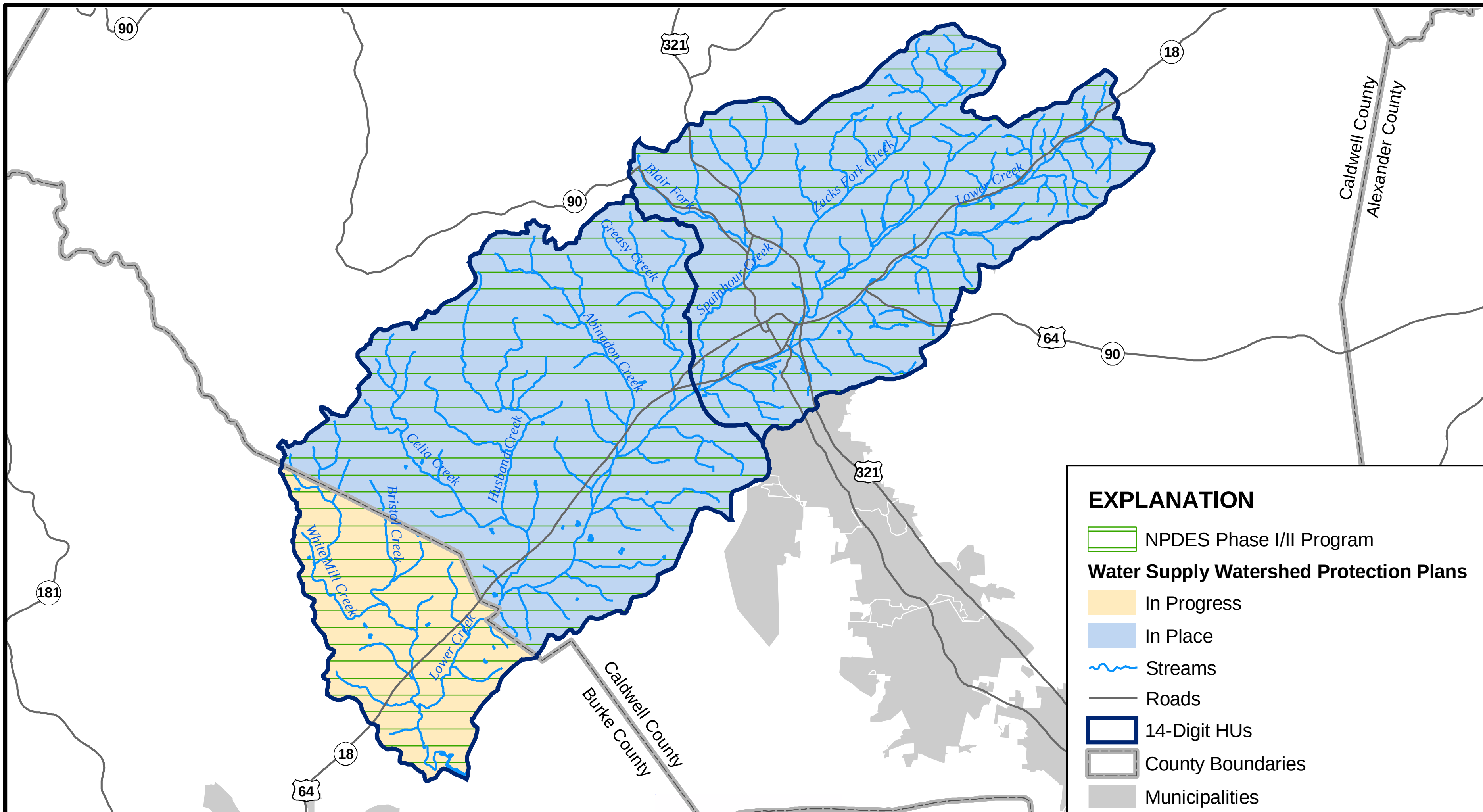
0 1 2 4 6 Miles

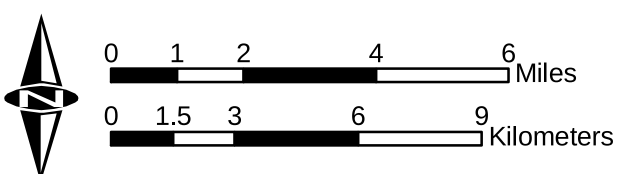
0 1.5 3 6 9 Kilometers

Data Source(s): NCCGIA, NHP

Prepared / Date:
Checked / Date:

NC Ecosystem Enhancement Program Catawba River Basin LWP Lower Creek Subbasin (03050101)		BasinPro Natural Resources Project 6470030275 Figure A-13





Data Source(s): NCCGIA

Prepared / Date:
Checked / Date:

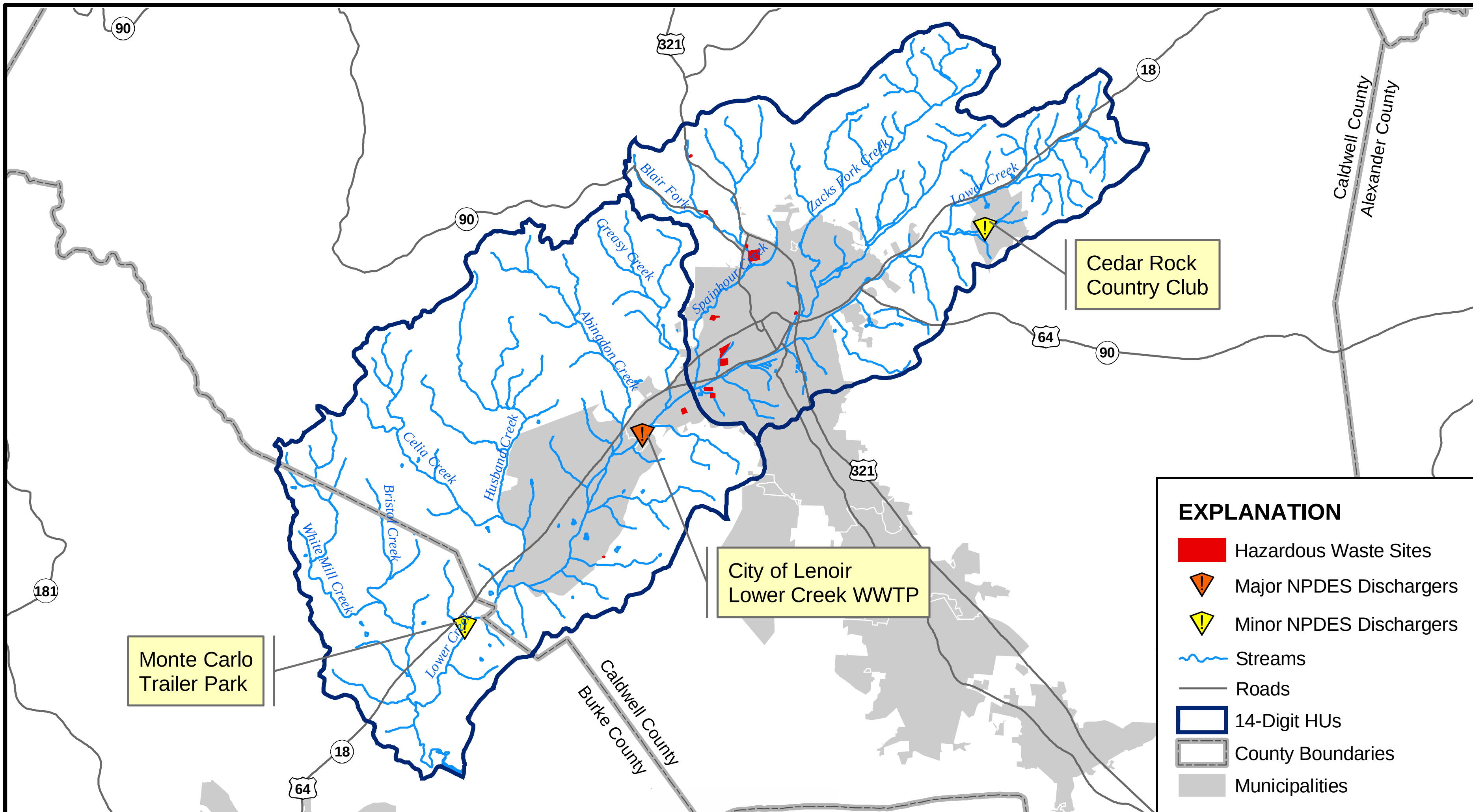
NC Ecosystem Enhancement Program
Catawba River Basin LWP
Lower Creek Subbasin (03050101)

MACTEC

BasinPro Planning Programs

Project 6470030275

Figure A-14



0 1 2 4 6 Miles
0 1.5 3 6 9 Kilometers

Ecosystem Enhancement Program

Data Source(s): NCCGIA, NCDWQ,
NC Division of Waste Management

Prepared / Date:
Checked / Date:

NC Ecosystem Enhancement Program
Catawba River Basin LWP
Lower Creek Subbasin (03050101)

MACTEC

BasinPro Pollution Sources

Project 6470030275

Figure A-15

APPENDIX B

INITIAL VISUAL ASSESSMENT OF THE LOCAL WATERSHED

TECHNICAL MEMORANDUM

DATE: October 20, 2003

TO: Project File

FROM: Greta Hawkins; Ben Leatherland

THROUGH: Richard Darling

SUBJECT: Catawba River Basin Local Watershed Planning
Initial Visual Assessment of the Watershed

COPIES: Kristin Cozza

MACTEC has performed a series of visual assessments in the Catawba (Cataloguing Unit 03050101) Lower Creek Basin (62,833.1 acres, 98.2 square miles) located in Caldwell and Burke Counties, North Carolina. A "windshield survey" of the two local watersheds (Hydrologic Units 80010 and 80020) comprising the study area was performed on July 30, 2003 by MACTEC personnel and DWQ staff around the City of Lenoir and Lower Creek. On September 4 and 19, 2003, MACTEC personnel reviewed additional areas of the watershed at road crossings and other accessible points along the tributaries to Lower Creek (Figure 1). MACTEC used these visual assessments to characterize the watershed and determine some initial restoration opportunities (Table 1).

Similar stream conditions were observed during all three field reviews. The major areas of concern in this basin include lack of riparian buffers, presence of livestock in the streams, previous channelization, stream bank erosion, sedimentation, potential furniture and timber production impacts, and point source pollution. While these issues may have degraded water quality, aquatic habitat, and natural hydrology of streams in the basin, such impairment also provides opportunities for enhancement and restoration.

During visual assessment efforts, riparian buffers were generally found to be either sparse or absent along many stream channels. This was particularly evident at Country Acres Golf Course, where no buffers exist along an unnamed tributary to Husband Creek (Figures 2 and 3), and at the Lenoir Golf Club, where no buffers exist along either Zack's Fork Creek or Lower Creek (Figures 4, 5, and 6). Re-establishing appropriate riparian buffers in these areas could significantly reduce active streambank erosion along these channels. Further upstream, narrow riparian buffers were observed along Lower Creek (low woody vegetation along the streambanks), though such vegetation was largely absent along most reaches (Figures 7 through 10).

Visual assessment efforts also revealed that livestock have access to streams in at least three locations; along Zack's Fork Creek, Lower Creek, and a tributary to Lower Creek. Cattle have access to Zack's Fork Creek on both sides of the Cottrell Hill Road bridge (Figures 11, 12, and 13). Cattle also cross underneath the Rocky Road bridge, with access to Lower Creek (Figures 14 and 15). The North Carolina Wetland Restoration Program (NCWRP) is currently evaluating specific reaches of Lower Creek near Rocky Road for restoration (Figures 16 through 19). An unnamed tributary to Lower Creek is the water source for a cattle farm along Jay Clark Road (Figures 20 and 21). Fencing these streams and providing alternative water sources would be an important component of restoration projects at these locations.

Channelized streams were observed throughout the Blair Fork sub-watershed. Indian Grave Road and Valway Road are both located within ten feet of the Blair Fork channel. MACTEC personnel observed piles of riprap apparently to continue channelization of Blair Fork along Valway Road (Figure 22). An unnamed tributary to Husband Creek appears to have been channelized through the Country Acres Golf Course (see Figures 2 and 3). Husband Creek also appears to have been channelized at a tree farm on Fleming Chapel Church Road (Figures 23 and 24). Similar modifications have likely occurred at locations along Zack's Fork, where additional cornfields and tree farms were observed.

Increased sedimentation was noted in the majority of streams observed within the basin. Construction activities along Zack's Fork Road (as observed on 9/4/03) may be contributing to sedimentation in Zack's Fork Creek. Eroding streambanks at tree farms on Hartland Road and Fleming Chapel Church Road (see Figures 23 and 24) and cornfields along Zack's Fork Road and Valway Road may also be contributing sediment to the basin's stream channels. A new residential development (Middleton Place) is in the early stages of construction near an unnamed tributary to Lower Creek (Figure 25). No erosion control measures were observed at this location during visual assessment efforts. Additional sedimentation may have also previously resulted from dam removal, as observed along Zack's Fork Creek (Figures 26 and 27).

Several furniture and timber production facilities were observed along North Carolina Highway 90 (NC-90), adjacent to Blair Fork. These facilities may pose some contamination risk, depending on wood treatment chemical use, storage, and disposal. These facilities should be monitored and assessed for possible restoration potential or storm water best management practice (BMP) retrofits.

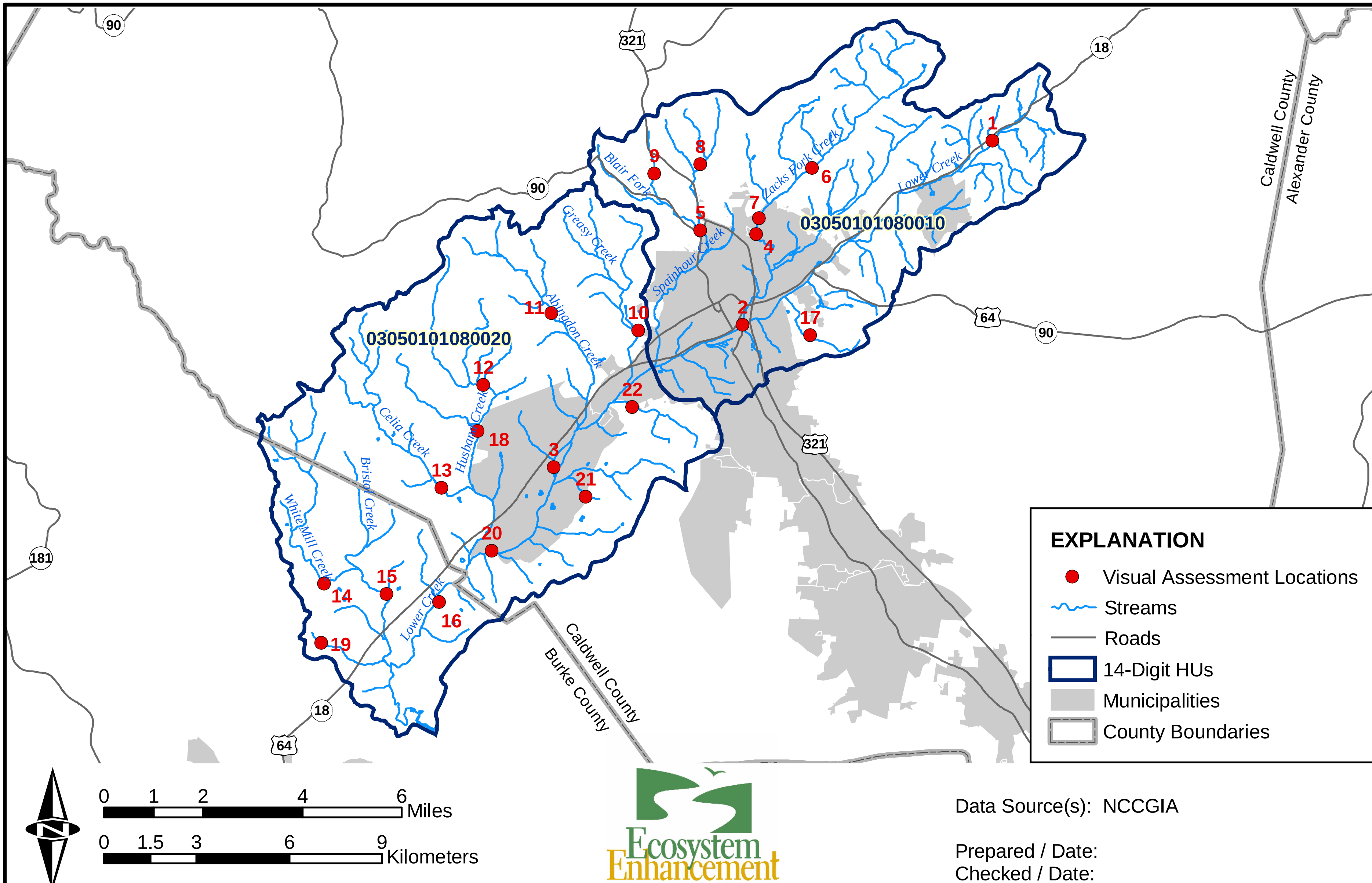
One major NPDES discharger and five minor NPDES dischargers are located within the watershed. During field reconnaissance efforts, MACTEC personnel observed two of these dischargers, Monte Carlo trailer park – a minor discharger – and the City of Lenoir Waste Water Treatment Plant – a major discharger. These sites may be considered for future water quality monitoring.

Based on three days of field visits to the watershed, it appears that current land use practices may provide restoration opportunities in three areas. First, streams with cattle access can be restored by excluding cattle and restoring the eroding banks. Second, channelized reaches in agricultural areas (i.e., tree farms and cornfields) may be restored to more appropriate sinuosity. Third, stream reaches with little or no buffer may be protected and planted to increase the riparian buffer. The most beneficial restoration sites appear to be those streams with cattle access that have been channelized and have little or no buffer. MACTEC personnel will continue to perform visual assessments of the watershed to determine other restoration opportunities.

Attachments:

Figure 1: Initial Visual Assessment Locations
Table 1: Initial Visual Assessment Summary
Figure 2: Unnamed Tributary to Husband Creek at Country Acres Golf Course, facing downstream
Figure 3: Unnamed Tributary to Husband Creek at Country Acres Golf Course, facing upstream
Figure 4: Zacks Fork Creek at Lenoir Golf Club (Norwood Street)
Figure 5: Zacks Fork Creek at Lenoir Golf Club (Norwood Street)
Figure 6: Lower Creek at Lenoir Golf Club (Norwood Street)
Figure 7: Lower Creek at NC-18 Farm Road, facing downstream
Figure 8: Lower Creek at NC-18 Farm Road, facing upstream
Figure 9: Tributary to Lower Creek at NC-18 Farm Road, confluence
Figure 10: Tributary to Lower Creek at NC-18 Farm Road, facing upstream
Figure 11: Tributary to Zack's Fork Creek at Cottrell Hill Road bridge, facing upstream
Figure 12: Tributary to Zack's Fork Creek at Cottrell Hill Road bridge, facing downstream
Figure 13: Tributary to Zack's Fork Creek at Cottrell Hill Road bridge, facing downstream
Figure 14: Lower Creek at Rocky Road bridge, facing upstream
Figure 15: Lower Creek at Rocky Road bridge, facing downstream
Figure 16: Lower Creek (potential NCWRP project site), facing downstream
Figure 17: Lower Creek (potential NCWRP project site), facing upstream
Figure 18: Lower Creek (potential NCWRP project site), facing upstream
Figure 19: Lower Creek (potential NCWRP project site), tributary

Figure 20: Unnamed tributary to Lower Creek at Cattle farm along Jay Clark Road
Figure 21: Unnamed tributary to Lower Creek at Cattle farm along Jay Clark Road
Figure 22: Blair Fork at H. Parsons, Inc. on Valway Road, downstream
Figure 23: Husband Creek at Tree farm on Fleming Chapel Church Road, facing downstream
Figure 24: Husband Creek at Tree farm on Fleming Chapel Church Road, facing upstream
Figure 25: Unnamed tributary to Lower Creek at Middleton Place Subdivision
Figure 26: Relic Pond Site on Zack's Fork Creek, facing upstream
Figure 27: Relic Pond Site on Zack's Fork Creek, facing upstream
Figure 28: Blair Fork at Valway Road (in front of Blair Fork Baptist Church), facing downstream
Figure 29: Blair Fork at Valway Road (in front of Blair Fork Baptist Church), facing upstream
Figure 30: Zack's Fork Creek at City of Lenoir Rotary Soccer Complex
Figure 31: Zack's Fork Creek at City of Lenoir Rotary Soccer Complex, facing upstream
Figure 32: Drainage ditch that runs into Zack's Fork Creek at City of Lenoir Rotary Soccer Complex
Figure 33: Drainage ditch that runs into Zack's Fork Creek at City of Lenoir Rotary Soccer Complex
Figure 34: Unnamed tributary to Blair Fork at Indian Grave Road, facing upstream
Figure 35: Unnamed tributary to Blair Fork at Indian Grave Road, facing downstream
Figure 36: Blair Fork at Valway Road, facing upstream
Figure 37: Blair Fork at Valway Road, facing downstream
Figure 38: Greasy Creek at Abington Road bridge, facing upstream
Figure 39: Greasy Creek at Abington Road bridge, facing downstream
Figure 40: Greasy Creek at Abington Road bridge, facing downstream
Figure 41: Abingdon Creek at Deerbrook Road, facing upstream
Figure 42: Abingdon Creek at Deerbrook Road, facing downstream
Figure 43: Celia Creek at Hartland Road, facing upstream
Figure 44: Celia Creek at Hartland Road, facing downstream
Figure 45: Celia Creek at Hartland Road
Figure 46: White Mill Creek at Piney Road, facing upstream
Figure 47: White Mill Creek at Piney Road, facing downstream
Figure 48: Bristol Creek at Hartland Road, facing upstream
Figure 49: Bristol Creek at Hartland Road, facing downstream
Figure 50: Lower Creek at Antioch Road, facing upstream
Figure 51: Lower Creek at Antioch Road, facing downstream
Figure 52: Unnamed tributary to Lower Creek at Haigler Road, facing upstream
Figure 53: Unnamed tributary to Lower Creek at Haigler Road, facing downstream
Figure 54: Lower Creek at Calico Road bridge, facing upstream
Figure 55: Lower Creek at Calico Road bridge, facing downstream
Figure 56: Unnamed tributary to Lower Creek at Craigs Mountain Road, facing upstream
Figure 57: Unnamed tributary to Lower Creek at Craigs Mountain Road, facing downstream
Figure 58: Miller Creek at Miller Hill Road bridge, facing upstream
Figure 59: Miller Creek at Miller Hill Road bridge, facing downstream



Ecosystem Enhancement PROGRAM

Data Source(s): NCCGIA

Prepared / Date:
Checked / Date:

NC Ecosystem Enhancement Program
Catawba River Basin LWP
Lower Creek Subbasin (03050101)

MACTEC

Initial Visual Assessment Locations

Project 6470030275

Figure B-1

LOCATION[1]	LOCATION DESCRIPTION	LATITUDE / LONGITUDE	UPSTREAM OBSERVATIONS	DOWNSTREAM OBSERVATIONS	POTENTIAL OPPORTUNITY	COMMENTS	PHOTO (Figure)
1	Lower Creek at Farm road off NC-18	35°57'47.9" N 81°26'28.7" W	active cropland within 15 feet of stream, sparse riparian vegetation, channel incision	channel incision, sparse riparian vegetation, sediment deposition from tributary	riparian buffer restoration; streambank stabilization	sandy substrate, minimal riffle habitat	7, 8, 9, 10
2	Zack's Fork Creek and Lower Creek at Lenoir Golf Club	35°54'28.3" N 81°31'42.3" W	sparse riparian vegetation; significant channel incision; in-stream sedimentation	greater riparian vegetation density near confluence; channel incision	stream restoration or enhancement; riparian buffer restoration; stormwater management	sandy substrate; potential thermal impairment	4, 5, 6
3	Lower Creek at Rocky Road bridge (potential NCWRP restoration project)	35°51'54.8" N 81°35'43.2" W	significant streambank instability and channel incision; cattle crossing underneath bridge with access to stream	significant streambank instability and channel incision	stream enhancement/ restoration; streambank stabilization; cattle exclusion and alternative water source	sedimentation; large point bars; mass wasting of streambanks	14, 15, 16, 17, 18, 19
4	Relic pond site on Zack's Fork Creek	35°56'04.5" N 81°31'26.6" W	forested riparian corridor; remnants of previous structures on floodplain	naturalized previous channel incision; urban area	stream restoration/ enhancement; sediment removal BMP	downstream city park; greenway trail along stream floodplain; potential utility conflicts	26, 27

LOCATION[1]	LOCATION DESCRIPTION	LATITUDE / LONGITUDE	UPSTREAM OBSERVATIONS	DOWNSTREAM OBSERVATIONS	POTENTIAL OPPORTUNITY	COMMENTS	PHOTO (Figure)
5	Blair Fork Creek at Valway Road (NC-90, near Blair Fork Baptist Church)	35°56'7.5" N 81°32'42.1" W	railroad ROW, roadway ROW, and utility line ROW; channel incision; Burns Oil Company; furniture and lumber companies upstream; riprap from railroad tressle	bedrock exposure; railroad ROW, roadway ROW, and utility line ROW; channel incision; crosses under SR90 and runs along Thomasville furniture plant	stream enhancement; riparian buffer restoration; potential monitoring site	potential infrastructure and utility conflicts; limited belt width; decrease in observed macobenthics compared to upstream	28, 29
6	Tributary to Zack's Fork Creek at Cottrell Hill Road bridge	35°57'16.2" N 81°30'19.1" W	obvious cattle entrance in the stream; substrate - sandy with a little silt; channel widens before bridge (due to cattle)	another cattle entrance; water clear; riffles just below bridge; channel narrows from ~20 ft to ~5 ft	cattle exclusion devices; riparian buffer restoration		11, 12, 13
7	Lenoir Rotary Soccer Complex (Zack's Fork Creek)	35°56'21.9" N 81°31'26.3" W	construction up to and potentially within channel; bank is steep and unvegetated	stream runs into forest after soccer fields; good riparian buffer; dumping dirt from construction of drainage ditch on hill above stream	riparian buffer restoration	excavating culvert along edge of soccer field; turbid release into channel	30, 31, 32, 33
8	Unnamed tributary to Blair Fork at Indian Grave Road	35°57'17.4" N 81°32'43.7" W	sandy substrate; clear water; channel width ~2.5 ft; moderate overhanging vegetation; no functional buffer on left side due to road; sand deposition	sandy with some pebbles; channel width ~4ft; no buffer on right due to road; adequate buffer on left	add sinuosity		34, 35

LOCATION[1]	LOCATION DESCRIPTION	LATITUDE / LONGITUDE	UPSTREAM OBSERVATIONS	DOWNSTREAM OBSERVATIONS	POTENTIAL OPPORTUNITY	COMMENTS	PHOTO (Figure)
9	Blair Fork at Valway Road	35°57'06.0" N 81°33'43.2" W	Thick vegetation over creek; channel ~ 2ft wide; some rocks	sediment deposit at end of large metal culvert; some riprap; right side is mowed lawn right up to the stream	contact landowners to increase buffer zone by planting and not mowing up to stream	Jones - 2185 Valway Road	36, 37
10	Greasy Creek at Abington Road bridge	35°54'20.8" N 81°33'58.8" W	sandy bottom covering some rocks near bridge; good buffer with overhanging vegetation	wider channel ~10 ft; tire in middle of channel; coarser sediment; buffer not as functional; pasture on right; few trees on left	riparian buffer restoration	small electric fence may be preventing cattle access to stream	38, 39, 40
11	Abingdon Creek at Deerbrook Road	35°54'36.8" N 81°35'51.2" W	dense vegetation; sandy substrate	rocks/riffles just past road; sandy with some pebbles; meandering; no buffer on right (yard)	contact landowner about increasing buffer		41, 42
12	unnamed tributary to Husband Creek at Country Acres Golf Course	35°53'19.4" N 81°37'17.3" W	no buffer, open through golf course; sandy bottom; channel ~5 ft.	more sandy - pebbly; small buffer for about 200 ft then open again	contact golf course to increase buffer by planting and not mowing up to stream (also check for chemicals/fertilizers in the stream)	Country Acres Golf Course (754-1992)	2, 3

LOCATION[1]	LOCATION DESCRIPTION	LATITUDE / LONGITUDE	UPSTREAM OBSERVATIONS	DOWNSTREAM OBSERVATIONS	POTENTIAL OPPORTUNITY	COMMENTS	PHOTO (Figure)
13	Celia Creek at Hartland Road	35°51'30.1" N 81°38'7.4" W	dense vegetation; fast flow; some rocks; sediment in water (not clear)	grassy island in middle - water only flowing to the right of island; sediment in water; vegetative buffer; tree farm to the left	possible water quality monitoring site	Lelia Tuttle Recreation Center (on right when looking downstream) - property of Little John Methodist Church - for info call 758-0832	43, 44, 45
14	White Mill Creek at Piney Road	35°49'45.9" N 81°40'35.8 W	Sediment buildup upstream of rock riffle (artificial?); adequate buffer - dense vegetation; clear water	sandy substrate; dense overhanging vegetation; adequate buffer; clear water	preservation		46, 47
15	Bristol Creek at Hartland Road	35°49'36.7" N 81°39'14.6" W	sandy; adequate vegetation (some trees)	better buffer - adequate vegetation; water slightly turbid; sandy	riparian buffer restoration; bank stabilization	barking dogs not tied up; adjacent properties - 2811, 2862, 2877 Hartland Rd.	48, 49
16	Lower Creek at Antioch Road	35°49'30.0" N 81°38'6.9" W	High turbidity; ~60 ft wide; stream at bankfull; unstable banks; trees on either side - adequate buffer	Turbid water; inadequate buffer on left; channel width about same	stream bank stabilization	Monte Carlo Trailer Park (minor NPDES discharger) nearby; numerous garbage trucks driving by	50, 51

LOCATION[1]	LOCATION DESCRIPTION	LATITUDE / LONGITUDE	UPSTREAM OBSERVATIONS	DOWNSTREAM OBSERVATIONS	POTENTIAL OPPORTUNITY	COMMENTS	PHOTO (Figure)
17	unnamed tributary to Lower Creek at Haigler Road	35°54'20.2" N 81°30'16.1" W	adequate vegetative buffer; undercut at pipe under road; sediment buildup on right bank; pipe crossing stream	undercut at pipe; pool with fish just after road; sediment built up just after pool; exposed rock; open pasture with minimal buffer	riparian buffer restoration; riprap to attenuatre velocity through pipe	138, 140, 141 Haigler Rd.	52, 53
18	Husband Creek at Tree farm on Fleming Chapel Church Road	35°52'30.8" N 81°37'22.8" W	stream straight (channelized?); adequate buffer on opposite bank; inadequate buffer on the farm side	same as upstream	increase sinuosity of channel		23, 24
19	unnamed tributary to Lower Creek at Cattle farm along Jay Clark Road	35°48'43.5" N 81°40'37.6 W	Active erosion channels in adjacent pasture; cattle access to a small tributary	same as upstream	cattle exclusion devices; increase vegetation on hills	possible wetland area upstream of road; kudzu on trees; 2261 Jay Clark Rd.(property across street from cattle farm)	20, 21
20	Lower Creek at Calico Road bridge	35°50'25.1" N 81°37'00.4" W	high turbidity	log in middle of channel	none	wide channel with lots of overhanging vegetation	54, 55
21	unnamed tributary to Lower Creek at Craigs Mountain Road	35°51'24.5" N 81°35'00.8" W	rocky substrate, not much sediment; adequate buffer - many old trees	right is horse field, horses do not access stream; adequate buffer - old hardwoods	increase buffer through horse pasture	2013 Craigs Mtn. Rd. (property on left upstream)	56, 57

LOCATION[1]	LOCATION DESCRIPTION	LATITUDE / LONGITUDE	UPSTREAM OBSERVATIONS	DOWNSTREAM OBSERVATIONS	POTENTIAL OPPORTUNITY	COMMENTS	PHOTO (Figure)
22	Miller Creek at Miller Hill Road bridge	35°52'59.9" N 81°34'04.1" W	PET distribution center on left with paved and gravel parking lots	factory on right (Broyhill furniture); clear water; may be channelized?; adequate buffer	possible water quality monitoring site		58, 59

[1] See Figure 1

Prepared / Date: *GKH 10/17/03*
Checked / Date:

Figure 2: Unnamed Tributary to Husband Creek at Country Acres Golf Course, facing downstream

Figure 3: Unnamed Tributary to Husband Creek at Country Acres Golf Course, facing upstream

Figure 4: Zacks Fork Creek at Lenoir Golf Club (Norwood Street)

Figure 5: Zacks Fork Creek at Lenoir Golf Club (Norwood Street)

Figure 6: Lower Creek at Lenoir Golf Club (Norwood Street)

Figure 7: Lower Creek at NC-18 Farm Road, facing downstream

Figure 8: Lower Creek at NC-18 Farm Road, facing upstream

Figure 9: Tributary to Lower Creek at NC-18 Farm Road, confluence

Figure 10: Tributary to Lower Creek at NC-18 Farm Road, facing upstream

Figure 11: Tributary to Zack's Fork Creek at Cottrell Hill Road bridge, facing upstream

Figure 12: Tributary to Zack's Fork Creek at Cottrell Hill Road bridge, facing downstream

Figure 13: Tributary to Zack's Fork Creek at Cottrell Hill Road bridge, facing downstream

Figure 14: Lower Creek at Rocky Road bridge, facing upstream

Figure 15: Lower Creek at Rocky Road bridge, facing downstream

Figure 16: Lower Creek (potential NCWRP project site), facing downstream

Figure 17: Lower Creek (potential NCWRP project site), facing upstream

Figure 18: Lower Creek (potential NCWRP project site), facing upstream

Figure 19: Lower Creek (potential NCWRP project site), tributary

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Figure 22: Blair Fork at H. Parsons, Inc. on Valway Road, downstream

Figure 23: Husband Creek at Tree farm on Fleming Chapel Church Road, facing downstream

Figure 24: Husband Creek at Tree farm on Fleming Chapel Church Road, facing upstream

Figure 25: Unnamed tributary to Lower Creek at Middleton Place Subdivision

Figure 26: Relic Pond Site on Zack's Fork Creek, facing upstream

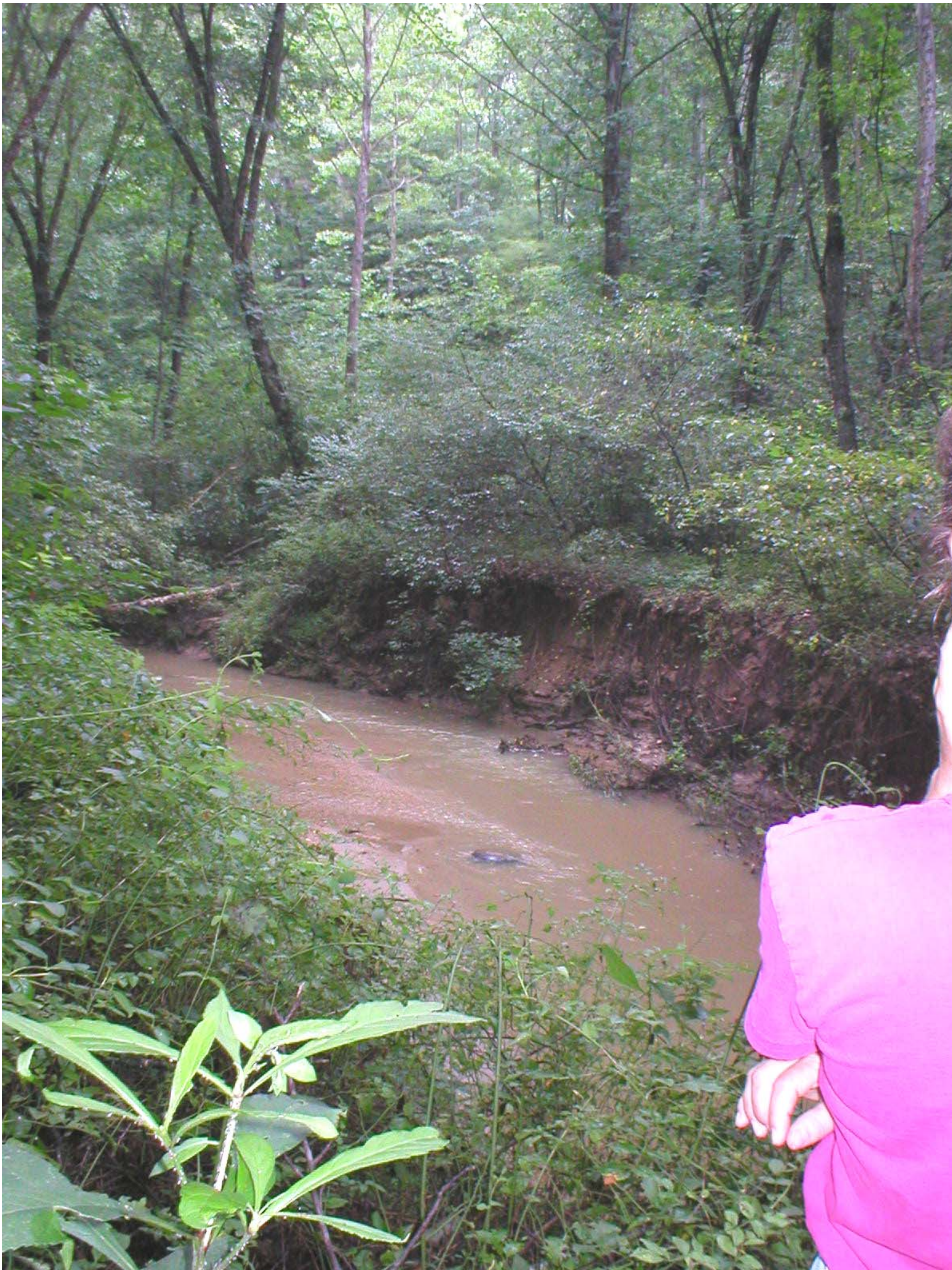


Figure 27: Relic Pond Site on Zack's Fork Creek, facing upstream

Figure 28: Blair Fork at Valway Road (in front of Blair Fork Baptist Church), facing downstream

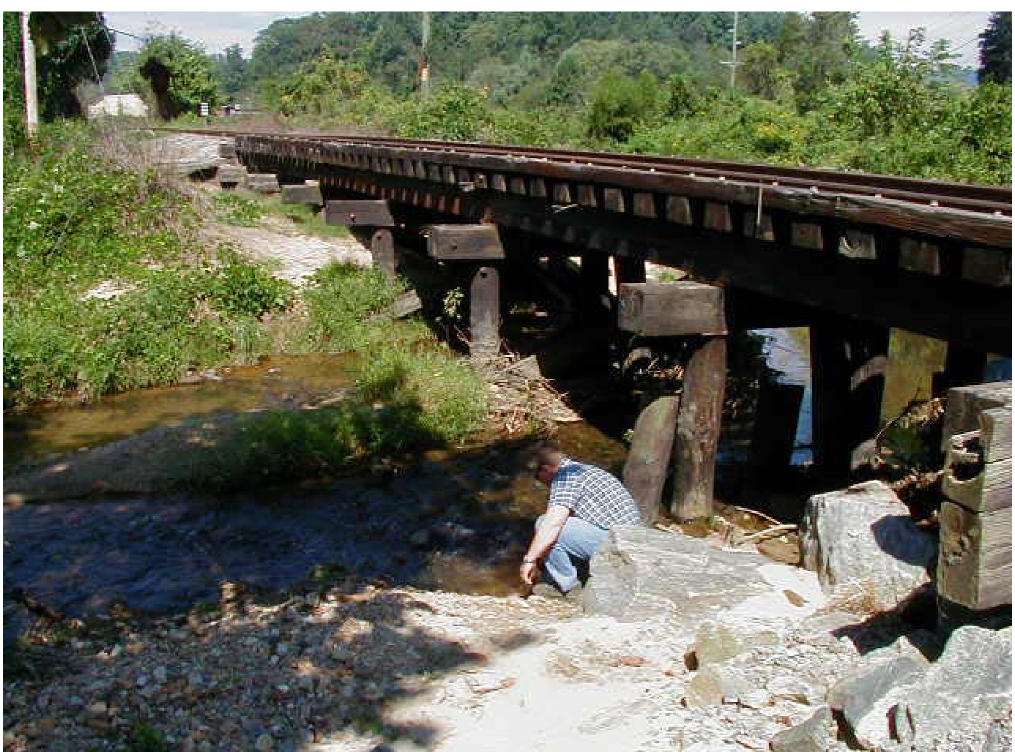


Figure 29: Blair Fork at Valway Road (in front of Blair Fork Baptist Church), facing upstream

Figure 30: Zack's Fork Creek at City of Lenoir Rotary Soccer Complex

Figure 31: Zack's Fork Creek at City of Lenoir Rotary Soccer Complex, facing upstream

Figure 32: Drainage ditch that run into Zack's Fork Creek at City of Lenoir Rotary Soccer Complex

Figure 33: Drainage ditch that runs into Zack's Fork Creek at City of Lenoir Rotary Soccer Complex

Figure 34: Unnamed tributary to Blair Fork at Indian Grave Road, facing upstream

Figure 35: Unnamed tributary to Blair Fork at Indian Grave Road, facing downstream

Figure 36: Blair Fork at Valway Road, facing upstream

Figure 37: Blair Fork at Valway Road, facing downstream

Figure 38: Greasy Creek at Abington Road bridge, facing upstream

Figure 39: Greasy Creek at Abington Road bridge, facing downstream

Figure 40: Greasy Creek at Abington Road bridge, facing downstream

Figure 41: Abingdon Creek at Deerbrook Road, facing upstream

Figure 42: Abingdon Creek at Deerbrook Road, facing downstream

Figure 43: Celia Creek at Hartland Road, facing upstream

Figure 44: Celia Creek at Hartland Road, facing downstream

Figure 45: Celia Creek at Hartland Road

Figure 46: White Mill Creek at Piney Road, facing upstream

Figure 47: White Mill Creek at Piney Road, facing downstream

Figure 48: Bristol Creek at Hartland Road, facing upstream

Figure 49: Bristol Creek at Hartland Road, facing downstream

Figure 50: Lower Creek at Antioch Road, facing upstream

Figure 51: Lower Creek at Antioch Road, facing downstream

Figure 52: Unnamed tributary to Lower Creek at Haigler Road, facing upstream

Figure 53: Unnamed tributary to Lower Creek at Haigler Road, facing downstream

Figure 54: Lower Creek at Calico Road bridge, facing upstream

Figure 55: Lower Creek at Calico Road bridge, facing downstream

Figure 56: Unnamed tributary to Lower Creek at Craigs Mountain Road, facing upstream

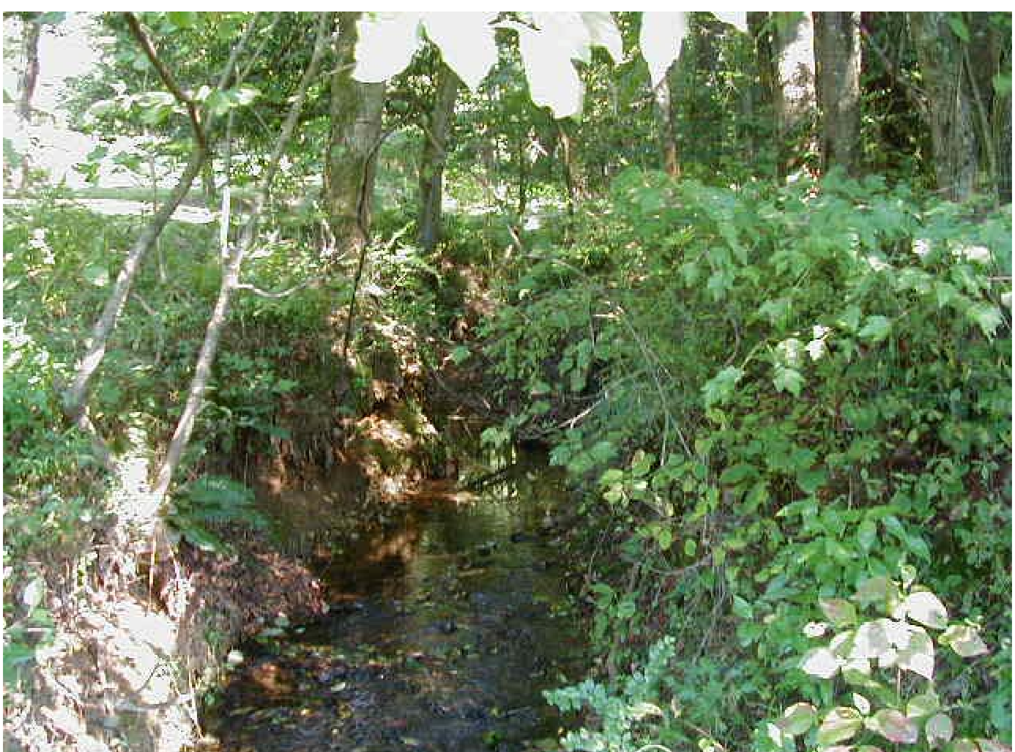


Figure 57: Unnamed tributary to Lower Creek at Craigs Mountain Road, facing downstream

Figure 58: Miller Creek at Miller Hill Road bridge, facing upstream

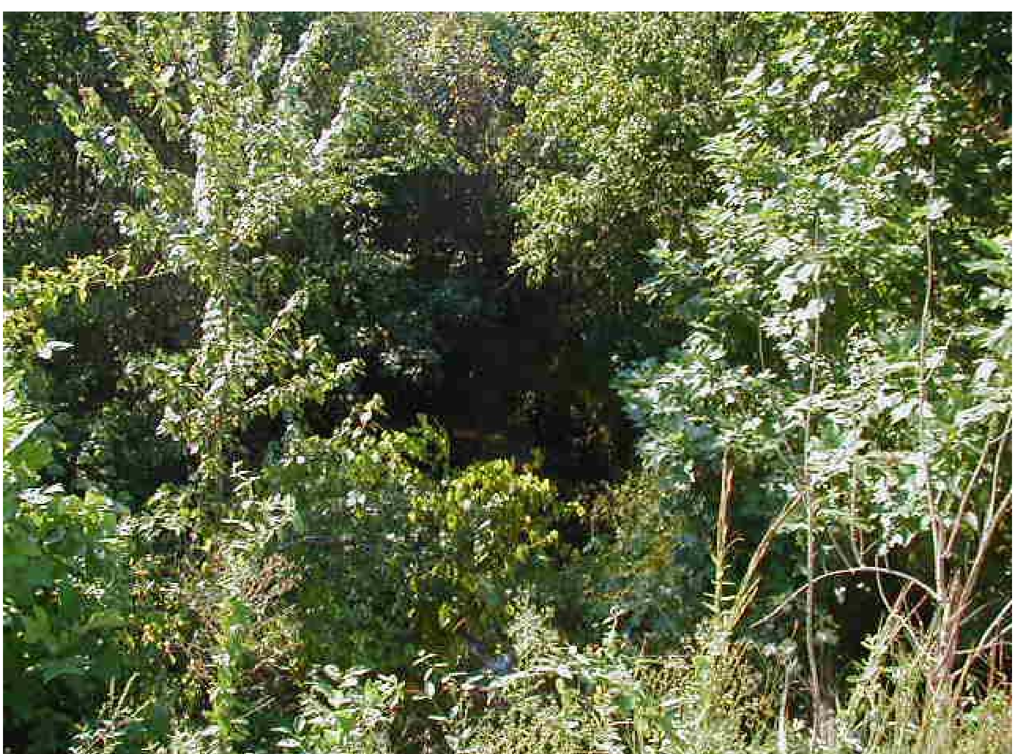


Figure 59: Miller Creek at Miller Hill Road bridge, facing downstream

APPENDIX C

SUBWATERSHED DELINEATION

MACTEC

TECHNICAL MEMORANDUM

DATE: January 27, 2004

TO: Project File

FROM: Ben Leatherland; Greta Hawkins

THROUGH: Richard Darling

SUBJECT: Catawba River Basin Local Watershed Planning
Subwatershed Delineation

COPIES: Kristin Cozza

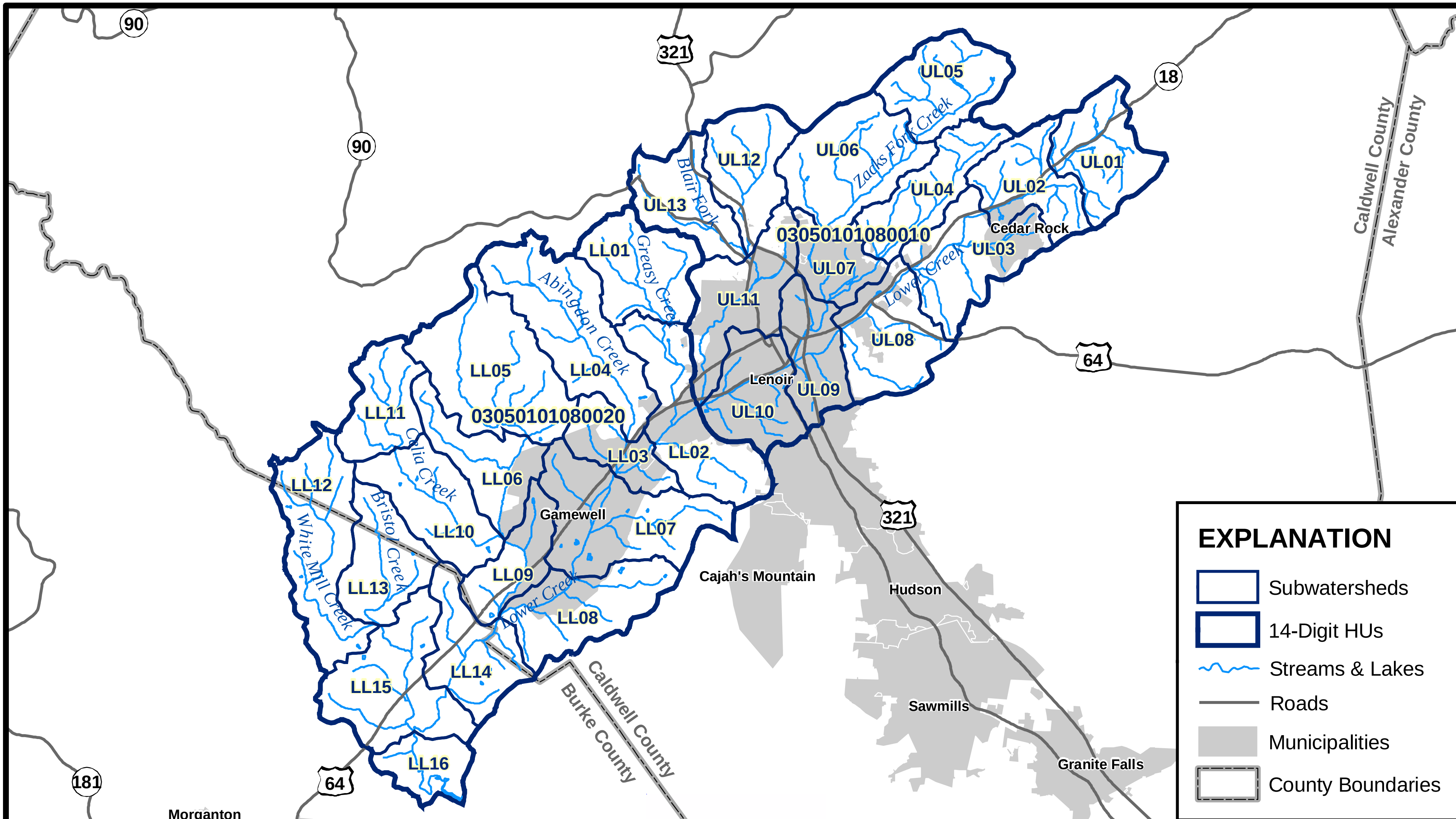
MACTEC has divided the Catawba River Cataloguing Unit 03050101 (Lower Creek Local Watershed) into 29 individual subwatersheds (Figure C-1). The local watershed includes Hydrologic Unit (HU) 03050101080010 (Upper Lower Creek) and HU 03050101080020 (Lower Lower Creek). The Lower Creek Local Watershed is approximately 62,833.1 acres in extent (approximately 98.2 square miles). The delineated subwatersheds will be used to rank and prioritize portions of the Lower Creek study area for restoration and preservation efforts. The delineated subwatersheds range in size from 1.66 square miles (LL16) to 5.67 square miles (LL05) (Table C-1). Subwatershed delineation involved creating subwatersheds for each tributary and stream segments between tributaries. Subwatersheds with similar land use were aggregated to arrive at the final 29 subwatersheds.

Table C-1: Lower Creek Subwatersheds

SUBWATERSHED	APPROXIMATE AREA (SQUARE MILES)	SUBWATERSHED	APPROXIMATE AREA (SQUARE MILES)
UL01	3.12	LL01	3.42
UL02	2.83	LL02	4.29
UL03	3.83	LL03	1.96
UL04	2.94	LL04	5.33
UL05	3.15	LL05	5.67
UL06	4.50	LL06	2.90
UL07	1.85	LL07	5.07
UL08	3.52	LL08	3.71
UL09	2.44	LL09	2.15
UL10	3.00	LL10	3.44
UL11	3.66	LL11	2.51
UL12	2.95	LL12	4.76
UL13	2.81	LL13	2.99
		LL14	3.11
		LL15	4.62
		LL16	1.66

Attachments:

Figure C-1: Sub-watershed Delineation



Data Source(s): NCCGIA

Prepared / Date:
Checked / Date:

NC Ecosystem Enhancement Program Catawba River Basin LWP Lower Creek Subbasin (03050101)	MACTEC	Subwatershed Designations Project 6470030275 Figure C-1

Watershed Assessment Report

February 14, 2006

Ecosystem Enhancement PROGRAM

Catawba River Basin

Lower Creek Watershed

Caldwell and Burke Counties

MACTEC

MACTEC Engineering and Consulting

3301 Atlantic Avenue • Raleigh, NC 27604

WATERSHED ASSESSMENT REPORT

LOWER CREEK WATERSHED, CATAWBA RIVER BASIN

LOCAL WATERSHED PLANNING (PHASE II)

CALDWELL AND BURKE COUNTIES

NORTH CAROLINA

Prepared For:

North Carolina Ecosystem Enhancement Program
2090 U.S. 70 Highway
Swannanoa, NC 28778

Prepared By:

MACTEC Engineering & Consulting, Inc.
3301 Atlantic Avenue
Raleigh, NC 27604

February 14, 2006

MACTEC Project 6470-05-0953

Table of Contents

Appendices

List of Tables

List of Figures

Errata:

There are two errors in the main text of this document that are stated in text and also carried through the functional analysis methods for the water quality metric. These errors were carried from data errors reported by the NC Division of Water Quality. These are:

(1) The text incorrectly states that the NC Division of Water Quality (DWQ) found semi-volatile organic pollutants in the landfill tributary to Blair Fork. They were not found at that location.
(2) DWQ did find a semi-volatile organic pollutant, terpineol, in Zacks Fork. This is not reflected in the main text and analyses.

These errors are corrected in Appendix H, the DWQ's Water Quality Monitoring Report.

I. EXECUTIVE SUMMARY

A. Background

The Lower Creek Watershed, part of the Catawba River Basin, is comprised of two 14-digit hydrologic units (HUs) (03050101080020 "Upper" Lower Creek and 03050101080010 "Lower" Lower Creek), draining an area of approximately 98.2 square miles. The watershed drains into Lake Rhodhiss, the water supply source for Lenoir and Gamewell Communities.

Phase I of the Local Watershed Plan, completed in May 2004, evaluated existing data regarding the hydrology, habitat and water quality functions within the watershed and identified areas for additional analyses. Phase II, initiated in January 2005 developed additional data relating to these three functions through GIS analyses (sinuosity, stream gradient, riparian buffer and impervious cover), field investigation of 82 sites throughout the watershed and water quality sampling at 31 points. The locations of these investigations and sampling points are shown in Figure 1. This watershed assessment report presents the new data, describes the approach taken in gathering and evaluating the data and discusses the findings reached from these analyses.

B. Assessment

For each major functional area (hydrology, habitat and water quality) specific parameters were selected from the Phase II data sources (GIS, field investigation and water quality sampling) to indicate the functional integrity of streams within each subwatershed (Table 1). Values were established for each particular parameter to designate level of function – functioning without stress, functioning but under stress or not functioning. An aggregate score was developed for each of the parameters representing a particular watershed function and this score was then used to assess whether that function was Functioning, Functioning at Risk or Not Functioning, according to the following definitions:

- **Functioning [F]:** the subject watershed function is performing naturally, without evidence of significant degradation or a stressed condition;
- **Functioning at Risk [FR]:** the subject watershed function is currently moderately degraded, but shows evidence of stress such that, without intervention, it could over time become not functioning;
- **Not Functioning [NF]:** the subject watershed function is currently stressed to the level of being highly degraded.

Table 1 Parameters Used for Functional Assessment

Function	PARAMETERS				
Hydrology	Sinuosity	Impervious Cover	Stream Gradient	Site Investigations (Hydrology)	
Habitat	Riparian Buffer	Site Investigations (Habitat)			
Water Quality	Riparian Buffer	Impervious Cover	Site Investigations (Water Quality)	DWQ Phys/Chem Monitoring	DWQ Benthic Monitoring

C. Functional Analyses

Table 2 presents the overall results of the functional analyses of hydrology, habitat, and water quality at the subwatershed level (grouped by mega-subwatershed). This information is also shown graphically on subwatershed maps for each watershed function in Figures 2, 3 and 4. Based upon this analysis, only White Mill Creek, a stream of moderate length (< 10 miles) in a relatively small (< 5 square mile) predominantly rural, undeveloped subwatershed and the upper portion of Abingdon Creek (AC01) a similar but slightly smaller subwatershed, are fully functional across all three watershed functions. In contrast, the lower reach of Spainhour Creek (SC02), a stream/subwatershed of similar scale to ACO1, but in a subwatershed that is highly urbanized is not functioning for all three watershed functions. Similarly, Blair Fork, the lower reach of Greasy Creek (GC02) and the middle of Lower Creek (LC05) are not functioning on the basis of both habitat and water quality due to the urbanized nature of these subwatersheds. Overall, most of the other subwatersheds are functioning at risk, several tending toward not functional on one or more of the three watershed functions.

Table 2 Summary of Functionality by Subwatershed

Subwatershed	Overall Functionality Upper Lower Creek		
	Hydrology	Habitat	Water Quality
ZF01	FR	F	F
ZF02	FR	FR	FR
ZF03	FR	FR	NF
ZFT1	FR	FR	FR
SC01	FR	FR	FR
SC02	NF	NF	NF
BF01	FR	NF	NF
GC01	FR	F	FR
GC02	FR	NF	NF
LC01	FR	F	F
LC02	FR	FR	FR
LC03	FR	FR	FR
LC04	FR	FR	FR
LC05	FR	NF	NF

Subwatershed	Overall Functionality Lower Lower Creek		
	Hydrology	Habitat	Water Quality
AC01	F	F	F
AC02	FR	FR	FR
HC01	FR	FR	FR
HC02	F	F	FR
HC03	FR	F	FR
CC01	F	F	FR
CC02	FR	NF	FR
BC01	F	FR	FR
BC02	FR	NF	FR
WM01	F	F	F
LC06	NF	FR	FR
LC07	FR	FR	FR
LC08	FR	FR	F
LC09	FR	NF	FR
LC10	FR	F	FR

D. Stressors

Table 3 provides a listing of the major stressors that are impacting the functionality of hydrology, habitat, and water quality within the Lower Creek watershed. These contributing factors do not impact the entire watershed uniformly as shown in the stressor table. On a macro level, the Lower Creek watershed can be described as having three distinct parts:

1. A currently rural, mostly forested, steeply sloped area with highly-erodible soils (ZF01, ZF02, ZFT1, SC01, LC01, LC02, LC03). This area is beginning to develop with single family homes on moderate to large lots;

   significant stressors in this area include:
   - channelization from agricultural and development activity;
   - sediment from upland and streambank erosion;
   - inadequate forested buffer from agricultural and development activity; and
   - fecal coliform bacteria from livestock.

2. A central urbanized area, characterized by high percentages of impervious cover, floodplain encroachment and many industrial facilities (LC04, LC05, LC06, LC07, ZF03, SC02, BF01, GC01, GC02);

   significant stressors in this area include:
   - channelization from development activity;
   - stormwater flow from impervious cover;
   - floodplain encroachment from development activity;
   - inadequate forested buffer from agricultural and an development activity;
   - toxicity from illicit connections and old landfill;
   - fecal coliform bacteria from sewer overflows;
   - nutrients from agricultural and landscaping activities; and
   - sediment from instream mining activities.

3. A relatively flatter, rural area with a variety of agricultural activities and forested cover (LC08, LC09, LC10, AC01, AC02, HC01, HC02, HC03, CC01, CC02, BC01, BC02, WM01);

   significant stressors in this area include:
   - Channelization from agricultural and development activity;
   - Sediment from bank erosion;
   - Inadequate forested buffer from agricultural and development activity; and
   - Stormwater flow from impervious cover.

Table 3 Stressors Impacting Watershed Functions

Note: Bolded subwatersheds indicate "not functioning" for at least one function.

Stressor	Source	Function Impacted	Impact	Subwatersheds Affected
Channelization	Alteration from agricultural or land development activities	Hydrology Habitat	– Flooding – Streambank erosion – Streambed scour – Loss of instream habitat – riffles, pools, edge habitat	LC01, LC02, LC03, LC04, **LCO5**, LC06, LC07, **LC08**, LC09, LC10, **ZF02**,, **ZFT1**, **SC01**, **SC02**, BF01, GC01, GC02, AC01, **AC02**, **HC01**, HC02, HC03, CC01, CC02, BC01, **BC02**, WM01
Stormwater Flow	Impervious Cover	Hydrology Habitat	– Flooding from increased peak flows – Streambank erosion – Streambed scour	LC03, LC04, **LC05**, **LC06**, LC07, LC09, **ZF03**, ZFT1, SC01, **SC02**, **BF01**, GC02, AC02, HC01, HC03, CC02,
Floodplain Encroachment	Land Development Activities	Hydrology	– Flooding – Downstream erosion	LCO4, LCO5, LC06, ZF03, SC02
Inadequate Forested Buffer	Agricultural and Land Development Activities	Habitat Water Quality	– Loss of aquatic organic habitat (wood, leaves) – Loss of terrestrial habitat – Sediment from streambank erosion – Non-point source pollution	LC02, LC03, LC04, LCO5, LC06, LC07, LC09, ZF02, ZF03, ZFT1, SC01, SC02, **BF01**, GC01, GC02, HC01, HC02, CC01, CC02, BC01, BC02,
Sediment	Upland Erosion	Water Quality Habitat	– Suspended solids – Homogeneous and embedded substrate	LC01, LC02, LC03, ZF01, ZF02, ZFT1, SC01, GC01
Sediment	Bank Erosion	Water Quality Habitat	– Suspended solids – Homogeneous and embedded substrate	LC03, LC03, LC04, LC05, LC06, LC07, LC08, ZF01, ZF02, ZF03, SC02, GC01, GC02, AC02, HC01, HC02, HC03, CC01, CC02, BC01, BC02
Sediment	In-stream Mining	Water Quality Habitat	– Suspended solids – Homogeneous and embedded substrate	LC06
Fecal Coliform Bacteria	Cattle	Water Quality	– Impacted water quality	LC05, LC08, ZF01, BF01, GC01
Fecal Coliform Bacteria	Sewer Overflows Illicit Connections	Water Quality	– Impacted water quality	ZF03, ZFT1M SC02, **BF01**,
Toxicity	Illicit Connections Legacy Issues	Water Quality	– Loss of aquatic life – Impacted water quality	**LC05**, SC01, **SC02**, **BF01**
Nutrients	Agricultural activity, lawns	Water Quality	– Loss of aquatic life – Algal growth	**SC02**, **BF01**, GC01, **GC02**

E. Watershed – Wide Issues

Major issues contributing to stream degradation within the Lower Creek Watershed that should be considered in developing improvement projects and management strategies include:

1. stream channelization and impervious cover resulting from development activity, increasing stormflow discharge rates and flow velocities;
2. stream channelization resulting from agricultural activity producing streambank erosion and reducing habitat;
3. streambank erosion and upland erosion of steeply sloped areas with highly erodible soils, producing high sediment loadings;
4. livestock and agriculture activities adjacent to streambanks; causing pollution and streambank erosion;
5. roadways, parking lots and buildings encroaching on the floodplains, reducing the channel and floodplains' capacity to transport flow;
6. the absence of adequate forested riparian buffer; reducing available terrestrial habitat, minimizing filtering of overland flow and reducing streambank integrity;
7. suspected discharge of pollutants into the stream from industrial and commercial facilities and legacy sites (e.g. landfills); and
8. periodic overflow of the public wastewater collection system.

The major concerns can be grouped into areas of land development, agricultural, and forestry practices, and urban non-point source pollution. These concerns are not unique to the Lower Creek watershed, and consequently there are proven means available to address them. While the degradation of hydrology, habitat, and water quality is a general concern in all watersheds, the fact that Lower Creek is tributary to Lake Rhodhiss, the water supply source for much of Lenoir-Gamewell community, elevates the need to effectively manage these impacts.

Land development is occurring at a modest pace within this watershed. This gives the local governments time to implement the necessary stormwater management, floodplain management, and erosion control programs to minimize the adverse impacts of development within the watershed.

The livestock, horticulture, and crop-growing activities located primarily in the lower portions of the watershed, while not a predominant land use, nevertheless have an impact upon water quality in Lower Creek and ultimately Lake Rhodhiss. Consequently, measures should be implemented to ensure that fecal coliform bacteria and nutrients from these activities do not enter the surface water system and that livestock do not damage streambanks.

Urban problems such as those associated with runoff from paved surfaces, discharge from industrial facilities directly into the storm drainage system, and sewer overflows are issues that are common to many local governments. The City of Lenoir, however, is in a unique situation, given the high incidence of both operating and previously-operating furniture manufacturing facilities. The local government officials have indicated that they have already begun to identify and implement solutions to these problems. The City of Lenoir has a project underway to address some of the sewer overflow concerns identified. As the local government's Phase II Stormwater Management plan is developed, the issues of illicit cross connections by industrial facilities, floodplain management, and control of runoff from paved surfaces should also be addressed.

Figure 1 Sampling Locations

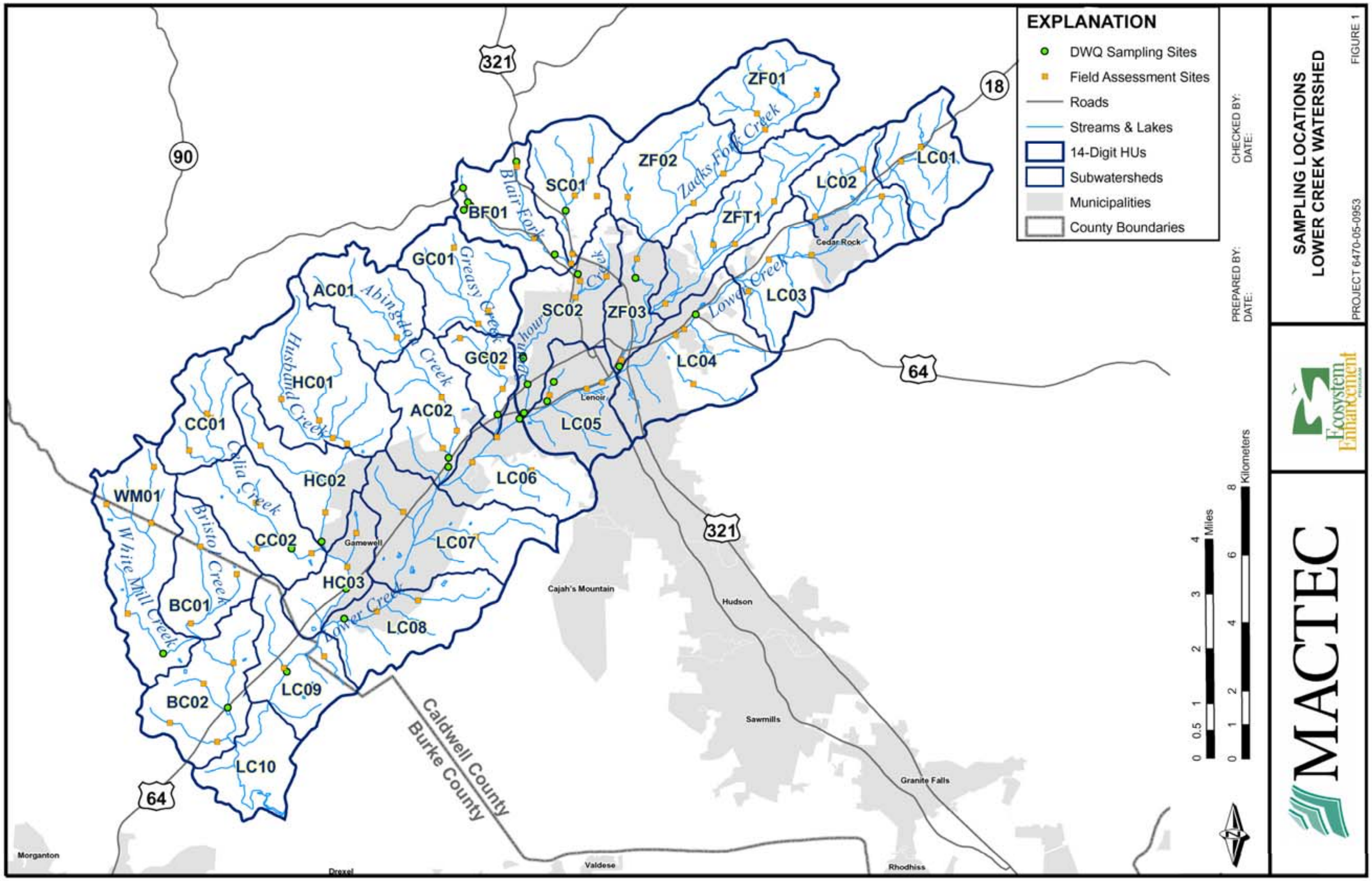


Figure 2 Overall Hydrology Functionality

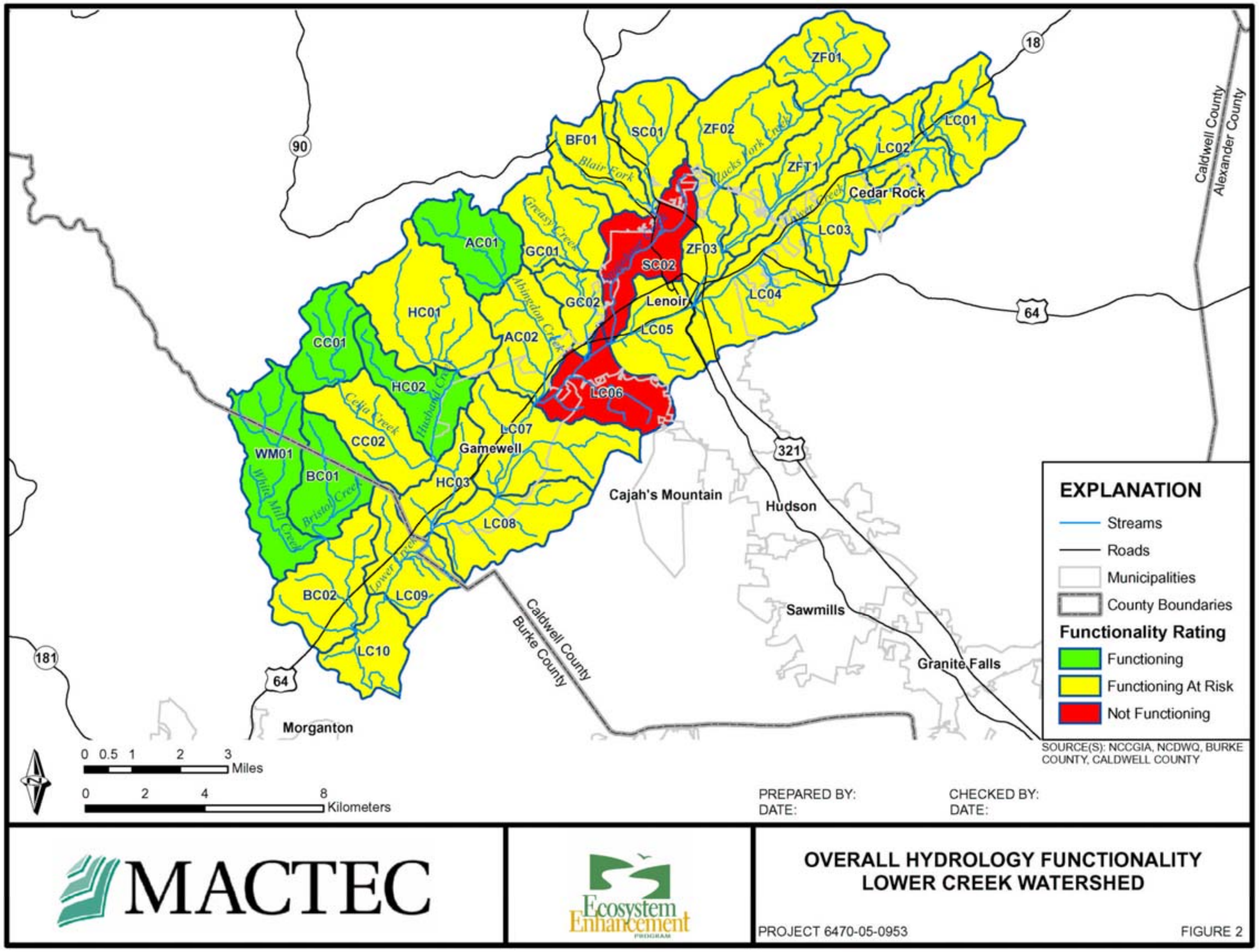


Figure 3 Overall Habitat Functionality

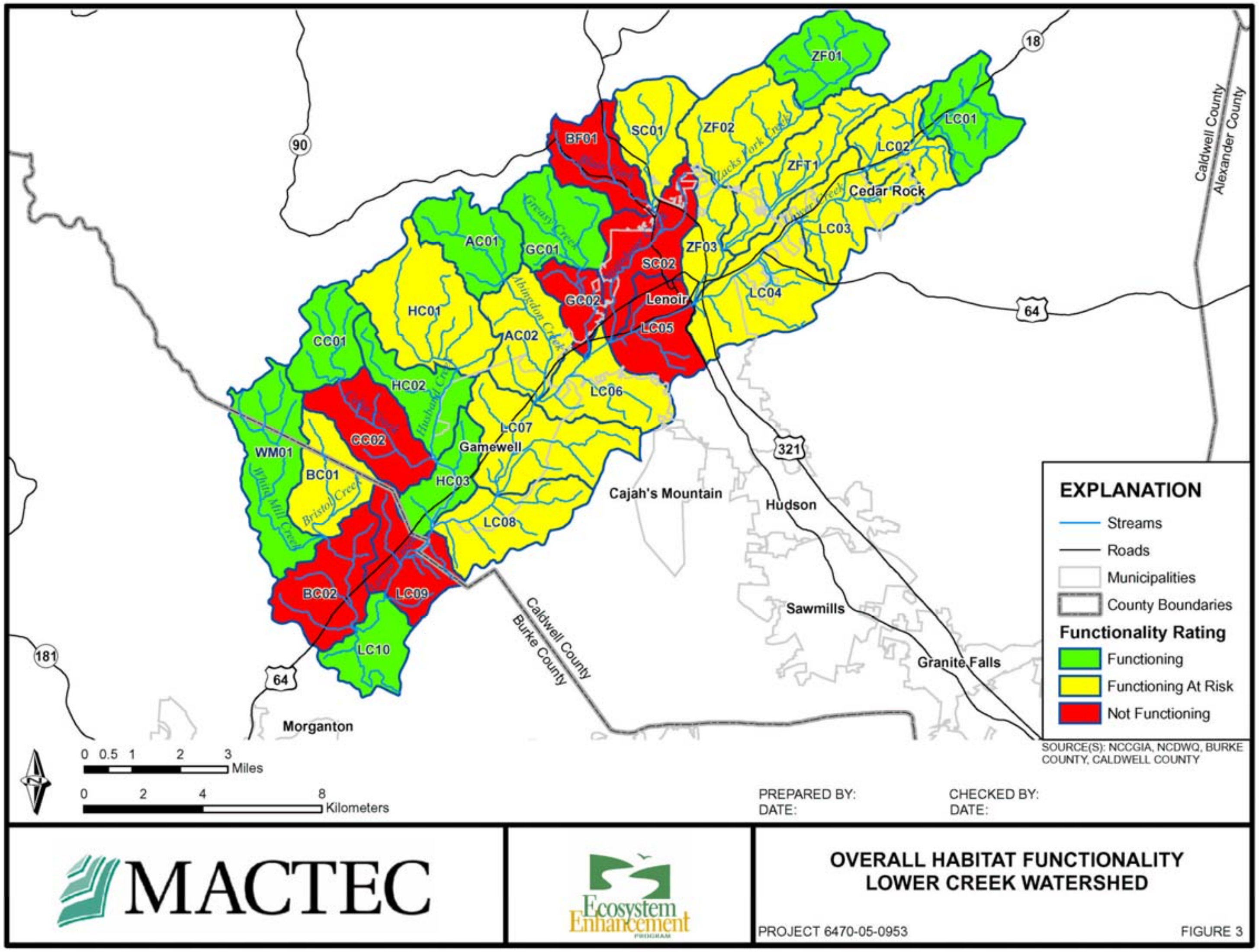
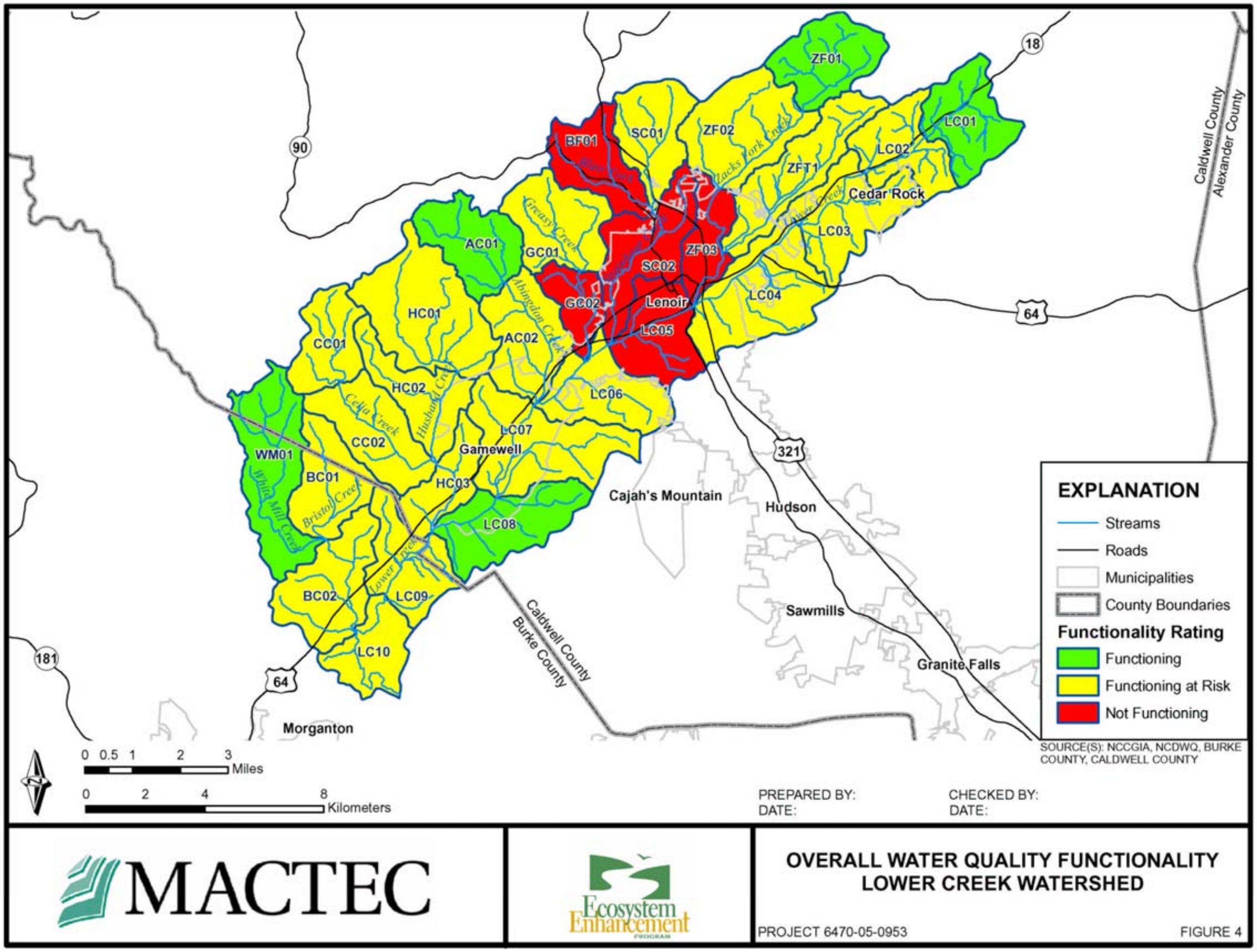


Figure 4 Overall Water Quality Functionality



II. INTRODUCTION

The North Carolina Division of Environment and Natural Resources (NCDENR) Ecosystem Enhancement Program (EEP) contracted with MACTEC Engineering & Consulting, Inc. (MACTEC) to develop a Local Watershed Plan (LWP) for the Lower Creek, comprising two 14-digit HUs in the Catawba River Basin. The watershed assessment contained in this report was done as a part of Phase II of that local watershed planning project, in advance of identifying specific watershed improvement projects and developing overall watershed management plan. This Watershed Assessment Report presents a functional status overview of the Lower Creek Watershed in terms of water quality, hydrology, and habitat. It also suggests potential sources of observed degradation of these functions. The information contained herein will be used in the identification and prioritization of watershed management strategies to address the ecological and community concerns in the Lower Creek Watershed.

A. Objectives

During Phase I of the project, MACTEC collected and summarized existing watershed information for each of the subwatersheds composing the Lower Creek Watershed. This initial characterization suggested that the main impacts to stream health are lack of riparian buffers, channelization, bank instability, and stormwater runoff. To further assess the ability of the existing watershed to sustain various water quality, hydrology, and habitat functions, it was recommended that additional watershed data be collected and analyzed.

The information presented in this report supplements MACTEC's *Findings and Recommendations Report* that was submitted to EEP on May 5, 2004 at the conclusion of the Phase I investigation. MACTEC conducted detailed geographic information systems (GIS) analyses and field assessments of the watershed in an effort to verify and quantify impacts to overall stream health in terms of water quality, hydrology, and habitat, performing the following tasks:

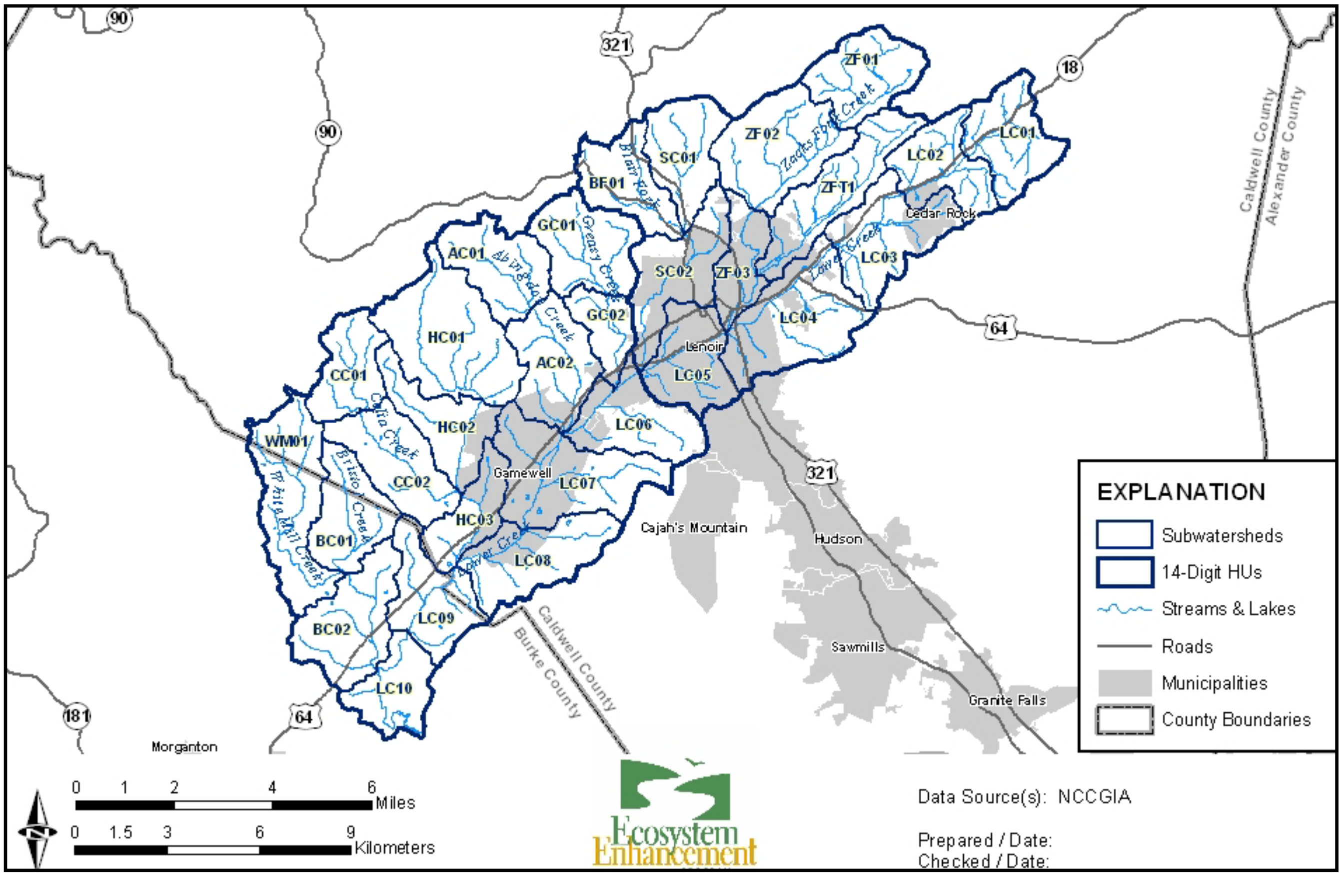
- collect and analyze GIS data to determine field assessment locations;
- collect geomorphic, riparian buffer, and habitat field data from representative sites;
- review and integrate NC Division of Water Quality (DWQ) monitoring data into the analysis;
- analyze data to extrapolate functionality characteristics to the entire watershed; and
- determine the functional status of hydrology, habitat, and water quality within the watershed.

B. Planning Area

The Lower Creek Watershed consists of two 14-digit hydrologic units (HUs), #03050101080010 (40.6 square miles) and #03050101080020 (57.6 square miles), and is located in Caldwell and Burke Counties (Figure 5) with a total drainage area of 98.2 square miles. The watershed includes the communities of Lenoir, Gamewell, Cedar Rock, and a portion of Cajah's Mountain. Major tributaries in the watershed include: Zacks Fork Creek; Blair Fork; Spainhour Creek; Greasy Creek; Abingdon Creek; Husband Creek; Celia Creek; Bristol Creek; and White Mill Creek. Lower Creek (below its junction with Zacks Fork), as well as Zacks Fork, Spainhour Creek, Bristol Creek, and Greasy Creek are included on North Carolina's 2004 Draft 303(d) list as impaired waters.

For purposes of this study, the 29 subwatersheds comprising the Lower Creek Watershed were analyzed separately and grouped into the watersheds of 9 named tributaries to Lower Creek and the two (upper and lower) main reaches of the Lower Creek itself.

Figure 5 Subwatershed Map



Upper Lower Creek
HUC 03050101080010

- LC01
- LC02
- LC03 } Upper Lower Creek
- LC04
- LC05
- ZF01
- ZF02 } Zacks Fork
- ZF03
- ZFT01
- SC01 } Spainhour Creek
- SC02
- BF01 } Blair Fork
- GC01 } Greasy Creek
- GC02

Lower Lower Creek
HUC03050101080020

- LC06
- LC07
- LC08 } Lower Lower Creek
- LC09
- LC10
- AC01 } Abingdon Creek
- AC02
- HC01
- HC02 } Husband Creek
- HC03
- CC01 } Celia Creek
- CC02
- BC01 } Bristol Creek
- BC02
- WM01 } White Mill Creek

III. FUNCTIONAL ASSESSMENT: APPROACH AND RESULTS BY SUBWATERSHED

A. Data Sources

1. GIS Analysis

Several key parameters within the Watershed are best studied on a watershed-wide, rather than site-specific basis. These include:

- impervious cover – an indicator of runoff production;
- riparian buffer – an indicator of habitat, bank stability, and contaminant removal;
- stream sinuosity – an indicator of channelization; and
- stream gradient – an indicator of streamflow velocity.

In contrast to the field investigation data which is site specific, GIS data provides a general overview of key indicators across an entire subwatershed. The GIS analysis also provided valuable insight in the selection of problem sites for evaluation in the field investigations.

GIS data layers including 2004 color digital aerial photography and LIDAR data from the NC Floodplain Mapping Update Program were utilized to perform the analyses required to characterize each of these four key parameters. The technical memoranda describing the methodology used in these analyses and their results can be found in:

- Appendix A – contains analysis of Impervious Cover
- Appendix B – contains analysis of Riparian Buffer
- Appendix C – contains analysis of Stream Sinuosity
- Appendix D – contains analysis of Stream Gradient

2. Field Assessment

Given the schedule and scope of this assessment, it was impractical to visually investigate all 208 miles of stream channel comprising the Lower Creek Watershed. Consequently, MACTEC developed a methodology to select a series of representative sample sites upon which to perform detailed field investigations. The results of these field investigations performed at these sample sites were then extrapolated to other sites within a particular subwatershed to assess the overall functionality within that subwatershed.

a) Site Selection Process

Since a primary purpose of this assessment was to identify the stressors that were affecting the hydrologic, habitat, and water quality functions within the Watershed, the site selection process was biased toward stream reaches that exhibited characteristics that were consistent with impaired functionality. The results of the GIS analyses were utilized to identify areas within each subwatershed potentially containing problem sites. In particular, sites were selected from stream reaches:

- having a sinuosity <1.2 – indicating a high probability of channelization; and
- lacking an adequate 30-foot forested riparian buffer – indicating potential for bank erosion and impaired habitat.

Since an ultimate objective is to identify viable mitigation sites, an additional site selection criterion was to focus on stream reaches that were characterized by a few, rather than many, property owners – in order to identify sites which had a high potential for restoration projects. Approximately 200 potential sites were produced from this GIS analysis. A total of 82 sites were selected for site investigation from this compilation, ensuring that there were representative sites in all subwatersheds, with the exception of LC10.

Subwatershed LC10 is the least developed watershed with the highest sinuosity. The confluence of Lower Creek and the Catawba River (Lake Rhodhiss) is located in LC10, making the stream wider and deeper at this point than any other point in the Watershed. This configuration, the proximity to the lake, and the fact that this subwatershed was relatively undeveloped, made access for field assessment extremely difficult. Consequently, no sites were investigated in this Watershed.

Table 4 below summarizes the sites investigated, listed by major watercourse. More detailed information on each of the sites investigated is contained in Appendix F.

Table 4 Field Investigation Data by Tributary

Tributary	# of Sites Assessed	Length Assessed (feet)	Total Length (feet)	Sample Size	Area (sq miles)	Sites per sq. mile	WQ Data Sites	303(d) Listed?
Zacks Fork	13	5,575	176,866	3.2%	13.4	0.97	2	Yes
Spainhour Creek	7	3,030	60,746	5.0%	6.6	1.06	5	Yes
Blair Fork	3	685	25,364	2.7%	2.8	1.07	9	No
Greasy Creek	6	1,620	60,801	2.7%	5.0	1.19	2	Yes
Abingdon Creek	4	1,230	68,969	1.8%	6.6	0.61	2	No
Husband Creek	9	4,050	99,462	4.1%	10.7	0.84	none	No
Celia Creek	6	2,200	58,035	3.8%	5.9	1.01	none	No
Bristol Creek	7	1,820	64,852	2.8%	6.9	1.02	none	No
White Mill Creek	4	1,300	52,486	2.5%	4.8	0.84	none	No
Upper Lower Creek	14	7,450	229,202	3.3%	17.7	0.79	4	Yes
Lower Lower Creek	9	4,750	200,705	2.4%	17.7	0.51	2	Yes
Overall	**82**	**33,710**	**1,097,489**	**3.1%**	**98.1**	**0.84**	**26**	**5**

b) Field Protocol

MACTEC developed a field assessment protocol, with input from DWQ and the EEP, which addressed key components impacting hydrology, habitat, and water quality. A copy of the Field Assessment Form utilized in the Lower Creek field assessment work is included in Appendix E. Upon completion of the field work, the data from each of the 82 field assessment forms was entered into a Microsoft® Access database in order to facilitate analysis. The database enabled queries to be made for specific parameters and their values related to hydrology, habitat, and water quality functions. Each functional query was then exported to Excel, where the data was grouped by subwatershed and further grouped into major tributaries.

c) Field Personnel

MACTEC and DWQ personnel visually assessed 82 sites during the period June 6 through June 29, 2005. Prior to beginning the field work, each team member was given a one-day field orientation on use of the field protocol by Dr. Kevin Nunnery, then MACTEC's Principal Natural Resources Scientist. This orientation was done to ensure that there was consistency in how the protocol was utilized in the field investigations. For each site to be assessed, a large scale (1" = 175 feet) GIS drawing was produced showing the stream to be assessed, property boundaries and hydric soils (if any), overlaying the high-quality digital aerial photographic background.

Field assessments were conducted by teams of two or three scientists and the results of the investigations were recorded on the field assessment forms. Digital photographs were also taken at each site to provide a representative record of the reach being assessed. The assessed reaches were generally 10 times the active channel width (i.e., stream width at bankfull discharge) and only applicable elements were scored. Assessed reach lengths varied with stream order and site complexity but typically ranged from 100 to 1200 feet (approximately 300 feet average).

3. DWQ Monitoring

a) Overview of Study

The NCDENR Division of Water Quality completed a report on September 1, 2005 which summarized the results of its monitoring on 26 sites in the Lower Creek Watershed during the fall of 2002 and February 2004 through April 2005 (Appendix H). Monitoring conducted during this period included benthic macroinvertebrate sampling, physical/chemical analysis, toxicity testing, and habitat assessments; extensive physical/chemical monitoring was performed on the Lower Creek main channel and on six of its tributaries (Table 5). Benthic sampling was performed at additional watershed sites and reference sites outside of the Watershed. This formal monitoring was supplemented by visual observations made during a series of stream walks conducted along portions of the Lower Creek, Zacks Fork, Spainhour Creek, Blair Fork, and Greasy Creek. Benthic sampling data from 2002 was used to provide information for Husband, Celia, Bristol, and White Mill Creeks, for which more current sampling data was not available.

b) Watershed-wide Findings

The report identifies a variety of both rural and urban impacts suspected of causing the impaired condition of the Lower Creek. These include:

- increased stormwater flow, primarily associated with development activities, responsible for scour, bank erosion, and habitat degradation;
- bank erosion, responsible for degradation of aquatic habitat and increased sediment loads (consistent with the results of TMDL modeling, reported in February, 2004);
- stressed sanitary sewer systems, particularly during stormflow events, responsible for high fecal coliform levels in urban areas of the watershed;
- livestock access to streambed areas, responsible for high fecal coliform levels in rural areas of the watershed;
- runoff from ornamental shrub nurseries and other agricultural activities, likely responsible for increased nutrient levels;
- possible discharges into the stormwater system from industrial sites, responsible for toxicity and presence of semi-volatile compounds; and
- suspected leachate flow from an old landfill in the upper reaches of Blair Fork, responsible for toxicity and high nutrient levels detected in this tributary.

Table 5 DWQ Monitoring Sites by Subwatershed (Source: DWQ Monitoring Report, Sept 2005)

Tributary	Sub watershed	Site No.	Site location	Benthos			Habitat	Toxicity 2005	Physical/ Chemical
				1997	2002	2004			
Zacks Fork	ZF03	Z1	Zacks Fork at US 321A	.	X	.	X	X	X
	ZF03	Z2	Zacks Fork at SR 1531	.	X	.	X	.	.
Spainhour Creek	SCO2	S1	Spainhour Creek below NC 18	.	.	.	X	X	X
	SC02	S2	Spainhour Creek at NC 18 Business	.	X	.	X	.	.
	SC01	S5	UT to Spainhour Creek at SR 1513	.	X	.	X	.	.
Greasy Creek	GC02	G1	Greasy Creek at SR 1425	X	X	X	.	X	X
	GC02	G2	Greasy Creek at SR 1305/Powell Brickyard Road	.	X	X	.	.	.
Blair Fork	BF01	B1	Blair Fork at SR 1525	.	.	.	X		X
	BF01	B2	Blair Fork at 1944 Valway / NC 90	.	X	.	X	X	X
	BF01	B4	Unnamed Tributary (UT) to Blair Fork at US 321	.	.	.	.	.	.
	BF01	B5	Blair Fork downstream of landfill at NC 90	.	.	.	.	X	.
	BF01	B7	Landfill UT to Blair Fork at NC 90	.	.	.	.	X	.
	BF01	B8	Blair Fork at NC 90 upstream of UT	.	.	.	.	.	.
	BF01	B9	Blair Fork at NC 90 above landfill	.	.	.	.	X	
Abingdon Creek	AC02	A1	Abingdon Creek at SR 1927/Old Morganton Road	.	.	.	.	.	X
	AC02	A2	Abingdon Creek at NC 18 Bypass	.	X	.	.	.	.
Husband Creek	HC02		Husband Creek at Old NC 18		X				
	HC02		Husband Creek at NC 18		X				
Bristol Creek	BC02		Bristol Creek at NC18		X				
Celia Creek	CC02		Celia Creek at Old NC 18		X				
White Mill Creek	WM01		White Mill Creek at Piney Rd/ SR 1427		X				
Upper Lower Creek	LC05	L3	Lower Creek at SR 1303	X	X	.	.	.	.
	LC04	L4	Lower Creek at NC 90	X	X	X	X	.	.
	LC05	U1	UT to Lower Creek at NC 18	.	.	.	.	X	X
	LC05	U2	UT to Lower Creek at Underdown Road	.	.	.	.	.	
Lower Lower Creek	LC09	L1	Lower Creek at SR 1501	X	X	.	.	.	X
	LC08	L2	Lower Creek at SR 1142	X	X	.	.	.	.

B. Functional Designations

Subjective designations were established for each of the parameters indicating the functional health of hydrology, habitat, and water quality functions. These designations and their definitions include:

- **Functioning [F]:** the subject watershed function is performing naturally, without evidence of significant degradation or a stressed condition;
- **Functioning at Risk [FR]:** the subject watershed function is currently moderately degraded, but shows evidence of stress such that, without intervention, it could over time become not functioning; and
- **Not Functioning [NF]:** the subject watershed function is currently stressed to the level of being highly degraded.

These designations were used in describing the relative health of the composite parameters, as well as the overall watershed function itself.

C. Hydrologic Assessment

1. Parameters Used in the Assessment

Ten parameters from the field site assessment protocol, which relate directly or indirectly to the hydrologic functionality of the watershed, were analyzed as part of the hydrologic functional assessment. These include:

Parameter	Functional Indication
1. Bottom substrate	Capacity of the steam to effectively transport sediment
2. Pool Variety	Status and trajectory of stream geomorphology
3. Riffle Habitats	Status and trajectory of stream geomorphology
4. Bank Stability	Presence of vegetation that would support bank integrity
5. Lateral Adjustment	Presence of lateral constraints to stream adjustment
6. Vertical Adjustment	Presence of bed aggradation
7. Bank Height Ratio	Degree of stream incision
8. BEHI	Potential for streambank erosion
9. Livestock Access	Access to the streambed by livestock can damage streambanks
10. Channelization	Extent to which the channel deviates from stabilized natural conditions

In addition to the field site assessment data pertaining to the hydrologic function, Stream Sinuosity, Stream Gradient, and Impervious Cover, all evaluated using GIS on a subwatershed-wide basis, were selected as parameters indicating hydrologic functionality across the subwatershed.

Sinuosity, the ratio of stream length to stream valley length, provides an indication of the degree of stream channelization. Where sinuosity falls below a ratio of approximately 1.2, there is strong evidence that the stream may have become channelized through human intervention, lateral constraints, or a combination of both.[1]

[1] Rosgen, David I. 1994. A Stream Classification System. Catena Vol. 22. Table 2, page 176. Elsevier Science, Amsterdam.

Stream Gradient, the ratio of the fall across a stream reach to the length of the reach, provides an indication of the potential for high streamflow velocities, particularly during stormflow events, which tend to produce high shear stresses resulting in bank erosion. Stream gradient also provides a relative indication of the slopes within the subwatershed. High upland slopes have greater potential for producing upland soil erosion when vegetative cover is disturbed, adding to the sediment load that the stream must carry. High stream gradient does not equal degraded function in itself for a stream, but it can be a measure of increased risk for erosion, especially in already unstable streams.

Impervious Cover provides an indication of the degree to which a particular subwatershed can reduce the portion of incident rainfall that becomes runoff through a combination of interception, infiltration, depression storage, and evapotranspiration. Generally, the greater degree to which a natural area has been modified through development or agricultural activity, the lesser the degree that these four mechanisms will serve to reduce the production of stormwater runoff. Consequently, higher impervious cover values tend to produce greater quantities of stormwater runoff, creating high streamflow velocities (which can cause bank erosion and down-cutting of the streambed) and high stormwater peak flows (which can cause downstream flooding).

2. GIS Assessment Scoring

Tables 6, 7 and 8 describe the method used to assign a functionality rating to sinuosity, stream gradient, and impervious cover and provide the results of applying this methodology to the values derived from the GIS analyses for each of these parameters on a subwatershed basis.

Table 6 Sinuosity Analysis by Subwatershed

Subwatershed	Length with Sinuosity < 1.2	Total Length of Stream	Percent Sinuosity < 1.2	Functionality
ZF01	13,990	44,247	32%	F
ZF02	38,298	48,858	78%	NF
ZF03	2,824	19,088	15%	F
ZFT1	47,107	65,044	72%	NF
SC01	25,153	30,433	83%	NF
SC02	22,229	30,313	73%	NF
BF01	14,804	25,364	58%	FR
GC01	17,653	37,338	47%	FR
GC02	9,660	23,463	41%	FR
AC01	11,196	31,845	35%	FR
AC02	29,582	37,125	80%	NF
HC01	35,790	51,630	69%	NF
HC02	16,828	26,772	63%	FR
HC03	13,931	21,060	66%	FR
CC01	14,775	30,610	48%	FR
CC02	17,654	27,425	64%	FR
BC01	13,825	24,110	57%	FR
BC02	32,221	40,742	79%	NF
WM01	33,357	52,486	64%	FR
LC01	25,177	51,597	49%	FR
LC02	30,810	47,426	65%	FR
LC03	24,844	47,418	52%	FR
LC04	29,836	55,084	54%	FR
LC05	23,888	27,677	86%	NF
LC06	17,815	33,655	53%	FR
LC07	33,008	58,265	57%	FR
LC08	37,446	40,578	92%	NF
LC09	22,771	41,818	54%	FR
LC10	9,752	26,389	37%	FR

Upper Lower Creek
Lower Lower Creek

Basis for Functionality Assignment

Functioning [F]

If <33% of the subwatershed has a sinuosity of less than 1.2

Functioning at Risk [FR]

If 33% to 66% of the subwatershed has a sinuosity of less than 1.2

Not Functioning [NF]

If >66% of the subwatershed has a sinuosity of less than 1.2

Table 7 Stream Gradient Analysis by Subwatershed

Subwatershed	# of Reaches	Total Stream Length (lf)	Minimum Gradient (%)	Maximum Gradient (%)	Average Gradient (%)	Functionality
ZF01	16	44,247	0.95	12.74	5.88	NF
ZF02	15	48,858	0.51	9.39	2.9	FR
ZF03	5	19,088	0.39	1.41	0.71	F
ZFT1	20	65,044	0.51	5.82	1.7	FR
SC01	9	30,433	1.04	7.02	3.19	FR
SC02	7	30,313	0.45	1.76	0.81	F
BF01	6	25,364	0.88	2.93	1.48	F
GC01	11	37,338	0.84	4.35	2.28	FR
GC02	8	23,463	0.53	2.46	1.22	F
AC01	8	31,845	1.09	3.46	1.96	F
AC02	10	37,125	0.49	3.55	1.73	F
HC01	15	51,630	0.71	3.28	1.51	F
HC02	6	26,772	0.37	1.96	1.01	F
HC03	7	21,060	0.34	1.72	1.06	F
CC01	9	30,610	0.88	3.21	1.76	F
CC02	8	27,425	0.41	3.02	1.41	F
BC01	6	24,110	0.57	1.7	1.19	F
BC02	12	40,742	0.21	2.79	1.03	F
WM0	15	52,486	0.47	2.41	1.31	F
LC01	19	51,597	0.79	17.76	4.42	NF
LC02	16	47,426	0.53	7.95	2.35	FR
LC03	18	47,418	0.41	10.43	2.39	FR
LC04	18	55,084	0.35	9.73	2.46	FR
LC05	10	27,677	0.15	2.72	1.15	F
LC06	11	33,655	0.21	8.76	2.13	FR
LC07	18	58,265	0.05	3.02	1.2	F
LC08	13	40,578	0.03	3.08	1.49	F
LC09	13	41,818	0.06	2.88	1.4	F
LC10	8	26,389	0.11	2.62	0.74	F

Upper Lower Creek
Lower Lower Creek

Basis for Functionality Assignment

Functioning [F]

If average stream gradient < 2% and maximum gradient < 4%

Functioning at Risk [FR]

If average stream gradient is ≥ 2% but ≤ 4% OR < 2% but maximum gradient > 4%

Not Functioning [NF]

If average stream gradient >4%

Table 8 Impervious Cover Analysis by Subwatershed

Sub-watershed	Watershed Area (acres)	Average Impervious Cover (IC) (acres)	Average IC %	Functionality
ZF01	2,015	102	5.0%	F
ZF02	2,877	170	5.9%	F
ZF03	1,251	370	29.6%	NF
ZFT1	2,440	248	10.2%	FR
SC01	1,888	203	10.8%	FR
SC02	2,339	654	28.0%	NF
BF01	1,801	325	18.0%	NF
GC01	2,186	170	7.8%	F
GC02	1,037	147	14.2%	FR
AC01	2,004	142	7.1%	F
AC02	2,199	300	13.6%	FR
HC01	3,630	431	11.9%	FR
HC02	1,853	158	8.5%	F
HC03	1,373	151	11.0%	FR
CC01	1,607	105	6.5%	F
CC02	2,203	238	10.8%	FR
BC01	1,916	177	9.2%	F
BC02	2,473	250	10.1%	FR
WM01	3,044	193	6.3%	F
LC01	1,997	103	5.1%	F
LC02	1,813	147	8.1%	F
LC03	2,450	254	10.4%	FR
LC04	3,187	467	14.7%	FR
LC05	1,921	552	28.7%	NF
LC06	2,166	411	19.0%	NF
LC07	3,245	429	13.2%	FR
LC08	2,376	228	9.6%	F
LC09	1,993	210	10.5%	FR
LC10	1,548	86	5.5%	F

Upper Lower Creek
Lower Lower Creek

Basis for Functionality Assignment

Functioning [F]

If average IC < 10%

Functioning at Risk [FR]

If average IC is
≥ 10% but ≤ 17%

Not Functioning [NF]

If average IC >17%

3. Field Assessment Scoring

For each of the 82 sites investigated, the raw data scores for each of the ten hydrology-related parameters were extracted from the Access database containing field data. This data was then grouped, along with that of other sites within the same subwatershed, into an Excel spreadsheet for analysis. The first step in the analyses was to obtain a composite score for each parameter across all sites investigated within a given subwatershed. This was done for each subwatershed by calculating a weighted-average score for each hydrology-related parameter, using the following formula:

$$A_w = \frac{\Sigma (P * L_i)}{L_T}$$

where: A_w = weighted average score for each parameter;

P = parameter value for each individual site assessed;

L_i = stream length of the individual site assessed; and

L_T = total stream length assessed for all sites within the subwatershed.

The weighted-average scores for a given parameter within a particular subwatershed were then translated into a functional rating. Since the scoring range for a particular parameter varied, individual rating ranges needed to be established for each parameter. Table 9 uses a shaded color key to designate how the weighted-average score for each of the ten hydrology-related parameters assessed was used to classify the functionality of that parameter for a particular site. A functional rating of Functioning (F), Functioning at Risk (FR), or Not Functioning (NF) was assigned to each parameter on a subwatershed-wide basis, depending upon where the weighted-average value for that parameter fell within the overall scoring ranges shown in the table. For example, the weighted average score for the parameter "riffle habitats" for the 4 sites investigated in subwatershed ZF02 was 11.01. Since that value falls within the range of 5 to 12, the overall functional rating for the "riffle habitats" parameter assigned to ZF02 was FR.

Once functional ratings were established for each parameter for a given subwatershed, an overall functionality rating for the hydrology function was developed for the subwatershed. The first step in deriving the overall rating was to assign 0 points to each NF rating, 3 points to each FR rating, and 5 points to each F rating. An average overall point score was then calculated across all ten parameters for the subwatershed. The overall functionality rating assigned to the Hydrology Function for a given subwatershed was:

Functioning (**F**) where the average point score was 4 or greater;

Functioning at Risk (**FR**) where the average point score was between 2 and 4; and

Not Functioning (**NF**) where the average point score was less than 2.

The detailed results of applying this scoring methodology to the sites within each subwatershed, is shown for the Lower Creek's upper and lower reaches and its nine tributaries in the tables contained in Appendix G.

Table 9 Field Data Functional Assessment Parameters – Hydrology

KEY:

(yellow)	**F** = Functioning
(orange)	**FR** = Functioning at Risk
(pink)	**NF** = Not Functioning

Parameter	Metric	Value	Overall Scoring
Bottom substrate	A. Substrate with good mix of gravel, cobble, and boulders		
	1. embeddedness <20% (very little sand, usually only behind large boulders)	15	**>10 = Functioning**
	2. embeddedness 20-40%	12	**4-10 = Functioning at Risk**
	3. embeddedness 40-80%	8	**< 4 = Not Functioning**
	4. embeddedness >80%	3	
	B. Substrate gravel and cobble		
	1. embeddedness <20%	14	
	2. embeddedness 20-40%	11	
	3. embeddedness 40-80%	6	
	4. embeddedness >80%	2	
	C. Substrate mostly gravel		
	1. embeddedness <50%	8	
	2. embeddedness >50%	4	
	D. Substrate homogeneous		
	1. substrate nearly all bedrock	3	
	2. substrate nearly all sand	3	
	3. substrate nearly all detritus	2	
	4. substrate nearly all silt/clay	1	
Pool Variety	A. Pools present		
	1. pools frequent (>30% of area surveyed)		**> 7 = Functioning**
	a. variety of pool sizes	10	**4- 7 = Functioning at Risk**
	b. pools same size (indicated pools filling in)	8	**< 4 = Not Functioning**
	2. pools infrequent (<30% of area surveyed)		
	a. variety of pool sizes	6	
	b. pools same size	4	
	B. Pools absent	0	
Riffle Habitats	A. Riffles Frequent (>15% of reach)		
	1. well defined riffle and run, riffle wide as stream, extends 2X width of stream	18	**>12 = Functioning**
	2. riffle as wide as stream but riffle length is not 2X stream width	16	**5-12 = Functioning at Risk**
	3. riffle not as wide as stream and riffle length is not 2X stream width	12	**< 5 = Not Functioning**
	B. Riffles Infrequent (5-15% of reach)		
	1. well defined riffle and run, riffle wide as stream, extends 2X width of stream	14	
	2. riffle as wide as stream but riffle	8	

KEY:	
(yellow)	**F** = Functioning
(orange)	**FR** = Functioning at Risk
(pink)	**NF** = Not Functioning

Parameter	Metric	Value	Overall Scoring
	length is not 2X stream width		
	3. riffle not as wide as stream and riffle length is not 2X stream width	4	
	C. Riffles Rare (<5% of reach)		
	1. well defined riffle and run, riffle wide as stream, extends 2X width of stream	5	
	2. riffle as wide as stream but riffle length is not 2X stream width	3	
	3. riffle not as wide as stream and riffle length is not 2X stream width	2	
	D. Riffles Absent	0	
Bank Stability	A. Banks Stable	Left bank	
	1. minimal evidence of erosion/bank failure (except outside of bends), erosion potential low	10	**>15 = Functioning**
	B. Erosion areas present		**4-15 = Functioning at Risk**
	1. trees dominant, ≥80% cover, saplings, shrubs, herbaceous layer ≤20%	8	**< 4 = Not Functioning**
	2. trees somewhat dominant, 50-80% cover, saplings, shrubs, herb. layer 20-40%	6	
	3. saplings, shrubs, herb. layer dominant 50-80%, trees 20-50%	4	
	4. herb. layer dominant, few trees and shrubs, high erosion and failure potential at high flow	2	
	5. little or no vegetation present (any layer), mass erosion and bank failure evident	0	

Lateral Adjustment	Stream is:		
	confined	0	**>4 = Functioning**
	partially confined	3	**2- 4 = Functioning at Risk**
	unconfined (free to adjust)	5	**< 2 = Not Functioning**
Vertical Adjustment	Aggradation (bed level change):		
	active aggradation occurring	0	**>4 = Functioning**
	historic aggradation evident (but not active)	3	**2- 4 = Functioning at Risk**
	no evidence of aggradation	5	**< 2 = Not Functioning**
Potential signs of bed aggradation: - extensive bar development (mid-channel, outside of bend); - extensive recent overbank deposits; - pools filling in buried structures; and - others			
Bank Height Ratio	Weighted average bank height ratio		
	1-1.2	10	**> 7 = Functioning**
	>1.2 - 1.5	8	**4- 7 = Functioning at Risk**
	>1.5 - 1.7	5	**< 4 = Not Functioning**
	>1.7 - 2.0	2	
	>2.0	0	
BEHI	Weighted average BEHI		
	5.0-9.5	20	**>15 = Functioning**
	10-19.5	15	**4-15 = Functioning at Risk**
	20-29.5	10	**< 4 = Not Functioning**
	30-39.5	5	
	40-45	2	
	46-50	0	
Livestock Access	No access	10	**> 7 = Functioning**
	Access to <10% of reach	10	**4- 7 = Functioning at Risk**
	Access to 10-30% of reach	8	**< 4 = Not Functioning**
	Access to 30-50% of reach	5	
	Access to 50-70% of reach	2	
	Access to 70-100% of reach	0	
Hydrologic Alteration	Channelization		
	Evidence of channelization present?		
	NO	10	**> 7 = Functioning**
	YES - extent of channelization:		**4- 7 = Functioning at Risk**
	0-20%	5	**< 4 = Not Functioning**
	20-40%	4	
	40-60%	3	
	60-80%	2	
	80-100%	1	

4. Overall Functionality Scoring

Up to this point, the results of the analyses produced individual functional ratings for sinuosity, stream gradient, and impervious cover for each of the 29 subwatersheds (all based on subwatershed-wide GIS analyses), as well as an overall functional rating for hydrology (based upon the field data for sites investigated within a particular subwatershed). A value of 0 was then assigned to each NF rating, a value of 3 was assigned to each FR rating, and a value of 5 was assigned to each F rating. These values were then averaged across each subwatershed to produce an overall functionality rating for the subwatershed. These results for each subwatershed are shown below in Table 10 and Figure 2.

Table 10 Overall Hydrologic Functionality by Subwatershed

Subwatershed	Sinuosity	Stream Gradient	Impervious Cover	Site Investigations (Hydrology)	Overall Functionality
ZF01	F	NF	F	FR	FR
ZF02	NF	FR	F	FR	FR
ZF03	F	F	NF	NF	FR
ZFT1	NF	FR	FR	FR	FR
SC01	NF	FR	FR	FR	FR
SC02	NF	F	NF	NF	NF
BF01	FR	F	NF	FR	FR
GC01	FR	FR	F	FR	FR
GC02	FR	F	FR	NF	FR
AC01	FR	F	F	FR	F
AC02	NF	F	FR	FR	FR
HC01	NF	F	FR	FR	FR
HC02	FR	F	F	FR	F
HC03	FR	F	FR	FR	FR
CC01	FR	F	F	FR	F
CC02	FR	F	FR	FR	FR
BC01	FR	F	F	FR	F
BC02	NF	F	FR	FR	FR
WM01	FR	F	F	FR	F
LC01	FR	NF	F	NF	FR
LC02	FR	FR	F	FR	FR
LC03	FR	FR	FR	FR	FR
LC04	FR	FR	FR	FR	FR
LC05	NF	F	NF	FR	FR
LC06	FR	FR	NF	NF	NF
LC07	FR	F	FR	FR	FR

Upper Lower Creek
Lower Lower Creek

Basis for Functionality Assignment

Functioning [F]

If % Forested Buffer within 30 feet is > 66.7%

Functioning at Risk [FR]

If % Forested Buffer within 30 feet is ≥ 33.3% but ≤ 66.7%

Not Functioning [NF]

If % Forested Buffer within 30 feet is < 33.3%

Subwatershed	Sinuosity	Stream Gradient	Impervious Cover	Site Investigations (Hydrology)	Overall Functionality
LC08	**NF**	F	F	**NF**	FR
LC09	FR	F	FR	**NF**	FR
LC10	FR	F	F		FR

Note: Since no field investigations were conducted in LC10, this field is blank.

The analyses provide exceptional detail regarding the hydrologic functionality within the watershed, taking results down to the subwatershed and, in the case of field data, the individual investigated site level. This data will be valuable in the subsequent stage of this study where individual watershed improvement projects are identified. However, for the purpose of this watershed assessment, findings are presented on the basis of the Lower Creek's two main reaches and its nine tributaries (mega-subwatersheds) a further analytical step was required. A methodology was needed to synthesize the information presented for 29 subwatersheds in Table 10 into an overall functional rating for the upper and lower reaches of Lower Creek and for each of its nine tributaries. A methodology similar to that used in synthesizing the hydrologic field data into an overall hydrology function rating for the subwatershed was used to develop this overall rating for each of the eleven streams (lower and upper Lower Creek and the nine named tributaries) studied.

In the case of hydrology we have a matrix of data that is 4 by the number of subwatersheds comprising a particular mega-subwatershed. For example, in the case of Husband Creek where there are three subwatersheds, there is a 3 by 4 matrix of data, containing 12 values relating to hydrologic functionality. As in the case of the field data analysis, a point value of 0 points was assigned to each NF rating, 3 points to each FR rating, and 5 points to each F rating. An average overall point score was then averaged across all of the points within the matrix, using the following formula:

$$F_{Hydrology} = \frac{\Sigma\ P_i}{S_T}$$

where:

$F_{Hydrology}$ = overall Hydrology functional score for a given stream;

P_i = points assigned to each functional value (sinuosity, gradient, IC and field data) for each subwatershed comprising the stream; and

S_T = total number of subwatersheds comprising the stream.

The overall functionality rating assigned to the Hydrology Function for a given stream was:

Functioning (**F**) where the overall point score was 4 or greater;

Functioning at Risk (FR) where the overall point score was between 2 and 4; and

Not Functioning (**NF**) where the overall point score was less than 2.

The detailed results from the application of this scoring methodology to each of the eleven mega-subwatersheds studied can be found in Section IV of this report. Results are presented in an individual Hydrology Function table provided under each stream's findings section.

D. Habitat Assessment

1. Parameters Used in Assessment

Five parameters from the field site assessment protocol, which relate directly or indirectly to the habitat functionality of the watershed, were analyzed as part of the Habitat functional assessment. These include:

Parameter	Functional Indication
1. Instream Habitat	Presence of conditions in the stream to support benthos and or fish
2. Bottom Substrate	Composition of the streambed as a stable habitat
3. Pool Variety	Presence of pools to support larger aquatic life
4. Riffle Habitats	Promotes oxygenation and food source for fish, habitat for benthos
5. Light Penetration	Absence of shading can lead to stream warming

In addition to these field assessment parameters, riparian buffer, evaluated using GIS on a subwatershed-wide basis, was selected as an additional indicator of habitat functionality across the subwatershed. The presence of an adequate riparian buffer protects streambanks from erosion and therefore serves to promote healthy aquatic habit. In addition, the riparian buffer itself provides terrestrial habitat and provides canopy for shading of the stream.

2. GIS Assessment Scoring

Table 11 describes the method used to assign a functionality rating to the adequacy of riparian buffer and provide the results of applying this methodology to the values derived from the GIS analysis for this parameter on a subwatershed basis.

One change has been made in the riparian buffer data since the Technical Memorandum on Riparian Buffer Characterization (Appendix B) was issued on July 22, 2005. During our evaluation of data relating to LC10, the most-downstream subwatershed on the Lower Creek, it was noted that the riparian buffer analysis had yielded a value of 16% as the amount of forested cover within a 30-foot buffer area, which would have earned it a rating of "Not Functioning". A review of the aerial photography and topographic map for this subwatershed indicates that there is a forested buffer along most of this reach of Lower Creek. The stream within this subwatershed, where it joins with Lake Rhodhiss, is quite sinuous (an average sinuosity of 1.43, significantly greater than any of the other 28 subwatersheds). The riparian analysis for the first (1 mile) reach of stream in this subwatershed shows a 91% forested rating for the 30-foot buffer. It is believed that below this point, where the stream meanders significantly, the GIS script used to analyze riparian buffer content did not correctly treat the meandering nature of the stream, counting "water" as a portion of the buffer area. In order to correct this anomaly, a value of 70% forested buffer was assigned to the three lower reaches in LC10, yielding an overall 74% (rather than 16%) value for forested buffer in this subwatershed.

Table 11 Riparian Buffer Analysis by Subwatershed

Subwatershed	Forested Area 30ft	Total Area 30ft	Percent Forested 30ft	Functionality
ZF01	1,723,570	2,503,301	69%	F
ZF02	1,178,356	3,053,719	39%	FR
ZF03	410,172	1,106,756	37%	FR
ZFT1	2,306,304	3,923,871	59%	FR
SC01	879,771	1,818,062	48%	FR
SC02	646,320	1,813,724	36%	FR
BF01	387,547	1,515,771	26%	NF
GC01	1,338,256	2,228,800	60%	FR
GC02	871,642	1,404,197	62%	FR
AC01	1,348,671	1,901,516	71%	F
AC02	1,549,096	2,216,528	70%	F
HC01	1,407,514	3,083,390	46%	FR
HC02	913,347	1,601,855	57%	FR
HC03	934,617	1,258,295	74%	F
CC01	629,216	1,828,239	34%	FR
CC02	923,381	1,638,866	56%	FR
BC01	796,943	1,440,191	55%	FR
BC02	1,376,846	2,461,521	56%	FR
WM01	2,335,268	3,135,928	74%	F
LC01	2,047,106	3,063,828	67%	F
LC02	1,344,155	2,829,099	48%	FR
LC03	1,821,973	2,835,848	64%	FR
LC04	2,168,982	3,294,442	66%	FR
LC05	783,354	1,656,432	47%	FR
LC06	1,343,052	2,015,080	67%	F
LC07	1,926,936	3,484,873	55%	FR
LC08	1,672,674	2,427,048	69%	F
LC09	1,623,009	2,497,056	65%	FR
LC10	1,142,694	1,553,550	74%	F

Upper Lower Creek
Lower Lower Creek

Basis for Functionality Assignment

Functioning [F]

If % Forested Buffer within 30 feet is > 66.7%

Functioning at Risk [FR]

If % Forested Buffer within 30 feet is ≥ 33.3% but ≤ 66.7%

Not Functioning [NF]

If % Forested Buffer within 30 feet is < 33.3%

3. Field Assessment Scoring

For each of the 82 sites investigated, the raw data scores for each of the five habitat-related parameters were extracted from the Access database containing field data. This data was then grouped, along with that of other sites within the same subwatershed, into an Excel spreadsheet for analysis. The first analysis step was to obtain a composite score for each parameter across all sites investigated within a given subwatershed. This was done for each subwatershed by calculating a weighted-average score for each habitat-related parameter, using the following formula:

$$A_w = \frac{\Sigma (P * L_i)}{L_T}$$

where: A_w = weighted average score for each parameter;

P = parameter value for each individual site assessed;

L_i = stream length of the individual site assessed; and

L_T = total stream length assessed for all sites within the subwatershed.

These weighted-average scores for a given parameter within a particular subwatershed were then translated into a functional rating. Since the scoring range for a particular parameter varied, individual rating ranges needed to be established for each parameter. Table 12 uses a shaded color key to designate how the weighted-average score for each of the five habitat-related parameters assessed was used to classify the functionality of that parameter for a particular site. A functional rating of Functioning (F), Functioning at Risk (FR), or Not Functioning (NF) was assigned to each parameter on a subwatershed-wide basis, depending upon where the weighted-average value for that parameter fell within the overall scoring ranges shown in the table. For example, the weighted average score for the parameter "light penetration" for the 4 sites investigated in subwatershed SC01 was 2.45. Since that value falls below 3, the overall functional rating for the "light penetration" parameter assigned to SC01 was NF.

Once functional ratings were established for each parameter for a given subwatershed, an overall functionality rating for the hydrology function was developed. The first step in deriving the overall rating was to assign 0 points to each NF rating, 3 points to each FR rating, and 5 points to each F rating. An average overall point score was then calculated across all ten parameters for the subwatershed. The overall functionality rating assigned to the Habitat Function for a given subwatershed was:

Functioning (**F**) where the average point score was 4 or greater;

Functioning at Risk (**FR**) where the average point score was between 2 and 4; and

Not Functioning (NF) where the average point score was less than 2.

Table 12 Field Data Functional Assessment Parameters – Habitat

KEY:
- **F** = Functioning (yellow)
- **FR** = Functioning at Risk (orange)
- **NF** = Not Functioning (pink)

Parameter	Metric	Value	Overall Scoring
Instream Habitat	4 or 5 types present, >70% of reach	20	**> 14 = Functioning**
	3 types present, >70% of reach	19	**10-14 = Functioning at Risk**
	2 types present, >70% of reach	18	**< 10 = Not Functioning**
	1 type present, >70% of reach	17	
	4 or 5 types present, 40-70% of reach	16	
	3 types present, 40-70% of reach	15	
	2 types present, 40-70% of reach	14	
	1 type present, 40-70% of reach	13	
	4 or 5 types present, 20-40% of reach	12	
	3 types present, 20-40% of reach	11	
	2 types present, 20-40% of reach	10	
	1 type present, 20-40% of reach	9	
	4 or 5 types present, <20% of reach	8	
	3 types present, <20% of reach	7	
	2 types present, <20% of reach	6	
	1 type present, <20% of reach	5	
	No types present	0	
Bottom substrate	A. Substrate with good mix of gravel, cobble, and boulders		
	1. embeddedness <20% (very little sand, usually only behind large boulders)	15	**>10 = Functioning**
	2. embeddedness 20-40%	12	**4-10 = Functioning at Risk**
	3. embeddedness 40-80%	8	**< 4 = Not Functioning**
	4. embeddedness >80%	3	
	B. Substrate gravel and cobble		
	1. embeddedness <20%	14	
	2. embeddedness 20-40%	11	
	3. embeddedness 40-80%	6	
	4. embeddedness >80%	2	
	C. Substrate mostly gravel		
	1. embeddedness <50%	8	
	2. embeddedness >50%	4	
	D. Substrate homogeneous		
	1. substrate nearly all bedrock	3	
	2. substrate nearly all sand	3	
	3. substrate nearly all detritus	2	
	4. substrate nearly all silt/clay	1	

Pool Variety	A. Pools present		**> 7 = Functioning** **4- 7 = Functioning at Risk** **< 4 = Not Functioning**
	1. pools frequent (>30% of area surveyed)		
	a. variety of pool sizes	10	
	b. pools same size (indicated pools filling in)	8	
	2. pools infrequent (<30% of area surveyed)		
	a. variety of pool sizes	6	
	b. pools same size	4	
	B. Pools absent	0	
Riffle Habitats	A. Riffles Frequent (>15% of reach)		
	1. well defined riffle and run, riffle wide as stream, extends 2X width of stream	18	**>12 = Functioning**
	2. riffle as wide as stream but riffle length is not 2X stream width	16	**5-12 = Functioning at Risk**
	3. riffle not as wide as stream and riffle length is not 2X stream width	12	**< 5 = Not Functioning**
	B. Riffles Infrequent (5-15% of reach)		
	1. well defined riffle and run, riffle wide as stream, extends 2X width of stream	14	
	2. riffle as wide as stream but riffle length is not 2X stream width	8	
	3. riffle not as wide as stream and riffle length is not 2X stream width	4	
	C. Riffles Rare (<5% of reach)		
	1. well defined riffle and run, riffle wide as stream, extends 2X width of stream	5	
	2. riffle as wide as stream but riffle length is not 2X stream width	3	
	3. riffle not as wide as stream and riffle length is not 2X stream width	2	
	D. Riffles Absent	0	
Light Penetration	Stream with (60-90%) shading with some breaks for light penetration	10	**>7 = Functioning**
	Stream with full canopy (90-100%) - breaks for light penetration absent	8	**3-7 = Functioning at Risk**
	Stream with (40-60%) shading - sunlight and shading essentially equal	7	**< 3 = Not Functioning**
	Stream with (10-40%) shading - full sun in all but a few areas	2	
	Stream with virtually no shading (0-10%)	0	

4. Overall Functionality Scoring

The results of the analysis produced individual functional ratings for riparian buffer for each of the 29 subwatersheds (based upon subwatershed-wide GIS analysis), as well as an overall functional rating for habitat (based upon the field data for sites investigated within a particular subwatershed). A value of 0 was then assigned to each NF rating, a value of 3 was assigned to each FR rating, and a value of 5 was assigned to each F rating. These values were then averaged across each subwatershed to produce an overall functionality rating for the subwatershed. The results for each subwatershed are shown below in Table 13 and Figure 3.

Table 13 Overall Habitat Functionality by Subwatershed

Subwatershed	Riparian Buffer	Site Investigations (Habitat)	Overall Functionality
ZF01	F	F	**F**
ZF02	FR	FR	FR
ZF03	FR	FR	FR
ZFT1	FR	FR	FR
SC01	FR	FR	FR
SC02	FR	NF	**NF**
BF01	NF	FR	**NF**
GC01	FR	F	**F**
GC02	FR	NF	**NF**
AC01	F	FR	**F**
AC02	F	NF	FR
HC01	FR	FR	FR
HC02	FR	F	**F**
HC03	F	FR	**F**
CC01	FR	F	**F**
CC02	FR	NF	**NF**
BC01	FR	FR	FR
BC02	FR	NF	**NF**
WM01	F	F	**F**
LC01	F	FR	**F**
LC02	FR	FR	FR
LC03	FR	FR	FR
LC04	FR	FR	FR
LC05	FR	NF	**NF**
LC06	F	NF	FR
LC07	FR	FR	FR
LC08	F	NF	FR
LC09	FR	NF	**NF**
LC10	F		**F**

Note: Since no field investigations were conducted in LC10, this field is blank.

These analyses provide exceptional detail regarding the habitat functionality within the watershed, taking results down to the subwatershed and, in the case of field data, the individual site level. This data will be valuable in the subsequent stage of this study where individual watershed improvement projects are identified. In order to synthesize the information presented for 29 subwatersheds in Table 13 into an overall functional rating for the upper and lower reaches of Lower Creek and for each of its nine tributaries (mega-subwatersheds), a methodology similar to that used with the hydrology functional assessment was employed.

In the case of habitat, we have a matrix of data that is 2 by the number of subwatersheds comprising a particular mega-subwatershed. For example, in the case of Husband Creek where there are three subwatersheds, there is a 3 by 2 matrix of data, containing 6 values relating to habitat functionality. As in the case of the field data analysis, a point value of 0 points was assigned to each NF rating, 3 points to each FR rating, and 5 points to each F rating. An average overall point score was then averaged across all of the points within the matrix, using the following formula:

$$F_{Habitat} = \frac{\Sigma \ P_i}{S_T}$$

where: $F_{Habitat}$ = overall Habitat functional score for a given stream;

P_i = points assigned to each functional value (riparian buffer and field data) for each subwatershed comprising the stream; and

S_T = total number of subwatersheds comprising the stream.

The overall functionality rating assigned to the Habitat Function for a given stream was:

Functioning (**F**) where the overall point score was 4 or greater;

Functioning at Risk (**FR**) where the overall point score was between 2 and 4; and

Not Functioning (NF) where the overall points score was less than 2.

The detailed results from the application of this scoring methodology can be found in Section IV of this report. Results are presented in an individual Habitat Function table provided for each stream.

E. Water Quality Assessment

1. Parameters Used in Assessment

Four parameters were used to determine functionality—impervious cover, riparian buffer, DWQ benthic data, and DWQ physical/chemical data. Where no DWQ physical/chemical data were available, field assessment parameters were used.

Impervious cover was evaluated using GIS on a subwatershed-wide basis, was selected as an indicator of water quality functionality across the subwatershed. The presence of impervious cover increases runoff, thereby producing higher levels of peak storm discharge and higher streamflow velocities during storms, both contributing to increased streambank erosion and higher sediment levels. In addition, runoff from paved areas contributes oils and other pollutants to the streams.

Riparian buffer was evaluated using GIS on a subwatershed-wide basis, was selected as an additional indicator of water quality functionality across the subwatershed. The presence of an adequate riparian buffer protects streambanks from erosion and therefore limits sediment load from these sources. In addition, an adequate riparian buffer can provide a filtering effect for nutrients and other pollutants contained in upland area runoff.

DWQ data. The water quality monitoring conducted by the DWQ in support of this watershed planning project (Appendix H) provides a third important source of data that is factored into the analysis of the overall water quality function within the Lower Creek and its tributaries. This water quality monitoring data is in the form of 1) physical/chemical monitoring data (parameters such as metals, nutrients, and suspended solids) found in Table 15 and 2) benthic monitoring data found in Table 16. Since the benthic data provides an excellent indicator of the overall stream health from a water quality perspective, it was utilized as a separate parameter in assessing the function of the subwatersheds, rather than being grouped with the results of the physical/chemical data.

Field assessments. Where physical/chemical sampling data was not available for a particular subwatershed, information from the field assessments within that watershed were used to provide the fourth functional parameter for assessment of water quality functionality. Five parameters from the field site assessment protocol, which relate directly or indirectly to the water quality functionality of the watershed, were analyzed as part of the water quality functional assessment. These include:

Parameter	Functional Indication
1. Water Odor	Can be an indicator of pollution by petroleum or other volatile compounds
2. Water Clarity	Can be an indicator of suspended solids
3. Periphyton Growth	Can be an indicator of nutrient loading
4. BEHI	Can be an indicator of streambank erosion/sediment loading
5. Livestock Access	Can be an indicator of the presence of fecal coliforms

2. GIS Assessment Scoring

Table 8 describes the method used to assign a functionality rating to impervious cover and provides the results of applying this methodology to the values derived from the GIS analysis for this parameter on a subwatershed basis. Table 11 describes the method used to assign a functionality rating to the adequacy of riparian buffer and provides the results of applying this methodology to the values derived from the GIS analysis for this parameter on a subwatershed basis.

3. Field Assessment Scoring

For each of the 82 sites investigated, the raw data scores for each of the five water quality-related parameters were extracted from the Access database containing field data. This data was then grouped, along with that of other sites within the same subwatershed, into an Excel spreadsheet for analysis. The first analysis step was to obtain a composite score for each parameter across all sites investigated within a given subwatershed. Since the water quality field parameters were more subjective than quantitative, a slightly different methodology was employed from that used for the hydrology and habitat functions. This methodology is shown below in Table 14. With the exception of BEHI, where a quantitative measure is provided, the other four parameters utilize a “no sites”, “few sites”, or “most sites” determination of functionality, based upon the presence of the particular parameter.

Once functional ratings were established for each parameter for a given subwatershed, an overall functionality rating for the water quality function was developed for the subwatershed. The first step in deriving the overall rating was to assign 0 points to each NF rating, 3 points to each FR rating, and 5 points to each F rating. An average overall point score was then calculated across all five parameters for the subwatershed. The overall functionality rating assigned to the Water Quality function for a given subwatershed was:

Functioning (F) where the average point score was 4 or greater;

Functioning at Risk (**FR**) where the average point score was between 2 and 4; and

Not Functioning (NF) where the average point score was less than 2.

The detailed results from the application of this scoring methodology can be found in Section IV of this report. Section IV provides an individual Water Quality Function table showing results for each of the eleven streams studied.

Table 14 Field Data Functional Assessment Parameters – Water Quality

KEY:

(yellow)	**F** = Functioning
(orange)	**FR** = Functioning at Risk
(pink)	**NF** = Not Functioning

Parameter	Metric	Value		Overall Scoring
Water Odor	none			**Functioning** where no Sites exhibit problems
	chemical			
	sewage			**Functioning at Risk** where a few exhibit problems
	sulfide			
	other			**Not Functioning** where majority exhibit problems
Water Clarity	clear			**Functioning** where no Sites exhibit problems
	slightly turbid			
	turbid			**Functioning at Risk** where a few sites exhibit problems
	turbid and milky			
	colored			**Not Functioning** where a majority exhibit problems
Periphyton Growth	none			**Functioning** where no sites exhibit problems
	some			**Functioning at Risk** where a few exhibit problems
	excessive			**Not Functioning** where a majority exhibit problems
BEHI	Weighted average BEHI			
	5.0-9.5	20	very low	**>15 = Functioning**
	10-19.5	15	low	**4-15 = Functioning at Risk**
	20-29.5	10	moderate	**< 4 = Not Functioning**
	30-39.5	5	high	
	40-45	2	very high	
	46-50	0	extreme	

Parameter	Metric	Value	Overall Scoring
Livestock Access	No access	10	**Functioning** where no livestock access
	Access to <10% of reach	10	**Functioning at Risk**
	Access to 10-30% of reach	8	where only one site
	Access to 30-50% of reach	5	has Livestock access
	Access to 50-70% of reach	2	**Not Functioning** where
	Access to 70-100% of reach	0	Livestock have access at a majority of the sites

4. *Water Quality Monitoring Scoring*

Although the data contained in the DWQ monitoring report (Appendix H) provides significant insight into the water quality issues in this Watershed which have led to impaired designations for Lower Creek, Zacks Fork, Spainhour Creek, and Greasy Creek, it presented some challenge to its incorporation in the overall functionality analysis. Since not every tributary was sampled and not all sampling points had the same test parameters, a different approach from that taken with integration of data from the field investigations and GIS analyses had to be developed. Discussions between MACTEC and the EEP led to the development of an assessment protocol by EEP which was then applied to the data by MACTEC.

Physical/chemical monitoring data was available for seven of the 29 subwatersheds (ZF03, SC02, BF01, GC02, AC02, LC05, and LC09). In order to develop a physical/chemical water quality functional rating for each of these subwatersheds, a matrix was developed showing where sampling data was available and classifying the results as "meeting standards", "not meeting standards", or "no data" for each sampling parameter. The standards (reference levels) used were those referenced in the NC DWQ report. Sampling points were determined to "not meet standards" where for:

- nutrients – >10% of baseflow samples exceed the benchmark value;
- metals – >10% of samples exceed the EPA chronic benchmark for a particular metal;
- semi-volatiles – any level detected;
- suspended solids – >10% of samples exceed 50 NTU;
- toxicity – 1 or more assays showed a positive toxicity response;
- fecal coliform bacteria – baseflow samples had a geometric mean >200 colonies/100ml or where >20% of the samples are >400 colonies/100 ml.

The total number of points where sample data was available was tabulated for each subwatershed. The percentage of sampled points meeting the standard (regardless of the type of sample) for each subwatershed was then calculated. The following functional ratings were then assigned to each of the seven subwatersheds for which data was available:

Functioning (**F**) – where more than two-thirds of the samples met the standard;
Functioning at Risk (**FR**) – where one-third to two-thirds of the samples met the standard; and
Not Functioning (**NF**) – where less than one-third of the samples met the standard.

Table 15 shows the results of this functional assignment to the physical/chemical monitoring data.

Table 15 Physical/Chemical Water Quality Monitoring Data Analysis by Subwatershed

Subwatershed	Map Code	Description	Nutrients	Metals	Semi-Volatiles	Suspended Solids	Toxicity	Fecal Coliforms	Functionality
ZF03	Z1	Zacks Fork at US 321A	ok	X		X	X	X	NF
SC02	S1	Spainhour Creek below NC 18	ok	X	ok	X		X	NF
SC02	S2	Spainhour Creek at NC 18 Business					X		
BF01	B1	Blair Fork at SR 1525	ok	X	ok	X		X	NF
BF01	B2	Blair Fork at 1944 Valway / NC 90	X	X	ok	X	X	X	
BF01	B4	Unnamed Tributary (UT) to Blair Fork at US 321	X	X					
BF01	B5	Blair Fork downstream of landfill at NC 90	X	X		ok	X	X	
BF01	B7	Landfill UT to Blair Fork at NC 90	X	X	X	ok	X	ok	
BF01	B8	Blair Fork at NC 90 upstream of UT		X					
BF01	B9	Blair Fork at NC 90 above landfill	ok	X		ok	ok		
GC02	G1	Greasy Creek at SR 1425	X	X	ok	X	X	X	NF
AC02	A1	Abingdon Creek at SR 1927/Old Morganton Road	ok	X	ok	X		ok-	FR
LC05	U1	UT to Lower Creek at NC 18	-	X	X	X	X	X	NF
LC05	U2	UT to Lower Creek at Underdown Road	-	X	-				
LC09	L1	Lower Creek at SR 1501	-	X	-	X		X	FR
		# of Sample Points	**16**	**16**	**10**	**11**	**8**	**12**	

KEY:		
	X	**= sample taken, not meeting standards**
	ok	**= sample taken, meets standards**
	(grey)	**= no sample taken**

Benthic monitoring data was available for 14 sampling locations, which were then related to 22 of the 29 subwatersheds (all but ZFT1 and LC05 through LC10). These locations are shown in Table 16 below. A functional rating was assigned by EEP to each of these 14 monitoring points, which then was extended to the 22 subwatersheds to which they related.

Table 16 Benthic Water Quality Monitoring Data Analysis by Subwatershed

Ref: NC Division of Water Quality. 2003. Existing stream data: Lower Creek Watershed., Watershed Assessment Team; NC Division of Water Quality, 2004. Technical brief: supplemental monitoring of benthic macroinvertebrate communities in Greasy and Lower Creeks, 2004. Watershed Assessment Team.

Site	Date	Sample Type	EPT Richness	EPT Biotic Index	Biotic Index	BioClass	Functional Rating	Subwatersheds Represented
Abingdon Cr at NC 18 Bypass	9/10/2002	Qual 5	20		5.6	Not Impaired	FR	AC02, AC01
Blair Fk at NC 90	9/9/2002	Qual 5	5		6.42	Not Rated	NF	BF01
Bristol Cr at NC 18	9/11/2002	Qual 5	12		5.56	Not Rated	FR	BC02, BC01
Celia Cr at Old NC 18	9/11/2002	Qual 5	10		5.78	Not Rated	FR	CC02, CC01
Greasy Cr at SR 1305	7/7/2004	EPT	19	3.72		Good-Fair	FR	GC01
Greasy Cr at NC 18	7/7/2004	EPT	13	4.12		Fair	NF	GC02
Husband Cr at Old NC 18	9/11/2002	Qual 5	24		5.28	Not Impaired	FR	HC02, HC01
Husband Cr at NC 18	9/11/2002	Qual 5	14		5.24	Not Rated	FR	HC03
Lower Cr at NC 90	7/7/2004	EPT	19	5.59		Good-Fair	FR	LC04, LC03, LC02, LC01
Spainhour Cr at NC 18 Bus	9/9/2002	Full Scale	15		6.46	Fair	NF	SC02
UT Spainhour Cr at SR 1513	9/9/2002	Qual 5	13		4.66	Not Rated	FR	SC01
White Mill Cr at Piney Rd/ SR 1427	9/11/2002	Qual 5	14		4.87	Not Rated	FR	WM01
Zacks Fk Cr at SR 1531	9/9/2002	Qual 5	19		5.67	Not Impaired	FR	ZF02, ZF01
Zacks Fk Cr at US 321A	9/10/2002	Qual 5	6		6.87	Not Rated	NF	ZF03

5. Overall Functionality Scoring

The individual functional ratings for impervious cover and riparian buffer for each of the 29 subwatersheds (based upon subwatershed-wide GIS analysis), the functional ratings for the 7 subwatersheds for which physical/chemical data was available (based upon DWQ monitoring data), and the functional ratings assigned to the 22 subwatersheds for which benthic data was available (based upon EEP functionality assignments) were listed by subwatershed. The results from analyzing the water quality data from field investigations was substituted for 21 of the 22 subwatersheds for which physical/chemical monitoring data was not available. A value of 0 was then assigned to each "NF" rating, a value of 3 was assigned to each "FR" rating, and a value of 5 was assigned to each "F" rating. These values were then averaged across each subwatershed to produce an overall functionality rating for the subwatershed. The results of this overall analysis for each subwatershed are shown below in Table 17 and Figure 4.

Table 17 Overall Water Quality Functionality by Subwatershed

Subwatershed	Riparian Buffer	Impervious Cover	Site Investigations (Water Quality)	DWQ Phys/Chem Monitoring	DWQ Benthic Monitoring	Overall Functionality
ZF01	F	F	F		FR	**F**
ZF02	FR	F	FR		FR	FR
ZF03	FR	NF	FR	NF	NF	**NF**
ZFT1	FR	FR	F			FR
SC01	FR	FR	FR		FR	FR
SC02	FR	NF	FR	NF	NF	**NF**
BF01	NF	NF	FR	NF	NF	**NF**
GC01	FR	F	F		FR	FR
GC02	FR	FR	FR	NF	NF	**NF**
AC01	F	F	F		FR	**F**
AC02	F	FR	F	FR	FR	FR
HC01	FR	FR	F		FR	FR
HC02	FR	F	F		FR	FR
HC03	F	FR	F		FR	FR
CC01	FR	F	F		FR	FR
CC02	FR	FR	F		FR	FR
BC01	FR	F	FR		FR	FR
BC02	FR	FR	FR		FR	FR
WM01	F	F	F		FR	**F**
LC01	F	F	F		FR	**F**
LC02	FR	F	F		FR	FR
LC03	FR	FR	F		FR	FR
LC04	FR	FR	F		FR	FR
LC05	FR	NF	F	NF		**NF**
LC06	F	NF	F			FR
LC07	FR	FR	F			FR
LC08	F	F	FR			**F**

Subwatershed	Riparian Buffer	Impervious Cover	Site Investigations (Water Quality)	DWQ Phys/Chem Monitoring	DWQ Benthic Monitoring	Overall Functionality
LC09	FR	FR	FR	FR		FR
LC10	F	F				FR

Note: Blank fields indicated data was not collected in the subwatershed for the given parameter.

Since for the purpose of this watershed assessment, findings are presented on the basis of the Lower Creek's two main reaches and its nine tributaries, a further analytical step was required. In order to synthesize the information presented for 29 subwatersheds in Table 17 into an overall functional rating for the upper and lower reaches of Lower Creek and for each of its nine tributaries (mega-subwatersheds), a methodology similar to that used with the hydrology functional assessment was employed.

In the case of water quality, we have a matrix of data that is 4 by the number of subwatersheds comprising a particular mega-subwatershed. For example, in the case of Upper Lower Creek where there are five subwatersheds, there is a 5 by 4 matrix of data producing 20 values relating to water quality functionality. As in the case of the field data analysis, a point value of 0 points was assigned to each NF rating, 3 points to each FR rating, and 5 points to each F rating. An average overall point score was then averaged across all of the points within the matrix, using the following formula:

$$F_{WQ} = \frac{\Sigma\ P_i}{S_T}$$

where: F_{WQ} = overall Water Quality functional score for a given stream;

P_i = points assigned to each functional value (riparian buffer, field data and DWQ data) for each subwatershed comprising the stream; and

S_T = total number of subwatersheds comprising the stream.

The overall functionality rating assigned to the Water Quality function for a given subwatershed was:

Functioning (F) where the overall point score was 4 or greater;

Functioning at Risk (**FR**) where the overall point score was between 2 and 4; and

Not Functioning (**NF**) where the overall points score was less than 2.

The detailed results from the application of this scoring methodology can be found in Section IV of this report. Section IV provides an individual Water Quality Function table for each of the eleven streams studied.

IV. DETAILED FINDINGS BY SUBWATERSHED AND MEGA-SUBWATERSHED

Findings from the watershed assessment are organized in the following sections by eleven "mega-subwatersheds"— a drainage area of each of the major reaches comprising the watershed (the upper and lower reaches of Lower Creek and each of the nine named tributaries). A detailed map of each of the eleven watercourses studied can be found in Appendix I.

A. Upper Lower Creek

The Upper Lower Creek mega-subwatershed is the watershed of the upper half of Lower Creek and includes 43.4 miles of streams that flow into the lower half of Lower Creek southwest of Lenoir. The 17.8-square mile watershed extends from the southwestern edge of Lenoir to the northeast (Appendix I, Figures 6 and 7). The upper half of Lower Creek and its tributaries begin in the southern section of the Bushy Mountains along the northwest slopes. Lower Creek and its tributaries begin by draining rural areas of forest on moderate to steep slopes of the southeast section of the Bushy Mountains along the northwest slopes. As Lower Creek and its tributaries come onto the valley floor, the land use becomes large-lot residential and agricultural. As Lower Creek approaches the City of Lenoir the land use changes to single-family lots and commercial. **Five subwatersheds comprise the Upper Lower Creek mega-subwatershed: LC01, LC02, LC03, LC04, and LC05.** Data used in characterizing this watershed were derived from field studies at 16 stream reaches (Appendix G), information from DWQ's four monitoring sites within the watershed (Appendix H), and GIS data on stream gradient, sinuosity, riparian buffer, and impervious cover (Appendix A through D; Table 18).

Table 18 Upper Lower Creek Mega-subwatershed Summary Information

Subwatershed	Area (mi²)	Stream Length (miles)	% Stream Length with Sinuosity ≤1.2	Average Stream Gradient (%)	Average % with 30-foot Forested Buffer	Average % IC
LC01	3.1	9.8	49	4.42	67	5.1
LC02	2.8	9.0	65	2.35	48	8.1
LC03	3.8	9.0	52	2.39	64	10.4
LC04	5.0	10.4	54	2.46	66	14.7
LC05	3.0	5.2	86	1.15	47	28.7
Total	**17.7**	**43.4**	**61**	**2.55**	**58**	**13.4**

1. *Hydrology*

Table 19 Hydrology Function for Upper Lower Creek

Subwatershed	Sinuosity	Stream Gradient	Impervious Cover	Site Investigations (Hydrology)	Overall Functionality
LC01	FR	NF	F	NF	FR
LC02	FR	FR	F	FR	FR
LC03	FR	FR	FR	FR	FR
LC04	FR	FR	FR	FR	FR
LC05	NF	F	NF	FR	FR
		Overall mega-subwatershed:			FR

Sinuosity and site investigations. GIS sinuosity analysis indicates that approximately 61% of the tributaries in the upper half of the Lower Creek mega-subwatershed are potentially channelized (sinuosity values ≤ 1.2). MACTEC's field observations confirmed that of the 16 stream sites investigated all were found to be significantly channelized (≥ 80%). DWQ (2005) visually confirmed evidence of channelization during their stream walk in subwatershed LC04. Widespread channelization of the tributaries in the upper half of Lower Creek has led to incision and steep stream banks, as exhibited by the high bank height ratios. The bank height ratio rated NF in all five subwatersheds. Stream reach sites North Wilkesboro #21 (LC01), Wendell #211 (LC02), Helton Farms #213 (LC02), and Wilkesboro Blvd #13 (LC03) are major examples of very high bank height ratios. DWQ (2005) observed that banks were high and actively eroding. Erosion of the unstable banks was found to be contributing sediment downstream which was indicated by the low bottom substrate scores and low riffle habitat scores seen in subwatersheds LC01, LC03, LC04, and LC05. At the North Wilkesboro #21 (LC01), Helton Farms #213 (LC02), Buttercup #208 (LC03), and Deepwood #204 (LC04) sites, the substrate was nearly all sand and the BEHI was high to very high indicating streambank erosion as a potential sediment source.

Stream gradient. Stream gradient is one of the factors contributing to high water velocity, which leads to an increase in erosion in streams with unstable banks. Based on GIS data, subwatershed LC01 was rated NF and subwatersheds LC02, LC03, and LC04 were rated FR. Only subwatershed LC05 was rated F.

Impervious cover. Based on GIS analysis of impervious cover (IC), subwatersheds LC01 (5.1%) and LC02 (8.1%) were both rated F. Subwatersheds LC03 (10.4%) and LC04 (14.7%) were rated FR due to urban development. Subwatershed LC05 covers the northeastern half of the City of Lenoir and therefore is the most urbanized and commercialized of the subwatersheds in the upper half of Lower Creek Watershed. Approximately 28.7% of the land use area of subwatershed LC05 is covered with impervious surface, which resulted in a rating of NF. DWQ (2005) noted the high impervious surface area adjacent to Lower Creek increased stormwater runoff and scour. The overall impervious cover for the Upper Lower Creek mega-subwatershed was 13.4%.

The overall hydrology function rating for the Upper Lower Creek mega-subwatershed was FR.

2. Habitat

Table 20 Habitat Function for Upper Lower Creek

Subwatershed	Riparian Buffer	Site Investigations (Habitat)	Overall Functionality
LC01	F	FR	**F**
LC02	FR	FR	FR
LC03	FR	FR	FR
LC04	FR	FR	FR
LC05	FR	NF	**NF**
Overall mega-subwatershed:			FR

Riparian buffer. The GIS analysis of riparian buffer indicates a lack of forested riparian buffer for the mega-subwatershed. Forested land use was present along only 58% of Upper Lower Creek. The lack of sufficient buffer contributes to streambank erosion, affecting aquatic habitat as is evident in subwatersheds LC02 and LC05 with 48% and 47% forested buffer, respectively. DWQ (2005), in their stream walk in subwatershed LC04, found that the riparian buffer was thin and inadequate due frequent breaks. Soils were also poorly bounded in the buffer areas allowing “upland inputs” to flow into the stream during storm events (DWQ, 2005).

Site investigations. Based on data from field site investigations, subwatersheds LC01, LC02, LC03, and LC04 were rated FR, due to poor bottom substrate, pool variety, and riffle habitat. Subwatershed LC05 was rated NF due to low scores in all parameters measured.

Overall, the mega-subwatershed was rated FR due to the absence of instream habitat from channelization, the loss of bottom substrate and riffle habitat from streambank erosion, and the lack of forested riparian buffer.

3. Water Quality

Table 21 Water Quality Function for Upper Lower Creek

Subwatershed	Riparian Buffer	Impervious Cover	Site Investigations (Water Quality)	DWQ Phys/Chem Monitoring	DWQ Benthic Monitoring	Overall Functionality
LC01	F	F	F		FR	F
LC02	FR	F	F		FR	FR
LC03	FR	FR	F		FR	FR
LC04	FR	FR	F		FR	FR
LC05	FR	NF	F	NF		NF
			Overall mega-subwatershed:			FR

Riparian buffer and impervious cover. As previously stated, the GIS analysis of riparian buffer indicated a lack of forested riparian buffer for the mega-subwatershed. The lack of sufficient forested buffer allows un-filtered stormwater runoff to enter tributaries and contributes to streambank erosion, adversely affecting water quality. The amount of impervious cover serves as an indication of the potential for water quality degradation caused by residential, commercial, and industrial areas. This measure denotes high potential for water quality impacts for highly urbanized LC05 (NF).

Site investigations. Site investigations at the Wendell #211 (LC02), Wilkesboro Blvd. #13 (LC04), and the Morganton Blvd. #16 (LC05) sites found colored and turbid water. Turbidity was listed as a reason for including Lower Creek on the 2004 NC Water Quality Assessment and Impaired Waters List (DWQ Draft, 2004; DWQ, 2005). The presence of periphyton growth, an indicator of nutrients in the water, was found only at the Cedar #209 site. DWQ (2005) in their stream walk of LC04 found turbid and milky colored water. They also found periphyton growth on bed sediment which was dominated by sand. High to very high bank erosion hazard index (BEHI) values were found at the North Wilkesboro #22 (LC01), Helton Farms #213 (LC02), Buttercup #208 (LC03), and Morganton Blvd. #3 (LC05) sites. These high BEHI values confirm the steep eroding stream banks as a source of sediment pollution as noted by DWQ (2005).

DWQ monitoring. Although the benthic community was not impaired on Upper Lower Creek, it was somewhat degraded, most likely due to both habitat and water quality concerns. A tributary that drains a highly industrial area of LC05 suffered from toxicity and had high metal, nutrient, and fecal coliform bacteria levels; in addition, semi-volatile organic pollutants were found in this stream. This resulted in an NF rating for LC05.

Overall the Upper Lower Creek mega-subwatershed was rated FR for water quality. Factors contributing to this rating include toxicity, high concentrations of metals, nutrients, and fecal coliform bacteria, moderately degraded benthos (DWQ, 2005), inadequate riparian buffer, and low scores for field investigations.

B. Lower Lower Creek

The Lower Lower Creek mega-subwatershed drains the lower half of Lower Creek and includes 37.9 miles of streams that flow into Lake Rhodhiss northeast of Morganton. The 17.7-square mile watershed extends from the southwestern edge of Lenoir to Lake Rhodhiss (Appendix I, Figures 8 and 9). The lower half of Lower Creek and its tributaries begin by draining urbanized areas of small-single family lots and commercial complexes in southern Lenoir. As Lower Creek flows southwest the land use begins to change to larger family lots, agriculture, and scattered commercial until nears its confluence with Lake Rhodhiss where the land use becomes forested. **Five subwatersheds comprise the Lower Lower Creek mega-subwatershed: LC06, LC07, LC08, LC09, and LC10.** Data used in characterizing this mega-subwatershed is derived from field studies at nine stream sites conducted in subwatersheds LC06 through LC09 (Appendix G). No physical data were collected in subwatershed LC10, only data derived from GIS analysis will be used to characterize the subwatershed. In addition, information from DWQ's two monitoring sites within the watershed (Appendix H) and GIS data on stream gradient, sinuosity, riparian buffer, and impervious cover (Appendix A through D; Table 22) were used in characterizing the mega-subwatershed.

Table 22 Lower Lower Creek Mega-subwatershed Summary Information

Subwatershed	Area (mi^2)	Stream Length (miles)	% Stream Length with Sinuosity ≤1.2	Average Stream Gradient (%)	Average % with 30-foot Forested Buffer	Average % IC
LC06	3.4	6.3	53	2.13	67	19.0
LC07	5.1	11.0	57	1.20	55	13.2
LC08	3.7	7.7	92	1.49	69	9.6
LC09	3.1	7.9	54	1.40	65	10.5
LC10	2.4	5.0	37	0.74	16	5.5
Total	**17.7**	**37.9**	**59**	**1.39**	**54**	**13.5**

1. Hydrology

Table 23 Hydrology Function for Lower Lower Creek

Subwatershed	Sinuosity	Stream Gradient	Impervious Cover	Site Investigations (Hydrology)	Overall Functionality
LC06	FR	FR	NF	NF	**NF**
LC07	FR	F	FR	FR	FR
LC08	NF	F	F	NF	FR
LC09	FR	F	FR	NF	FR
LC10	FR	F	F		FR
		Overall mega-subwatershed:			FR

Note: Since no field investigations were conducted in LC10, this field is blank.

Sinuosity and site investigations. The GIS sinuosity analysis indicates that approximately 54% of the tributaries in the lower half of the Lower Creek mega-subwatershed are potentially channelized (sinuosity values ≤ 1.2). MACTEC's field observations confirmed that all of the nine investigated stream sites were found to be significantly channelized (≥ 80%). Widespread channelization of the tributaries in the lower half of Lower Creek has led to incision and steep stream banks, as exhibited by the high bank ratios. The bank height ratio rated NF in all five subwatersheds. Stream sites Martin Marietta #318 (LC06), City of Lenoir #1 (LC06), Gamewell School #319 (LC07), and Craig Mountain #306 (LC08) are examples of very high bank height ratios. Erosion of unstable banks was found to be contributing sediment downstream, which was indicated by the low bottom substrate scores and low riffle habitat scores seen in subwatersheds LC06, LC07, LC08, and LC09. At the City of Lenoir #1, Gamewell School #319, Racetrack #300, and Antioch #302 sites, the substrate was nearly all sand and the BEHI was high to very high indicating streambank erosion as a potential sediment source. At the City of Lenoir #1 site, a sand dredging operation is present, which poses a downstream sediment risk.

Clay Sedimentation at Racetrack #300 Site

Stream gradient. Stream gradient influences water velocity in that steeper gradients produce higher water velocities, which in turn increase streambank erosion. Based on GIS data, subwatershed LC06 was rated FR and subwatersheds LC07, LC08, and LC09 were rated F.

Impervious cover. Based on GIS analysis of impervious cover, subwatershed LC06 was rated NF due to an impervious cover of approximately 19%. Subwatershed LC06 is located in the southeastern half of the City of Lenoir and therefore is an area of heavy urbanization. Subwatersheds LC07 and LC09 were rated FR due an impervious cover of 13.2% and 10.5%, respectively. Subwatersheds LC08 an LC10 were rated F with an impervious cover of 9.5% and 5.5%, respectively. DWQ (2005) noted the high impervious surface area adjacent to Lower Creek, which increases stormwater runoff and scour.

The overall hydrology function rating for the Lower Lower Creek mega-subwatershed was FR.

Impervious Cover and Runoff at Gamewell School #319 Site

2. Habitat

Table 24 Habitat Function for Lower Lower Creek

Subwatershed	Riparian Buffer	Site Investigations (Habitat)	Overall Functionality
LC06	F	NF	FR
LC07	FR	FR	FR
LC08	F	NF	FR
LC09	FR	NF	**NF**
LC10	F		**F**
Overall mega-subwatershed:			FR

Note: Site Investigation data unavailable for LC10

Riparian buffer. The GIS analysis of riparian buffer indicates a lack of riparian buffer for two of the five subwatersheds comprising the lower half of Lower Creek. Forested land use along the tributaries within those subwatersheds was 57%. The lack of sufficient buffer contributes to streambank erosion, affecting aquatic habitat as is evident in subwatershed LC07 with only 55% forested buffer.

Site investigations. Data based on field site investigations rated subwatersheds LC06, LC08, and LC09, as NF due to very low scores for bottom substrate, pool variety, and riffle habitat. Subwatershed LC07 was rated FR due to low scores for instream habitat, bottom substrate, and riffle habitat.

Overall, the mega-subwatershed was rated FR due to the lack of instream habitat from channelization, the loss of bottom substrate and riffle habitat from streambank erosion, and the lack of forested riparian buffer.

3. *Water Quality*

Table 25 Water Quality Function for Lower Lower Creek

Subwatershed	Riparian Buffer	Impervious Cover	Site Investigations (Water Quality)	DWQ Phys/Chem Monitoring	DWQ Benthic Monitoring	Overall Functionality
LC06	F	NF	F			FR
LC07	FR	FR	F			FR
LC08	F	F	FR			F
LC09	FR	FR	FR	FR		FR
LC10	F	F				FR
			Overall mega-subwatershed:			FR

Note: Site Investigation data unavailable for LC10

Riparian buffer and impervious cover. The lack of sufficient buffer allows stormwater runoff to enter tributaries un-filtered and contributes to streambank erosion, affecting water quality. The amount of impervious cover serves as an indication of the potential for water quality degradation caused by residential, commercial, and industrial areas. This measure denotes high potential for water quality impacts for urbanized LC06 (NF).

Site investigations. MACTEC found turbid water at Broyhill Furniture #14 and Union Grove Road #15. Turbidity was listed as a reason for including Lower Creek on the 2004 NC Water Quality Assessment and Impaired Waters List (DWQ Draft, 2004; DWQ, 2005). Site investigations of the remaining stream sites did not find evidence of water odor, discolored water, or the presence of periphyton growth. High to very high BEHI values were found at the City of Lenoir #1, Gamewell School #319, Racetrack #300, and Antioch #302 sites. These high BEHI values confirm steep eroding stream banks as a source of sediment pollution as noted by DWQ (2005).

DWQ monitoring. 2002 benthic monitoring in Lower Lower Creek revealed highly impacted benthic communities. Physical/chemical monitoring results from a site in LC09 indicated above normal concentration of metals, suspended solids, and fecal coliform bacteria. LC09 was rated FR for DWQ monitoring.

Based on riparian buffer, impervious cover, site investigations, and DWQ data, the Lower Lower Creek mega-subwatershed was rated FR for water quality.

C. Zacks Fork

The Zacks Fork mega-subwatershed includes 33.5 miles of named streams that flow into the upper portion of Lower Creek. The 13.4-square mile subwatershed is located north of the City of Lenoir (Appendix I, Figure 10). Most of Zacks Fork and its tributaries drain relatively steep slopes of mostly rural areas of agricultural, large-lot residential, and forested land uses. The lower section of Zacks Fork just prior to its confluence with Lower Creek becomes commercial-residential in nature. **Four subwatersheds comprise the Zacks Fork mega-subwatershed: ZF01, ZF02, ZF03, and ZFT1.** Data derived from field studies at 13 stream reaches (Appendix G), information from DWQ on their two monitoring sites within the watershed (Appendix H), and GIS data on stream gradient, sinuosity, riparian buffer, and impervious cover (Appendix A through D; Table 26) were used in characterizing the subwatersheds.

Table 26 Zacks Fork Mega-subwatershed Summary Information

Subwatershed	Area (mi^2)	Stream Length (miles)	% Stream Length with Sinuosity ≤ 1.2	Average Stream Gradient (%)	Average % with 30-foot Forested Buffer	Average IC (%)
ZF01	3.15	8.4	32	5.88	69	5.0
ZF02	4.50	9.3	78	2.90	39	5.9
ZF03	1.95	3.6	15	0.71	37	29.6
ZFT1	3.80	12.2	72	1.70	59	10.2
Total	**13.40**	**33.5**	**49**	**2.80**	**51**	**12.7**

Cattle in Stream at North Wilkesboro #22 Site

1. Hydrology

Table 27 Hydrologic Function for Zacks Fork

Subwatershed	Sinuosity	Stream Gradient	Impervious Cover	Site Investigations (Hydrology)	Overall Functionality
ZF01	F	NF	F	FR	FR
ZF02	NF	FR	F	FR	FR
ZF03	F	F	NF	NF	FR
ZFT1	NF	FR	FR	FR	FR
		Overall mega-subwatershed:			FR

Sinuosity and site investigations. The GIS sinuosity analysis indicates that approximately 49.3% of the tributaries in the Zacks Fork Creek mega-subwatershed are potentially channelized (i.e. sinuosity values ≤ 1.2). The 13 stream sites investigated confirmed that only two (Bartley Kincaid #5 [ZF01] and Zinfandel #66 [ZF02]) were not channelized (≤20%) and were rated F. Seven stream sites were found to be highly channelized (≥80%) and were rated NF. DWQ (2005) visually confirmed evidence of channelization during their stream walk in ZF03. Channelization was widespread and found in the four subwatersheds. The channelization has led to incision and steep stream banks, as evidenced by the high bank height ratios. The bank height ratio was rated NF for the four subwatersheds. DWQ (2005) visually confirmed this rating in their stream walks. A low stream bank stability rating is an indicator of potential sediment loading for streams. As indicted by field measurements at the thirteen stream sites and visual observations made by DWQ (2005) in their stream walks, bank stability for the Zacks Fork mega-subwatershed is a problem. Unstable banks lead to additional sediment downstream, which was evident by low bottom substrate scores (homogeneous substrate and high embeddedness) and low riffle habitat scores as seen in subwatershed ZF03. As noted by MACTEC, at both the Powell #67 and Harper Morgan #108 sites (ZF03), the substrate was nearly all sand and the BEHI was very high indicating that streambank erosion may be a source of sediment. The amount of sediment within the stream system was large enough that DWQ (2005) observed sand ridges or "dunes" three inches in height in the stream bottom located upstream of the Lenoir Golf Course.

Stream gradient. Stream gradient or slope is a factor controlling water velocity which is related to potential streambank erosion. Based on GIS data analysis, only one subwatershed ZF03 was rated F for stream gradient. The other subwatersheds ZF01, ZF02, and ZFT1 were rated FR, NF, and FR, respectively for stream gradient.

Impervious cover. Impervious surfaces such as roads, parking lots, shopping centers, and large building complexes, when located near or adjacent to inadequately buffered streams, cause an increase in stream velocity and volume during storm events. The higher flows associated with stormwater runoff transport additional sediment into the stream and increase scouring and channel erosion at the discharge point. In addition, the high water velocity and volume will re-suspend existing instream sediment (DWQ, 2005).

Based on GIS analysis of impervious cover or surface, subwatersheds ZF01 (5.0%) and ZF02 (5.9%) both were rated F (Appendix A). Subwatershed ZFT1 was rated FR due to the urban development in the lower reaches of the tributary located within the City of Lenoir. Subwatershed ZF03 is the most urbanized of the Zacks Fork subwatersheds and as such, 29.6% of the land use area is covered with an impervious surface, which resulted in a rating of NF.

The overall hydrology function rating for the Zacks Fork mega-subwatershed based on sinuosity, stream gradient, impervious cover, and site investigations was FR.

2. *Habitat*

Table 28 Habitat Function for Zacks Fork

Subwatershed	Riparian Buffer	Site Investigations (Habitat)	Overall Functionality
ZF01	F	F	**F**
ZF02	FR	FR	FR
ZF03	FR	FR	FR
ZFT1	FR	FR	FR
Overall mega-subwatershed:			FR

Riparian buffer. The GIS analysis of riparian buffer found that within a 30-foot buffer along Zacks Fork and its tributaries, only 44% of the land is forested. The lack of sufficient forested buffer contributes to streambank erosion, limits the availability of terrestrial habitat, and promotes increased temperatures in the stream thereby, affecting aquatic habitat. DWQ (2005) stream walks and MACTEC's field observations confirm the lack of adequate forested buffer in the subwatersheds and in particular in subwatershed ZF03. Only subwatershed ZF01 was rated F for riparian buffer.

Site investigations. Based on data from field site investigations, subwatershed ZF01 was rated F and the other three subwatersheds were rated FR. While subwatershed ZF01 was found to be F, bottom substrate and pool variety for the subwatershed was rated FR, due to sedimentation brought about by bank instability. Streambank erosion is most evident in subwatershed ZF03 where excess sediment deposits from local and upstream sources is a major source of habitat loss (DWQ, 2005), as indicated by the bottom substrate being nearly all sand and the absence of riffles.

Overall, the mega-subwatershed was rated FR due to the absence of instream habitat from channelization, the loss of bottom substrate and riffle habitat from streambank erosion, and the lack of forested riparian buffer.

3. Water Quality

Table 29 Water Quality Function for Zacks Fork

Subwatershed	Riparian Buffer	Impervious Cover	Site Investigations (Water Quality)	DWQ Phys/Chem Monitoring	DWQ Benthic Monitoring	Overall Functionality
ZF01	F	F	F		FR	**F**
ZF02	FR	F	FR		FR	FR
ZF03	FR	NF	FR	NF	NF	**NF**
ZFT1	FR	FR	F			FR
			Overall mega-subwatershed:			FR

Riparian buffer and impervious cover. A forested riparian buffer acts as a filter or a sink for nutrients, thereby improving a stream's water quality by limiting the introduction of nutrients into the stream. Therefore, the presence or absence of riparian buffer and the condition of the buffer, when present, can be used as an indirect indicator of stream quality. The amount of impervious cover serves as an indication of the potential for water quality degradation caused by residential, commercial, and industrial areas. This measure denotes high potential for water quality impacts for highly urbanized ZF03 (NF).

Site investigations. Site investigations data for water quality rated subwatersheds ZF01 and ZFT1 as F and subwatersheds ZF02 and ZF03 as FR. The Dimmette #62 (ZF02) and Harper Morganton #108 (ZF03) sites exemplify the degraded water quality in Zacks Fork due to very high BEHI, chemical and sewage odor, and low water clarity.

Cattle were observed to have access to the stream at two sites, the Cottrell Hill #32 site and the Zacks Fork #403 site in subwatershed ZF02. In addition, observations by MACTEC upstream of the Truesdale #51 site in subwatershed ZF01 indicated access to the stream by horses and cattle. DWQ (2005) reported that local residents near Powell Street have reported reoccurring problems with overflowing manholes. In conjunction with the local residents reports of June 23, 2005, at the Harper Morgan #108 site (ZF03) upstream of water quality sampling site Z1, MACTEC and DWQ staff observed a heavy sewage flow into Zacks Fork. Sampling site Z1 was the only site where low DO was recorded. This observation was made during a storm event on May 20, 2004 and may be connected to raw sewage entering the creek (DWQ, 2005).

DWQ monitoring. Benthic monitoring revealed a highly degraded benthic community in lower Zacks Fork (ZF03), but a community that was much more diverse and healthy above the urbanized area of the mega-subwatershed. Fecal coliform bacteria levels exceeded the NC standard in baseflow and stormflow. High metal levels were found in stormflows. ZF03 was rated NF for DWQ benthic and physical/chemical monitoring.

Sewage in Zacks Fork Creek at Harper Morganton Site

Based on riparian buffer, impervious cover, site investigation data, and DWQ data, the Zacks Fork mega-subwatershed was rated FR for water quality.

D. Spainhour Creek

The Spainhour Creek mega-subwatershed includes 11.5 miles of stream that flows into the middle portion of Lower Creek. The 6.6-square mile subwatershed extends from its confluence with Lower Creek near the center of Lenoir to the northwest. Spainhour Creek originates in the forested slopes of the Green Mountains, north of US 321 and Indian Grave Road intersection. The middle stream reach flows through commercial and industrial areas with the final stream reach flowing through the City.

Two subwatersheds comprise the Spainhour Creek mega-subwatershed: SC01 and SC02 (Appendix I, Figure 11). Data derived from field studies at seven stream sites (Appendix G), information from DWQ's five monitoring sites within the mega-subwatershed (Appendix H), and GIS data on stream gradient, sinuosity, riparian buffer, and impervious cover (Appendix A through D; Table 30) were used to characterize the subwatersheds.

Table 30 Spainhour Creek Mega-subwatershed Summary Information

Subwatershed	Area (mi^2)	Stream Length (miles)	% Stream Length with Sinuosity ≤ 1.2	Average Stream Gradient (%)	Average % with 30-foot Forested Buffer	Average % IC
SC01	2.95	5.8	83	3.19	48	10.8
SC02	3.66	5.7	73	0.81	36	28.8
Total	**6.61**	**11.5**	**78**	**2.00**	**42**	**19.8**

1. Hydrology

Table 31 Hydrology Function for Spainhour Creek

Subwatershed	Sinuosity	Stream Gradient	Impervious Cover	Site Investigations (Hydrology)	Overall Functionality
SC01	NF	FR	FR	FR	FR
SC02	NF	F	NF	NF	**NF**
		Overall mega-subwatershed:			**NF**

Sinuosity and site investigations. The GIS sinuosity analysis indicates that approximately 78% of the streams within the Spainhour Creek mega-subwatershed are potentially channelized (sinuosity values ≤ 1.2). MACTEC's field observations confirmed that only one of the seven stream sites investigated was not channelized (≤20%) and was rated F. The remaining six stream sites were found to be highly channelized (≥80%) and were rated NF. The channelization has led to incision and steep stream banks, as evidenced by the high bank height ratios visually confirmed by DWQ (2005), in their stream walks, and the moderate to very high BEHI. As indicted by field measurements at the seven sites (Appendix G) and visual observation made by DWQ (2005), bank stability for the watershed is a problem due to bank erosion and under cutting. In several stream reaches of SC02 the problem of bank stability has prompted land owners to stabilize the streambanks with tires (DWQ 2005). At the Advent #96 (SC02) site both streambanks are stabilized with rip-rap and gabion baskets, and in areas not stabilized the banks are failing. Unstable banks are leading to additional sediment being transported downstream, which is evident by low bottom substrate scores and low riffle habitat scores. Visual observations by

DWQ (2005) indicated that bank erosion was severe; in particular the stream reach from Meadow Lane to the confluence with Blair Fork Creek where several structures were in danger of being lost.

Hard Bank Stabilization along Stream at Main Street #109 Site

Stream gradient. Stream gradient is a factor controlling water velocity, and high water velocity in streams with unstable banks leads to an increase in erosion. Based on GIS data analysis, subwatershed SC01 was rated FR and SC02 was rated F. Based on observations made by DWQ the lower reaches of Spainhour Creek are widening, which indicates the stream is attempting to develop a new floodplain and water velocities should be lowering in response to this development. A lower water velocity in SC02 is important because of the unstable streambanks and the potential for failure.

Impervious cover. Based on GIS data analysis for impervious cover, subwatershed SC01 had a 10.8% IC, which resulted in a rating of FR. The amount of impervious cover for subwatershed SC02 was 28.8%, which resulted in a rating of NF. Impervious surfaces, mainly roads, and large building complexes are located near or adjacent to Spainhour Creek in subwatershed SC02. The amount of impervious surface has increased stormwater flow velocity and volume during storm events, which has increased scouring (DWQ, 2005).

2. *Habitat*

Table 32 Habitat Function for Spainhour Creek

Subwatershed	Riparian Buffer	Site Investigations (Habitat)	Overall Functionality
SC01	FR	FR	FR
SC02	FR	NF	**NF**
Overall mega-subwatershed:			**NF**

Riparian buffer. The GIS analysis of riparian buffer indicates a lack of adequate riparian buffer for the two subwatersheds of Spainhour Creek with only a 42% forested land use along the tributaries. The lack of sufficient forested buffer contributes to streambank erosion, affecting aquatic habitat as is evident in SC02. DWQ's (2005) stream walk in subwatershed SC02 and MACTEC's field observations in both subwatersheds confirm the lack of adequate buffer.

Site investigations. Based on data from field site investigations, subwatershed SC01 was rated FR and subwatershed SC02 was rated NF. Streambank erosion is most evident in subwatershed SC02 where excess sediment deposits from local and upstream sources is a major source of habitat loss, as evident by the absence of the thalweg in the lower reaches of SC02 (DWQ 2005).

Overall, the mega-subwatershed was rated NF due to the absence of instream habitat from channelization, the loss of bottom substrate and riffle habitat from streambank erosion, and the lack of forested riparian buffer.

3. *Water Quality*

Table 33 Water Quality Function for Spainhour Creek

Subwatershed	Riparian Buffer	Impervious Cover	Site Investigations (Water Quality)	DWQ Phys/Chem Monitoring	DWQ Benthic Monitoring	Overall Functionality
SC01	FR	FR	FR		FR	FR
SC02	FR	NF	FR	NF	NF	**NF**
			Overall mega-subwatershed:			**NF**

Riparian buffer and impervious cover. Commercial lands and road corridors located adjacent to tributaries in the subwatershed are contributing to the water quality problem through increased stormwater runoff due to impervious surface and minimized forested buffers along streams. Degraded riparian buffers have allowed nutrients, metals, and other pollutants to enter the stream during storm events (DWQ, 2005). The amount of impervious cover serves as an indication of the potential for water quality degradation caused by residential, commercial, and industrial areas. This measure denotes high potential for water quality impacts for this urbanized mega-subwatershed.

Site investigations. Observations of slightly turbid water quality and the presence of periphyton growth, an indicator of nutrients in the water, were seen at the Indian Grave Road #31 (SC01) site. Periphyton growth was also observed in subwatershed SC01 at Blair Baptist Church #110 and Blair Fork & Blowing Rock #111 sites. Slightly turbid water color and a strong smell of sewage were recorded at the Advent #96 site (SC02). The sewage smell may have been due to overflowing sewer manholes and/or failing collection systems as reported by DWQ (2005).

DWQ monitoring. The benthic community was highly degraded on highly urbanized lower Spainhour Creek, but the community on a tributary upstream of most of this urban development was relatively diverse and healthy. Lower Spainhour Creek was characterized by high fecal coliform bacteria levels, high metal and nutrient levels, and toxicity. High levels of nitrite-nitrate and total phosphorous found here can be an indication of failing sewage collection systems. SC02 was rated NF for both benthic and physical/chemical monitoring, and SC01 was rated FR for benthic monitoring.

The cumulative score for water quality for the Spainhour Creek mega-subwatershed was NF, based on riparian buffer, impervious cover, site investigations, and DWQ data.

E. Blair Fork

The Blair Fork mega-subwatershed includes 4.8 miles of streams that flow into the middle reach of Spainhour Creek and is comprised of one subwatershed, BF01. The 2.8-square mile subwatershed is located along and south of US 321, north of the City of Lenoir (Appendix I, Figure 12). Most of Blair Fork Creek and its tributaries originate by draining relatively steep slope rural areas of large-lot residential and forest land uses. In the middle and lower reaches of the mega-subwatershed, the land use becomes commercial and industrial with transportation corridors along and adjacent to floodplains. Data derived from field studies at four stream reaches (Appendix G), information from DWQ on their eight monitoring sites within the watershed (Appendix H), and GIS data on stream gradient, sinuosity, riparian buffer, and impervious cover (Appendix A through D; Table 34) were used in characterizing this mega-subwatershed.

Table 34 Blair Fork Mega-subwatershed Summary Information

Subwatershed	Area (mi²)	Stream Length (miles)	% Stream Length with Sinuosity ≤ 1.2	Average Stream Gradient (%)	Average % with 30-foot Forested Buffer	Average % IC
BF01	2.8	4.8	58	1.48	26	18
Total	**2.8**	**4.8**	**58**	**1.48**	**26**	**18**

1. Hydrology

Table 35 Hydrology Function for Blair Fork

Subwatershed	Sinuosity	Stream Gradient	Impervious Cover	Site Investigations (Hydrology)	Overall Functionality
BF01	FR	F	NF	FR	FR
		Overall mega-subwatershed:			FR

Sinuosity and site investigations. The GIS sinuosity analysis indicates that approximately 58% of the tributaries in the Blair Fork mega-subwatershed are potentially channelized (sinuosity values ≤ 1.2). MACTEC's field observations confirmed that all 3 stream sites investigated were highly channelized and rated NF. In conjunction with the channelization, streams were incised with moderate to high BEHI and were rated FR for BEHI. DWQ visually confirmed incised channels and high BEHI during their stream walk (DWQ, 2005). High BEHI indicates that sediment can be introduced into the stream during peak flow events. As observed by MACTEC at the field sites and DWQ (2005) during their stream walks, bank stability was low and rated NF. In conjunction with the high values for BEHI, MACTEC found unstable banks at Collettsville #92 and Blowing Rock #33. Extensive use of rip-rap was documented by both MACTEC and DWQ, presumably to stabilize stream banks.

Stream gradient. Stream gradient is a major factor controlling water velocity which is related to potential streambank erosion. Based on GIS data analysis, stream gradient is not an issue for the Blair Fork mega-subwatershed.

Impervious cover. In the Blair Fork mega-subwatershed impervious surfaces, mainly roads and parking lots associated with light industrial uses are located in or adjacent to the floodplains of the tributaries. Based on GIS analysis for impervious cover, the mega-subwatershed was found to have an 18% IC.

The overall hydrology function rating for the Blair Fork mega-subwatershed based on sinuosity, impervious cover, and site investigations was FR.

2. Habitat

Table 36 Habitat Function for Blair Fork

Subwatershed	Riparian Buffer	Site Investigations (Habitat)	Overall Functionality
BF01	NF	FR	NF
Overall mega-subwatershed:			**NF**

Riparian buffer. The GIS analysis of riparian buffer indicated only 26% forested land use in a 30-foot buffer along Blair Fork and its tributaries. The absence of sufficient riparian buffer contributes to streambank erosion, limits the availability of terrestrial habitat, and promotes increased temperatures due to the lack of shading of the stream, thereby affecting aquatic habitat. DWQ (2005) stream walks and MACTEC's field observations confirm the lack of adequate forested buffer and in those reaches where forested buffer was present, frequent breaks were reported which diminished the buffer's effect.

Site investigations. The low values for light penetration are another indication of the absence of riparian buffer and potential degraded habitat due to increased stream temperature. Both DWQ and MACTEC observed stream reaches where streambanks had been rip-rapped, limiting streamside habitat due to the loss of vegetation.

The absence and degradation of riparian buffer, the infrequency of pools due to channelization and sedimentation, and the rip-rapping of stream banks are the reasons why the Blair Fork mega-subwatershed was rated NF.

3. Water Quality

Table 37 Water Quality Function for Blair Fork

Subwatershed	Riparian Buffer	Impervious Cover	Site Investigations (Water Quality)	DWQ Phys/Chem Monitoring	DWQ Benthic Monitoring	Overall Functionality
BF01	NF	NF	FR	NF	NF	NF
			Overall mega-subwatershed:			**NF**

Riparian buffer and impervious cover. The absence of forested buffer in this mega-subwatershed is contributing to nutrient loading due to the lack vegetation to uptake nutrients and an increase in streambank erosion (DWQ, 2005). The amount of impervious cover serves as an indication of the potential for water quality degradation caused by residential, commercial, and industrial areas. This measure denotes high potential for water quality impacts for this urbanized mega-subwatershed.

Site investigations. Site investigations data for water quality rate the subwatershed as FR. One of the three sites tested positive for turbidity but none of the sites had indications of periphyton growth. However, DWQ (2005) reported periphyton growth at site B1 which is located upstream of the Blair Fork and Spainhour confluence. Cattle were observed to have access to the stream at Collettsville #92 site. In addition, DWQ (2005) observed straight piping during their stream walk.

DWQ monitoring. Blair Fork's benthic community was severely degraded, revealing toxicity impacts. Toxicity was measured in Blair Fork, and this was traced to an unlined county landfill in the Blair Fork headwaters. Other sources of toxicity may be present, as well. High nutrients and metal levels were also found in Blair Fork, and one likely source of these pollutants is the landfill. High fecal coliform bacteria concentrations (>400 colonies/100 ml) were found in 100% of the baseflow samples for Blair Fork at SR1525 and 50% of the samples for Blair Fork at 1944 Valway.

The cumulative score for water quality based on riparian buffer, impervious cover, site investigations, and DWQ data rated the Blair Fork mega-subwatershed as NF.

F. Greasy Creek

The Greasy Creek mega-subwatershed includes 11.5 miles of streams that flow into the lower half of Lower Creek. The 5.0-square mile watershed is located west of the City of Lenoir (Appendix I, Figure 13). Greasy Creek and its tributaries begin by draining moderately sloped rural areas of large-lot residential and forested lands. As Greasy Creek moves toward Lenoir the land use changes to 2-acre family lots and single-family residential until entering the City where land use changes to commercial near the Creek's confluence with Lower Creek. **Two subwatersheds comprise the Greasy Creek: GC01 and GC02.** Data derived from field studies at six stream reaches (Appendix G), information from DWQ's two monitoring sites within the mega-subwatershed (Appendix H), and GIS data on stream gradient, sinuosity, riparian buffer, and impervious cover (Appendix A through D; Table 38) were used in characterizing this mega-subwatershed.

Table 38 Greasy Creek Mega-subwatershed Summary Information

Subwatershed	Area (mi²)	Stream Length (miles)	% Stream Length with Sinuosity ≤ 1.2	Average Stream Gradient (%)	Average % with 30-foot Forested Buffer	Average % IC
GC01	3.4	7.1	47	2.28	60	7.8
GC02	1.6	4.4	41	1.22	62	14.2
Total	**5.0**	**11.5**	**44**	**1.75**	**61**	**11.0**

1. Hydrology

Table 39 Hydrology Function for Greasy Creek

Subwatershed	Sinuosity	Stream Gradient	Impervious Cover	Site Investigations (Hydrology)	Overall Functionality
GC01	FR	FR	F	FR	FR
GC02	FR	F	FR	NF	FR
		Overall mega-subwatershed:			FR

Sinuosity and site investigations. The GIS sinuosity analysis indicates that approximately 44% of the tributaries in Greasy Creek mega-subwatershed are potentially channelized (sinuosity values ≤ 1.2). MACTEC's field observations confirmed of the six stream sites investigated, only Church Jack #221 (GC01) was not significantly channelized (≤20%) and rated F. The remaining five reach sites were found to be highly channelized (≥80%) and rated NF. Widespread channelization of the tributaries in the Greasy Creek has led to incision and steep stream banks, as exhibited by the high bank height ratios. The bank height ratio rated NF in the two subwatersheds. Stream reach sites Gravell Hill #218 (GC01) and West Lenoir #225 (GC02) are major examples of very high bank height ratios. The unstable banks were found to be contributing sediment downstream, which was indicated by the low bottom substrate scores and low riffle habitat scores seen in subwatershed GC02. Substrate at the West Lenoir #225 site (GC02) was nearly all sand; at Gravell Hill #218 (GC01) and Powell Brickyard #224 (GC02) sites, the BEHI was high, indicating streambank erosion as a potential sediment source.

Stream gradient. Stream gradient is one of the factors contributing to water velocity and high water velocity is a factor in streambank erosion. Based on GIS data, subwatershed GC01 was rated FR and subwatershed GC02 was rated F.

Impervious cover. Based on GIS analysis of impervious cover, subwatershed GC01 was rated F, due to an impervious cover value of only 7.8%. Subwatershed GC02 had an impervious cover of 14.2% due to urban development and rated FR. Given the development within subwatershed GC02, an increase in stormwater runoff and associated pollutants can be expected.

The overall hydrology function rating for the Greasy Creek mega-subwatershed based on sinuosity, stream gradient, impervious cover, and site investigation was FR.

2. Habitat

Table 40 Habitat Function for Greasy Creek

Subwatershed	Riparian Buffer	Site Investigations (Habitat)	Overall Functionality
GC01	FR	F	**F**
GC02	FR	NF	**NF**
Overall mega-subwatershed:			FR

Riparian buffer. The GIS analysis of riparian buffer indicates a lack of adequate riparian buffer for the Greasy Creek mega-subwatershed. Along Greasy Creek and its tributaries only 61% of the land was forested. The lack of sufficient buffer contributes to streambank erosion, affecting aquatic habitat as is evident in subwatersheds GC01 and GC02 with 60% and 62% forested buffer, respectively.

Site investigations. Data based on field site investigations of subwatershed GC01 rated the subwatershed as F for all parameters except for bottom substrate and light penetration, which were rated as FR. Subwatershed GC02 was rated NF due to low scores in all parameters measured.

Overall, the mega-subwatershed was rated FR due to the absence of instream habitat from channelization, the loss of bottom substrate and riffle habitat from streambank erosion, and the lack of forested riparian buffer.

3. Water Quality

Table 41 Water Quality Function for Greasy Creek

Subwatershed	Riparian Buffer	Impervious Cover	Site Investigations (Water Quality)	DWQ Phys/Chem Monitoring	DWQ Benthic Monitoring	Overall Functionality
GC01	FR	F	F		FR	FR
GC02	FR	FR	FR	NF	NF	NF
			Overall mega-subwatershed:			**FR**

Riparian buffer and impervious cover. The lack of sufficient buffer allows stormwater to enter a tributary unabated and contributes to streambank erosion, affecting water quality. The amount of impervious cover serves as an indication of the potential for water quality degradation caused by residential, commercial, and industrial areas. This measure denotes moderate potential for water quality impacts for GC02 (FR).

Site investigations. MACTEC observed turbid water at the West Lenoir #225 site. The presence of periphyton growth is an indicator of nutrient enrichment and was found at the Gravell Hill #218 site (GC01). High BEHI values were found at the Gravell Hill #218 (GC01) and West Lenoir #225 (GC02) sites. These high BEHI values indicated that steep eroding stream banks were a potential source of sediment pollution in the aquatic environment for subwatershed GC02. DWQ's water quality test for fixed residue and turbidity supported the sediment problem (DWQ, 2005).

DWQ monitoring. The benthic community of lower Greasy Creek was impaired, but several miles upstream it was more diverse and healthy. Physical/chemical sampling demonstrated high levels of metals, fecal coliform bacteria, and nutrients. GC01 was rated FR for benthic monitoring, but GC02 was NF for both physical/chemical and benthic monitoring.

The cumulative score for water quality based on riparian buffer, impervious cover, site investigations, and DWQ data rated the Greasy Creek mega-subwatershed FR.

G. Abingdon Creek

The Abingdon Creek mega-subwatershed includes 13.0 miles of streams that flow into the lower half of Lower Creek near the northeast town limits of Gamewell. The 6.5-square mile subwatershed is located southwest of the City of Lenoir (Appendix I, Figure 14). Abingdon Creek and its tributaries begin by draining moderately sloped rural areas of large-lot residential and forested lands. As Abingdon Creek flows southeast the land use changes to 2-acre family lots and single family until near the community of Gamewell where land use changes to commercial near the creek's confluence with Lower Creek. **Two subwatersheds comprise the Abingdon Creek mega-subwatershed: AC01 and AC02.** Data used in characterizing this mega-subwatershed is derived from field studies at four stream reaches (Appendix

G), DWQ data at two sites (Appendix H), and GIS data on stream gradient, sinuosity, riparian buffer, and impervious cover (Appendix A through D; Table 42).

Table 42 Abingdon Creek Mega-subwatershed Summary Information

Subwatershed	Area (mi²)	Stream Length (miles)	% Stream Length with Sinuosity ≤ 1.2	Average Stream Gradient (%)	Average % with 30-foot Forested Buffer	Average % IC
AC01	3.1	6.0	35	1.96	71	7.1
AC02	3.4	7.0	80	1.73	70	13.6
Total	**6.5**	**13.0**	**58**	**1.85**	**71**	**10.4**

1. Hydrology

Table 43 Hydrology Function for Abingdon Creek

Subwatershed	Sinuosity	Stream Gradient	Impervious Cover	Site Investigations (Hydrology)	Overall Functionality
AC01	FR	F	F	FR	**F**
AC02	NF	F	FR	FR	FR
		Overall mega-subwatershed:			**F**

Sinuosity and site investigations. The GIS sinuosity analysis indicates that approximately 58% of the tributaries in Abingdon Creek mega-subwatershed are potentially channelized (sinuosity values ≤ 1.2). MACTEC's field observations confirmed that of the four stream sites investigated, only the Taylor Family #36 (AC02) was significantly channelized (≥80%). The remaining reach sites were found not to be channelized (≤20%), which resulted in the two subwatersheds being rated F for channelization. Stream reach sites Huffman #314, Caldwell Board of Education #316, and Taylor Family in subwatershed AC02 are examples of very high bank height ratios. The unstable banks were found to be contributing sediment downstream, which was indicated by the low bottom substrate scores and low riffle habitat scores seen in subwatershed AC02. MACTEC documented, that the substrate at the Taylor Family #36 site was nearly all sand. At the Huffman #314 and Caldwell Board of Education #316 sites (AC02) the BEHI was high indicating streambank erosion as a potential sediment source.

Stream gradient. Stream gradient is one of the factors contributing to water velocity, and high water velocity is a factor in streambank erosion. Based on GIS data, both subwatersheds AC01 and AC02 were rated F. Given the results for stream gradient, high water velocity due to gradient is not an issue for the Abingdon Creek mega-subwatershed.

Impervious cover. Based on GIS analysis of impervious cover, subwatershed AC01 was rated F due to an impervious cover of 7.1%. Subwatershed AC02 had an impervious cover of 13.6% due to urban development and was rated FR. Given the development within subwatershed AC02 an increase in stormwater runoff and associated pollutants can be expected.

The overall hydrology function rating for the Abingdon Creek Watershed based on sinuosity, stream gradient, impervious cover, and site investigation was rated F.

2. Habitat

Table 44 Habitat Function for Abingdon Creek

Subwatershed	Riparian Buffer	Site Investigations (Habitat)	Overall Functionality
AC01	F	FR	**F**
AC02	F	NF	FR
Overall mega-subwatershed:			**F**

Riparian buffer. GIS analysis of riparian buffers indicated the presence of adequate riparian buffer within 71% of the buffer zone along Abingdon Creek and its tributaries. Abingdon Creek mega-subwatershed was one of only two subwatersheds within Lower Creek that had an adequate forested buffer.

Site investigations. Subwatershed AC01 rated FR to due a low score for bottom substrate. Subwatershed AC02 rated NF due low scores for instream habitat, pool variety, and light penetration and very low scores for bottom substrate and riffle habitat.

Overall, the mega-subwatershed was rated F due to the absence of instream habitat from channelization, the loss of bottom substrate and riffle habitat from streambank erosion, and the lack of forested riparian buffer.

3. Water Quality

Table 45 Water Quality Function for Abingdon Creek

Subwatershed	Riparian Buffer	Impervious Cover	Site Investigations (Water Quality)	DWQ Phys/Chem Monitoring	DWQ Benthic Monitoring	Overall Functionality
AC01	F	F	F		FR	**F**
AC02	F	FR	F	FR	FR	FR
			Overall mega-subwatershed:			**F**

Riparian buffer and impervious cover. The amount of impervious cover serves as an indication of the potential for water quality degradation caused by residential, commercial, and industrial areas. This measure denotes moderate potential for water quality impacts for AC02 (FR).

Site investigations. Poor water quality due to odor, clarity, and periphyton growth were not evident at the stream reach sites within the Abingdon Creek mega-subwatershed. However, very high BEHI values were found at the Huffman #314 and Caldwell Board of Education #316 sites (AC02). These high BEHI values indicated that steep eroding stream banks were a potential source of sediment pollution in the aquatic environment for subwatershed AC02. While DWQ did not perform any water quality test for this watershed it is anticipated that TKN and phosphorus levels may be elevated due to the plant nursery (Taylor Family #36) located in the lower reach of the mega-subwatershed.

DWQ monitoring. Benthic monitoring revealed a relatively healthy community of benthic macroinvertebrates. Physical/chemical monitoring generally revealed lower levels of pollutants than in other streams sampled. AC01 and AC02 were rated FR for benthic monitoring, and AC02 was rated FR for physical/chemical monitoring.

Based on riparian buffer, impervious cover, site investigation data, and DWQ data, water quality was found to be F for the Abingdon Creek mega-subwatershed.

H. Husband Creek

The Husband Creek mega-subwatershed includes 18.9 miles of streams that flow into the lower half of Lower Creek southeast of the town of Gamewell near the Caldwell and Burke County Line. The 10.7-square mile watershed is located approximately four miles southwest of the City of Lenoir (Appendix I, Figure 15). Husband Creek and its tributaries begin by draining moderately sloped rural areas of large-lot residential and forested lands. As Husband Creek flows to the southeast, land use changes to agricultural, 2 acre family lots and single family and maintains this land use up to Husband Creek's confluence with Lower Creek. **Three subwatersheds comprise the Husband Creek mega-subwatershed: HC01, HC02, and HC03.** Data derived from field studies at nine stream reaches (Appendix G), DWQ data at two sites (Appendix H), and GIS data on stream gradient, sinuosity, riparian buffer, and impervious cover (Appendix A through D; Table 46) were used in characterizing this mega-subwatershed.

Table 46 Husband Creek Mega-subwatershed Summary Information

Subwatershed	Area (mi^2)	Stream Length (miles)	% Stream Length with Sinuosity ≤ 1.2	Average Stream Gradient (%)	Average % with 30-foot Forested Buffer	Average % IC
HC01	5.7	9.8	69	1.51	46	11.9
HC02	2.9	5.1	63	1.01	57	8.5
HC03	2.1	4.0	66	1.06	74	11.0
Total	**10.7**	**18.9**	**66**	**1.19**	**59**	**10.5**

1. Hydrology

Table 47 Hydrology Function for Husband Creek

Subwatershed	Sinuosity	Stream Gradient	Impervious Cover	Site Investigations (Hydrology)	Overall Functionality
HC01	NF	F	FR	FR	FR
HC02	FR	F	F	FR	F
HC03	FR	F	FR	FR	FR
		Overall mega-subwatershed:			FR

Sinuosity and site investigations. The GIS sinuosity analysis indicates that approximately 66% of the tributaries in Husband Creek mega-subwatershed are potentially channelized (sinuosity values ≤ 1.2). MACTEC's field observations confirmed that of the nine stream sites investigated, only Crooked Creek #42 (HC01) was not channelized (≤20%). The remaining reach sites were found to be significantly channelized (≥80%). HC02 and HC03 were rated NF and subwatershed HC01 was rated FR for channelization. Stream reach sites Kingston #37 (HC02), Poteet #115 (HC02), and Mauck #305 (HC03) are major examples of very high bank height ratios. At the Crooked Creek #42 (HC01), Kingston #37 (HC02), and Frank Martin #303 (HC03) sites, the BEHI was high indicating streambank erosion as a potential sediment source. Bank stability was rated NF for subwatershed HC01 and FR for subwatersheds HC02 and HC03.

Stream gradient. Stream gradient is one of the factors contributing to water velocity, and high water velocity is factor in streambank erosion. Based on GIS data, all three subwatersheds were rated F. Given the results for stream gradient, high water velocity due to gradient is not an issue for the Husband Creek mega-subwatershed.

Impervious cover. Based on GIS analysis of impervious cover, subwatersheds HC01 and HC03 were rated FR due to an impervious cover of approximately 11.9% and 11.0%, respectively. Subwatershed HC02 had an impervious cover of 8.5% and rated F. Given the location of road corridors relative to tributaries within subwatersheds HC01 and HC03, hydrocarbons and other pollutants in stormwater runoff can be expected to affect the quality of Husband Creek.

The overall hydrology function rating for the Husband Creek mega-subwatershed based on sinuosity, stream gradient, impervious cover, and site investigation was FR.

2. Habitat

Table 48 Habitat Function for Husband Creek

Subwatershed	Riparian Buffer	Site Investigations (Habitat)	Overall Functionality
HC01	FR	FR	FR
HC02	FR	F	F
HC03	F	FR	**F**
Overall mega-subwatershed:			**F**

Riparian buffer. GIS analysis of riparian buffer indicated the presence of adequate riparian buffer within 55% of the buffer zone along Husband Creek and its tributaries. The lack of sufficient buffer contributes to streambank erosion, affecting aquatic habitat as is evident in subwatersheds HC01 and HC02 with 46% and 57% forested buffer, respectively. Subwatershed HC03 had a 74% forest buffer zone.

Site investigations. HC01 and HC03 were rated FR due to low scores for bottom substrate, pool variety, and riffle habitat. Subwatershed HC03 was rated F.

The low scores for bottom substrate and riffle habitat from streambank erosion coupled with the lack of adequate riparian buffer are reasons for the Husband Creek mega-subwatershed receiving a rating of F for Habitat.

3. Water Quality

Table 49 Water Quality Function for Husband Creek

Subwatershed	Riparian Buffer	Impervious Cover	Site Investigations (Water Quality)	DWQ Phys/Chem Monitoring	DWQ Benthic Monitoring	Overall Functionality
HC01	FR	FR	F		FR	FR
HC02	FR	F	F		FR	FR
HC03	F	FR	F		FR	FR
			Overall mega-subwatershed:			**FR**

Note: DWQ monitoring data unavailable for the Husband Creek Watershed

Riparian buffer and impervious cover. The lack of sufficient buffer allows stormwater to enter a tributary unabated, which contributes to streambank erosion, affecting water quality. The amount of impervious cover serves as an indication of the potential for water quality degradation caused by residential, commercial, and industrial areas. This measure denotes moderate potential for water quality impacts for HC01 and HC03.

Site investigations. At the stream reach sites within the Husband Creek mega-subwatershed, evidence of poor water quality due to odor, clarity, and periphyton growth was not found. However, high BEHI values were found at the Rocky Road #112 (HC01), Crooked Creek #42 (HC01), and Kingston #37 (HC02), and Poteet #115 (HC02) sites. These high BEHI values indicated that steep eroding stream banks were a potential source of sediment pollution in the aquatic environment for all three subwatersheds. While DWQ did not perform any physical/chemical monitoring for this watershed, TKN levels may be elevated due to fertilizer use on the golf course located in subwatershed HC01.

DWQ monitoring. The benthic community in Husband Creek is somewhat impacted but still maintains a moderate level of diversity, which resulted in a rating of FR for both subwatersheds.

Based on riparian buffer, impervious cover, DWQ data, and site investigation data, water quality was found to be FR for the Husband Creek mega-subwatershed.

I. Celia Creek

The Celia Creek mega-subwatershed includes 11.0 miles of streams that flow into Husband Creek southwest of the town of Gamewell. The 5.9-square mile subwatershed is located approximately five miles southwest of the City of Lenoir (Appendix I, Figure 16). Celia Creek and its tributaries begin by draining moderately sloped rural areas of large-lot residential and forested lands. As Celia Creek flows to the southeast, land use changes to agricultural, 2-acre family lots and single family use and maintains this land use up to Celia Creek's confluence with Husband Creek. **Two subwatersheds comprise the Celia Creek mega-subwatershed: CC01 and CC02.** Data used in this characterizing this mega-subwatershed is derived from field studies at five stream reaches (Appendix G), DWQ data at two sites (Appendix H), and GIS data on stream gradient, sinuosity, riparian buffer, and impervious cover (Appendix A through D; Table 50).

Table 50 Celia Creek Mega-subwatershed Summary Information

Subwatershed	Area (mi^2)	Stream Length (miles)	% Stream Length with Sinuosity ≤ 1.2	Average Stream Gradient (%)	Average % with 30-foot Forested Buffer	Average % IC
CC01	2.5	5.8	48	1.76	34	6.5
CC02	3.4	5.2	64	1.41	56	10.8
Total	**5.9**	**11.0**	**56**	**1.53**	**45**	**9.0**

1. *Hydrology*

Table 51 Hydrology Function for Celia Creek

Subwatershed	Sinuosity	Stream Gradient	Impervious Cover	Site Investigations (Hydrology)	Overall Functionality
CC01	FR	F	F	FR	**F**
CC02	FR	F	FR	FR	FR
		Overall mega-subwatershed:			**F**

Sinuosity and site investigations. The GIS sinuosity analysis indicates that approximately 56% of the tributaries in the Celia Creek mega-subwatershed are potentially channelized (sinuosity values ≤ 1.2). MACTEC's field observations confirmed that of the five stream sites investigated, only Abbie #105 was not channelized (≤20%). The remaining four reach sites were significantly channelized (≥80%), which resulted in the two subwatersheds being rated FR for channelization. Stream reach sites Timber #400 (CC01) and Abbie #105 (CC02) are major examples of very high bank height ratios. The unstable banks were found to be contributing sediment downstream, which was indicated by the low bottom substrate scores and low riffle habitat scores seen in subwatershed CC02. MACTEC documented that the substrate at the Hartland #104 (CC02) site was nearly all sand.

Stream gradient. Stream gradient is one of the factors contributing to water velocity and high water velocity is factor in streambank erosion. Based on GIS data, both subwatersheds CC01 and CC02 were rated F. Given the results for stream gradient, high water velocity due to gradient is not an issue for the Celia Creek mega-subwatershed.

Impervious cover. Based on GIS analysis of impervious cover, subwatershed CC01 was rated F due to an impervious cover of 6.5%. Subwatershed CC02 had an impervious cover of 10.8% due to urban development and rated FR. Given the development within subwatershed CC02, an increase in stormwater runoff and associated pollutants can be expected.

The overall hydrologic rating for the Celia Creek mega-subwatershed based on sinuosity, stream gradient, impervious cover, and site investigation was F.

2. Habitat

Table 52 Habitat Function for Celia Creek

Subwatershed	Riparian Buffer	Site Investigations (Habitat)	Overall Functionality
CC01	FR	F	**F**
CC02	F	FR	**NF**
Overall mega-subwatershed:			FR

Riparian buffer. GIS analysis of riparian buffer indicated the presence of adequate riparian buffer within approximately 45% of the buffer zone along Celia Creek and its tributaries. The lack of sufficient forested buffer contributes to streambank erosion, affecting aquatic habitat as is evident in subwatersheds CC01 and CC02 with 34% and 56% forested buffer, respectively.

Site investigations. Data based on field site investigations of subwatershed CC01 rated the subwatershed as F. Subwatershed CC02 rated FR due low scores for instream habitat, pool variety, and riffle habitat and very low scores for bottom substrate, light penetration, and pool variety.

Overall, the mega-subwatershed was rated FR due to the absence of instream habitat from channelization, the loss of bottom substrate and riffle habitat from streambank erosion, and the lack of forested riparian buffer.

3. Water Quality

Table 53 Water Quality Function for Celia Creek

Subwatershed	Riparian Buffer	Impervious Cover	Site Investigations (Water Quality)	DWQ Phys/Chem Monitoring	DWQ Benthic Monitoring	Overall Functionality
CC01	FR	F	F		FR	FR
CC02	FR	FR	F		FR	FR
			Overall mega-subwatershed:			**FR**

Note: DWQ monitoring data unavailable for the Celia Creek Watershed

Riparian buffer and impervious cover. The lack of sufficient forested buffer allows stormwater to enter a tributary unabated, which contributes to streambank erosion, affecting water quality. The amount of impervious cover serves as an indication of the potential for water quality degradation caused by residential, commercial, and industrial areas. This measure denotes moderate potential for water quality impacts for CC02 (FR).

Site investigations. Investigations at the stream reach sites within the Celia Creek mega-subwatershed did not find evidence of poor water quality due to odor, clarity, and periphyton growth. However, moderately high BEHI values were found at the Timber #400 (CC01) and Hartland #104 (CC02) sites. These BEHI values indicated that eroding stream banks were a potential source of sediment pollution in the aquatic environment for both subwatersheds.

DWQ monitoring. The benthic community in Celia Creek is somewhat impacted but still maintains a moderate level of diversity, which resulted in a rating of FR for both subwatersheds.

Based on riparian buffer, impervious cover, DWQ data, and site investigation data, water quality was found to be FR for the Celia Creek mega-subwatershed.

J. Bristol Creek

The Bristol Creek mega-subwatershed includes 12.3 miles of streams that flow into the lower half of Lower Creek near the community of Chesterfield in northeast Burke County. The 6.9-square mile subwatershed is located approximately eight miles southwest of the City of Lenoir (Figure 13, Appendix I-17). Bristol Creek and its tributaries begin by draining moderately sloped rural areas of large-lot residential and forested lands. As Bristol Creek flows to the southeast, land use changes to agricultural, 2-acre family lots and single family and maintains this land use up to Bristol Creek's confluence with Lower Creek. **Two subwatersheds comprise the Bristol Creek mega-subwatershed: BC01 and BC02.** Data derived from field studies at seven stream reaches (Appendix G), DWQ data at one site (Appendix H), and GIS data on stream gradient, sinuosity, riparian buffer, and impervious cover (Appendix A through D; Table 54) were used in this characterizing this mega-subwatershed.

Table 54 Bristol Creek Mega-subwatershed Summary Information

Subwatershed	Area (mi²)	Stream Length (miles)	% Stream Length with Sinuosity ≤ 1.2	Average Stream Gradient (%)	Average % with 30-foot Forested Buffer	Average % IC
BC01	3.0	4.6	57	1.19	55	9.2
BC02	3.9	7.7	79	1.03	56	10.1
Total	**6.9**	**12.3**	**68**	**1.11**	**56**	**9.7**

1. Hydrology

Table 55 Hydrology Function for Bristol Creek

Subwatershed	Sinuosity	Stream Gradient	Impervious Cover	Site Investigations (Hydrology)	Overall Functionality
BC01	FR	F	F	FR	F
BC02	NF	F	FR	FR	FR
		Overall mega-subwatershed:			FR

Sinuosity and site investigations. The GIS sinuosity analysis indicates that approximately 68% of the tributaries in Bristol Creek mega-subwatershed are potentially channelized (sinuosity values ≤ 1.2). MACTEC's field observations confirmed that of the five stream sites investigated, three, Old Farmhouse #329 (BC01), Lyndsey #328 (BC01), and Rader #336 (BC02), were not channelized (≤20%). The remaining two reach sites were significantly channelized (≥80%), which resulted in subwatershed BC01 being rated F and subwatershed BC02 being rated FR for channelization. The bank height ratio for both subwatersheds was rated NF. Stream sites Old Farmhouse #329 (BC01), Thorneburg #300 (BC01), and Saddlecreek #334 (BC02) are examples of very high bank height ratios. The unstable banks were found to be contributing sediment downstream, which was indicated by the low bottom substrate scores, pool variety, and low riffle habitat scores seen in subwatershed BC02. MACTEC documented at the Morris #333 and Rader # 336 sites (BC02) that the substrate was nearly all sand.

Stream gradient. Stream gradient is one of the factors contributing to water velocity and high water velocity is a factor in streambank erosion. Based on GIS data, both subwatersheds BC01 and BC02 were rated F. Given the results for stream gradient, high water velocity due to gradient is not an issue for the Bristol Creek mega-subwatershed.

Impervious cover. Based on GIS analysis of impervious cover, subwatershed BC01 had an impervious cover of 9.2%, which resulted in the subwatershed being rated F. Subwatershed BC02 had an impervious cover of 10.1%, which resulted in the subwatershed being rated FR. Given the single family and associated urban development within the subwatersheds, impacts from stormwater runoff can be expected.

The overall hydrologic rating for the Bristol Creek mega-subwatershed based on sinuosity, stream gradient, impervious cover, and site investigation was rated FR.

2. Habitat

Table 56 Habitat Function for Bristol Creek

Subwatershed	Riparian Buffer	Site Investigations (Habitat)	Overall Functionality
BC01	FR	FR	FR
BC02	FR	NF	NF
Overall mega-subwatershed:			NF

Riparian buffer. The GIS analysis of riparian buffer indicated the absence of adequate riparian buffer for the mega-subwatershed with approximately 56% of the buffer zone having a forested land use along Bristol Creek and its tributaries. The lack of sufficient forested buffer contributes to streambank erosion, affecting aquatic habitat as is evident in subwatersheds BC01 and BC02 with 55% and 56% forested buffer, respectively.

Site investigations. Subwatershed BC01 was rated FR due to low scores for instream habitat, bottom substrate, and pool variety. Subwatershed BC02 rated NF due to very low scores for instream habitat, bottom substrate, and pool variety and low scores for riffle habitat and light penetration.

The mega-subwatershed was rated NF for habitat due to the lack of instream habitat, the loss of bottom substrate and riffle habitat from sedimentation, and the lack of adequate riparian buffer.

3. Water Quality

Table 57 Water Quality Function for Bristol Creek

Subwatershed	Riparian Buffer	Impervious Cover	Site Investigations (Water Quality)	DWQ Phys/Chem Monitoring	DWQ Benthic Monitoring	Overall Functionality
BC01	FR	F	FR		FR	FR
BC02	FR	FR	FR		FR	FR
			Overall mega-subwatershed:			FR

Note: DWQ monitoring data unavailable for the Bristol Creek Watershed

Riparian buffer and impervious cover. The lack of sufficient forested buffer allows stormwater to enter a tributary unabated and contributes to streambank erosion, affecting water quality. The amount of impervious cover serves as an indication of the potential for water quality degradation caused by residential, commercial, and industrial areas. This measure denotes moderate potential for water quality impacts for BC01 (FR).

Site investigations. Evidence of poor water quality due to odor and periphyton growth was not observed during investigations at the stream sites within the Bristol Creek mega-subwatershed. However, slightly turbid to turbid waters were observed. In addition, moderately high to high BEHI values were found at the Lyndsey #328 (BC01), Saddlecreek #334 (BC02), and Rader #336 (BC02) sites. These BEHI values indicated that eroding stream banks were a potential source of sediment pollution in the aquatic environment for both subwatersheds. DWQ did not perform any physical/chemical water quality test for this watershed. Based on livestock access to the tributaries in subwatershed BC01, there may be elevated levels for TKN in Bristol Creek (USGS 2005; DWQ 2005).

DWQ monitoring. The benthic community in Bristol Creek is somewhat impacted but still maintains a moderate level of diversity, which resulted in a rating of FR for both subwatersheds.

Based on riparian buffer, impervious cover, DWQ data, and site investigation data, water quality was found to be FR for the Bristol Creek mega-subwatershed.

K. White Mill Creek

The White Mill Creek mega-subwatershed is comprised of one subwatershed (WM01) and includes 9.9 miles of streams that flow into Bristol Creek north of the community of Chesterfield in northeast Burke County. The 4.8-square mile subwatershed is located approximately 10 miles southwest of the City of Lenoir (Appendix I, Figure 18). White Mill Creek and its tributaries begin by draining moderately sloped rural areas of large-lot residential and forested lands. Data used in characterizing this watershed is derived from field studies at four stream reaches (Appendix G), DWQ data at one site (Appendix H), and GIS data on stream gradient, sinuosity, riparian buffer, and impervious cover (Appendix A through D; Table 58).

Table 58 White Mill Creek Mega-subwatershed Summary Information

Subwatershed	Area (mi²)	Stream Length (miles)	% Stream Length with Sinuosity ≤ 1.2	Average Stream Gradient (%)	Average % with 30-foot Forested Buffer	Average % IC
WM01	4.8	9.9	64	1.31	74	6.3
Total	**4.8**	**9.9**	**64**	**1.31**	**74**	**6.3**

1. Hydrology

Table 59 Hydrology Function for White Mill Creek

Subwatershed	Sinuosity	Stream Gradient	Impervious Cover	Site Investigations (Hydrology)	Overall Functionality
WM01	FR	F	F	FR	**F**
			Overall mega-subwatershed:		**F**

Sinuosity and site investigations. The GIS sinuosity analysis indicates that approximately 64% of the tributaries in Bristol Creek mega-subwatershed are potentially channelized (sinuosity values ≤ 1.2). MACTEC's field observations confirmed that of the four stream sites investigated, only one, Playmore Beach #101 was significantly channelized (≥80%). The remaining three stream sites were not channelized (≤20%). The four stream sites had moderately high to high bank height ratios. Erosion of the unstable banks was found to be contributing sediment downstream, which was indicated by the low bottom substrate scores. MACTEC documented that the Harshaw #331 site substrate was nearly all sand.

Stream gradient. Stream gradient is one of the factors contributing to water velocity and high water velocity is factor in streambank erosion. Given the results for stream gradient, high water velocity due to gradient is not an issue for the White Mill Creek mega-subwatershed.

Impervious cover. Based on GIS analysis of impervious cover, the mega-subwatershed had an impervious cover of 6.3%.

The overall hydrologic rating for the White Creek mega-subwatershed based on sinuosity, stream gradient, impervious cover, and site investigation was rated F.

2. Habitat

Table 60 Habitat Function for White Mill Creek

Subwatershed	Riparian Buffer	Site Investigations (Habitat)	Overall Functionality
WM01	F	F	F
Overall mega-subwatershed:			F

Riparian buffer. The GIS analysis of riparian buffer indicated the presence of adequate riparian buffer for the subwatershed with approximately 74% of the buffer zone having a forested land use along Bristol Creek and its tributaries.

Site investigations. Only one parameter, bottom substrate, was documented as being low, which suggests the stream is not effective in transporting sediment.

Based on the presence of forested riparian habitat and the results of site investigations, the mega-subwatershed rated F for Habitat function.

3. Water Quality

Table 61 Water Quality Function for White Mill Creek

Subwatershed	Riparian Buffer	Impervious Cover	Site Investigations (Water Quality)	DWQ Phys/Chem Monitoring	DWQ Benthic Monitoring	Overall Functionality
WM01	F	F	F		FR	**F**
			Overall mega-subwatershed:			**F**

Note: DWQ monitoring data unavailable for the White Mill Creek Subwatershed

Riparian buffer and impervious cover. The amount of impervious cover serves as an indication of the potential for water quality degradation caused by residential, commercial, and industrial areas. This measure denotes low potential for water quality impacts for the mega-subwatershed.

Site investigations. Investigations at the stream sites within the White Mill Creek mega-subwatershed did not find evidence of poor water quality due to odor and periphyton growth. However, slightly turbid waters were found at Harshaw #331 site. In addition, moderately high to high BEHI values were found at all four sites. These BEHI values indicate that eroding stream banks were a potential source of sediment pollution in the aquatic environment for the subwatersheds.

DWQ monitoring. The benthic community in White Mill Creek is somewhat impacted but still maintains a moderate level of diversity.

Based on riparian buffer, impervious cover, DWQ data, and site investigation data, water quality was found to be F for the White Mill Creek mega-subwatershed.

FINAL

Technical Memorandum:

Evaluation and Prioritization of Mitigation Opportunities
Lower Creek and Hunting Creek Watersheds

October 2, 2009

Prepared for

NORTH CAROLINA ECOSYSTEM ENHANCEMENT PROGRAM

By

EQUINOX ENVIRONMENTAL CONSULTATION & DESIGN, INC.

All landowner contact information has been removed in this document, with the exception of PINs. (HCB, October 12, 2011)

Table of Contents

List of Figures

List of Tables

Technical Memorandum:

Evaluation and Prioritization of Mitigation Opportunities Lower Creek and Hunting Creek Watersheds

Prepared for

NORTH CAROLINA ECOSYSTEM ENHANCEMENT PROGRAM

By

EQUINOX ENVIRONMENTAL CONSULTATION & DESIGN, INC.
October 2, 2009

Geographic Information System (GIS) analysis to identify potential ecological enhancement opportunities and site prioritization in the Lower Creek and Hunting Creek watersheds has been completed. This Technical Memorandum (TM) provides a brief description of project selection and prioritization methodology along with maps and lists of identified project opportunities.

1. Background

The North Carolina Ecosystem Enhancement Program (NCEEP) has requested the services of Equinox Environmental Consultation and Design, Inc. (Equinox) under a contract amendment #D08020S to identify and facilitate mitigation opportunities in the Lower Creek (14-digit catalog units 03050101080010 and 03050101080020; Burke and Caldwell counties), Hunting Creek (14-digit catalog units 03050101060050; Burke County), and Muddy Creek (14-digit catalog units 03050101040010, 03050101040020, and a portion of 03050101030060; Burke and McDowell counties) watersheds.

The GIS analysis and site prioritization focused on the Lower and Hunting Creek watersheds. Equinox examined 2008 Caldwell and 2005 Burke color photos; 2009 Caldwell and Burke digital parcel information; and 2007 North Carolina stream mapping project data set (NC LIDAR - detailed hydrologic data base) within the Lower and Hunting Creek watersheds. Prioritization for the Muddy Creek watershed will be based on the 2008 site search and will focus on outreach versus specific site evaluations.

To further refine project site identification in the Lower Creek watershed, the following 29 sub-watersheds delineated during previous local watershed planning efforts were utilized:

- Abingdon Creek (AC01 – AC02);
- Blair Fork (BF01);
- Bristol Creek (BC01 – BC02);
- Celia Creek (CC01 – CC02);
- Greasy Creek (GC01 – GC02);
- Husband Creek (HC01 – HC03);
- Lower Creek (LC01 – LC10);
- Spainhour Creek (SC01 – SC02);
- White Mill Creek (WM01);
- Zacks Fork (ZF01 – ZF03); and
- Zacks Fork Tributary (ZFT1).

Restoration and preservation sites identified within the Lower Creek watershed were noted within the following tables and figures as to their location within a priority sub-watershed as identified in the Lower Creek local watershed planning effort (Final Lower Creek Watershed Management Plan Section 6.3, 2006). The 13 Lower Creek priority sub-watersheds considered in this exercise included the following:

Restoration – High Priorities

- Upper Celia Creek (CC01);
- Middle Husban Creek (HC02);
- Upper Lower Creek (LC01);
- Zacks Fork (ZF01 – ZF03); and
- Zacks Fork Tributary (ZFT1).

Restoration – Moderate Priorities

- Lower Abingdon Creek (AC02);
- Bristol Creek (BC01);
- Upper Greasy Creek (GC01); and
- Lower Husband Creek (HC03).

Preservation Priorities

- Upper Abingdon Creek (AC01); and
- White Mill Creek (WM01).

The GIS analysis and site prioritization results will be used to direct outreach efforts within the Lower and Hunting creek watersheds. Outreach within the Muddy Creek Watershed will be directed towards landowners expressing interest during the 2008 mitigation site search.

2. Restoration and Enhancement Sites

Equinox used GIS analysis and professional judgment to identify potential project sites based on the following criteria:

- Stream reach with minimal or no forested buffer;
- Drainage area (at most downstream point on project reach) less than 10 square miles;
- Minimum reach length of 2,000 contiguous linear feet; and
- Reach involving 3 or fewer landowners.

Based on these criteria, 95 potential project sites (77 in the Lower Creek watershed and 18 in the Hunting Creek watershed) were identified (Figures 1 & 2). Project reaches were expanded to include additional landowners if the parcels were immediately adjacent to the primary project area, the stream reach was contiguous, and the buffer width was inadequate. For project reaches containing more than 3 landowners, site expansion was terminated if the adjacent parcel contained less than 500 linear feet of additional project potential. Additionally sites involving only 1 or 2 landowners were expanded to include adjacent parcels even if they contained <500 linear feet of additional project potential. For example, a 3,000 linear foot project reach involving 2 landowners was expanded to include an additional landowner containing 300 linear feet of project opportunity. A single site identification number was assigned to a set of reaches with contiguous parcels and/or to a set of reaches with multiple parcels but in single ownership.

Project prioritization was performed on individual parcels within a site and not on the site as a whole. Each identified parcel was prioritized to distinguish between projects of varying feasibility and mitigation value. Each parcel was prioritized based on the following 3 criteria:

- Total parcel reach length with ownership on both sides;
- Watershed drainage area as determined at the downstream end of individual parcels; and
- Parcel containing a potential wetland restoration project component.

Scores for individual attributes and their application to the prioritization system are discussed below and shown in Tables 1 & 2.

Reach Length
Parcels identified with longer reaches were considered higher priority and thus applied a higher score for this category. Aerial analysis was utilized to omit NC LIDAR stream reaches that did not clearly indicate a defined channel and individual parcel reach calculations were based on the corrected stream lengths. The categories and the associated scores are as follows:

- Reach length (<2,000 linear feet) = 0;
- Reach length (2,000 – 2,999 linear feet) = 1;
- Reach length (3,000 – 3,999 linear feet) = 2;
- Reach length (4,000 – 4,999 linear feet) = 3;
- Reach length (5,000 – 5,999 linear feet) = 4;
- Reach length (6,000 – 9,999 linear feet) = 5; and
- Reach length (>10,000 linear feet) = 6.

Drainage Area
Due to project feasibility and potential for project success, reaches associated with smaller drainage areas were considered higher priority. The categories and scores assigned based on drainage area are as follows:

- Drainage area (>6 square miles) = 0;
- Drainage area (3 – 6 square miles) = 1; and
- Drainage area (<3 square miles) = 2.

Potential Wetland Component
A limited GIS analysis of soils data and aerial photography was conducted to identify parcels that contained potential wetland restoration components. Parcels containing hydric soils and/or aerial imagery indicating hydric conditions were considered to contain potential wetland components. Aerial imagery indications included features such as ditches and mottled herbaceous signatures in proximity to stream channels. The categories and scores assigned are as follows:

- Wetland restoration component not associated with parcel = 0; and
- Wetland restoration component associated with parcel = 1.

Parcel Prioritization
Parcel scores for each criterion were summed to obtain a total priority score. Total priority scores ranged from 0 to 9 out of a possible high score of 9. Parcels were classified as Low, Medium, or High priority and were categorized and ranked as follows:

- Parcel score (0 – 3) = Low Priority;
- Parcel score (4 – 6) = Medium Priority; and
- Parcel score (7 – 9) = High Priority.

Maps of the 95 identified restoration and enhancement sites (Figures 1 & 2) and the corresponding prioritization and parcel information (Tables 1 & 2) are included.

Lower Creek Watershed

Figure: 1
Potential Restoration & Enhancement Sites

Legend

- Lower Creek Watershed
- AC01 Subwatersheds
- Municipal Boundaries

Priority Subwatersheds

- R/E High
- R/E Moderate
- Preservation

Priority Parcels

- High
- Medium
- Potential Restoration & Enhancement Sites
- Streams

Roads

- Interstate
- Primary
- Secondary

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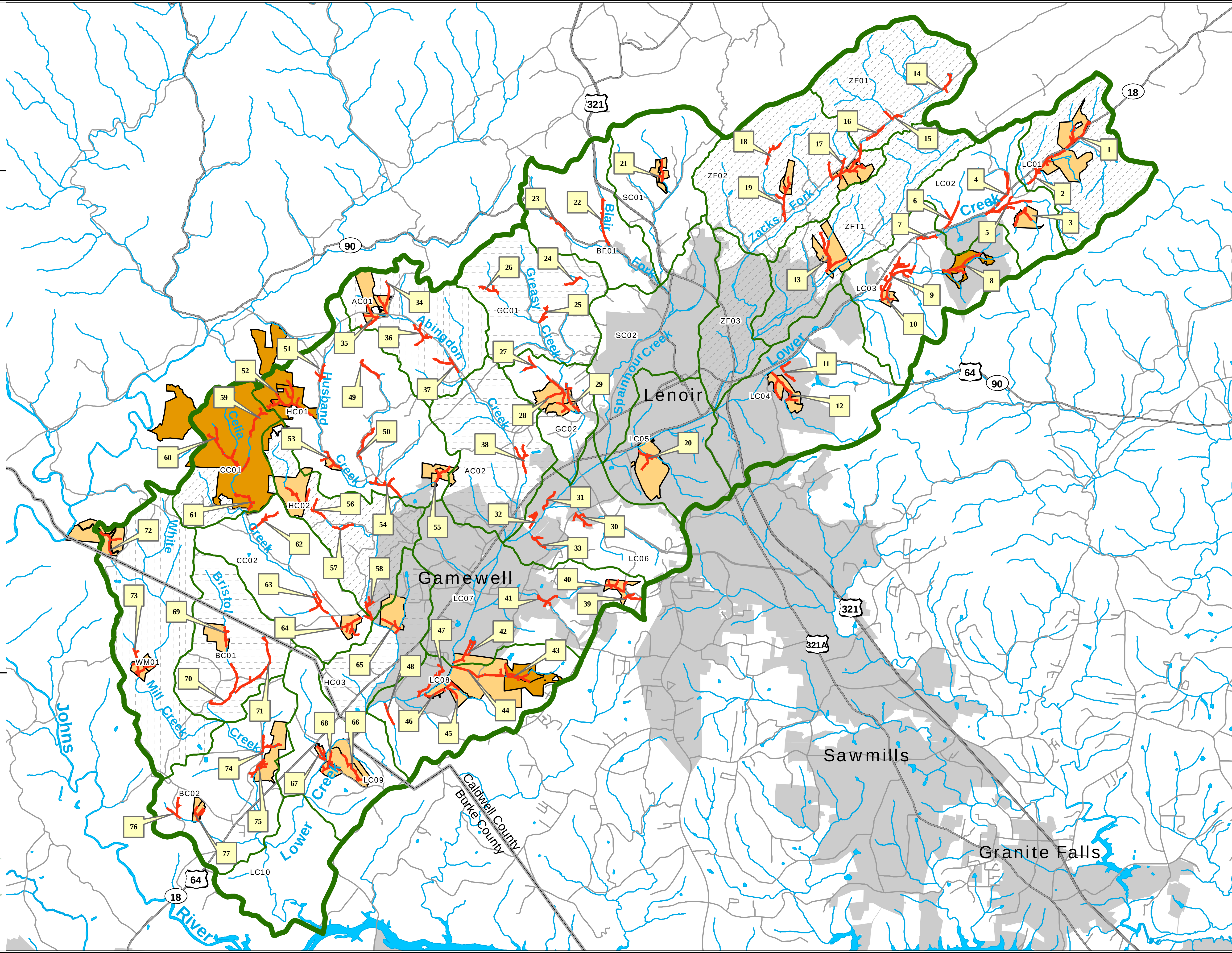
Ecosystem Enhancement PROGRAM

EQUINOX ENVIRONMENTAL CONSULTATION & DESIGN



Landowner information removed Oct'11_HCB.

Table 1. Lower Creek Watershed – Identified Restoration & Enhancement Sites Prioritization

ID	Main Stream	SWS	PIN	[redacted]	R/E Ownership Both Sides (lf)	Score	R/E Ownership One Side (lf)	Drainage Area (sq.mi.)	Score	Potential Wetland Opportunity	Score	Total Score	Rank	SWS Priority	Ownership
1	Lower Creek	LC01	2881077750	[redacted]	5,714	4	0	0.7	2	No	0	6	Med	Yes	Private
2	UT Lower Creek	LC01	2871963062 2881157126	[redacted]	3,661	2	935	1.8	2	No	0	4	Med	Yes	Private
2	UT Lower Creek	LC01	2871952916	[redacted]	0	0	160	1.7	2	No	0	2	Low	Yes	Private
2	UT Lower Creek	LC01	2871857044	[redacted]	2,255	1	351	2.1	2	Yes	1	4	Med	Yes	Private
2	UT Lower Creek	LC01	2871950960	[redacted]	0	0	166	1.8	2	No	0	2	Low	Yes	Private
2	UT Lower Creek	LC01	2871965192	[redacted]	0	0	357	1.7	2	No	0	2	Low	Yes	Private
2	UT Lower Creek	LC01	2871744347 2871773763	[redacted]	696	0	1,129	3.0	1	No	0	1	Low	Yes	Private
2	UT Lower Creek	LC01	2871733608	[redacted]	0	0	188	3.0	1	No	0	1	Low	Yes	Private
2	UT Lower Creek	LC01	2871731555	[redacted]	0	0	48	3.0	1	No	0	1	Low	Yes	Private
2	UT Lower Creek	LC01	2871749432	[redacted]	563	0	109	3.0	1	No	0	1	Low	Yes	Private
2	UT Lower Creek	LC01	2871746197	[redacted]	0	0	376	3.0	1	No	0	1	Low	Yes	Private
2	UT Lower Creek	LC01	2871736492	[redacted]	0	0	284	3.0	1	No	0	1	Low	Yes	Private
2	UT Lower Creek	LC01	2871732424	[redacted]	0	0	124	3.0	1	No	0	1	Low	Yes	Private
3	UT Lower Creek	LC02	2871614729	[redacted]	0	0	168	0.1	2	No	0	2	Low	No	Private
3	UT Lower Creek	LC02	2871614331 2871617600	[redacted]	0	0	315	0.1	2	No	0	2	Low	No	Private
3	UT Lower Creek	LC02	2871608667	[redacted]	3,055	2	483	0.3	2	No	0	4	Med	No	Private
4	UT Lower Creek	LC02	2871542188 2871446108	[redacted]	1,310	0	198	0.6	2	No	0	2	Low	No	Private
4	UT Lower Creek	LC02	2871437136	[redacted]	863	0	198	0.7	2	No	0	2	Low	No	Private
4	UT Lower Creek	LC02	2871523443 2871521676	[redacted]	865	0	0	0.7	2	No	0	2	Low	No	Private
4	UT Lower Creek	LC02	2871416088	[redacted]	776	0	0	0.7	2	No	0	2	Low	No	Private
5	Lower Creek	LC02	2871416088 2871728200	[redacted]	1,776	0	1,690	4.1	1	Yes	1	2	Low	No	Private
5	Lower Creek	LC02	2871404840 2871307794 2871511188	[redacted]	3,297	2	849	4.9	1	No	0	3	Low	No	Private
5	Lower Creek	LC02	2871523443	[redacted]	0	1	1,028	4.0	1	No	0	2	Low	No	Private
6	Lower Creek	LC02	2871116913	[redacted]	0	0	878	0.3	2	No	0	2	Low	No	Private
6	Lower Creek	LC02	2871026344 2871011076	[redacted]	1,834	0	878	0.6	2	No	0	2	Low	No	Private
6	Lower Creek	LC02	2871002181	[redacted]	952	0	0	0.7	2	No	0	2	Low	No	Private
7	Lower Creek	LC03	2860984519	[redacted]	311	0	858	6.0	0	No	0	0	Low	No	Private
7	Lower Creek	LC03	2860887433	[redacted]	60	0	1,027	6.2	0	No	0	0	Low	No	Private
7	Lower Creek	LC03	2860896281	[redacted]	0	0	1,473	6.2	0	Yes	1	1	Low	No	Private
7	Lower Creek	LC03	2860789768	[redacted]	0	0	413	6.2	0	No	0	0	Low	No	Private

SWS Priority "Yes" indicates priority sub-watershed identified in the *Final Lower Creek Watershed Management Plan* (July 2006).

Table 1 Continued. Lower Creek Watershed – Identified Restoration & Enhancement Sites Prioritization

ID	Main Stream	SWS	PIN	[redacted]	R/E wnership oth Sides (lf)	Score	R/E Ownership One Side (lf)	Drainage Area (sq.mi.)	Score	Potential Wetland Opportunity	Score	Total Score	Rank	SWS Priority	Ownership
8	UT Lower Creek	LC03	2870181252		5,682	4	309	0.8	2	Yes	1	7	High	No	Private
8	UT Lower Creek	LC03	2860969412		0	0	309	0.8	2	No	0	2	Low	No	Private
9	Lower Creek	LC03	2860767431 2860669005		1,626	0	1,394	8.3	0	Yes	1	1	Low	No	Private
9	Lower Creek	LC03	2860556741		0	0	1,207	8.5	0	No	0	0	Low	No	Private
9	Lower Creek	LC03	2860548855		0	0	810	8.5	0	No	0	0	Low	No	Private
9	Lower Creek	LC03	2860679055		870	0	1,366	7.8	0	Yes	1	1	Low	No	Private
9	Lower Creek	LC03	2860459213 2860446772		204	0	1,594	8.5	0	No	0	0	Low	No	Private
9	Lower Creek	LC03	2860553843 2860568234		1,721	0	1,576	8.5	0	Yes	1	1	Low	No	Private
9	Lower Creek	LC03	2860543114		0	0	784	8.5	0	No	0	0	Low	No	Private
9	Lower Creek	LC03	2860663621		2,345	1	686	8.3	0	Yes	1	2	Low	No	Private
10	Lower Creek	LC03	2860548855		697	0	0	0.1	2	No	0	2	Low	No	Private
10	Lower Creek	LC03	2860543114		2,193	1	0	0.1	2	Yes	1	4	Med	No	Private
11	UT Lower Creek	LC04	2759689643 2759771299		2,289	1	0	0.2	2	No	0	3	Low	No	Private
11	UT Lower Creek	LC04	2759773274		276	0	180	0.1	2	No	0	2	Low	No	Private
11	UT Lower Creek	LC04	2759774433		131	0	180	0.1	2	No	0	2	Low	No	Private
12	UT Lower Creek	LC04	2759664708 2759748691 2759758634		5,232	4	827	1.1	2	No	0	6	Med	No	Private
12	UT Lower Creek	LC04	2759671820		0	0	514	1.1	2	No	0	2	Low	No	Private
12	UT Lower Creek	LC04	2759650860		0	0	312	0.1	2	No	0	2	Low	No	Private
13	UT Zacks Fork	ZFT1	2860174229 2860065116		4,265	3	1,801	0.8	2	Yes	1	6	Med	Yes	Private
13	UT Zacks Fork	ZFT1	2850996378		1,924	0	921	0.2	2	Yes	1	3	Low	Yes	Private
13	UT Zacks Fork	ZFT1	2860061798		0	0	723	0.8	2	No	0	2	Low	Yes	Private
13	UT Zacks Fork	ZFT1	2860061420		0	0	156	0.8	2	No	0	2	Low	Yes	Private
14	UT Zacks Fork	ZF01	2872035889		575	0	0	0.3	2	No	0	2	Low	Yes	Private
14	UT Zacks Fork	ZF01	2872024542		1,051	0	0	0.3	2	Yes	1	3	Low	Yes	Private
14	UT Zacks Fork	ZF01	2872002981		799	0	0	0.4	2	Yes	1	3	Low	Yes	Private
15	Zacks Fork	ZF01	2861694177		0	0	284	1.7	2	No	0	2	Low	Yes	Private
15	Zacks Fork	ZF01	2861683873		51	0	284	1.7	2	No	0	2	Low	Yes	Private
15	Zacks Fork	ZF01	2861593220		1,868	0	0	1.8	2	Yes	1	3	Low	Yes	Private
16	Zacks Fork	ZF01	2861386598		2,652	1	0	3.1	1	No	0	2	Low	Yes	Private

SWS Priority "Yes" indicates priority sub-waters [redacted]

Table 1 Continued. Lower Creek Watershed – Identified Restoration & Enhancement Sites Prioritization

ID	Main Stream	SWS	PIN	[redacted]	R/E wnership oth Sides (lf)	Score	R/E Ownership One Side (lf)	Drainage Area (sq.mi.)	Score	Potential Wetland Opportunity	Score	Total Score	Rank	SWS Priority	Ownership
17	Zacks Fork	ZF02	2861355306		504	0	0	3.3	1	No	0	1	Low	Yes	Private
17	Zacks Fork	ZF02	2861046946		703	0	195	0.1	2	No	0	2	Low	Yes	Private
17	Zacks Fork	ZF02	2861049203 2861135552 2861340872 2861243034 2861142591		5,499	4	932	3.7	1	Yes	1	6	Med	Yes	Private
17	Zacks Fork	ZF01/ZF02	2861363370		1,546	0	89	3.3	1	No	0	1	Low	Yes	Private
17	Zacks Fork	ZF02	2861130896 2861037345		104	0	931	3.9	1	No	0	1	Low	Yes	Private
17	Zacks Fork	ZF02	2861162282 2861168051		798	0	310	0.2	2	No	0	2	Low	Yes	Private
17	Zacks Fork	ZF02	2861052020 2861053993		399	0	195	0.1	2	No	0	2	Low	Yes	Private
17	Zacks Fork	ZF02	2861155063		0	0	310	0.2	2	No	0	2	Low	Yes	Private
17	Zacks Fork	ZF02	2861258619		0	0	89	3.3	1	No	0	1	Low	Yes	Private
18	UT Zacks Fork	ZF02	2851655108		305	0	63	0.4	2	No	0	2	Low	Yes	Private
18	UT Zacks Fork	ZF02	2851477421		2,691	1	63	0.7	2	No	0	3	Low	Yes	Private
19	UT Zacks Fork	ZF02	2851635265 2851741101 2851635265		2,177	1	0	0.2	2	Yes	1	4	Med	Yes	Private
19	UT Zacks Fork	ZF02	2851623531		1,845	0	418	1.5	2	Yes	1	3	Low	Yes	Private
19	UT Zacks Fork	ZF02	2851710824 2851618278		0	0	733	1.5	2	No	0	2	Low	Yes	Private
19	UT Zacks Fork	ZF02	2851700829		0	0	793	1.5	2	No	0	2	Low	Yes	Private
19	UT Zacks Fork	ZF02	2851616090 2851616266		0	0	674	1.5	2	Yes	1	3	Low	Yes	Private
19	UT Zacks Fork	ZF02	2851606550		0	0	637	1.5	2	No	0	2	Low	Yes	Private
20	UT Lower Creek	LC05	2749515252		4,041	3	0	0.8	2	Yes	1	6	Med	No	Private
21	UT Spainhour Creek	SC01	2841647775		0	0	233	0.4	2	No	0	2	Low	No	Private
21	UT Spainhour Creek	SC01	2841647391		2,286	1	233	0.5	2	Yes	1	4	Med	No	Private
22	Blair Fork	BF01	2841212655 2841110788		2,476	1	0	0.6	2	No	0	3	Low	No	Private
22	Blair Fork	BF01	2831920954		536	0	0	0.9	2	No	0	2	Low	No	Private
22	Blair Fork	BF01	2841105363 2841009317		1,127	0	0	0.9	2	No	0	2	Low	No	Private
22	Blair Fork	BF01	2840187574		613	0	0	1.0	2	Yes	1	3	Low	No	Private
23	UT Blair Fork	BF01	2831703783		0	0	357	0.4	2	No	0	2	Low	No	Private
23	UT Blair Fork	BF01	2831705469		773	0	357	0.5	2	Yes	1	3	Low	No	Private
23	UT Blair Fork	BF01	2830893779		976	0	0	0.6	2	Yes	1	3	Low	No	Private
24	UT Greasy Creek	GC01	2830879065 2830853247		2,102	1	0	0.3	2	No	0	3	Low	Yes	Private
25	UT Greasy Creek	GC01	2830639390		2,577	1	0	0.1	2	No	0	3	Low	Yes	Private

SWS Priority “Yes” indicates priority sub-watersh[redacted]

Table 1 Continued. Lower Creek Watershed – Identified Restoration & Enhancement Sites Prioritization

ID	Main Stream	SWS	PIN	[redacted]	R/E Ownership Both Sides (lf)	Score	R/E Ownership One Side (lf)	Drainage Area (sq.mi.)	Score	Potential Wetland Opportunity	Score	Total Score	Rank	SWS Priority	Ownership
26	UT Greasy Creek	GC01	2830156139	[redacted]	0	0	371	0.1	2	No	0	2	Low	Yes	Private
26	UT Greasy Creek	GC01	2830159100	[redacted]	277	0	587	0.1	2	No	0	2	Low	Yes	Private
26	UT Greasy Creek	GC01	2830149167	[redacted]	248	0	170	0.1	2	No	0	2	Low	Yes	Private
26	UT Greasy Creek	GC01	2830247611	[redacted]	1,121	0	0	0.5	2	No	0	2	Low	Yes	Private
26	UT Greasy Creek	GC01	2830234926 2830254642	[redacted]	162	0	416	0.3	2	No	0	2	Low	Yes	Private
26	UT Greasy Creek	GC01	2830145433	[redacted]	0	0	262	0.1	2	No	0	2	Low	Yes	Private
27	UT Greasy Creek	GC02	2739585999	[redacted]	800	0	0	0.1	2	No	0	2	Low	Yes	Private
27	UT Greasy Creek	GC02	2739585408	[redacted]	1,504	0	0	0.2	2	No	0	2	Low	Yes	Private
28	Greasy Creek	GC02	2739752928 2739861677 2739749694 2739950167	[redacted]	5,805	4	843	4.1	1	Yes	1	6	Med	No	Private
28	Greasy Creek	GC02	2739679290	[redacted]	555	0	0	0.2	2	No	0	2	Low	No	Private
29	UT Greasy Creek	GC02	2739867944 2739965298	[redacted]	734	0	262	0.1	2	Yes	1	3	Low	No	Private
29	UT Greasy Creek	GC02	2739752928 2739950167	[redacted]	2,450	1	262	0.2	2	Yes	1	4	Med	No	Private
30	UT Miller Creek	LC06	2748058752	[redacted]	773	0	1,592	1.8	2	Yes	1	3	Low	No	Private
30	UT Miller Creek	LC06	2738967108	[redacted]	0	0	465	1.9	2	No	0	2	Low	No	Private
30	UT Miller Creek	LC06	2738954898	[redacted]	1,101	0	1,840	1.9	2	No	0	2	Low	No	Private
31	UT Lower Creek	LC06	2738558847	[redacted]	70	0	0	0.1	2	No	0	2	Low	No	Private
31	UT Lower Creek	LC06	2738679061	[redacted]	2,036	1	0	0.1	2	No	0	3	Low	No	Private
32	UT Lower Creek	LC06	2738650432	[redacted]	1,188	0	1,333	0.1	2	No	0	2	Low	No	Private
32	UT Lower Creek	LC06	2738558847	[redacted]	0	0	1,333	0.1	2	No	0	2	Low	No	Private
33	UT Lower Creek	LC06	2738645347	[redacted]	445	0	0	0.1	2	No	0	2	Low	No	Private
33	UT Lower Creek	LC06	2738538916 2738544274	[redacted]	667	0	0	0.4	2	No	0	2	Low	No	Private
33	UT Lower Creek	LC06	2738730727	[redacted]	1,665	0	0	0.3	2	Yes	1	3	Low	No	Private
34	UT Abingdon Creek	AC01	2820332593 2820336901	[redacted]	2,697	1	0	0.2	2	Yes	1	4	Med	Yes	Private
34	UT Abingdon Creek	AC01	2820355397	[redacted]	1,340	0	0	0.1	2	No	0	2	Low	Yes	Private
35	Abingdon Creek	AC01	2820251056 2820226497	[redacted]	3,155	2	0	0.5	2	No	0	4	Med	Yes	Private
35	Abingdon Creek	AC01	2820210973 2820224001 2820206846	[redacted]	1,226	0	0	0.2	2	No	0	2	Low	Yes	Private
35	Abingdon Creek	AC01	2820119735	[redacted]	162	0	0	0.2	2	No	0	2	Low	Yes	Private

SWS Priority "Yes" indicates priority sub-waters [redacted]

Table 1 Continued. Lower Creek Watershed – Identified Restoration & Enhancement Sites Prioritization

ID	Main Stream	SWS	PIN	[redacted]	R/E Ownership Both Sides (lf)	Score	R/E Ownership One Side (lf)	Drainage Area (sq.mi.)	Score	Potential Wetland Opportunity	Score	Total Score	Rank	SWS Priority	Ownership
36	Abingdon Creek	AC01	2820629176	[redacted]	427	0	0	0.1	2	No	0	2	Low	Yes	Private
36	Abingdon Creek	AC01	2820610429 2820610766 2820517615	[redacted]	727	0	0	1.3	2	No	0	2	Low	Yes	Private
36	Abingdon Creek	AC01	2820607254	[redacted]	2,384	1	0	1.7	2	No	0	3	Low	Yes	Private
36	Abingdon Creek	AC01	2820504942	[redacted]	1,071	0	0	1.4	2	No	0	2	Low	Yes	Private
37	Abingdon Creek	AC01	2729887967 2729793129	[redacted]	1,698	0	488	1.8	2	No	0	2	Low	Yes	Private
37	Abingdon Creek	AC01	2729985059	[redacted]	668	0	351	2.0	2	No	0	2	Low	Yes	Private
37	Abingdon Creek	AC01	2729889476	[redacted]	0	0	889	2.0	2	No	0	2	Low	Yes	Private
38	Abingdon Creek	AC02	2738594872 2739512369	[redacted]	1,852	0	2,550	5.1	1	Yes	1	2	Low	Yes	Private
38	Abingdon Creek	AC02	2739319175	[redacted]	0	0	1,334	4.8	1	No	0	1	Low	Yes	Private
38	Abingdon Creek	AC02	2739408206	[redacted]	0	0	1,216	5.1	1	No	0	1	Low	Yes	County
39	UT Lower Creek	LC07	2747399141	[redacted]	1,486	0	0	0.1	2	No	0	2	Low	No	Private
39	UT Lower Creek	LC07	2748207277	[redacted]	338	0	0	0.1	2	No	0	2	Low	No	Private
39	UT Lower Creek	LC07	2747495263	[redacted]	776	0	0	0.1	2	No	0	2	Low	No	Private
40	UT Lower Creek	LC07	2748207277	[redacted]	4,382	3	0	0.3	2	No	0	5	Med	No	Private
41	UT Lower Creek	LC07	2737891346	[redacted]	730	0	221	0.8	2	No	0	2	Low	No	Private
41	UT Lower Creek	LC07	2737692199	[redacted]	971	0	0	1.3	2	Yes	1	3	Low	No	Private
41	UT Lower Creek	LC07	2737791079 2737675919 2737675919	[redacted]	1,472	0	221	1.2	2	No	0	2	Low	No	Private
42	UT Lower Creek	LC07	2737145763	[redacted]	992	0	263	0.1	2	No	0	2	Low	No	Private
42	UT Lower Creek	LC07	2737041872	[redacted]	0	0	1,006	0.3	2	No	0	2	Low	No	Private
42	UT Lower Creek	LC07	2737126828	[redacted]	1,570	0	263	0.5	2	Yes	1	3	Low	No	Private
42	UT Lower Creek	LC07	2737350669	[redacted]	959	0	0	0.3	2	No	0	2	Low	No	Private
43	UT Lower Creek	LC08	2737528714 2737611913	[redacted]	5,028	4	0	0.8	2	Yes	1	7	High	No	Private
44	UT Lower Creek	LC08	2737126828	[redacted]	5,222	4	0	1.3	2	No	0	6	Med	No	Private
45	UT Lower Creek	LC08	2727817625	[redacted]	304	0	0	0.2	2	No	0	2	Low	No	Private
45	UT Lower Creek	LC08	2727825040	[redacted]	3,201	2	0	0.8	2	Yes	1	5	Med	No	Private
46	UT Lower Creek	LC08	2727609475	[redacted]	274	0	0	0.1	2	No	0	2	Low	No	Private
46	UT Lower Creek	LC08	2727817625	[redacted]	324	0	0	0.1	2	No	0	2	Low	No	Private
46	UT Lower Creek	LC08	2727825040	[redacted]	1,473	0	0	0.1	2	No	0	2	Low	No	Private
47	UT Lower Creek	LC08	2727836470 2727830872	[redacted]	1,458	0	89	0.1	2	Yes	1	3	Low	No	Private
47	UT Lower Creek	LC08	2727820507	[redacted]	1,450	0	89	0.1	2	Yes	1	3	Low	No	Private
47	UT Lower Creek	LC08	2727619860	[redacted]	2,106	1	0	0.2	2	No	0	3	Low	No	Private
48	UT Lower Creek	LC08	2727400344 2726397205	[redacted]	1,469	0	556	0.5	2	No	0	2	Low	No	Private
48	UT Lower Creek	LC08	2727302224	[redacted]	0	0	556	0.5	2	No	0	2	Low	No	Private

SWS Priority “Yes” indicates priority sub-waters [redacted]

Table 1 Continued. Lower Creek Watershed – Identified Restoration & Enhancement Sites Prioritization

ID	Main Stream	SWS	PIN	[redacted]	R/E Ownership Both Sides (lf)	Score	R/E Ownership One Side (lf)	Drainage Area (sq.mi.)	Score	Potential Wetland Opportunity	Score	Total Score	Rank	SWS Priority	Ownership
49	UT Husband Creek	HC01	2729184585 2729285200 2729187624 2729279603		1,999	0	358	0.3	2	No	0	2	Low	No	Private
49	UT Husband Creek	HC01	2729382283		690	0	0	0.4	2	No	0	2	Low	No	Private
49	UT Husband Creek	HC01	2729289661		0	0	358	0.3	2	No	0	2	Low	No	Private
50	UT Husband Creek	HC01	2729236076 2729226685 2729126310		1,897	0	0	1.4	2	No	0	2	Low	No	Private
50	UT Husband Creek	HC01	2729223277 2729212801		1,077	0	123	1.4	2	No	0	2	Low	No	Private
50	UT Husband Creek	HC01	2729114112 2729211033		634	0	328	1.5	2	No	0	2	Low	No	Private
50	UT Husband Creek	HC01	2729105861		0	0	328	1.5	2	No	0	2	Low	No	Private
51	Husband Creek	HC01	2719985343 2719972779		1,289	0	508	0.6	2	Yes	1	3	Low	No	Private
51	Husband Creek	HC01	2719875343		89	0	508	0.6	2	No	0	2	Low	No	Private
51	Husband Creek	HC01	2719778888		531	0	0	0.1	2	No	0	2	Low	No	Private
51	Husband Creek	HC01	2719888319		212	0	0	0.4	2	No	0	2	Low	No	Private
52	UT Husband Creek	HC01	2719454356		185	0	0	0.1	2	No	0	2	Low	No	Private
52	UT Husband Creek	HC01	2810302773 2719556971		10,220	6	0	0.5	2	Yes	1	9	High	No	Private
53	Husband Creek	HC01	2719702741		662	0	0	0.2	2	No	0	2	Low	No	Private
53	Husband Creek	HC01	2719801254		2,155	1	141	2.2	2	Yes	1	4	Med	No	Private
53	Husband Creek	HC01	2719915461		418	0	493	1.9	2	Yes	1	3	Low	No	Private
53	Husband Creek	HC01	2719819253		88	0	352	1.9	2	No	0	2	Low	No	Private
54	Husband Creek	HC01	2728491083		647	0	736	5.0	1	No	0	1	Low	No	Private
54	Husband Creek	HC01	2728175105 2728372872		1,850	0	197	4.3	1	Yes	1	2	Low	No	Private
54	Husband Creek	HC01	2728398345		0	0	239	0.6	2	No	0	2	Low	No	Private
54	Husband Creek	HC01	2728486871		531	0	502	5.0	1	Yes	1	2	Low	No	Private
54	Husband Creek	HC01	2728472818		195	0	0	5.1	1	No	0	1	Low	No	Private
55	UT Husband Creek	HC01	2728791536 2728883533		2,699	1	0	0.1	2	Yes	1	4	Med	No	Private
56	UT Husband Creek	HC02	2718776782		1,333	0	658	0.1	2	No	0	2	Low	Yes	Private
56	UT Husband Creek	HC02	2718873056		1,705	0	130	0.8	2	Yes	1	3	Low	Yes	Private
56	UT Husband Creek	HC02	2718763656		1,322	0	130	0.7	2	No	0	2	Low	Yes	Private
56	UT Husband Creek	HC02	2718680426		3,203	2	0	0.6	2	No	0	4	Med	Yes	Private
57	UT Husband Creek	HC02	2728052611		1,523	0	0	1.1	2	No	0	2	Low	Yes	Private
57	UT Husband Creek	HC02	2718945973		673	0	0	1.0	2	No	0	2	Low	Yes	Private

SWS Priority “Yes” indicates priority sub-watersh[redacted]

Table 1 Continued. Lower Creek Watershed – Identified Restoration & Enhancement Sites Prioritization

ID	Main Stream	SWS	PIN	[redacted]	R/E Ownership Both Sides (lf)	Score	R/E Ownership One Side (lf)	Drainage Area (sq.mi.)	Score	Potential Wetland Opportunity	Score	Total Score	Rank	SWS Priority	Ownership
58	Husband Creek	HC02	2727294144	[redacted]	1,747	0	437	8.3	0	Yes	1	1	Low	Yes	Private
58	Husband Creek	HC02	2727278988	[redacted]	0	0	1,236	8.4	0	No	0	0	Low	Yes	Private
58	Husband Creek	HC02	2727189516	[redacted]	0	0	437	8.3	0	No	0	0	Low	Yes	Private
58	Husband Creek	HC02/CC02	2727272831	[redacted]	0	0	2,022	5.9	1	No	0	1	Low	Yes	Private
58	Husband Creek	CC02	2727267877	[redacted]	0	0	785	5.9	1	No	0	1	Low	Yes	Private
59	UT Celia Creek	CC01	2719234234	[redacted]	4,440	3	0	0.3	2	No	0	5	Med	Yes	Private
60	Celia Creek	CC01	2719234234	[redacted]	9,680	5	0	0.8	2	Yes	1	8	High	Yes	Private
61	Celia Creek	CC01	2719234234	[redacted]	3,502	2	0	1.7	2	No	0	4	Med	Yes	Private
62	UT Celia Creek	CC02	2718457993	[redacted]	719	0	0	0.1	2	No	0	2	Low	No	Private
62	UT Celia Creek	CC02	2718356597	[redacted]	2,471	1	207	0.2	2	No	0	3	Low	No	Private
62	UT Celia Creek	CC02	2718257175	[redacted]	0	0	568	0.2	2	No	0	2	Low	No	Private
62	UT Celia Creek	CC02	2718340711	[redacted]	0	0	362	0.2	2	No	0	2	Low	No	Private
63	Celia Creek	CC02	2717791597	[redacted]	0	0	611	4.7	1	No	0	1	Low	No	Private
63	Celia Creek	CC02	2717891123 2717887563	[redacted]	2,287	1	1,436	5.1	1	Yes	1	3	Low	No	Private
63	Celia Creek	CC02	2717689850 2717782510	[redacted]	996	0	1,676	5.1	1	No	0	1	Low	No	Private
64	Celia Creek	CC02	2727155509	[redacted]	599	0	0	0.1	2	No	0	2	Low	No	State
64	Celia Creek	CC02	2727163377	[redacted]	4,341	3	74	5.8	1	Yes	1	5	Med	No	Private
64	Celia Creek	CC02	2717977353	[redacted]	0	0	1,341	5.6	1	No	0	1	Low	No	Private
64	Celia Creek	CC02	2717855939	[redacted]	0	0	151	5.6	1	No	0	1	Low	No	Private
64	Celia Creek	CC02	2717971239	[redacted]	0	0	1,115	5.5	1	No	0	1	Low	No	Private
65	UT Husband Creek	HC03	2727480060	[redacted]	2,491	1	412	0.7	2	Yes	1	4	Med	Yes	Private
65	UT Husband Creek	HC03	2727468045	[redacted]	0	0	412	0.7	2	No	0	2	Low	Yes	Private
66	UT Lower Creek	LC09	2726054122 2726150779	[redacted]	3,809	2	0	0.1	2	Yes	1	5	Med	No	Private
67	UT Lower Creek	LC09	2716769412	[redacted]	182	0	0	0.1	2	Yes	1	3	Low	No	Private
67	UT Lower Creek	LC09	2716864595 2716862471 2716870046	[redacted]	2,476	1	0	0.9	2	Yes	1	4	Med	No	Private
68	UT Lower Creek	LC09	2716942910 2726054122	[redacted]	4,305	3	0	0.1	2	Yes	1	6	Med	No	Private
69	Bristol Creek	BC01	2707965355	[redacted]	2,057	1	206	1.1	2	Yes	1	4	Med	Yes	Private
69	Bristol Creek	BC01	2717176384	[redacted]	338	0	206	0.1	2	No	0	2	Low	Yes	Private
70	Bristol Creek	BC01	2717134434 2717036080 2717112922	[redacted]	2,758	1	0	2.2	2	No	0	3	Low	Yes	Private
70	Bristol Creek	BC01	2707902599	[redacted]	787	0	0	2.3	2	No	0	2	Low	Yes	Private
70	Bristol Creek	BC01	2717004811	[redacted]	1,844	0	0	2.3	2	No	0	2	Low	Yes	Private

SWS Priority "Yes" indicates priority sub-watersh[redacted]

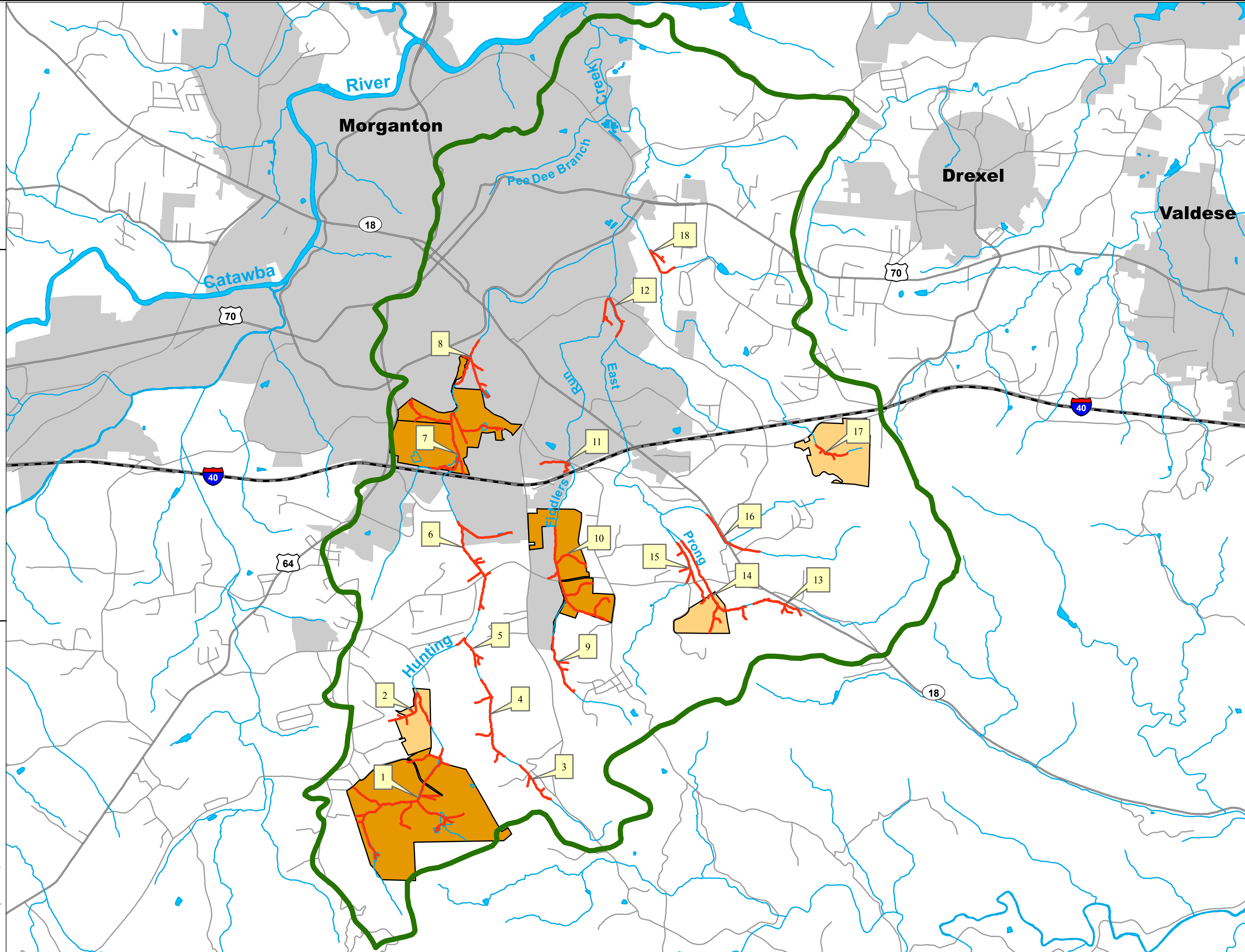
Table 1 Continued. Lower Creek Watershed – Identified Restoration & Enhancement Sites Prioritization

ID	Main Stream	SWS	PIN	[redacted]	R/E Ownership Both Sides (lf)	Score	R/E Ownership One Side (lf)	Drainage Area (sq.mi.)	Score	Potential Wetland Opportunity	Score	Total Score	Rank	SWS Priority	Ownership
71	UT Bristol Creek	BC01	2717229897 2717323638 2717322895 2717322627	[redacted]	609	0	0	0.5	2	No	0	2	Low	Yes	Private
71	UT Bristol Creek	BC01	2717432049	[redacted]	774	0	0	0.4	2	No	0	2	Low	Yes	Private
71	UT Bristol Creek	BC01	2717433984	[redacted]	0	0	1,023	0.4	2	No	0	2	Low	Yes	Private
71	UT Bristol Creek	BC01	2717367348	[redacted]	1,322	0	2,017	0.4	2	No	0	2	Low	Yes	Private
71	UT Bristol Creek	BC01	2717216877 2717226724	[redacted]	1,832	0	0	0.7	2	No	0	2	Low	Yes	Private
71	UT Bristol Creek	BC01	2717442874 2717442874	[redacted]	0	0	994	0.1	2	No	0	2	Low	Yes	Private
71	UT Bristol Creek	BC01	2717112922	[redacted]	917	0	0	0.7	2	No	0	2	Low	Yes	Private
72	UT White Mill Creek	WM01	1798945448	[redacted]	3,628	2	0	0.2	2	No	0	4	Med	Yes	Private
73	White Mill Creek	WM01	2707333232 2707430864	[redacted]	4,378	3	0	3.3	1	No	0	4	Med	Yes	Private
73	White Mill Creek	WM01	2707353163	[redacted]	1,685	0	0	0.3	2	No	0	2	Low	Yes	Private
74	UT Bristol Creek	BC02	2716461825	[redacted]	526	0	181	0.1	2	No	0	2	Low	No	Private
74	UT Bristol Creek	BC02	2716389274 2716379205	[redacted]	327	0	556	0.5	2	No	0	2	Low	No	Private
74	UT Bristol Creek	BC02	2716375731	[redacted]	0	0	556	0.5	2	No	0	2	Low	No	Private
74	UT Bristol Creek	BC02	2716367454 2716364554	[redacted]	471	0	410	8.0	0	No	0	0	Low	No	Private
74	UT Bristol Creek	BC02	2716366980	[redacted]	791	0	181	0.7	2	No	0	2	Low	No	Private
74	UT Bristol Creek	BC02	2716259096	[redacted]	0	0	210	8.0	0	No	0	0	Low	No	Private
74	UT Bristol Creek	BC02	2716466198	[redacted]	1,125	0	0	0.1	2	No	0	2	Low	No	Private
75	Bristol Creek	BC02	2716259096	[redacted]	2,338	1	0	9.0	0	Yes	1	2	Low	No	Private
75	Bristol Creek	BC02	2716466198	[redacted]	2,134	1	0	0.1	2	Yes	1	4	Med	No	Private
76	UT Bristol Creek	BC02	2706637047 2706619965	[redacted]	2,471	1	0	0.1	2	No	0	3	Low	No	Private
76	UT Bristol Creek	BC02	2706517469	[redacted]	958	0	0	0.1	2	No	0	2	Low	No	Private
76	UT Bristol Creek	BC02	2706615032 2706617049	[redacted]	369	0	0	0.3	2	No	0	2	Low	No	Private
77	UT Bristol Creek	BC02	2706813184 2706820293 2706812577	[redacted]	2,568	1	486	0.1	2	Yes	1	4	Med	No	Private
77	UT Bristol Creek	BC02	2706818044	[redacted]	0	0	486	0.1	2	No	0	2	Low	No	Private

SWS Priority "Yes" indicates priority sub-watersh[redacted]

Hunting Creek Watershed

Figure: 2
Potential Restoration & Enhancement Sites



Legend

- Hunting Creek Watershed
- Municipal Boundaries

Priority Parcels

- High
- Medium
- Potential Restoration & Enhancement Sites
- Streams

Roads

- Interstate
- Primary
- Secondary

N
W E
S

0 0.25 0.5 1 1.5
Miles

Ecosystem Enhancement PROGRAM

EQUINOX ENVIRONMENTAL CONSULTATION & DESIGN

Table 2. Hunting Creek Watershed – Identified Restoration & Enhancement Sites Prioritization

ID	Main Stream	PIN	[redacted]	R/E Ownership Both Sides (lf)	Score	R/E Ownership One Side (lf)	Drainage Area (sq.mi.)	Score	Potential Wetland Opportunity	Score	Total Score	Rank	Ownership
1	Hunting Creek	2701118549	[redacted]	18,737	6	840	1.5	2	Yes	1	9	High	State
1	Hunting Creek	2701345209	[redacted]	554	0	840	1.6	2	Yes	1	3	Low	Private
2	Hunting Creek	2701158763	[redacted]	3,801	2	571	2.3	2	No	0	4	Med	Private
2	Hunting Creek	2701067108	[redacted]	270	0	898	0.3	2	No	0	2	Low	Private
2	Hunting Creek	2701057871	[redacted]	0	0	327	0.1	2	No	0	2	Low	Private
3	UT Hunting Creek	2701638797 2701733124	[redacted]	0	0	1,783	0.8	2	No	0	2	Low	Private
3	UT Hunting Creek	2701620884	[redacted]	536	0	1,403	0.8	2	Yes	1	3	Low	Private
3	UT Hunting Creek	2701617868	[redacted]	770	0	381	0.5	2	No	0	2	Low	Private
4	UT Hunting Creek	2701578662	[redacted]	0	0	979	1.5	2	No	0	2	Low	Private
4	UT Hunting Creek	2701476304	[redacted]	0	0	1,506	1.5	2	No	0	2	Low	Private
4	UT Hunting Creek	2701456959	[redacted]	1,148	0	2,385	1.5	2	No	0	2	Low	State
4	UT Hunting Creek	2701663535	[redacted]	0	0	1,858	1.5	2	No	0	2	Low	Private
4	UT Hunting Creek	2701547620	[redacted]	1,794	0	0	1.0	2	Yes	1	3	Low	Private
5	UT Hunting Creek	2701487664 2701494560 2701498046	[redacted]	884	0	1,553	1.7	2	Yes	1	3	Low	Private
5	UT Hunting Creek	2701388500	[redacted]	0	0	699	1.7	2	No	0	2	Low	Private
5	UT Hunting Creek	2701490370	[redacted]	52	0	1,104	2.9	2	No	0	2	Low	Private
5	UT Hunting Creek	2701397156	[redacted]	266	0	0	2.8	2	No	0	2	Low	Private
6	Hunting Creek	2702343586 2702351117	[redacted]	0	0	644	5.5	1	No	0	1	Low	Private
6	Hunting Creek	2702345028	[redacted]	0	0	729	5.3	1	No	0	1	Low	Private
6	Hunting Creek	2702532087	[redacted]	0	0	1,194	5.1	1	Yes	1	2	Low	Private
6	Hunting Creek	2702535884	[redacted]	0	0	503	5.3	1	No	0	1	Low	Private
6	Hunting Creek	2702327865	[redacted]	780	0	1,582	5.2	1	No	0	1	Low	Private
6	Hunting Creek	2702535437	[redacted]	433	0	450	5.2	1	No	0	1	Low	Private
6	Hunting Creek	2702550180	[redacted]	2,504	1	1,279	5.5	1	No	0	2	Low	Private
6	Hunting Creek	2702528505	[redacted]	356	0	407	4.9	1	No	0	1	Low	Private
6	Hunting Creek	2702524008	[redacted]	0	0	513	4.9	1	No	0	1	Low	Private
6	Hunting Creek	2702427114 2702416300	[redacted]	0	0	1,467	4.9	1	No	0	1	Low	Private
6	Hunting Creek	2702416788	[redacted]	0	0	202	4.9	1	No	0	1	Low	Private
6	Hunting Creek	2702510358	[redacted]	274	0	750	4.9	1	No	0	1	Low	Private
7	Hunting Creek	2702280586 2702397164	[redacted]	12,349	6	0	7.3	0	Yes	1	7	High	State
8	Hunting Creek	2703517663	[redacted]	3,307	2	1,331	8.2	0	No	0	2	Low	State
8	Hunting Creek	2703411710	[redacted]	1,389	0	1,331	7.4	0	No	0	0	Low	County

Table 2 Continued. Hunting Creek Watershed – Identified Restoration & Enhancement Sites Prioritization

ID	Main Stream	PIN	[redacted]	R/E Ownership Both Sides (lf)	Score	R/E Ownership One Side (lf)	Drainage Area (sq.mi.)	Score	Potential Wetland Opportunity	Score	Total Score	Rank	Ownership
9	Fiddlers Run	2702716303	[redacted]	0	0	589	0.6	2	No	0	2	Low	County
9	Fiddlers Run	2701881549	[redacted]	0	0	731	0.6	2	No	0	2	Low	Private
9	Fiddlers Run	2701873483	[redacted]	0	0	1,294	0.5	2	No	0	2	Low	Private
9	Fiddlers Run	2701799014	[redacted]	0	0	368	0.6	2	No	0	2	Low	Private
9	Fiddlers Run	2702802899	[redacted]	0	0	589	0.6	2	No	0	2	Low	State
9	Fiddlers Run	2701888042 2701896094	[redacted]	994	0	3,371	0.6	2	No	0	2	Low	Private
10	Fiddlers Run	2702716303	[redacted]	0	0	926	1.1	2	No	0	2	Low	County
10	Fiddlers Run	2702802899 2702831861 2702913592	[redacted]	6,915	5	4,418	1.3	2	No	0	7	High	State
10	Fiddlers Run	2702737279	[redacted]	601	0	2,566	1.3	2	No	0	2	Low	State
11	UT Fiddlers Run	2702870512	[redacted]	2,129	1	0	0.1	2	No	0	3	Low	Private
12	East Prong / Fiddlers Run	2713040633	[redacted]	0	0	765	2.4	2	No	0	2	Low	Private
12	East Prong / Fiddlers Run	2713047373	[redacted]	3,198	2	765	6.5	0	Yes	1	3	Low	City
13	East Prong	2712911032 2712901840 2712902794 2712806425	[redacted]	2,066	1	38	1.3	2	No	0	3	Low	Private
13	East Prong	2712801607	[redacted]	710	0	0	1.3	2	Yes	1	3	Low	Private
13	East Prong	2712715228	[redacted]	930	0	0	1.4	2	Yes	1	3	Low	Private
14	East Prong	2712419916	[redacted]	0	0	1,063	1.8	2	No	0	2	Low	Private
14	East Prong	2712444290	[redacted]	0	0	751	1.9	2	No	0	2	Low	Private
14	East Prong	2712521204 2712512945	[redacted]	0	0	699	1.8	2	No	0	2	Low	Private
14	East Prong	2712438422	[redacted]	0	0	843	1.9	2	No	0	2	Low	Private
14	East Prong	2712615228	[redacted]	0	0	1,217	1.5	2	No	0	2	Low	Private
14	East Prong	2712429773	[redacted]	0	0	561	1.8	2	No	0	2	Low	Private
14	East Prong	2712423507	[redacted]	0	0	561	1.8	2	No	0	2	Low	Private
14	East Prong	2712337323	[redacted]	0	0	1,595	1.9	2	No	0	2	Low	Private
14	East Prong	2712409543	[redacted]	3,155	2	365	1.8	2	Yes	1	5	Med	Private
14	East Prong	2712700630	[redacted]	676	0	1,023	1.5	2	No	0	2	Low	Private
15	UT East Prong	2712419916	[redacted]	0	0	874	0.2	2	Yes	1	3	Low	Private
15	UT East Prong	2712423507	[redacted]	1,334	0	550	0.9	2	Yes	1	3	Low	Private
15	UT East Prong	2712337323	[redacted]	1,417	0	550	1.0	2	No	0	2	Low	Private
15	UT East Prong	2712409543 2712415644	[redacted]	327	0	874	0.2	2	Yes	1	3	Low	Private
15	UT East Prong	2712336826	[redacted]	0	0	283	1.0	2	No	0	2	Low	Private
16	UT East Prong	2712648270 2712730533	[redacted]	1,508	0	0	0.5	2	Yes	1	3	Low	Private
16	UT East Prong	2712543500	[redacted]	1,616	0	0	1.2	2	No	0	2	Low	Private
17	UT Hunting Creek	2722182460	[redacted]	2,334	1	0	0.3	2	Yes	1	4	Med	Private
18	UT Hunting Creek	2713373806	[redacted]	1,768	0	951	2.7	2	Yes	1	3	Low	Private
18	UT Hunting Creek	2713273751	[redacted]	235	0	951	2.7	2	No	0	2	Low	Private

3. Preservation Sites

Additionally, Equinox identified preservation opportunities within the Lower and Hunting Creek watershed areas based on the following criteria:

- Forested stream reaches with a minimum riparian buffer of 100 feet on each bank;
- Minimum reach length of 5,000 linear feet; and
- Reach containing an individual landowner.

Based on these criteria, 53 sites (48 in the Lower Creek watershed and 5 in the Hunting Creek watershed) were identified (Figures 3 & 4). Contiguous parcels in single ownership were combined and a single site identification number was assigned.

Projects that qualified as potential preservation projects were prioritized based on the following 5 criteria:

- Total site reach length;
- Maximum contiguous reach length;
- Percentage of site containing headwater reaches;
- Site adjacent to protected lands; and
- Site containing potential restoration and enhancement project components.

Scores for individual attributes and their application to the prioritization system are discussed below and shown in Tables 3 & 4.

<u>Reach Length</u>
The total linear feet of identified preservation reaches within a site were summed to determine their categories and scored as follows:

- Total reach length (5,000 – 9,999 linear feet) = 0;
- Total reach length (10,000 – 14,999 linear feet) = 1;
- Total reach length (15,000 – 19,999 linear feet) = 2; and
- Total reach length (>20,000 linear feet) = 3.

<u>Maximum Contiguous Reach Length</u>
Sites were further assessed to determine the maximum contiguous linear feet of potential preservation opportunity. Sites identified with longer contiguous reaches were considered higher priority and thus applied a higher score for this category. The categories and associated scores are as follows:

- Maximum contiguous reach length (<5,000 linear feet) = 0;
- Maximum contiguous reach length (5,000 – 9,999 linear feet) = 1;
- Maximum contiguous reach length (10,000 – 14,999 linear feet) = 2;
- Maximum contiguous reach length (15,000 – 19,999 linear feet) = 3;
- Maximum contiguous reach length (20,000 – 29,999 linear feet) = 4; and
- Maximum contiguous reach length (>30,000 linear feet) = 5.

Percentage of Headwater Reaches

Individual sites were assessed to determine the percentage of intact headwater stream reaches as compared to the total linear feet of preservation opportunity within the site. Intact headwater streams were defined as stream reaches contained entirely within the identified site and that had adequate riparian buffers to the stream origin. The stream channel origin was defined as the most upstream line as depicted by the NC LIDAR data set. Sites containing a greater percentage of intact headwater streams were considered higher priority and were categorized and scored as follows:

- Percentage of headwater reaches (<25%) = 0;
- Percentage of headwater reaches (25 - 49%) = 1;
- Percentage of headwater reaches (50 - 74%) = 2; and
- Percentage of headwater reaches (>75%) = 3.

Site Location

Potential preservation sites located adjacent to currently protected lands were given an additional point. The categories and scores assigned based on project location are as follows:

- Site not adjacent to protected lands = 0; and
- Site adjacent to protected lands = 1.

Restoration/Enhancement Component

Identified preservation sites were further screened to determine if the parcel was identified as restoration and enhancement site. A higher score was applied if a restoration and enhancement reach was contained within the preservation parcel.

- Restoration/enhancement component not associated with site = 0; and
- Restoration/enhancement component associated with site = 1.

Site Prioritization

Parcel scores for each criterion were summed to obtain a total priority score. Total priority scores for all parcels ranged from 0 to 10 out of a possible high score of 13. Preservation sites were classified as Low, Medium, or High priority and were categorized and ranked as follows:

- Parcel score (0 – 3) = Low Priority;
- Parcel score (4 – 7) = Medium Priority; and
- Parcel score (8 – 13) = High Priority.

Maps of the 53 preservation sites identified (Figures 3 & 4) and the corresponding prioritization and parcel information (Tables 3 & 4) are included.

Lower Creek Watershed

Figure: 3
Potential Preservation Sites

Legend

Lower Creek Watershed
AC01 Subwatersheds
Municipal Boundaries

Priority Subwatersheds

R/E High
R/E Moderate
Preservation

Priority Parcels

High
Medium
Low

Streams

Roads

Interstate
Primary
Secondary

N S W E

0 0.5 1 2 3 Miles

Ecosystem Enhancement PROGRAM

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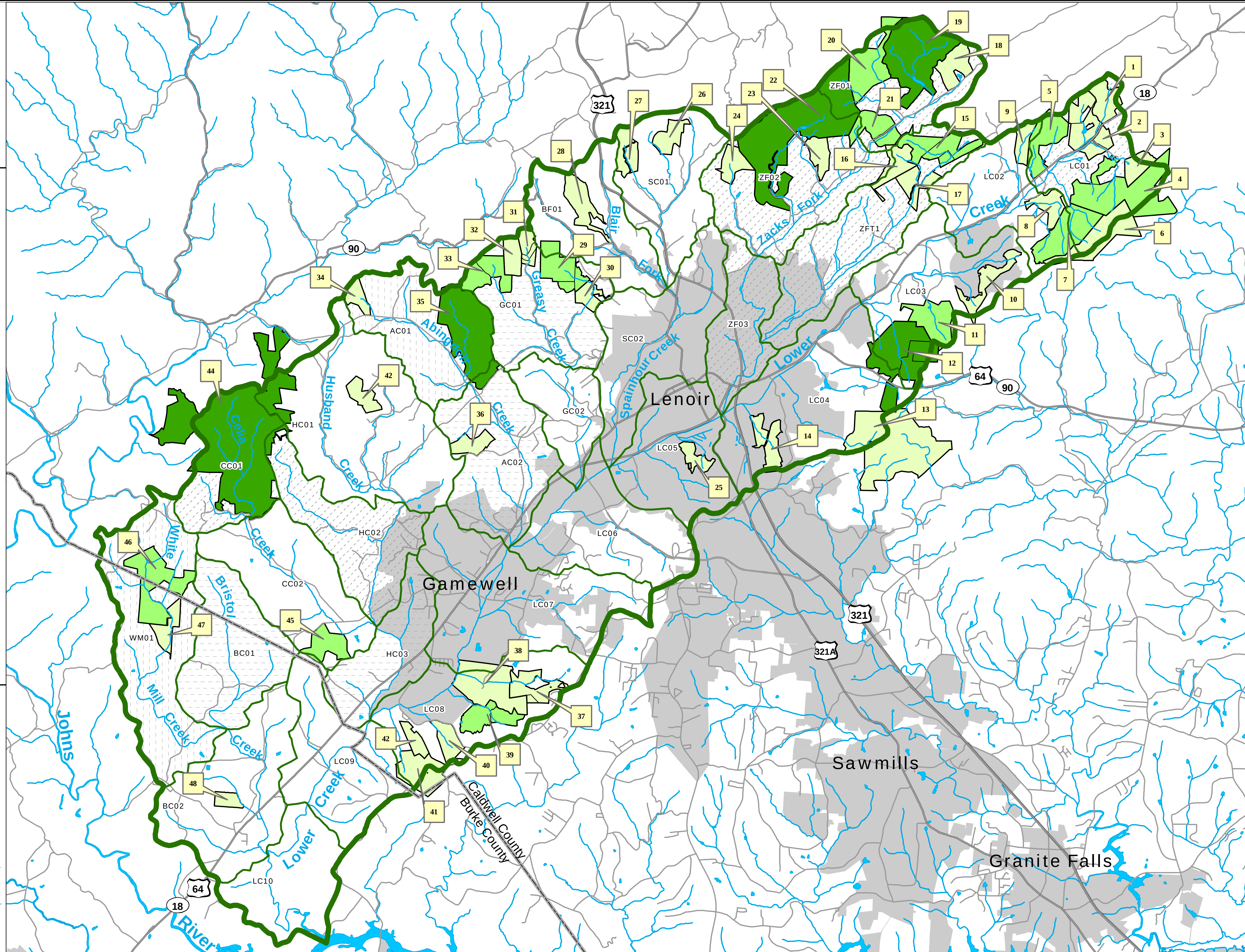


Table 3. Lower Creek Watershed – Identified Preservation Sites Prioritization

ID	Main Stream	SWS	PIN	[redacted]	Acres	Total Preservation (lf)	Score	Maximum Contiguous (lf)	Score	Headwater Streams (%)	Score	Adjacent to Protected Lands	Score	Rest / Enh Opportunity	Score	Total Score	Rank	SWS Priority	Ownership
1	Lower Creek	LC01	2882205727	[redacted]	141	7,111	0	4,044	0	71%	2	No	0	No	0	2	Low	Yes	Private
2	UT Lower Creek	LC01	2881077750 2882008585		268	8,916	0	2,470	0	57%	2	No	0	Yes	1	3	Low	Yes	Private
3	UT Lower Creek	LC01	2881551128		95	6,183	0	5,629	1	34%	1	No	0	No	0	2	Low	Yes	Private
4	UT Lower Creek	LC01	2881254145 2881526397		546	27,157	3	9,093	1	72%	2	No	0	No	0	6	Med	Yes	Private
5	UT Lower Creek	LC01	2871773763		212	12,503	1	5,545	1	90%	3	No	0	No	0	5	Med	Yes	Private
6	UT Lower Creek	LC01/LC02	2880861877		302	5,745	0	2,206	0	10%	0	No	0	No	0	0	Low	Yes	Private
7	UT Lower Creek	LC01/LC02	2881228768		304	23,949	3	11,843	2	58%	2	No	0	No	0	7	Med	Yes	Private
8	UT Lower Creek	LC02	2871728200		113	5,585	0	2,183	0	55%	2	No	0	Yes	1	3	Low	No	Private
9	UT Lower Creek	LC02	2871565937		89	7,235	0	5,563	1	18%	0	No	0	No	0	1	Low	No	Private
10	UT Lower Creek	LC03	2870353841		152	11,213	1	2,123	0	51%	2	No	0	No	0	3	Low	No	Private
11	UT Lower Creek	LC03	2860816855		219	12,518	1	11,552	2	65%	2	No	0	No	0	5	Med	No	Private
12	UT Lower Creek	LC03/LC04	2769796665 2769684443 2769493278		529	28,770	3	16,413	3	73%	2	No	0	No	0	8	High	No	Private
13	UT Lower Creek	LC04	2769427378		784	9,839	0	5,588	1	74%	2	No	0	No	0	3	Low	No	Private
14	UT Lower Creek	LC04	2759433724		155	9,324	0	9,324	1	24%	0	No	0	No	0	1	Low	No	Private
15	UT Zacks Fork	ZFT1/ZF01	2871160535 2861953700 2861760773		252	17,377	2	8,536	1	39%	1	No	0	No	0	4	Med	Yes	Private
16	UT Zacks Fork	ZFT1	2861763949		141	6,519	0	2,861	0	94%	3	No	0	No	0	3	Low	Yes	Private
17	UT Zacks Fork	ZFT1	2861642114		116	6,807	0	1,850	0	41%	1	No	0	No	0	1	Low	Yes	Private
18	UT Zacks Fork	ZF01	2872035889		152	9,479	0	2,955	0	10%	0	No	0	Yes	1	1	Low	Yes	Private
19	UT Zacks Fork	ZF01	2862647176		598	40,978	3	40,105	5	10%	0	No	0	No	0	8	High	Yes	City
20	UT Zacks Fork	ZF01	2862228937		279	16,232	2	9,433	1	57%	2	No	0	No	0	5	Med	Yes	Private
21	UT Zacks Fork	ZF01/ZF02	2861386598		176	11,937	1	3,823	0	67%	2	No	0	Yes	1	4	Med	Yes	Private
22	UT Zacks Fork	ZF01/ZF02	2851477421		1061	59,665	3	16,351	3	92%	3	No	0	Yes	1	10	High	Yes	Private
23	UT Zacks Fork	ZF02	2851961100		102	6,591	0	4,273	0	86%	3	No	0	No	0	3	Low	Yes	Private
24	UT Zacks Fork	ZF02	2851158221		111	9,774	0	6,811	1	25%	1	No	0	No	0	2	Low	Yes	Private
25	UT Lower Creek	LC05	2749816244		78	6,950	0	2,197	0	14%	0	No	0	No	0	0	Low	No	Private
26	UT Spainhour Creek	SC01	2841678559		109	5,881	0	2,389	0	80%	3	No	0	No	0	3	Low	No	Private
27	UT Spainhour Creek	SC01	2841362134		133	8,024	0	7,598	1	10%	0	No	0	No	0	1	Low	No	Private
28	UT Blair Fork	BF01	2831920954		176	9,467	0	5,972	1	10%	0	No	0	No	0	1	Low	No	Private
29	UT Greasy Creek	BF01/GC01	2830773211 2830879065 2830853247		226	13,417	1	5,500	1	90%	3	No	0	Yes	1	6	Med	No	Private
30	UT Greasy Creek	GC01	2840047897 2830954086		82	6,725	0	4,436	0	37%	1	No	0	No	0	1	Low	Yes	Private
31	UT Greasy Creek	GC01	2830580911 2830572967 2830573229		85	7,013	0	6,582	1	50%	2	No	0	No	0	3	Low	Yes	Private
32	UT Greasy Creek	GC01	2830388059		101	6,581	0	3,283	0	71%	2	No	0	No	0	2	Low	Yes	Private
33	UT Greasy Creek	GC01	2830068172 2830262926		197	14,223	1	6,681	1	86%	3	No	0	No	0	5	Med	Yes	Private
34	UT Abingdon Creek	AC01	2820140349		81	6,064	0	5,250	1	60%	2	No	0	No	0	3	Low	Yes	Private

SWS Priority "Yes" indicates priority sub-waters [redacted]

Table 3 Continued. Lower Creek Watershed – Identified Preservation Sites Prioritization

ID	Main Stream	SWS	PIN	[redacted]	Acres	Total Preservation (lf)	Score	Maximum Contiguous (lf)	Score	Headwater Streams (lf)	Score	Adjacent to Protected Lands	Score	Rest / Enh Opportunity	Score	Total Score	Rank	SWS Priority	Ownership
35	UT Abingdon Creek	AC01	2820829890	[redacted]	584	34,923	3	33,211	5	10%	0	No	0	No	0	8	High	Yes	County
36	UT Abingdon Creek	AC02	2739027177	[redacted]	99	7,154	0	2,487	0	78%	3	No	0	No	0	3	Low	Yes	Private
37	UT Lower Creek	LC08	2737512452 2737611913	[redacted]	161	6,566	0	2,891	0	25%	1	No	0	Yes	1	2	Low	No	Private
38	UT Lower Creek	LC07/LC08	2737126828	[redacted]	374	14,061	1	3,289	0	43%	1	No	0	Yes	1	3	Low	No	Private
39	UT Lower Creek	LC08	2736098505 2736390742	[redacted]	177	16,160	2	4,346	0	52%	2	No	0	No	0	4	Med	No	Private
40	UT Lower Creek	LC08	2727609475	[redacted]	112	7,735	0	7,735	1	50%	2	No	0	No	0	3	Low	No	Private
41	UT Lower Creek	LC08/LC09	2726652528	[redacted]	241	5,940	0	4,499	0	25%	1	No	0	No	0	1	Low	No	Private
42	UT Lower Creek	LC08	2726587143	[redacted]	70	6,104	0	6,104	1	40%	1	No	0	No	0	2	Low	No	Private
43	UT Husband Creek	HC01	2729169044	[redacted]	96	6,527	0	5,535	1	49%	1	No	0	No	0	2	Low	No	Private
44	UT Celia Creek	CC01/HC01	2810302773 2719234234	[redacted]	1721	73,278	3	19,800	3	80%	3	No	0	Yes	1	10	High	Yes	Private
45	UT Celia Creek	CC02/LC09	2717855939	[redacted]	158	7,110	0	3,055	0	50%	2	Yes	2	Yes	1	5	Med	No	Private
46	UT White Mill Creek	WM01	2708512700	[redacted]	354	22,371	3	10,741	2	57%	2	No	0	No	0	7	Med	Yes	Private
47	UT White Mill Creek	WM01	2707572250 2707682602 2707563056	[redacted]	108	6,577	0	3,310	0	7%	0	No	0	No	0	0	Low	Yes	Private
48	UT Bristol Creek	BC02	2716034146	[redacted]	56	5,535	0	5,535	1	6%	0	No	0	No	0	1	Low	No	Private

SWS Priority "Yes" indicates priority sub-water [redacted]

Hunting Creek Watershed

Figure: 4
Potential Preservation Sites

Legend

- Hunting Creek Watershed
- Municipal Boundaries

Priority Parcels

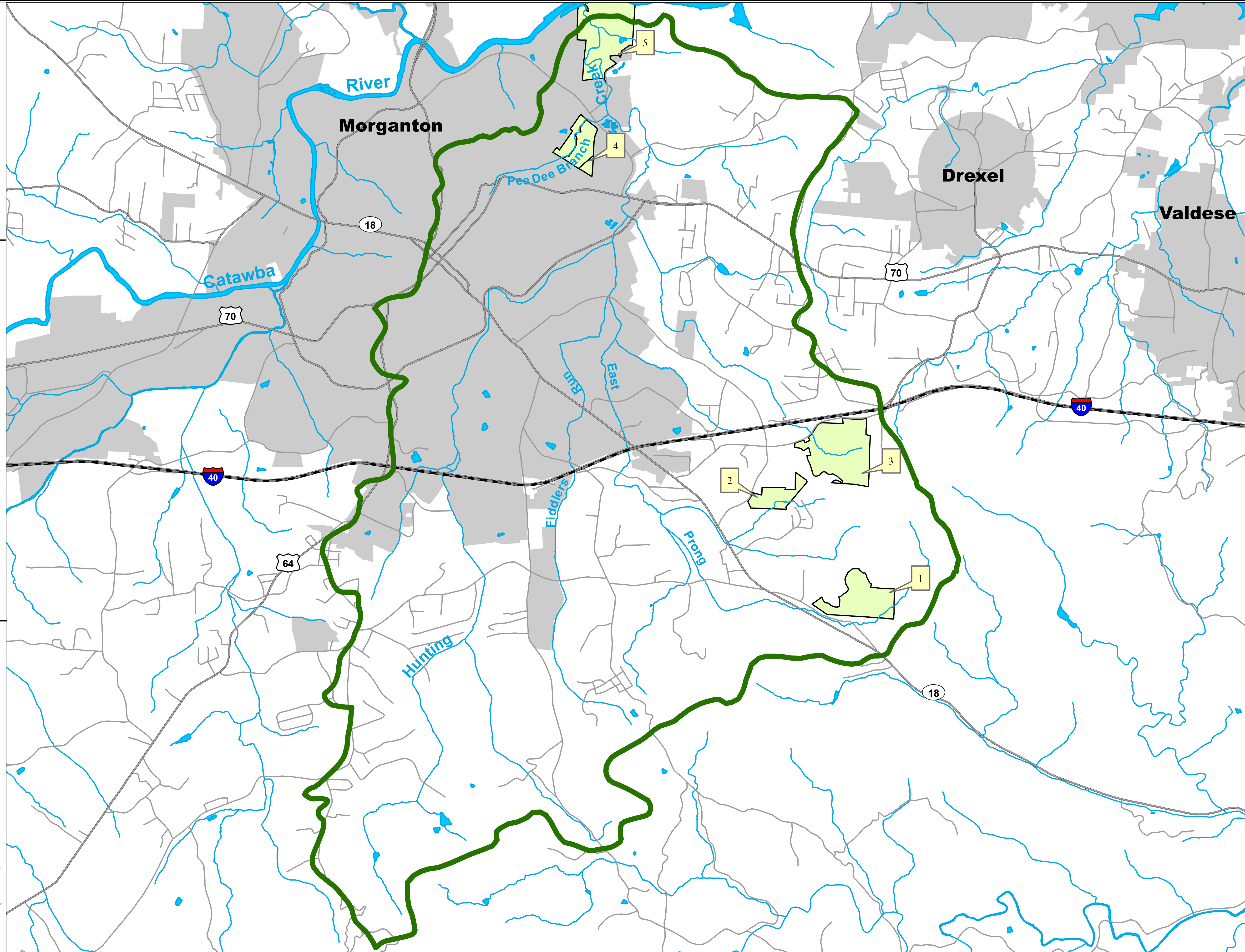
- High
- Medium
- Low
- Streams

Roads

- Interstate
- Primary
- Secondary

N
W E
S

0 0.25 0.5 1 1.5 Miles



Ecosystem Enhancement Program

EQUINOX ENVIRONMENTAL CONSULTATION & DESIGN

Table 4. Hunting Creek Watershed – Identified Preservation Sites Prioritization

ID	Main Stream	PIN	[redacted]	Acres	Total Preservation (lf)	Score	Maximum Contiguous (lf)	Score	Headwater Streams (%)	Score	Adjacent to Protected Lands	Score	Rest / Enh Opportunity	Score	Total Score	Rank	Ownership
1	East Prong	2722222442	[redacted]	103	6,547	0	3,760	0	33%	1	No	0	No	0	1	Low	Private
2	UT East Prong	2712861003	[redacted]	45	5,483	0	3,131	0	0%	0	No	0	No	0	0	Low	Private
3	UT Hunting Creek	2722182460	[redacted]	166	6,298	0	2,490	0	67%	2	No	0	Yes	1	3	Low	Private
4	Pee Dee Branch	2704916148 2704828494 2704925144	[redacted]	66	5,644	0	4,705	0	20%	0	No	0	No	0	0	Low	Private
5	Hunting Creek	2714065927	[redacted]	171	9,762	0	8,033	1	6%	0	No	0	No	0	1	Low	City

4. References

Mactec and NCEEP. Final Lower Creek Watershed Management Plan. July 2006.

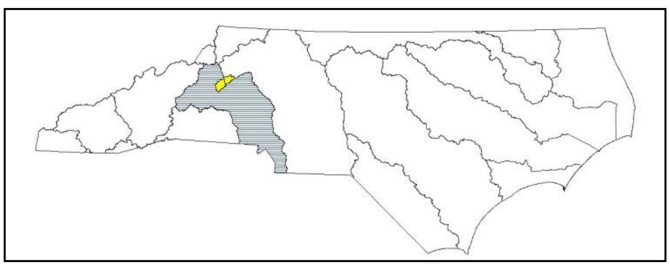
N.C. Ecosystem Enhancement Program

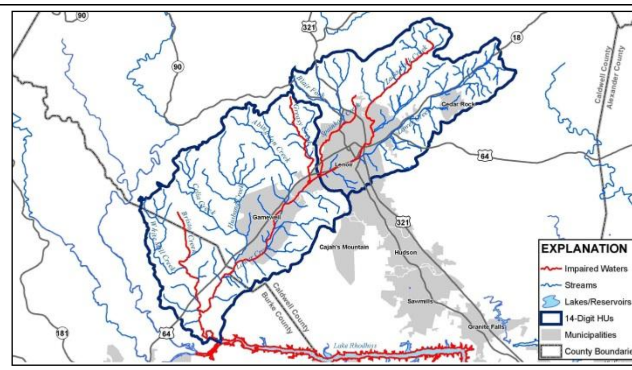
Restoring... Enhancing... Protecting Our State

LOWER CREEK LOCAL WATERSHED PLAN

FACT SHEET

Location: **River Basin:** **Cataloging Unit:** **14-digit Hydrologic Units:** **Counties:**	Near Lenoir, NC Catawba 03050101 03050101080010, 03050101080020 Burke, Caldwell
Watershed Area:	99 square miles
Planning Contact:	Hal Bryson - Ecosystem Enhancement Program (828) 450-9408 or Hal.Bryson@ncdenr.gov
Participants:	Western Piedmont COG; Technical Advisory Committee
Contractor Hired for Watershed Assessment	MACTEC Engineering: Guy Winebrenner at (919) 465-2019 or ngwinebrenner@mactec.com





Project Overview

The Lower Creek watershed is 99 square miles and is located in Burke and Caldwell Counties, including the towns of Lenoir and Gamewell. This watershed is in the foothills of the Southern Appalachians and is characterized by both rural and urban landscapes. Agriculture, residential development, and the furniture industry are major economic drivers of the area. Lower Creek and its receiving body, Lake Rhodhiss, are on North Carolina's 2006 303(d) list of impaired waters. Zack's Fork, Greasy Creek, Bristol Creek, and Spainhour Creek are major tributaries within the Lower Creek watershed, and are also on the 303(d) list.

Intensive field monitoring and GIS assessment have pinpointed major causes of degradation for watershed streams, which include stormwater pollution and scour, lack of riparian vegetation, channelization, sedimentation, chronically high fecal coliform bacteria, nutrients, floodplain encroachment, and toxicity. With the help of the Lower Creek Technical Advisory Committee, subwatersheds and streams were prioritized for restoration and preservation activities and a set of management recommendations was developed to conserve and restore water and habitat quality in the Lower Creek watershed. Key stressors and associated management strategies are listed in the table below.

Thirty-eight stream and wetland restoration and preservation projects were identified in priority subwatersheds. In addition, four stormwater BMPs were named specific examples of stormwater treatment retrofit locations. A number of institutional measures were named for consideration by Burke and Caldwell Counties and the municipalities of Lenoir and Gamewell. These measures were presented to each local government's governing body (county commission or town/city council) and officially endorsed as guidance by each. These institutional measures follow:

1. Adopt the Lower Creek *Watershed Management Plan* as a supplement to comprehensive plans.
2. Develop comprehensive stormwater management ordinances
3. Amend subdivision ordinances to promote Low Impact Development and other measures that limit development impacts
4. Adopt and enforce more comprehensive riparian buffer ordinances
5. Monitor compliance with and enforcement of erosion and sedimentation control ordinances
6. Develop steep slope ordinances
7. Amend ordinances to prohibit development in the 100 year floodplain
8. Develop a robust public education program
9. Adopt a comprehensive watershed-based land use plan for the Lower Creek watershed to protect Lake Rhodhiss

Key Stressors for Watershed Streams and Applicable Management Strategies

Stressor	Management Strategy
Stream bank erosion	Stream restoration, riparian buffers, livestock exclusion, sand dredging BMPs
Lack of adequate forested buffer	Stream restoration, riparian buffers
Stream channelization	Stream restoration
Impervious cover	Stormwater BMPs, stormwater ordinance, low impact development
Upland erosion	Agriculture & forestry BMPs, erosion and sedimentation control ordinance, subdivision ordinance modifications, steep slope ordinance, public education
Livestock access to streams	Livestock exclusion
Floodplain development	Floodplain development ordinance
Urban toxicants	Illicit discharge program, landfill strategy, watershed education program, stormwater BMPs
Nutrients	Illicit discharge program, ag BMPs, riparian buffers, watershed education program, stormwater BMPs, additional studies
Fecal coliform bacteria	Retrofit wastewater collection system, agricultural BMPs, illicit discharge program, watershed education program, stormwater BMPs

Project Schedule

An initial characterization of the watershed was finalized in May 2004, and the Watershed Assessment Report was completed in February 2006. A final Watershed Plan was completed in July 2006. Efforts to implement plan recommendations are on-going, coordinated through a stakeholder group named the Lower Creek Advisory Team. Caldwell County and both municipalities in the County's portion of the Lower Creek watershed, Lenoir and Gamewell, adopted a comprehensive stormwater and sedimentation control ordinance in October 2007. A stormwater wetland has been constructed in the Lower Creek floodplain in the City of Lenoir, with the help of a Clean Water Management Trust Fund grant. The Lower Creek Watershed Restoration Implementation Plan, conducted by the Burke and Caldwell County Soil and Water Conservation Districts and funded through a 319 grant, is implementing best management practices in the watershed. EEP is currently pursuing stream restoration projects in the watershed as well.

Planning Documents for Download

Preliminary Watershed Characterization: Findings and Recommendations for Lower Creek (20 MB)
Watershed Assessment Report (2 MB; for appendices, contact EEP)
Division of Water Quality Monitoring Report (1 MB)
Watershed Management Plan (3 MB; for appendices, contact EEP)
Watershed Management Plan Executive Summary (<1 MB)
Findings and Recommendations Summary (<1 MB)

Summary of Findings and Recommendations for the Lower Creek Local Watershed Plan

The Lower Creek Local Watershed Plan (LWP) area is 99 square miles and is located in Burke and Caldwell Counties, including the towns of Lenoir and Gamewell. This watershed is in the foothills of the Southern Appalachians, includes the hydrologic units 03050101080010, 03050101080020, and is characterized by both rural and urban landscapes. Most streams in the LWP area are classified as C waters, but the downstream fourth of Lower Creek and its tributaries are Water Supply IV. Agriculture, residential development, and the furniture industry are major economic drivers of the area. Lower Creek and its receiving body, Lake Rhodhiss, are on North Carolina's 2006 303(d) list of impaired waters. Zack's Fork, Greasy Creek, Bristol Creek, and Spainhour Creek are major tributaries within the Lower Creek watershed, and are also on the 303(d) list. Lower Creek and its tributaries have been on the 303(d) list since 2000 and are all impaired due to impaired biological integrity; Lower Creek is also impaired due to violations of the turbidity standard.

The local watershed planning effort began in 2003 and was completed in 2006. It was a three-phased effort, including a preliminary watershed characterization, detailed watershed assessment, and development of plan recommendations. Its objectives were to (1) perform a detailed assessment of watershed conditions, identifying key stressors for stream health especially for 303(d) listed streams, and (2) develop a comprehensive strategy to restore and preserve stream integrity. A broad group of planning and natural resource professionals, the Lower Creek Technical Advisory Committee, met frequently to oversee the plan's progress and develop recommendations. This group was composed of representatives of Lenoir, Gamewell, Caldwell and Burke County planning departments, Division of Forest Resources, Caldwell County Cooperative Extension service, Natural Resources and Conservation Service, Caldwell County Pathways, Carolina Land and Lakes Resource Conservation and Development, Foothills Conservancy, Duke Power, NC Wildlife Resources Commission, Burke County Soil and Water Conservation District, NC Division of Water Quality, and Western Piedmont Council of Governments,

Intensive field monitoring and GIS assessment pinpointed major causes of degradation for watershed streams. Streams flowing through Lenoir, including Lower Creek, Zack's Fork, Blair Fork, and Spainhour Creek, are impacted by a suite of urban stressors, including toxicants, high levels of fecal coliform bacteria, nutrients, channelization, and stormflow scour resulting from high levels of impervious cover. Rural streams were impacted by excess nutrients from agricultural operations and widespread habitat degradation caused by stream channelization, excess sedimentation from stream bank erosion and upland erosion, and lack of adequate forested buffer.

Key stressors for streams in the Lower Creek watershed and management strategies to address them are listed in the Table 1. These management strategies address known stressors for the Lower Creek watershed using a combination of stream and wetland restoration, institutional measures, best management practices (BMPs), and stressor-specific solutions. In order to improve degraded streams and reduce the Lower Creek watershed's impacts on Lake Rhodhiss, it is essential for multiple stakeholders—State, County, and local governments, natural resource programs, land trusts, and local citizens—to participate in a coordinated strategy for watershed restoration.

Table 1. Key watershed stressors and management strategies for the Lower Creek watershed

Stressors and Issues	Management Strategies
Stream bank erosion	Stream restoration, riparian buffers, livestock exclusion, sand dredging BMPs
Lack of adequate forested buffer	Stream restoration, riparian buffers
Stream channelization	Stream restoration
Impervious cover	Stormwater BMPs, stormwater ordinance, low impact development
Upland erosion	Agriculture & forestry BMPs, erosion and sedimentation control ordinance, subdivision ordinance modifications, steep slope ordinance, public education
Livestock access to streams	Livestock exclusion
Floodplain development	Floodplain development ordinance
Urban toxicants	Illicit discharge program, landfill strategy, watershed education program, stormwater BMPs
Nutrients	Illicit discharge program, ag BMPs, riparian buffers, watershed education program, stormwater BMPs, additional studies
Fecal coliform bacteria	Retrofit wastewater collection system, agricultural BMPs, illicit discharge program, watershed education program, stormwater BMPs

Projected BMPs to be implemented in order of priority

Sites/farms/homes/business
Best Management Practice
Units/Amount
Cost
(Lower Creek North) Target one livestock operation
Feed/Waste Storage Structure
2
$50,000
(Lower Creek North) Target as a complimentary practice to a Feed/Waste Storage Structure
Heavy Use Protection Area
2,490 Sq ft
$14,110
(Lower Creek North) Target one livestock farm, two streams
Stream Crossing
2 Each
$10,133
(Lower Creek North, Zacks Fork) Target 3 livestock farms, 1322'/farm
Livestock Exclusion Fencing
3,967 Lift
$10,115
(Lower Creek North, Zacks Fork) Target 3 livestock farms
Water Facilities
6 Each
$12,658
(Lower Creek North) Target two livestock farms
Wells
2 Each
$11,800
(Lower Creek North) Target 3 to 4 ornamental farms
Conservation Cover
100 Acres
$22,133
(Lower Creek South) Target 3 to 4 ornamental farms
Field Borders
10 Acres
$7,200
(Lower Creek Lenoir, North) Target 1 ornamental farm or as a complimentary practice to a storm water project
*Grassed Waterways/swales
300 Lift
$1,200
(Lower Creek North) Target 2 ornamental farms and 3 to 4 non-agricultural sites
*Critical Area Planting
4 Acres
$11,800
(Greasy Creek, Spainhour Creek) Target 10 small acreages with cropland
Cropland Conversion – grass/trees
10
$3,300
(Lower Creek South) Target one ornamental crop field
Rock Lined Outlet
60 Lift
$2,146
(Lower Creek Lenoir, Zacks Fork) Target two private homeowners and 3 businesses or public entities
*Cisterns
5 Each
$13,333
(Lower Creek Watershed) Target 3 private individual properties
*Abandoned Well Closures
3 Each
$6,000
(Lower Creek Lenoir, Zacks Fork) Target one private homeowner and/or 2 public entities or 2 small businesses
*Bioretention area or backyard rain garden
2 Each
$15,400
(Lower Creek Lenoir, Zacks Fork) Target one private homeowner or public entity or one small business
*Storm water Wetland or Backyard Wetland
1 Each
$6,908
(Lower Creek North, Lenoir, South) Target 3,111'length x 70'wide (Both sides) of stream bank agricultural or non-agricultural
*Riparian Buffer
5 Acres
$1,380
(Lower Creek Lenoir) Target 1 public or private entity
*Stream Restoration
300 Lift
$40,480
(Lower Creek, Lenoir) Target 2 public or private entity
*Stream bank and Shoreline Protection
300 Lift
$13,104
Total
$253,200

Using the NRCS Current Load Reduction Estimations for 2005 the Following reductions shall be acheived associated with implementation:
Nitrogen reductions @ 10,000lbs per year
Phosphorus reductions @ 7,000lbs per year
Sedimentation-Siltation reduction @ 10,000tons per year

Total Maximum Daily Load (TMDL) For Turbidity

Final Report

EPA Approved Date: April 12, 2005

Lower Creek (Subbasin 03-08-31) Catawba River Basin North Carolina

Prepared by:
NC Department of Environment and Natural Resources
Division of Water Quality
Water Quality Section
1617 Mail Service Center
Raleigh, NC 27699-1617
(919) 733-5083

INDEX OF TMDL SUBMITTAL

303(d) List Information

State: North Carolina
Counties: Caldwell and Burke
Basin: Catawba River Basin

303(D) LISTED WATERS

Stream name	Description	Class	Index #	Subbasin	Miles
Lower Creek	From Zack's Fork to Caldwell Co SR 1143	C	11-39-(0.5)b	30831	5.1
Lower Creek	From Caldwell County SR1143 to a point 0.7 miles downstream of Bristol Creek	WS-IV	11-39-(6.5)	30831	6.8
Lower Creek	From a point 0.7 miles downstream of Bristol Creek to Rhodhiss Lake, Catawba	WS-IV CA	11-39-(9)	30831	1.8

14 digit HUC or Cataloging Unit(s):	03050101080010 and 03050101080020
Area of Impairment:	13.7 miles
Water Quality Standard Violated:	Turbidity
Pollutant of Concern	Turbidity
Applicable Water Quality Standards for Class C and WS-IV Waters:	Turbidity not to exceed 50 NTU
Sources of Impairment:	Urban Runoff/Storm Sewers, Municipal Point Sources, Non-urban development

Public Notice Information

A draft of the TMDL was publicly noticed through various means, including notification in a local newspaper, *Lenoir News Topic*, on 02/10/05. The TMDL was also available from the Division of Water Quality's website during the comment period at: http://h2o.enr.state.nc.us/tmdl/TMDL_list.htm. The public comment period began 02/10/05 and was held for 30 days.

Public notice date: *February 10, 2005*
Submittal date: *March 16, 2005*
Establishment date:
Did notification contain specific mention of TMDL proposal? *Yes*
Were comments received from the public? *No*
Was a responsiveness summary prepared? *No*

TMDL Information

Critical conditions:	Turbidity exceedences occur under both wet and dry conditions predominantly during late spring to early fall seasons. The TMDL was developed using WARMF using data from 1992-2003. Water years 1992-1997 were used to calibrate the model and verification was performed using water years 1998-2003.
Seasonality:	Seasonal variation in hydrology, climatic conditions, and watershed activities are represented through the use of a continuous flow gage and the use of all readily available water quality data collected in the watershed.
Development tools:	WARMF model
Supporting documents:	Total Maximum Daily Load (TMDL) For Turbidity in Lower Creek, NC Division of Water Quality (2004)

TMDL summary

TMDL Allocations	Existing TSS Load 1998-2003 (kg/day)	TMDL - TSS Load (kg/day)	Required Reduction (%)
Wasteload Allocations			
WLA - NC0023981 (6.0 MGD, 30 mg TSS/L limit)	**-----**	**681**	**0%**
WLA - NC0043231 (0.009 MGD, 30 mg TSS/L limit)	**-----**	**1.0**	**0%**
WLA - NC0048755 (0.005 MGD, 30 mg TSS/L limit)	**-----**	**0.6**	**0%**
WLA – MS4 stormwater [1]	**15,639**	**4,377**	**72%**
WLA – NCG010000 (General Construction Permits)		**50 NTU**	
Sum of WLAs		***5,060***	
Load Allocations/ non permitted			
Load Allocation [2]	**48,284**	**13,542**	**72%**
Non-Permitted Stormwater below MS4 area [3]	**41,587**	**11,682**	**72%**
Sum of LAs		***25,224***	
Margin of Safety - Explicit 10%			
Total TSS Load at outlet to Lake Rhodhiss (kg/day)	**105,500**	**30,280**	**72%**

TABLE OF CONTENTS

INDEX OF FIGURES

INDEX OF TABLES

1.0 Introduction

Problem Definition

The 2002 North Carolina Water Quality Assessment and Impaired Waters List (also known as the Integrated 305(b) and 303(d) Report) identified Lower Creek in the Catawba River Basin as impaired by elevated turbidity. Based on this report, the impaired segments (assessment units 11-39-(0.5)b, 11-39-(6.5), and 11-39-(9)) include the portion of Lower Creek from the confluence of Zack's Fork and Lower Creek in Caldwell County to Rhodhiss Lake in Burke County (subbasin 03-08-31). As per the 2002 Integrated Report, the three stream segments of interest totaled 12.7 miles. Recently, tools that improve the accuracy of measuring stream length have been used to measure theses segments and have determined a total length of 13.7 miles. This report will establish a Total Maximum Daily Load (TMDL) for turbidity for Lower Creek downstream of the confluence with Zack's Fork and will serve as a management approach or restoration plan aimed toward reducing loadings of sediment from various sources in order to attain applicable surface water quality standards for turbidity.

TMDL Components

In accordance with Section 305(b) of the Federal Clean Water Act (CWA) (33 U.S.C. 1315(B)), the State of North Carolina is required to biennially prepare and submit to the USEPA a report addressing the overall water quality of the State's waters. This report is commonly referred to as the 305(b) Report or the Water Quality Inventory Report. In accordance with Section 303(d) of the Clean Water Act (CWA), the State is also required to biennially prepare and submit to USEPA a report that identifies waters that do not meet or are not expected to meet surface water quality standards (SWQS) after implementation of technology-based effluent limitations or other required controls. This report is commonly referred to as the 303(d) List. The 303(d) process requires that a TMDL be developed for each of the waters appearing on Category 5 of North Carolina's Water Quality Assessment and Impaired Waters List (formerly Part 1 of North Carolina's 303(d) list). The objective of a TMDL is to quantify the amount of a pollutant a water body can assimilate without violating a state's water quality standards and allocate that load capacity to point and nonpoint sources in the form of wasteload allocations (WLAs), load allocations (LAs), and a margin of safety (MOS) (USEPA, 1991). Generally, the primary components of a TMDL, as identified by EPA (1991, 2000) and the Federal Advisory Committee (USEPA FACA, 1998) are as follows:

Target identification or selection of pollutant(s) and end-point(s) for consideration. The pollutant and end-point are generally associated with measurable water quality related characteristics that indicate compliance with water quality standards. North Carolina indicates known pollutants on the 303(d) list.

Source assessment. All sources that contribute to the impairment should be identified and loads quantified, where sufficient data exist.

Reduction target. Estimation or level of pollutant reduction needed to achieve water quality goal. The level of pollution should be characterized for the waterbody, highlighting how current conditions deviate from the target end-point. Generally, this component is identified through water quality modeling.

Allocation of pollutant loads. Allocating pollutant control responsibility to the sources of impairment. The wasteload allocation portion of the TMDL accounts for the loads associated with existing and future point sources. Similarly, the load allocation portion of the TMDL accounts for the loads associated with existing and future non-point sources, stormwater, and natural background.

Margin of Safety. The margin of safety addresses uncertainties associated with pollutant loads, modeling techniques, and data collection. Per EPA (2000), the margin of safety may be expressed explicitly as unallocated assimilative capacity or implicitly due to conservative assumptions.

Seasonal variation. The TMDL should consider seasonal variation in the pollutant loads and end-point. Variability can arise due to stream flows, temperatures, and exceptional events (e.g., droughts, hurricanes).

Critical Conditions. Critical conditions indicate the combination of environmental factors that result in just meeting the water quality criterion and have an acceptably low frequency of occurrence.

Section 303(d) of the CWA and the Water Quality Planning and Management regulation (USEPA, 2000) require EPA to review all TMDLs for approval or disapproval. Once EPA approves a TMDL, then the waterbody may be moved to Category 4a of the Integrated 305(b) and 303(d) Report. Waterbodies remain in Category 4a until compliance with water quality standards is achieved. Where conditions are not appropriate for the development of a TMDL, management strategies may still result in the restoration of water quality.

The goal of the TMDL program is to restore designated uses to water bodies. Thus, the implementation of sediment controls throughout the watershed will be necessary to restore uses in the most downstream portion of Lower Creek. Although a site-specific implementation plan is not included as part of this TMDL, reduction strategies are needed. The involvement of local governments and agencies will be critical in order to develop implementation plans and reduction strategies. Implementation discussion will begin during public review of the TMDL.

Water Quality Target

Turbidity is a unit of measurement quantifying the degree to which light traveling through a water column is scattered by the suspended organic and inorganic particles. The scattering of light increases with a greater suspended load. Turbidity is commonly measured in Nephelometric Turbidity Units (NTU), but may also be measured in Jackson Turbidity Units (JTU).

Lower Creek has been classified by the NC DWQ as Class C above its intersection with Caldwell County SR 1143. From Caldwell County SR 1143 to a point 0.7 miles down stream of Bristol Creek, Lower Creek is classified as WS-IV. The remainder of Lower Creek (to Rhodhiss Lake) is classified as WS-IV CA. Class C waters are defined as "Waters protected for secondary recreation, fishing, wildlife, fish and aquatic life propagation and survival, agriculture and other uses suitable for Class C. Secondary recreation includes wading, boating, and other uses involving human body contact with water where such activities take place in an infrequent, unorganized, or incidental manner." Water supply watershed (WS) classification is assigned to watersheds based on land use characteristics of the area. A Critical Area (CA) designation is also listed for watershed areas within a half-mile and draining to the water supply intake or reservoir where an intake is located. For turbidity, Class WS-IV, and WS-IV (CA) have the same water quality standard as Class C. The North Carolina fresh water quality standard for turbidity in Class C waters (T15A: NCAC 2B.0211 (3)k) states:

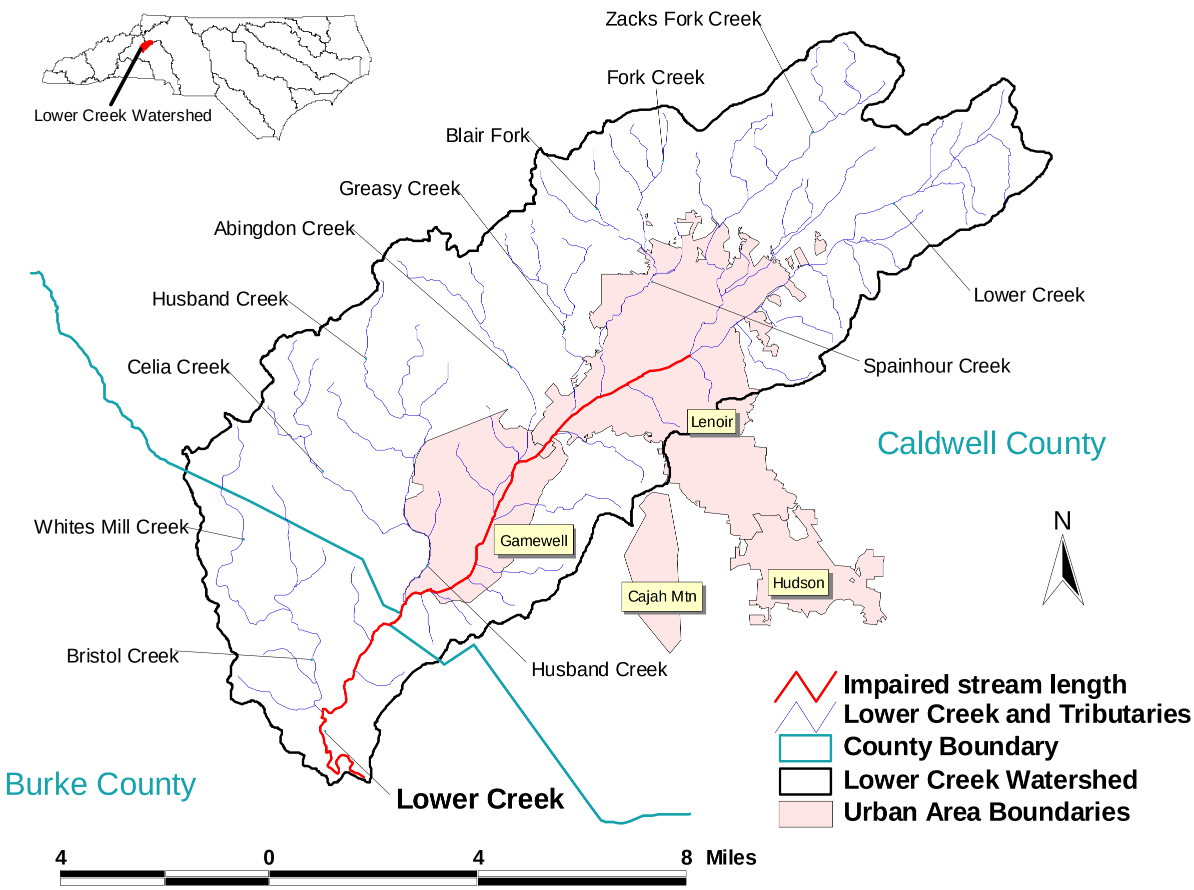
> *The turbidity in the receiving water shall not exceed 50 Nephelometric Turbidity Units (NTU) in streams not designated as trout waters and 10 NTU in streams, lakes or reservoirs designated as trout waters; for lakes and reservoirs not designated as trout waters, the turbidity shall not exceed 25 NTU; if turbidity exceeds these levels due to natural background conditions, the existing turbidity level cannot be increased. Compliance with this turbidity standard can be met when land management activities employ Best Management Practices (BMPs) [as defined by Rule .0202 of this Section] recommended by the Designated Nonpoint Source Agency [as defined by Rule .0202 of this Section]. BMPs must be in full compliance with all specifications governing the proper design, installation, operation and maintenance of such BMPs;*

The in-stream numeric target is the restoration objective that is expected to be reached by implementing the specified load reductions in this TMDL. The target allows for evaluation of progress toward the goal of reaching water quality standards for the impaired stream by comparing the in-stream data to the target. In the Lower Creek watershed, the applicable water quality target is the 50 NTU standard.

Watershed Description

The Lower Creek watershed includes the City of Lenoir and drains primarily the southwest portion of Caldwell County into the upper reaches of Lake Rhodhiss (see Figure 1). Lower Creek is predominantly located within the Northern Inner Piedmont ecoregion, however, portions of the headwaters are located in the Eastern Blue Ridge Foothills region. The watershed also includes Zacks Fork Creek [AU#11-39-1, 8.2 mi.], Spainhour Creek [AU#11-39-3, 4.3 mi.], Greasy Creek [AU#11-39-4, 4.5 mi.], and Bristol Creek [AU#11-39-8, 5.6 mi.]. Lower Creek consists of two USGS 14-digit hydrologic unit codes (HUCs); units 03050101080010 and 03050101080020.

Figure 1. Lower Creek watershed and surrounding area. Impaired stream length is based on the 2004 Integrated List of Impaired Waters (2004 Integrated 305(b) and 303(d) Report).



1.1.1 Land use/ Land cover

The land use/land cover characteristics of the watershed were determined using 1996 land cover data that were developed from 1993-94 LANDSAT satellite imagery. The North Carolina Center for Geographic Information and Analysis, in cooperation with the NC Department of Transportation and the United States Environmental Protection Agency Region IV Wetlands Division, contracted Earth Satellite Corporation of Rockville, Maryland to generate comprehensive land cover data for the entire state of North Carolina. Land cover/land use data for the Lower Creek watershed is identified in Figure 2. During the formation of this geographic dataset, the proportion of synthetic cover was used to identify developed land as either low density developed (50-80% synthetic cover) or high density developed (80-100% synthetic cover) (Earth Satellite Corporation, 1997).

Figure 2. Land use/ land cover distribution within the Lower Creek watershed.

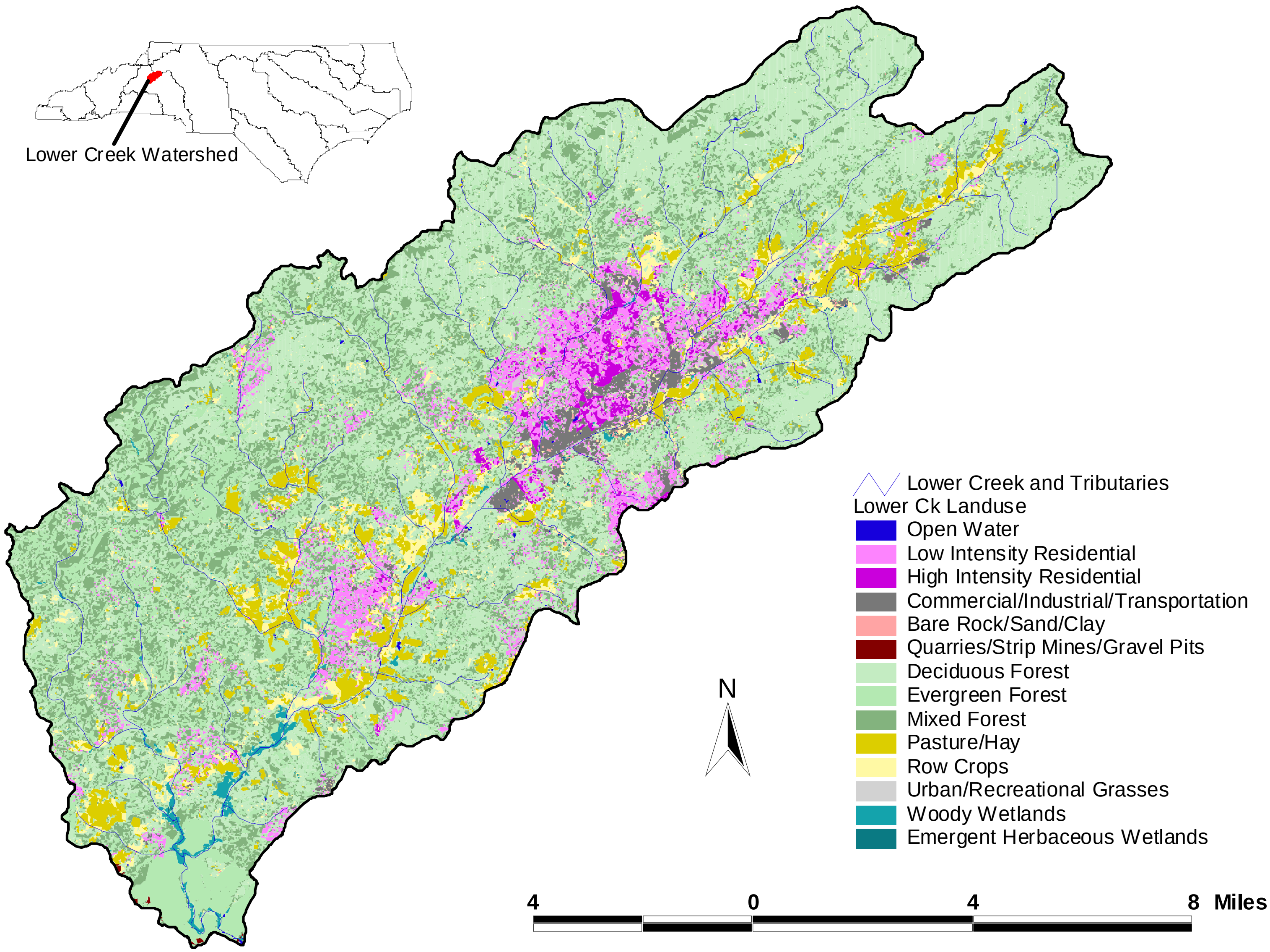


Table 1 Detailed land use/ land cover distribution within Lower Creek watershed.

Land use/ Land cover		Acres	Watershed area (%)
Water	Open Water	57	0.1%
Developed	Low Intensity Residential	3,824	6.1%
	High Intensity Residential	772	1.2%
	Commercial/Industrial/Transportation	1,538	2.4%
Forested Upland	Deciduous Forest	22,840	36.4%
	Evergreen Forest	13,377	21.3%
	Mixed Forest	13,127	20.9%
Herbaceous Planted/Cultivated	Pasture/Hay	3,854	6.1%
	Row Crops	2,594	4.1%
	Urban/Recreational Grasses	271	0.4%
Wetlands	Woody Wetlands	434	0.7%
	Emergent Herbaceous Wetlands	25	0.04%
Barren	Bare Rock/Sand/Clay	88	0.1%
	Transitional	21	0.03%

As identified in Table 1, 1993-94 LANDSAT satellite imagery identify Forest (78.6%), Herbaceous Planted/Cultivated (10.6), and Developed area (9.7%) as the predominant landuses in the Lower Creek watershed.

1.1.2 Geology

Portions of Burke and Caldwell Counties lie within the Northern Inner Piedmont and Southern Crystaline Ridge and Mountain Ecoregions (Level 4). Predominantly, two rock types occur in the Lower Creek watershed; metamorphic rocks of the Inner Piedmont, Milton belt, and Raleigh belt (gneiss, schist and amphibolite) and metamorphosed granitic rock, (NCGS, 1991).

1.1.3 Soils

Soils types and characteristics vary throughout the Lower Creek watershed. A full list of soils found in Caldwell County is located in Appendix A. As seen in Appendix A, the predominant soils include Cecil sandy loam, Chestnut gravelly loam, Chestnut and Edneyville soils, Evard fine sandy loam, and Pacolet fine sandy loam. (USDA, 1991). Each of these soils has an erosion hazard of “severe” or “very severe” indicating their potential for future erosion in inadequately protected areas. The estimated erosion for each erosion classification is based on estimated annual soil loss in metric tons per hectare. Values were determined using the Universal Soil Loss Equation assuming bare soil conditions and using rainfall and climate factors for North Carolina. A “severe” classification indicates a estimated loss of 10 to 25 tons per hectare and a “very severe” indicates more than 25 tons per hectare of annual erosion.

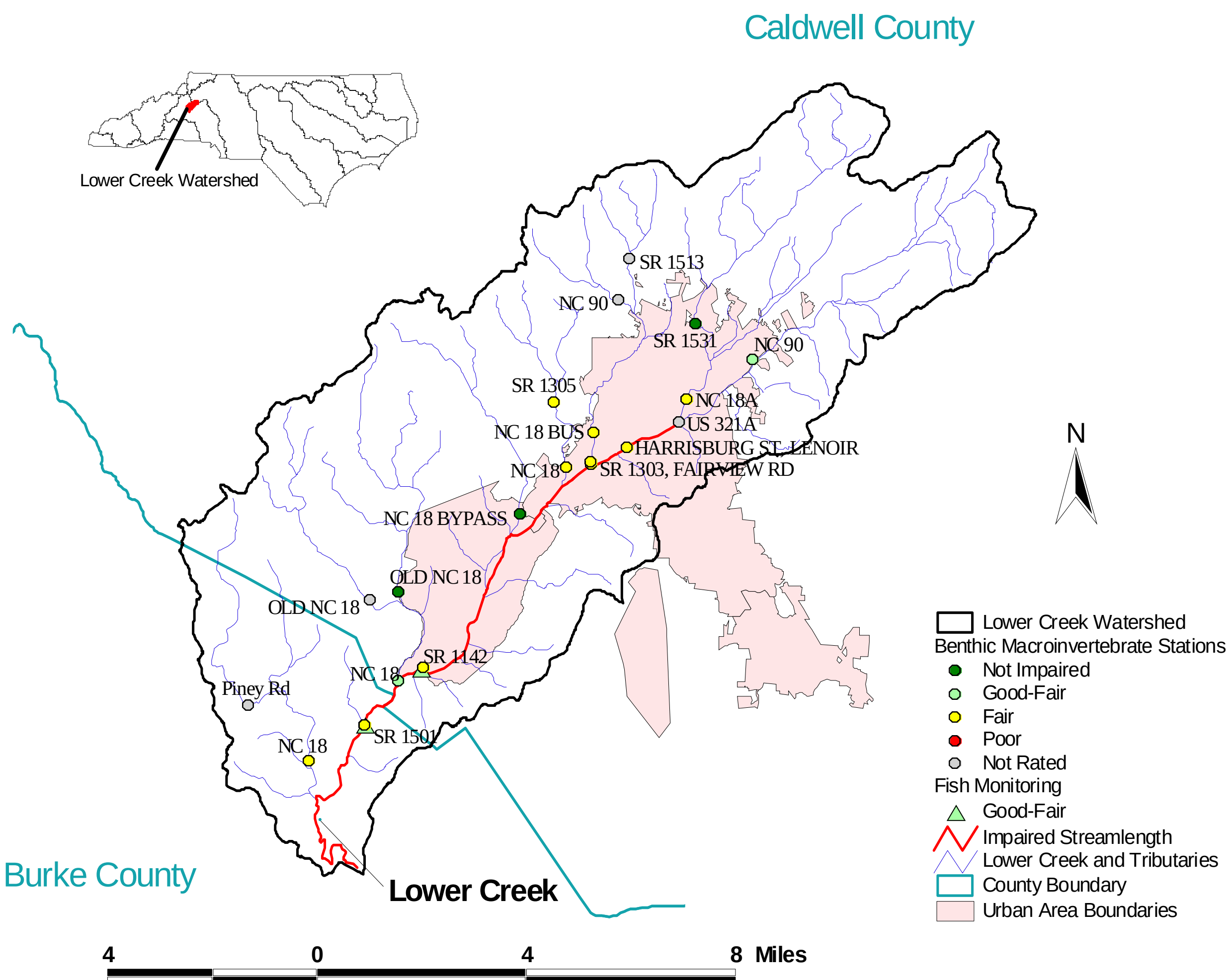
Water Quality Monitoring Program

Water quality monitoring performed by the NCDENR has shown occasional violations of the water quality standard for turbidity (81 out of 81 samples or 22% between 1/1997 and 3/2004). As part of this TMDL, chemical and biological assessments were conducted throughout the Lower Creek watershed to characterize the impact of turbidity impairment. Both chemical and biological assessments suggest significant water quality and habitat impairment and support the inclusion of Lower Creek on the Impaired Waters List (2002 Integrated 305(b) and 303(d) Report).

1.1.4 Biological Monitoring

The DWQ maintains an extensive biological monitoring network of ambient stations. In the Lower Creek watershed recent monitoring conducted by DWQs Environmental Sciences Branch has included a watershed survey (1997), a reconnaissance survey (May 2002), an assessment for basin wide monitoring plans (1999 and 2004), and monitoring for biological stressors (2003). Most recently, in March 2003, an intensive monitoring effort was conducted that included benthic macroinvertebrate populations, fish populations, physical and water chemistry characteristics, and site descriptions and instream and riparian habitats at seventeen locations in the Lower Creek watershed. These locations are shown in Figure 3. A summary of fish and benthic invertebrate results from this study are presented in Appendix B.

Figure 3. Lower Creek watershed including fish and benthic macroinvertebrate monitoring, locations.



Most notable in this study was the widespread finding of severe streambank erosion with little riparian buffer protection. Each site sampled in the 2002 Lower Creek study showed impacted water quality resulting in reduced benthic fauna. Sandy habitat coupled with urban/industrial runoff from the City of Lenoir produced the most stressed benthic communities as demonstrated in Lower Creek, lower Zack's Fork and lower Spainhour Creek. Tributary catchments such as Abingdon Creek, Greasy Creek, Husband Creek, Bristol Creek, and the UT to Spainhour Creek that were not affected by urban nonpoint runoff from the City of Lenoir supported more diverse benthic communities. Agricultural runoffs from farms (cropland and animals) located in tributary catchments were thought to affect the benthic communities in these streams, but not as severely as urban runoff from the City of Lenoir. The UT to Spainhour Creek and the Bristol Creek watershed (including White Mill Creek) were the only streams that supported a benthic community that contained long-lived stoneflies and philopotamid caddisflies. For more extensive discussion of results, see NCDWQ (2003) and Appendix B. While this biological information is not used directly in calculation the TMDL, it will be a primary information source when implementing the load and wasteload reductions set forward in this TMDL.

1.1.5 Chemical Monitoring

Lower Creek was listed as impaired on North Carolina's 1998 and 2000 303(d) Reports based on turbidity data collected in the early 1990s throughout the Lower Creek watershed. Since that time, monitoring has continued at station C1750000 (Lower Creek at SR 1501 near Morganton) on a monthly basis and violations to the turbidity standard continue to occur. Turbidity concentrations at station C1750000 ranged from 4.4 NTU to 1400 NTU with an average of 64 NTU, a median value of 21 NTU, and mode value of 27 NTU. Turbidity monitoring for years 1997-2003 are presented below in Figure 4 and in Appendix C. Figure 5 shows the monitoring station locations in the Lower Creek watershed.

Figure 4. Water quality monitoring for turbidity in Lower Creek at ambient station C1750000 (Lower Creek at SR 1501 near Morganton) for years 1997-2003.

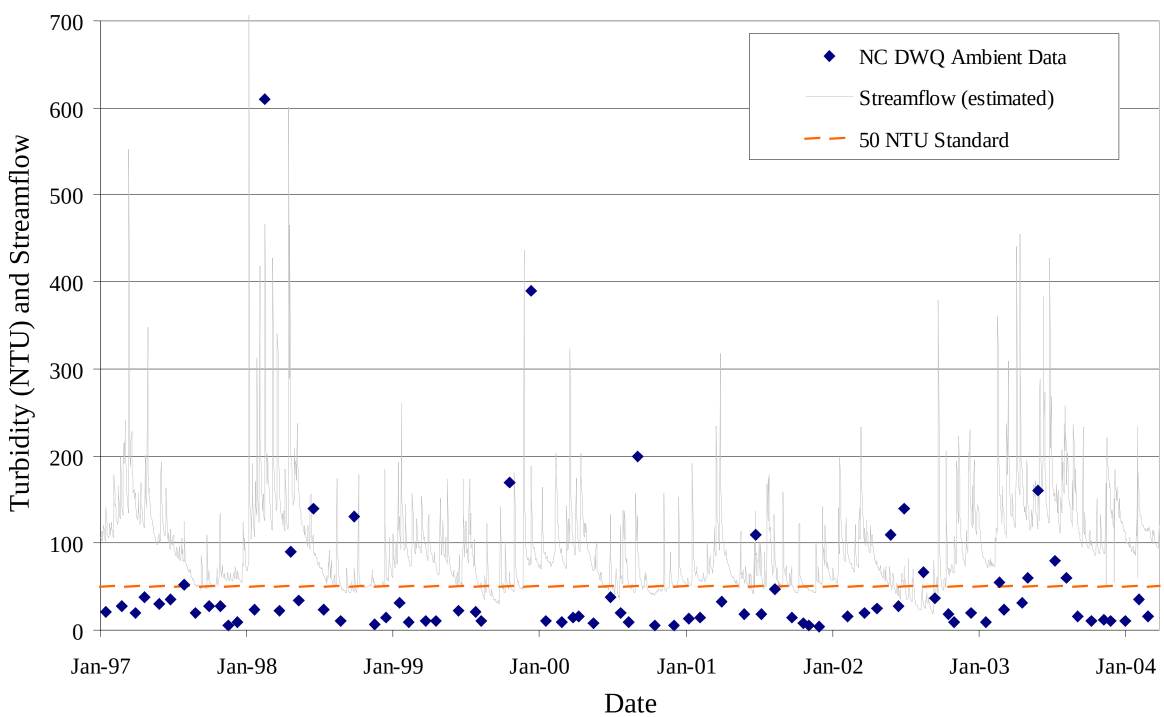
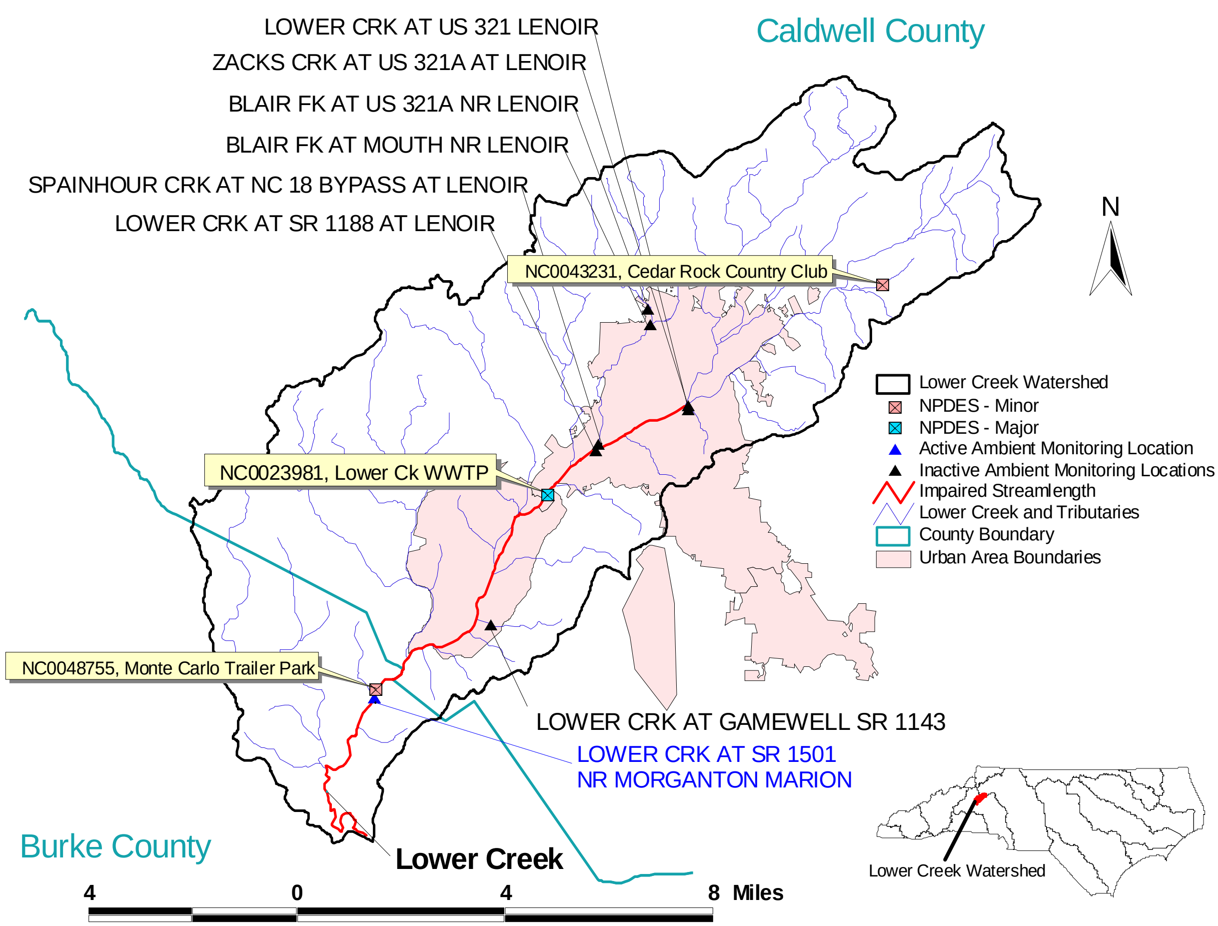


Figure 5. Lower Creek watershed including active and inactive ambient chemical monitoring, and major and minor NPDES permitted facilities.



2.0 Source Assessment

A source assessment is used to identify and characterize the known and suspected sources of turbidity in the Lower Creek watershed. This section outlines the assessment completed for the purpose of developing this TMDL. The NCDENR's Geographic Information System (GIS) was used extensively to watershed characterization. Data sources used in assessing Long Creek are identified in Appendix D.

Assessment of Point Sources

Two categories are included under this discussion; NPDES-regulated municipal and industrial wastewater treatment facilities and NPDES general permitted facilities.

2.1.1 NPDES-Regulated Municipal and Industrial Wastewater Treatment Facilities

Discharges from wastewater treatment facilities may contribute sediment to receiving waters as total suspended solids (TSS) and/or turbidity. Municipal treatment plants and industrial treatment plants are required to meet surface water quality criteria for turbidity in their effluent. Since these facilities are routinely achieving surface water quality criteria, this TMDL will not impose additional limits to current practices or existing effluent limits for POTWs and industrial treatment plants. When effluent turbidity concentrations exceed surface water quality criteria, and result in permit violations, action will be taken through the NPDES unit of North Carolina's Division of Water Quality.

Currently, there is one major NPDES permitted wastewater treatment plant discharger and two minor NPDES permitted facilities located in the Lower Creek watershed. The Lower Creek WWTP (NC0023981) has a permitted flow of 6.0 MGD with an effluent TSS limit of 30 mg/l on a monthly average and 45 mg/L on a weekly average. Cedar Rock Country Club (NC0043231) discharges to Lower Ck at a permitted flow of 0.009 MGD with a monthly average TSS limit of 30 mg/L and daily maximum TSS limit of 45 mg/L. Monte Carlo Trailer Park (NC0048755) discharges to Lower Creek at a permitted flow of 0.005 MGD with a monthly average TSS limit of 30 mg/L and daily maximum TSS limit of 45 mg/L. Monthly effluent averages for NC 0023981 are located in Appendix E.

2.1.2 NPDES General Permits

Twenty-six general permitted facilities are located in the Lower Creek watershed. A list of these facilities is presented in Appendix F. General permitted facilities, while not subject to effluent TSS or turbidity limitations, are required to develop a stormwater pollution prevention plan, and conduct qualitative and/or quantitative measurements at each stormwater discharge outfall and vehicle maintenance area. Sampling methodology and constituents to be measured are characteristic of the volume and nature of the permitted discharge. For example, general permits for mining operations require the permitee to measure settleable solids, total suspended solids, turbidity, rainfall, event duration, and flow in stormwater discharge areas. Measurements of pH, oil and grease, total suspended solids, rainfall, and flow are required in on-site vehicle maintenance areas. Similarly, monitoring is required in mine dewatering areas, wastewater associated with sand/gravel mining, and in overflow from other process recycle wastewater systems.

Facilities submitting a notice of intent (NOI) for coverage under a general permit, prior to establishment or approval of a TMDL for a priority pollutant(s) for stormwater discharges (i.e. wet weather flows), may be covered under a general permit during its term. For such facilities continued coverage under the reissuance of a general permit is subject to the facility demonstrating that it does not have a reasonable potential to violate applicable water quality standards for such pollutants due to the stormwater discharge(s). In part, the decision to reissue is based on the submission of water quality measurements. For facilities that do have a reasonable potential for violation of applicable water quality standards due to the stormwater discharge(s) the facility shall apply for an individual permit 180 days prior to the expiration of their general permit. Once the individual permit is issued and becomes effective the facility will no longer have coverage under the general permit.

All construction activities in the Lower Creek watershed that disturb one or more acres of land are subject to NC general permit NCG010000 and as such are required to not cause or contribute to violations of Water Quality Standards. As stated in Permit NCG010000, page 2, "The discharges allowed by this General Permit shall not cause or contribute to violations of Water Quality Standards. Discharges allowed by this permit must meet applicable wetland standards as outlined in 15A NCAC 2B .0230 and .0231 and water quality certification requirements as outlined in 15A NCAC 2H .0500". Monitoring requirements for these construction activities are outlined in Section B (page 5) of NCG010000. As stated, "All erosion and sedimentation control facilities shall be inspected by or under the direction of the permittee at least once every seven calendar days (at least twice every seven days for those facilities discharging to waters of the State listed on the latest EPA approved 303(d) list for construction related indicators of impairment such as turbidity or sedimentation) and within 24 hours after any storm event of greater that 0.5 inches of rain per 24 hour period." (NCG010000, Section B)

As per 40 CFR § 122.44(d)(1)(vii)(B), where a TMDL has been approved, NPDES permits must contain effluent limits and conditions consistent with the requirements and assumptions of the WLA in the TMDL. While effluent limitations are generally expressed numerically, EPA guidance on NPDES-regulated municipal and small construction storm water discharges is that these effluent limits be expressed as best management practices (BMPs) or other similar requirements, rather than numeric effluent limits (EPA, 2002). Compliance with the turbidity standard in Lower Creek is expected to be met when construction and other land management activities in the Lower Creek watershed employ adequate BMPs. Upon approval of this TMDL, DWQ will notify the NC Division of Land Resources (DLR) and other relevant agencies, including county and local offices in the Lower Creek watershed (Caldwell and Burke Counties) responsible in overseeing construction activities, as to the impaired status of Lower Creek and the need for a high degree of review in the construction permit review process.

Assessment of Nonpoint and Stormwater Sources

Nonpoint and stormwater sources include various erosional processes, including sheetwash, gully and rill erosion, wind, landslides, dry ravel, and human excavation that contribute sediment during storm or runoff events. Sediments are also often produced as a result of stream channel and bank erosion and channel disturbance (EPA, 1999).

Nonpoint sources account for the vast majority of sediment loading to surface waters. A few of these sources include:

- Natural erosion occurring from the weathering of soils, rocks, and uncultivated land; geological abrasion; and other natural phenomena.

- Erosion from agricultural activities. This erosion can be due to the large land area involved and the land-disturbing effects of cultivation. Grazing livestock can leave areas of ground with little vegetative cover. Unconfined animals with direct access to streams can cause streambank damage and erosion.

- Erosion from unpaved roadways can be a significant source of sediment to rivers and streams. Exposed soils, high runoff velocities and volumes and poor road compaction all increase the potential for erosion.

- Runoff from active or abandoned mines may be a significant source of solids loading. Mining activities typically involve removal of vegetation, displacement of soils and other significant land disturbing activities.

- Soil erosion from forested land that occurs during timber harvesting and reforestation activities. Timber harvesting includes the layout of access roads, log decks, and skid trails; the construction and stabilization of these areas; and the cutting of trees. Established forest areas produce very little erosion.

- Streambank and streambed erosion processes often contribute a significant portion of the overall sediment budget. The consequence of increased streambank erosion is both water quality degradation as well as increased stream channel instability and accelerated sediment yields. Streambank erosion can be traced to two major factors: stream bank characteristics (erodibility potential) and hydraulic/gravitational forces (Rosgen, online). The predominant processes of stream bank erosion include: surface erosion, mass failure (planar and rotational), fluvial entrainment (particle detachment by flowing water, generally at the bank toe), freeze-thaw, dry ravel, ice scour, liquifaction/collapse, positive pore water pressure, both saturated and unsaturated failures and soil piping.

2.1.3 Stormwater Discharges in the Lower Creek Basin

Urban runoff can contribute significant amounts of turbidity and is addressed and regulated under the Storm Water Phase II Final Rule (EPA, 2000). Amendments were made to the Clean Water Act in 1990 and most recently in 1999 pertaining to permit requirements for stormwater dischargers associated with industrial activities and municipal separate storm sewer systems (MS4s). MS4s can discharge sediment to waterbodies in response to storm events through road drainage systems, curb and gutter systems, ditches, and storm drains. This rule applies to a cities or counties which own or operate a municipal separate storm sewer system (MS4). As a result of the Phase II Rule, MS4 owners are required to obtain a National Point Source Discharge Elimination System (NPDES) permit for their stormwater discharges to surface waters.

An MS4 becomes part of the Phase II program in one of three ways; (1) automatic designation, (2) state designation, or (3) petitioning. According to the 2000 US Census Urbanized Area, the Lower Creek watershed includes portions of the Hickory “Urbanized area.” This area includes portions of Lenoir, Gamewell, and Cajah’s Mountain. The total Phase II area included as part of the Hickory Urbanized area within the Lower Creek watershed is approximately 13,187 acres (20.6 mi^2), or approximately 21% of the total Lower Creek watershed.

2.1.4 Water Quality Assessment

When streamflow gage information is available, a load duration curve (LDC) analysis is useful in identifying and differentiating between storm-driven and steady-input sources (Stiles 2002, Cleland 2002, ASIWPCA 2002).). This method determines the relative ranking of a given flow based on the percent of time that historic flows exceed that value. Flow data have been collected by USGS at the primary site (USGS Gage 02140991) from 1985 to the present. Excursions that occur only during low-flow events (flows that are frequently exceeded) are likely caused by continuous or point source discharges, which are generally diluted during storm events. Excursions that occur during high-flow events (flows that are not frequently exceeded) are generally driven by storm-event runoff. A mixture of point and nonpoint sources may cause excursions during normal flows. Table 2 identifies the number of turbidity samples exceeding the 50 NTU criterion under a variety of flow conditions.

Table 2 Number of violations to the 50 NTU turbidity standard in Lower Creek classified by flow range.

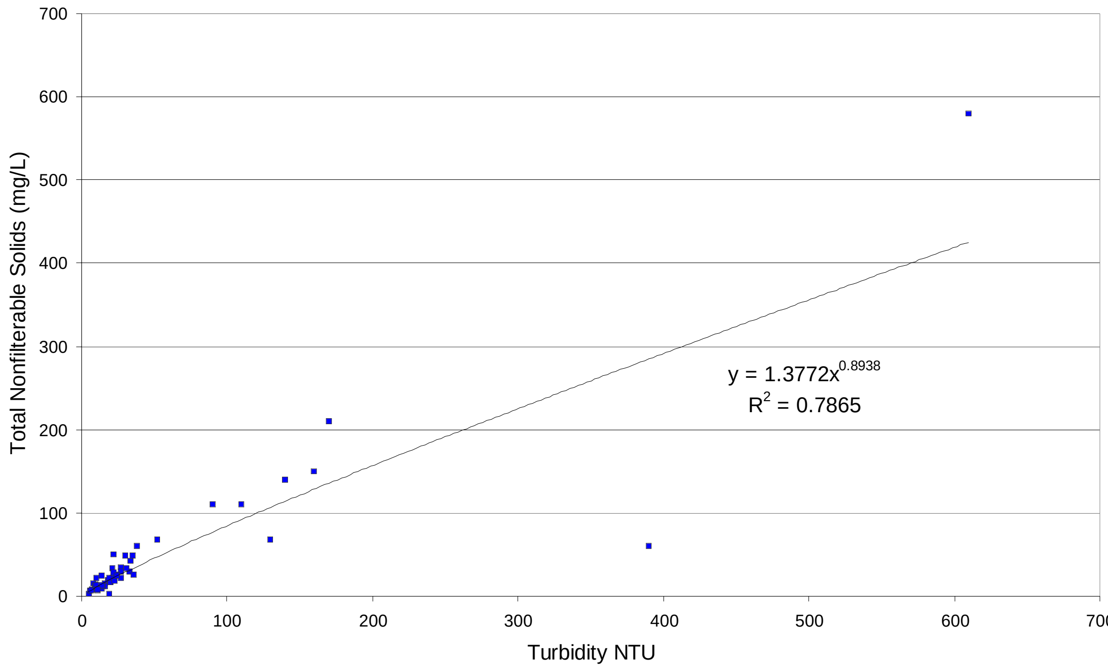
Percent of Time Flows are Equaled or Exceeded	Total number of samples	Number of samples >50 NTU
0% - 10% (high flows)	8	6
10% - 40% (moist conditions)	20	4
40% - 60% (mid-range flows)	15	2
60% - 95% (dry conditions)	34	5
95% - 100% (low flows)	4	1
All flows	81	18

Because turbidity is measured as NTUs and not as a concentration, another parameter that is measured as a concentration must be used to represent turbidity loadings in the watershed. For this TMDL, total nonfilterable solids (or TSS, method 00530) was selected based its correlation with turbidity. The correlation was determined using the below formula:

$$\rho_{xy} = \frac{\frac{1}{n}\sum_{i=1}^{n}(x_i - \mu_x)(y_i - \mu_y)}{\sigma_x \cdot \sigma_y} \qquad \text{where: } -1 \le \rho_{xy} \le 1$$

Given this, a linear regression was developed between turbidity and TSS to allow for the use of TSS values in developing a LDC. This regression is shown in Figure 6. Steps used to develop the LDC are presented in Appendix G.

Figure 6. Power regression between Total Nonfilterable Solids and Turbidity at Lower Creek at station C1750000 using data collected during years 1997-2003.



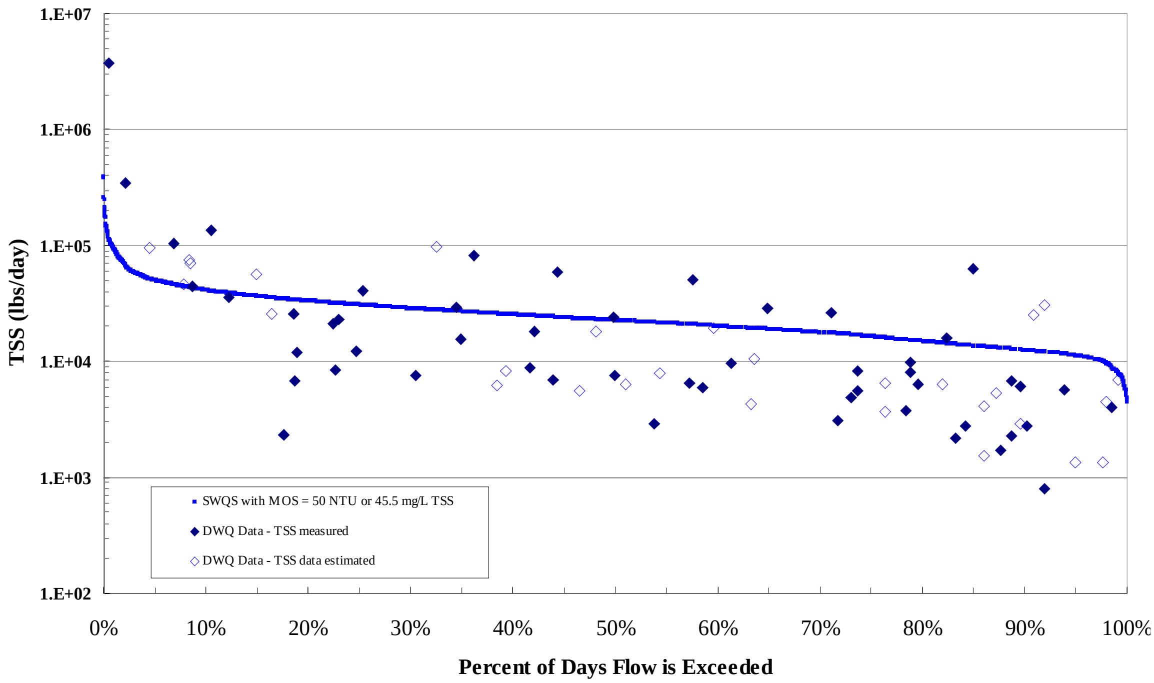
Using the drainage-area and point source adjusted flow values, flow duration graphs were developed for the Lower Creek ambient station. Monitoring data was then matched up with the flow duration ranking based on the collection date. Flow gage information is not available in the Lower Creek watershed, thus, daily flow data (during 1985 through 2004) from a nearby USGS Station #02140991, Johns River at Arneys Store, was used to establish the historic flow regimes and define ranges for the high, typical, and low flow conditions. Flows at the Lower Creek ambient station near SR 1501 were estimated based on a drainage area ratio between USGS station #02140991 and the watershed area upstream of SR 1501. Flows were also adjusted to account for the Lower Ck WWTP (NC0023981). Table 3 presents flow statistics for station #02140991 obtained from the USGS and LDC analysis.

Table 3 Flow statistics for USGS gage station #02140991 during years 1985-2004.

Parameter	Value
Drainage Area	201 mi^2
Average flow	346 cfs
Minimum flow	19 cfs
Maximum flow	16,100 cfs
High Flow Range (> 10% exceed)	> 607 cfs
Nonpoint Source Contributions from runoff (10-85%)	117- 607 cfs
Low Flow Range (95-100%)	< 86 cfs

Figure 7 shows TSS data as a function of estimated flow duration at the Lower Creek ambient station. As shown in Figure 7, the surface water quality violations occur under all flows ranges and are likely attributable to a variety of point and nonpoint sources.

Figure 7. Load duration curve for Turbidity at Lower Creek, ambient station C1750000 (years 1997-2003) and estimated flow at USGS 02141245 using flow data from USGS station 02140991 (Johns River at Arneys Store).



3.0 Technical Approach

Based on the preliminary source and data assessment, the Watershed Analysis Risk Management Framework (WARMF) model was selected to evaluate turbidity in Lower Creek. WARMF is a decision support system designed to support the watershed approach and TMDL calculations. The model has been applied to watershed regions in the USA and Taiwan (Systech Engineering, 2001).

WARMF contains several embedded models adapted from the ILWAS model, ANSWERS, SWMM, and WASP. The model simulates hydrology and water quality for the landscape of a river basin. WARMF divides a watershed into land catchments, river segments, and reservoirs and uses the continuously stirred tank reactor (CSTR) model for flow routing and mass balance within a given soil layer or river segment.

Simulated parameters include flow, temperature, water depth and velocity, and constituent concentrations. In the case of total suspended solids (surrogate for turbidity), the model simulates the deposition and transportation of sand, silt and clay from the land surface, instream sources, and point source discharges. The soil erosivity factor is a function of soil type and is available from Natural Resources Conservation Service. Data entry boxes are provided for a soil erosivity factor, and percents of clay, silt, and sand in the surface soil. The erosion and deposition of soil particles are calculated separately for clay, silt, and sand. Algorithms for sediment erosion and pollutant transport from farm lands and other land uses were adapted from ANSWERS and the universal soil loss equation. The model also includes a facility for calculating TMDLs for non-point source loads under different control levels of point source loads and vice versa.

In December 2003, NCDWQ entered into a contract with Systech to update the WARMF model to add three additional data years to extend the model database through September 2003. The new version of WARMF, used in the development of this TMDL, included updates or improvements to meteorology, air quality, USGS gage data, water quality data, NPDES point source data, septic system data, and reservoir release data.

Parameter Adjustment

The Lower Creek watershed is represented as 16 catchments within the model (Figure 8). Simulations were run for the Lower Creek watershed within WARMF. Hydrology and water quality results were compared to observed data. Model parameters were adjusted to improve the model results and reduce the error between simulated and observed data. During hydrology calibration, parameters for soil thickness, initial soil moisture, field capacity, saturated moisture and hydraulic conductivity were adjusted (see Appendix H). In addition precipitation weighting factors were adjusted to improve the water balance. Table 4 lists ranges of values set for the Lower Creek watershed. WARMF's autocalibrator tool was used to improve the hydrology calibration. Using this tool, multiple simulations are performed while small parameter adjustments are made until model results are improved.

Figure 8. Lower Creek as represented in the WARMF model. Subwatersheds were labeled 1-16 to assist in identifying wasteload and load allocations.

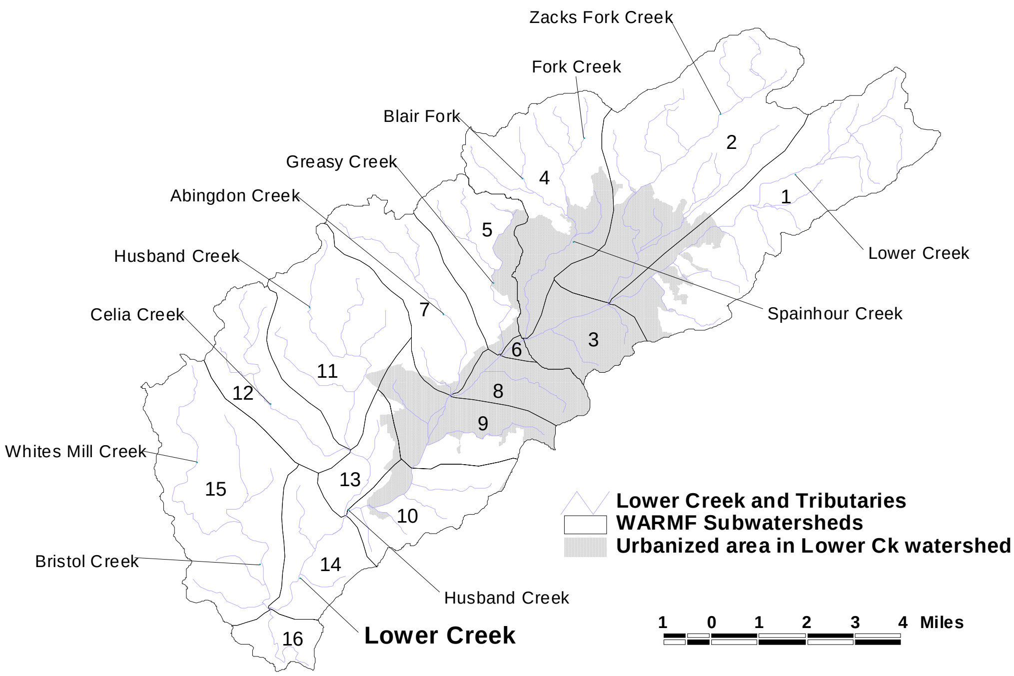


Table 4 Hydrology Parameter Ranges for Lower Creek Watershed.

Parameter	Lower Range	Upper Range
Soil thickness	20 cm	400 cm
Initial Mositure	0.3	0.4
Field Capacity	0.2	0.25
Saturated Moisture	0.35	0.5
Horizontal Conductivity	500 cm/d	10,000 cm/d
Vertical Conductivity	7.5 cm/d	300 cm/d
Precipitation weighting	0.8	1.3

Some of the input parameters that affect suspended sediment concentrations include buffer zone coefficients, livestock exclusion, and bank vegetation and stability factors. For each land catchment draining to a stream, a percent buffered parameter is specified. This is representative of the percent of runoff that will pass through a buffer before entering the stream. Other buffer inputs include buffer width, slope and roughness. Buffer parameters for the entire Catawba River Basin (including Lower Creek) were set based on a GIS study performed by a Duke Energy intern in 2001 (Job 2001). In the Lower Creek watershed, percent buffered ranged from 47% to 87% buffered, buffer width was assumed to be 20 m and slope and roughness were set at 0.01 and 0.3 respectively. In the

Lower Creek Watershed Report published by Western Piedmont Council of Governments (WPCOG 1998), it was stated that Lower Creek and many tributaries have steep incised banks that lack vegetation. The stream data collection performed by WPCOG indicated that bank erosion ranged from moderate to severe. It was also stated that at many locations, animals have direct access to the streams. Coefficients for bank erosion and vegetation as well as livestock exclusion BMPs were set based on this qualitative information. To account for livestock having direct access to streams, it was specified that in the pasture landuse, 5 percent of the loading from livestock was directly deposited to the stream instead of being applied to the land surface. Empirical factors for bank vegetation and bank stability factors were set to equal 0.003. A typical range for these parameters is from 0.0 to 0.01, with a higher value representing less vegetation and less bank stability. Based on stream substrate data collected by WPCOG (1998), which indicated a composition of mostly sand and some gravel and silt, the stream substrate for Lower Creek was set to be 60% sand, 20% silt and 40% clay in WARMF. Other parameters that were adjusted during calibration include soil and steam reaction rates. Table 5 summarizes a few reaction rates specified for the Lower Creek watershed.

Table 5 Reaction rates for Lower Creek Watershed.

Reaction	Soil	Stream
BOD Decay	0.1 day^{-1}	0.5 day^{-1}
Nitrification	0.01 day^{-1}	0.1 day^{-1}
Fecal Coliform Decay	0.1 day^{-1}	1 day^{-1}

Model Results

Simulated results were compared to all available data from 1992 through 2003 for the primary Lower Creek monitoring station at SR 1501 near Morganton. Measured stream flow data was only available from 1/1/1993 through 9/30/1994. Therefore, the hydrology calibration was performed for this time period. Water quality calibration was performed using water years 1992 through 1997. Then, model verification was performed by holding all model coefficients constant and running simulations on water years 1998 through 2003. The following plots show both calibration and verification results for hydrology and various water quality parameters. Figure 9 shows the simulated stream flow in Lower Creek compared to observed data for 1993 and 1994. The model captured the general hydrograph and recession though some peaks flows were under predicted and others were over predicted. Table 6 and Figure 10 present the summary statistics and a scatter plot for the hydrology calibration. This data shows a good comparison of mean, minimum and maximum flow values between simulated and observed. The correlation coefficient (R^2) is 0.698 and relative and absolute errors are 0.15 and 1.029 respectively. Figure 11 shows the frequency distribution of flow for both simulated and observed and Figure 12 shows a cumulative flow comparison. Both plots indicate good agreement with the overall water balance.

Figure 9. Simulated and observed flow at Lower Creek USGS station, 02141245.

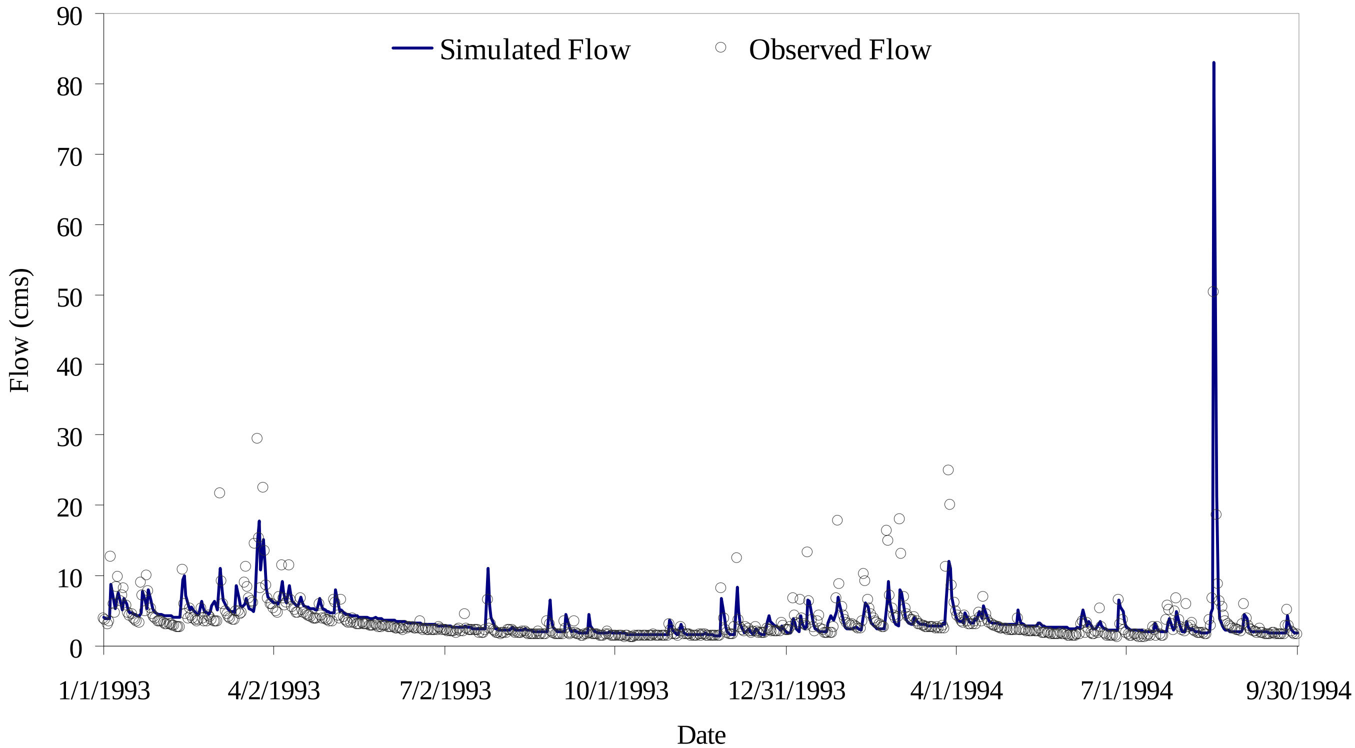


Table 6 Summary statistics for Lower Creek hydrology calibration, 1992-1997..

	Mean	Minimum	Maximum	# Points	Relative Error	Absolute Error	RMS Error	r-squared
Lower Ck 92-97	3.186	1.26	83.09	638	0.15	1.028	2.16	0.689
Observed	3.549	1.22	50.41	638	0	0	0	1

Figure 10. Scatter plot for Lower Creek hydrology calibration, 1992-1997.

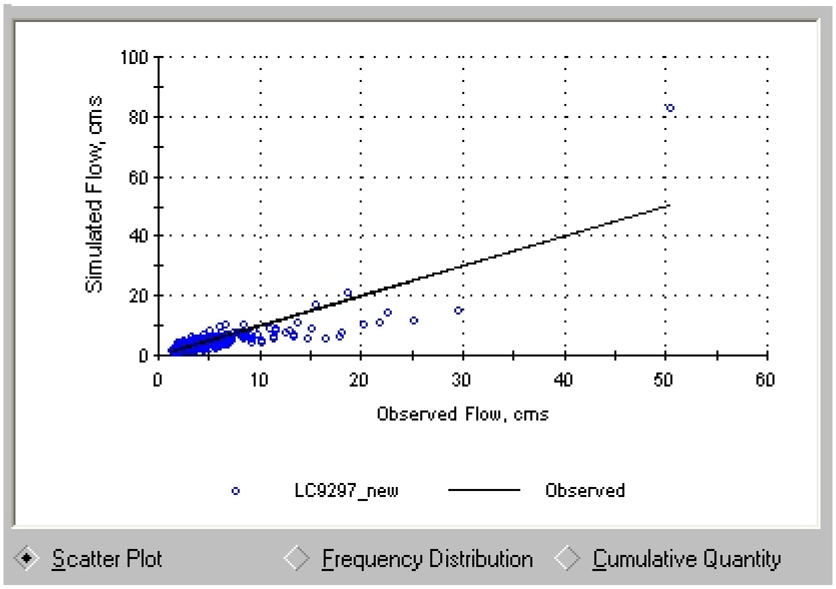


Figure 11. Frequency distribution of flow calibration for Lower Creek, 1992-1997.

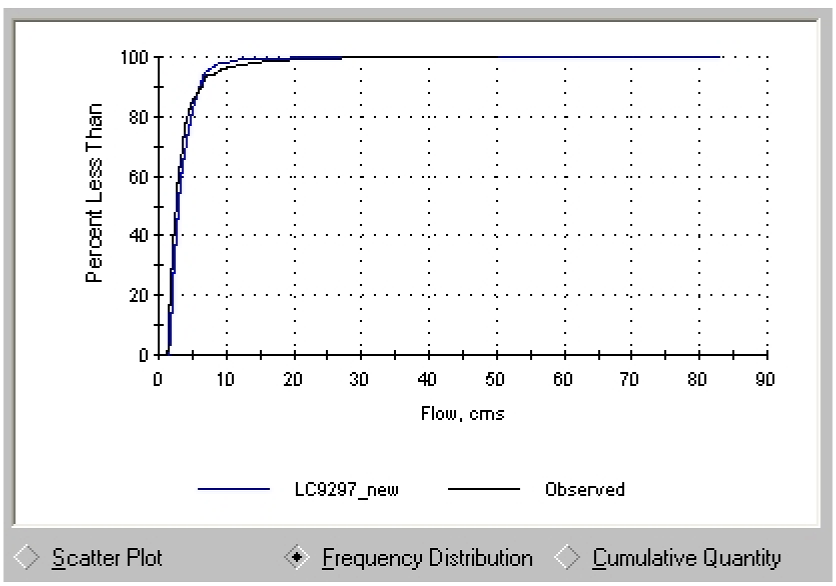


Figure 12. Cumulative flow plot calibration for Lower Creek, 1992-1997.

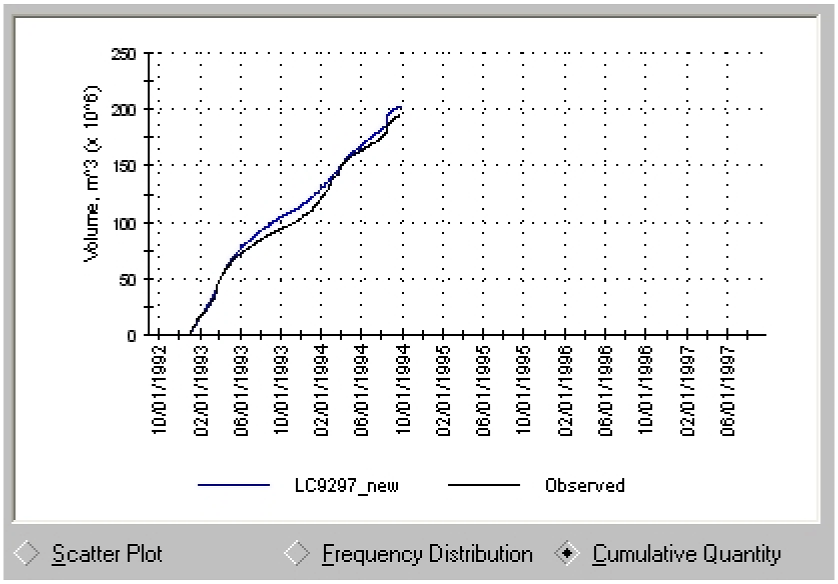


Figure 13 shows the simulated and observed temperature in Lower Creek for 1992-1997. The simulation shows good agreement with the seasonal pattern of temperature. Table 7 and Figures 14 and 15 show the summary statistics, scatter plot, and frequency distribution plot. The results indicate a good match of simulated with observed including an R^2 of 0.815. The seasonal pattern of temperature in years 1997-2003 also matched well with a resulting R^2 of 0.82.

Figure 13. Simulated and observed temperature calibration in Lower Creek, 1992-1997.

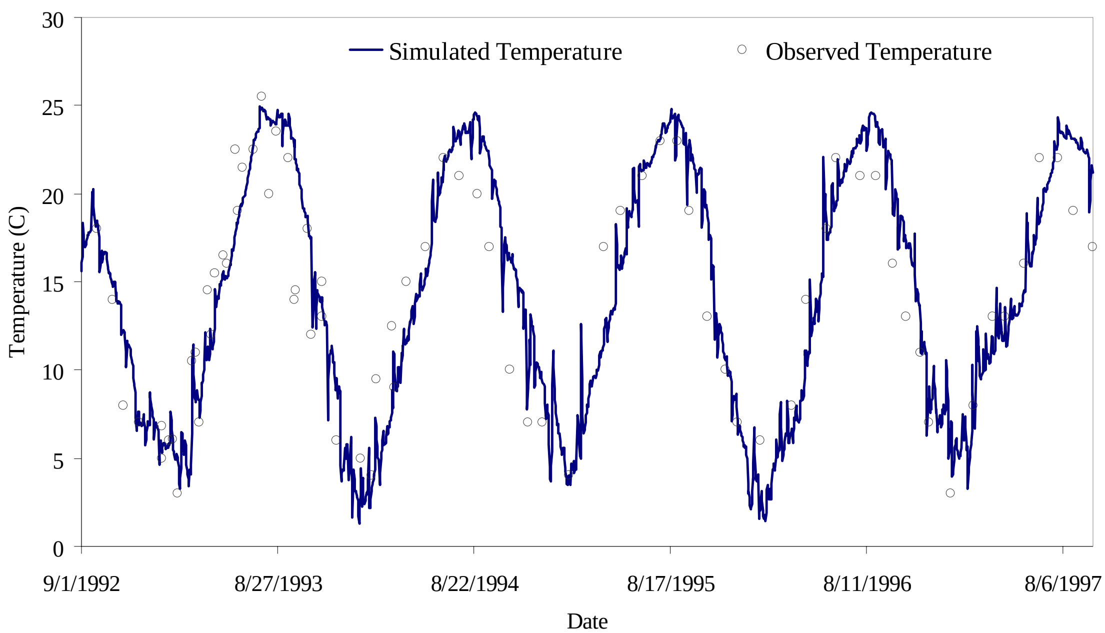


Table 7 Summary statistics for Lower Creek temperature calibration, 1992-1997.

	Mean	Minimum	Maximum	# Points	Relative Error	Absolute Error	RMS Error	r-squared
Lower Ck 92-97	14.28	1.326	24.97	76	0.512	2.212	2.902	0.815
Observed	14.05	3	25.5	76	0	0	0	1

Figure 14. Scatter plot for Lower Creek temperature calibration 1992-1997.

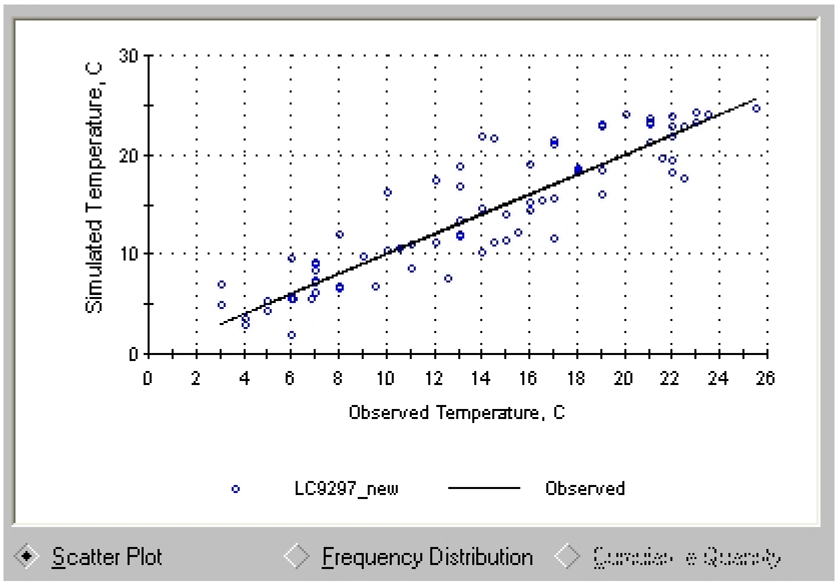


Figure 15. Frequency distribution of temperature calibration for Lower Creek, 1992-1997.

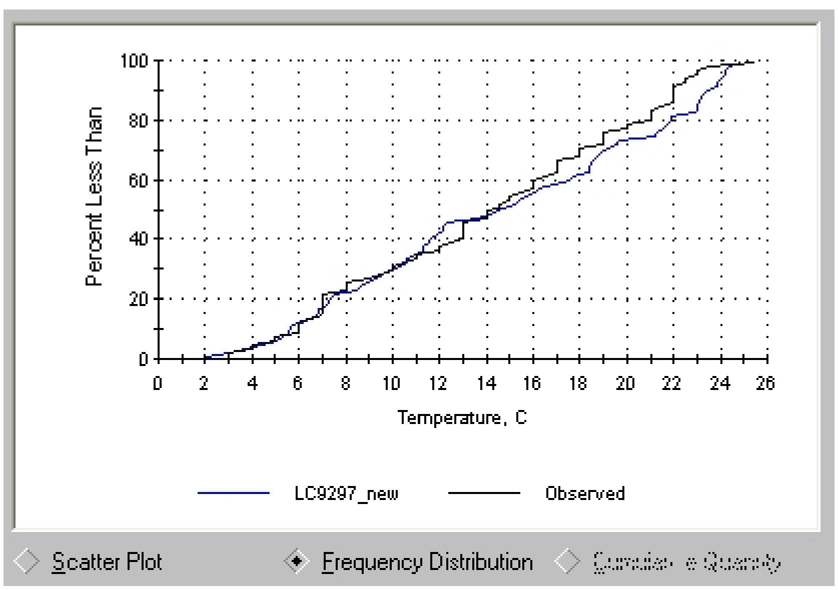


Table 8 and Figures 16 and 17 show the summary statistics, scatter plot, and frequency distribution plot for TSS calibration in Lower Creek for 1992-1997. The results indicate a good match of simulated with observed including an R^2 of 0.816. Similar results found for 1998-2003.

Table 8 Summary statistics for Lower TSS calibration 1992-1997.

	Mean	Minimum	Maximum	# Points	Relative Error	Absolute Error	RMS Error	r-squared
Lower Ck 92-97	75.54	8.281	35260	51	3.657	36.97	90.3	0.814
Observed	59.2	3	558	51	0	0	0	1

Figure 16. Scatter plot for Lower Creek TSS calibration 1992-1997.

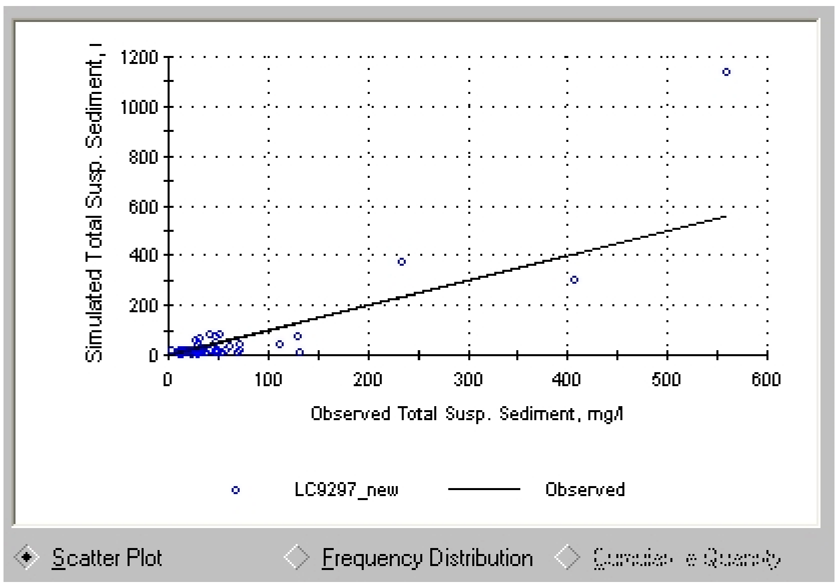
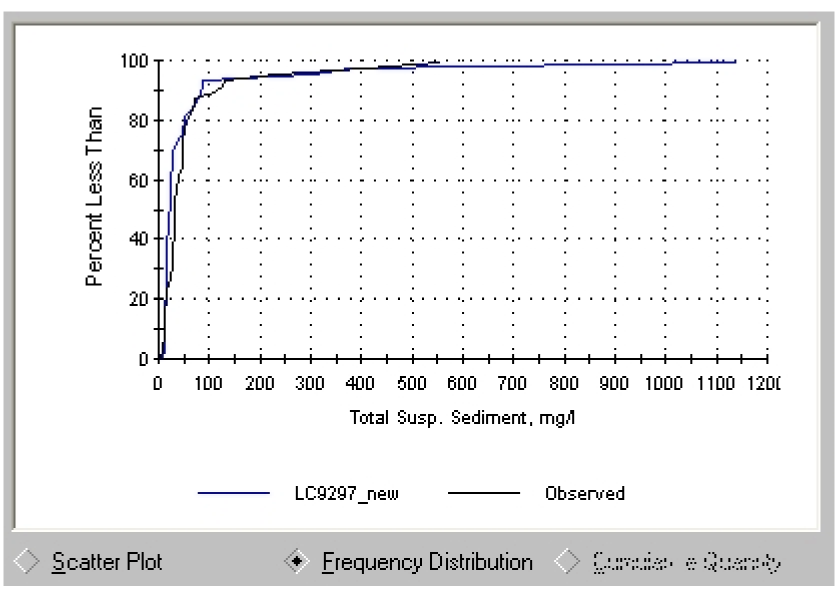


Figure 17. Frequency distribution of TSS calibration for Lower Creek, 1992-1997.



Figures 18 and 19 show a plot of observed and simulated TSS in Lower Creek for water years 1998-2003. The results indicate a good match of simulated with observed including an R^2 of 0.736. Figures 20 and 21 show the scatter plot and frequency distribution plot for TSS calibration in Lower Creek for 1998-2003

Figure 18. Simulated and observed TSS in Lower Creek during 1998-2003 using calibrated model.

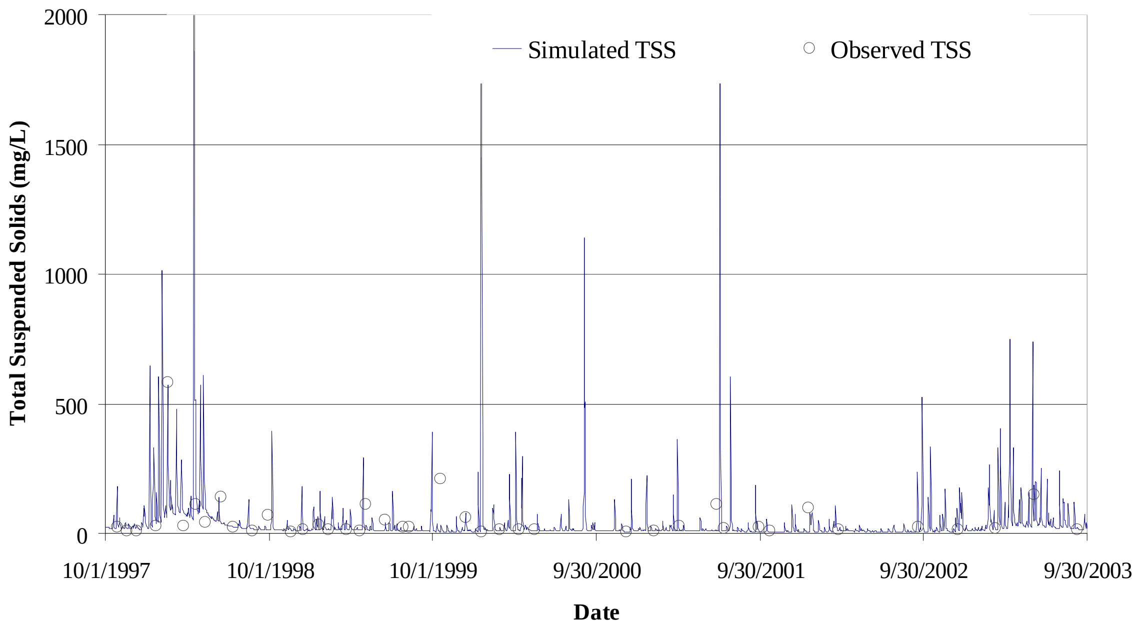


Figure 19. Simulated and observed TSS in Lower Creek, 1998-2003, close-up view.

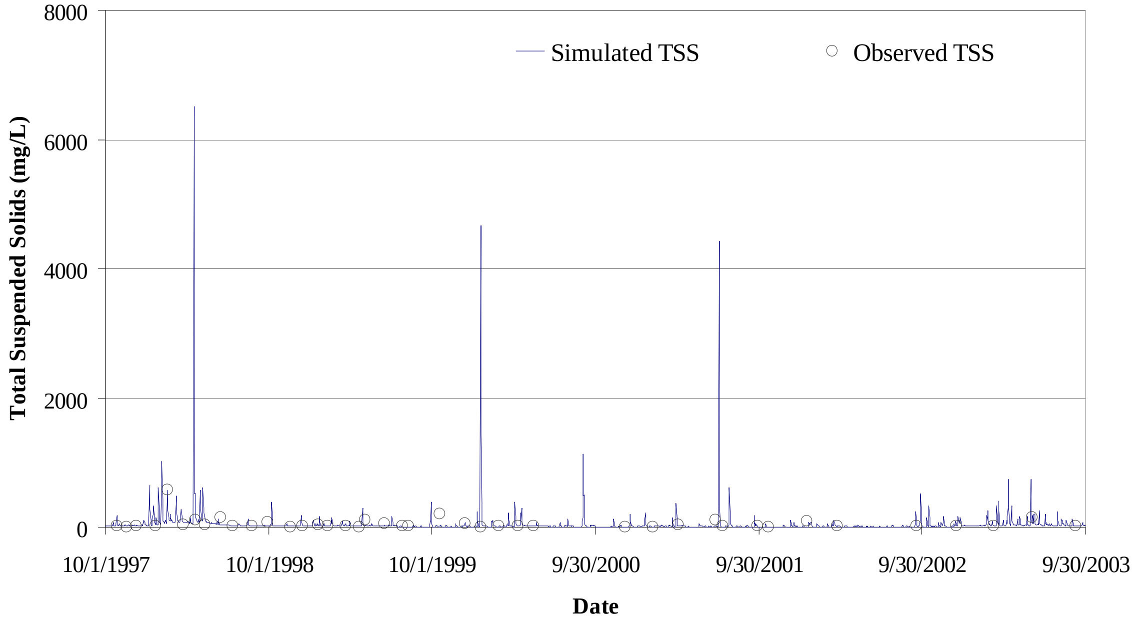


Table 9 Summary statistics for Lower Creek TSS 1998-2003.

	Mean	Minimum	Maximum	# Points	Relative Error	Absolute Error	RMS Error	r-squared*
Lower Ck 92-97	44.61	5.2	6518	43	27.68	62.97	226.2	0.736
Observed	52.23	3	580	43	0	0	0	1

* based on exclusion of one false recording measurement taken during 1/19/2000

Figure 20. Scatter plot for Lower Creek TSS 1998-2003.

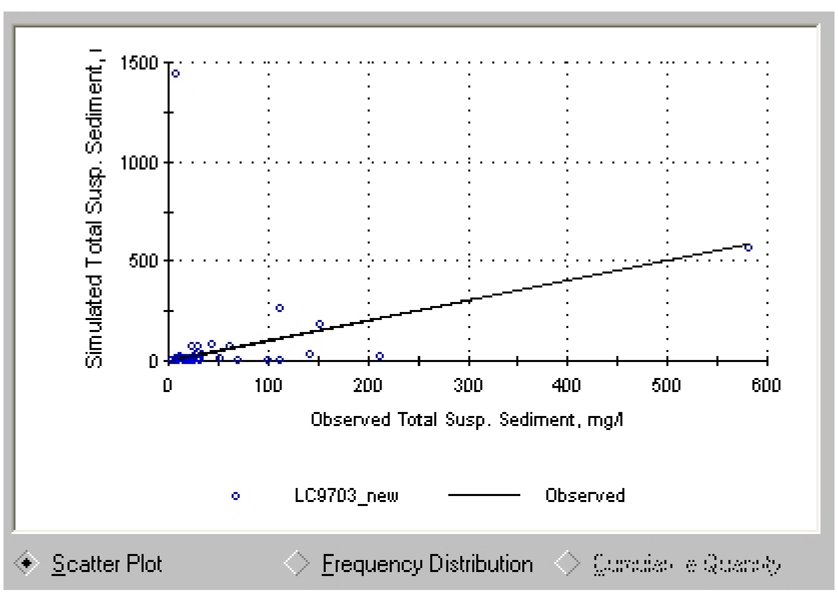
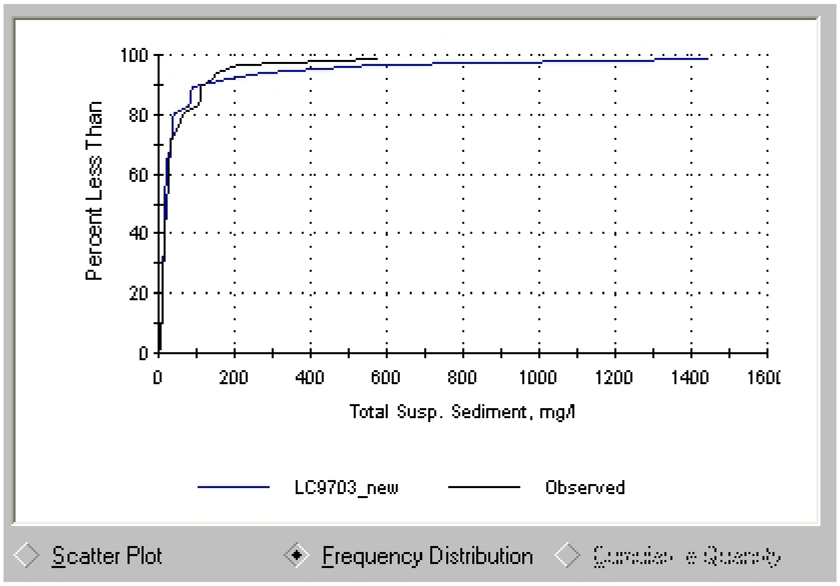


Figure 21. Frequency distribution of TSS for Lower Creek, 1998-2003.



Existing TSS loading (1998-2003) predicted by the calibrated model is presented below in Table 10. Streambank erosion was the largest TSS contributor at 98% of the total TSS load. The remaining 2% of the total TSS load was distributed among the remaining urban and nonurban landuses. The City of Lenior WWTP was the only significant point source in the Lower Creek watershed with TSS effluent requirements.

Table 10 Existing TSS loading by land use sources in the Lower Creek watershed.

Landuse/ Landcover	Simulated 1998-2003 TSS Load (kg/day)	Percent of Total TSS Load
Deciduous Forest	279	0.26%
Evergreen Forest	209	0.20%
Mixed Forest	206	0.20%
Pasture	294	0.28%
Cultivated	399	0.38%
Recreational Grasses	6.4	0.01%
Barren	32	0.03%
Low Int. Develop.	399	0.38%
High Int. Develop.	156	0.15%
Commercial / Industrial	301	0.29%
Stream Bank Erosion	103,204	97.9%
TOTAL	105,500	100%

4.0 TMDL Calculation

A Total Maximum Daily Load (TMDL) represents the assimilative or carrying capacity of a waterbody, taking into consideration point and nonpoint sources of pollutants of concern, natural background and surface water withdrawals. A TMDL quantifies the amount of a pollutant a water body can assimilate without violating a state's water quality standards (in our case, Class C and WS-IV freshwaters) and allocates that load capacity to known point and nonpoint sources in the form of wasteload allocations (WLAs), load allocations (LAs). In addition, the TMDL must include a margin of safety (MOS), either implicitly or explicitly, that accounts for the uncertainty in the relationship between pollutant loads and the quality of the receiving waterbody. This definition is expressed by the following equation:

TMDL = ΣWLAs + ΣLAs + MOS

A TMDL is developed as a mechanism for identifying all the contributors to surface water quality impacts and setting goals for load reductions for pollutants of concern as necessary to meet the SWQS. The Code of Federal Regulations (40 CFR §130.2(1)) states that TMDLs can be expressed in terms of mass per time, toxicity, or other appropriate measures. This TMDL will be expressed in terms of both a mass per time (kg/day) and percent reduction based on modeled stream flow and instream TSS concentrations and will be calculated for the most downstream water quality limited river segment of Lower Creek (segment above the confluence with the Catawba River). A total of 93 TSS values were used in this TMDL analysis; 51 collected during 1992-1997 period used in calibrating WARMF and 42 collected during 1998-2003 used to develop the TMDL reduction.

TMDL Endpoints

TMDL endpoints represent the instream water quality targets used in quantifying TMDLs and their individual components. As discussed in Section 3, turbidity as a measure is not applicable to the estimation of loading to a stream. TSS was selected as a surrogate measure for turbidity. Based on the regression analysis, a TSS limit of 46 mg/L was determined to be equivalent to a turbidity measure of 50 NTU. As will be discussed in Section 4.3, a 10% explicit margin of safety was applied to the endpoint and resulted in a reduction of the target value from 50 NTU to 45 NTU (46 mg TSS/L to 41 mg TSS/L). The criteria used to develop this TMDL was a 1 day maximum concentration of 41 mg TSS/L to be met 90% of the time.

Critical Conditions and Seasonal Variation

In Lower Creek, elevated turbidity concentrations occur under both low and high flow conditions (Figure 7). The majority of turbidity violations during 1998-2003 occurred during the summer months between April and September with the most violations occurring in May (four violations) and June (five violations). Table 11 shows the number of violations in each month during the 1998-2003 period. The TMDL has been set such that the turbidity standard is met under all seasons and flow conditions for the 1998-2003 period.

Table 11 Number of violations to the 50 NTU standard for each month during the 1998-2003 period.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Violations (#)	0	2	0	2	4	5	3	2	2	1	0	1

Margin of Safety

A Margin of Safety (MOS) is provided to account for "lack of knowledge concerning the relationship between effluent limitations and water quality" (40 CFR 130.7(c)). The MOS may be incorporated into a TMDL either implicitly, through the use of conservative assumptions to develop the allocations, or explicitly through a reduction in the TMDL target. For this TMDL, an explicit margin of safety was incorporated in the analysis by setting the TMDL target at 45 NTU, or equivalent 41 mg TSS/L, which is 10% lower than the water quality target of 50 NTU or equivalent 46 mg TSS/L.

Reserve Capacity

Reserve capacity is an optional means of reserving a portion of the loading capacity to allow for future growth. Reserve capacities are not included at this time. The loading capacity of each stream is expressed as a function of the current load (Section 4.0), and both WLAs and LAs are expressed as reductions for the entire Lower Creek watershed. Therefore, the reductions from current levels, outlined in this TMDL, must be attained in consideration of any new sources that may accompany future development. Strategies for source reduction will apply equally to new development as to existing development.

TMDL Calculation

Using WARMF model runs for water years 1998-2003, a TSS reduction of 72% is needed to order to meet water quality standards for turbidity at the outlet of the Lower Creek watershed.

Table 12 Unallocated TMDL load and percent reduction.

	Current Load (kg/day)	Target Load (kg/day)	Reduction Required
Lower Creek Watershed	105,500	30,280	72%

Allocations

Additional analysis is required to address the TMDL reduction by identifying point and nonpoint contributors of turbidity and calculating wasteload and load allocations.

4.1.1 Wasteload Allocations

As previously discussed, one major and two minor NPDES-permitted facilities are located in the Lower Creek watershed. Each of these facilities is subject to monthly TSS effluent limitation of 30 mg TSS/L. For the purposes of this TMDL, wasteload allocations for NC0023981, NC0043231, and NC0048755 are based on permitted flow and effluent TSS limits and do not result in additional reductions for these facilities.

As per Phase II stormwater rules, MS4 (small municipal separate storm sewer systems) permittees are responsible for reducing pollutant loads associated with stormwater outfalls for which it owns or otherwise has responsible control. The City of Lenior and Town of Gamewell are located in the Lower Creek watershed and are part of the overall Hickory Urbanized area as delineated by the 2000 US Census (NCDWQ, 2004b). To estimate turbidity loading for this MS4 area within the Lower Creek watershed, steps were taken to identify the percent of MS4 area within each of the 15 subwatersheds in the

Lower Ck watershed (as shown in the WARMF diagram in Figure 8) and the associated landuse / land cover within each MS4 area. WARMF allows the user to calculate landuse based loading within each subwatershed. Given this, subwatershed and landuse specific TSS loading from WARMF outputs were used in conjunction with the MS4 area and its corresponding landuse within each subwatershed to identify TSS loading on a subwatershed scale for the MS4 area.

TSS loading from streambank erosion represented a significant portion of the overall loading (See Appendix I). The fraction of loading from streambank erosion attributed to the MS4 area was determined in all subwatersheds that contained MS4 area by multiplying the annual streambank erosion load (kg/year) in each subwatershed by the percent of MS4 area in that subwatershed. To determine TSS stormwater loads in subwatersheds downstream of the MS4 area, scenarios were run in WARMF in which all of the urban area (low density, high density and commercial / industrial) was converted to the mixed forest landuse category. The relative difference between current conditions (1998-2003) and this altered landuse condition was used to determine the loading attributable to general, non-permitted stormwater and was determined only for subwatersheds 14 and 16. Streambank erosion TSS loading in 14 and 16 is further outlined in Appendix J. Wasteload allocations and are shown below in Table 9 and detailed in Appendices K and L.

4.1.2 Load Allocations

As earlier noted, Lower Creek is primarily composed of forested (78%) urbanized (10%) and agricultural (10%) land uses. Load allocations were calculated using WARMF and are shown below in Table 13 and detailed in Appendices M and N.

Table 13. Lower Creek TMDL Wasteload and Load Allocations for Turbidity expressed as kg/day TSS.

TMDL Allocations	Existing TSS Load 1998-2003 (kg/day)	TMDL - TSS Load (kg/day)	Required Reduction (%)
Wasteload Allocations			
WLA - NC0023981 (6.0 MGD, 30 mg TSS/L limit)	**-----**	**681**	**0%**
WLA - NC0043231 (0.009 MGD, 30 mg TSS/L limit)	**-----**	**1.0**	**0%**
WLA - NC0048755 (0.005 MGD, 30 mg TSS/L limit)	**-----**	**0.6**	**0%**
WLA – MS4 stormwater [1]	**15,639**	**4,377**	**72%**
WLA – NCG010000 (General Construction Permits)		**50 NTU**	
Sum of WLAs		***5,060***	
Load Allocations/ non permitted			
Load Allocation [2]	**48,284**	**13,542**	**72%**
Non-Permitted Stormwater below MS4 area [3]	**41,587**	**11,682**	**72%**
Sum of LAs		***25,224***	
Margin of Safety - Explicit 10%			
Total TSS Load at outlet to Lake Rhodhiss (kg/day)	**105,500**	**30,280**	**72%**

[1] WLA for MS4 based on the landuse area within the Hickory "Urbanized" area as defined by Phase II boundaries. The MS4 WLA was determined within each of the 16 subwatersheds based on the type of landuse in the MS4 area in that subwatershed and the landuse loading as determine by the WARMF model. Streambank erosion attributable to the MS4 area was determined by multiplying the relative percent of MS4 area in a subwatershed by the total TSS load within that watershed.

[2] Equal to TMDL minus WLA and nonpermitted stormwater. LA is further broken down by landuse in Appendix N.

[3] Nonpermitted stormwater TSS loading occurring in subwatersheds 14 and 16; subwatersheds in which no MS4 area exists. This load was determined by comparing current conditions to conditions in which urban landuses were converted to mixed forest. In subwatersheds 14 and 16, TSS loading increased 59% and 53%, respectively, when comparing current conditions to modified landuse WARMF scenarios. The load given is the sum of stormwater loads in subwatersheds 14 and 16.

5.0 Follow – up Monitoring

Turbidity monitoring will continue on a monthly interval at the ambient monitoring station at SR 1501 near Morganton and will allow for the evaluation of progress towards the goal of reaching water quality standards. Discuss EEP monitoring and study here.

Additional monitoring could focus on identifying critical areas of streambank erosion and turbidity source assessment in the watershed. This would further aid in the evaluation of the progress towards meeting the water quality standard.

6.0 Implementation

Turbidity impairments in the Lower Creek watershed are primarily due to excessive stream channel and bank erosion. This erosion is, in part, a result of higher flows and volumes associated with increased urbanization and impervious surface in the Lower Creek watershed. Enforcement of stormwater BMP requirements for construction sites, education on farm practices, and consideration of urban stormwater controls for sediment are potential management options for improving turbidity levels. Other TSS sources include runoff from disturbed landuses, such as agriculture and construction areas where conversion from rural to urban uses is occurring. While stormwater controls are required on construction sites, significant loadings can occur due to initial periods of land disturbance before controls are in place or during high rainfall periods during which the controls are inadequate. North Carolina Phase II rules require development, implementation, and enforcement of an erosion and sediment control program for construction activities that disturb one or more acres of land. In addition, Phase II rules require the development, implementation, and enforcement of a program to address discharges of post-construction storm water runoff from new development and redevelopment areas.

Implementation of conservation management plans and best management practices are the best means of controlling agricultural sources of suspended solids. Several programs are available to assist farmers in the development and implementation of conservation management plans and best management practices. The Natural Resource Conservation Service is the primary source of assistance for landowners in the development of resource management pertaining to soil conservation, water quality improvement, wildlife habitat enhancement, and irrigation water management. The USDA Farm Services Agency performs most of the funding assistance. All agricultural technical assistance is coordinated through the locally led Naturally Resource Conservation Service offices (Soil Conservation Districts). The funding programs include:

- **The Environmental Quality Incentive Program (EQIP)** is designed to provide technical, financial, and educational assistance to farmers/producers for conservation practices that address natural resource concerns, such as water quality. Practices under this program include integrated crop management, grazing land management, well sealing, erosion control systems, agri-chemical handling facilities, vegetative filter strips/riparian buffers, animal waste management facilities and irrigation systems.

- **The Conservation Reserve Program (CRP)** is designed to provide technical and financial assistance to farmers/producers to address the agricultural impacts on water quality and to maintain and improve wildlife habitat. CRP practices include the establishment of filter strips, riparian buffers and permanent wildlife habitats. This program provides the basis for the Conservation Reserve Enhancement

Program (CREP). In 1999 The North Carolina DENR Departments of Environmental Protection and Agriculture, in partnership with Commodity Credit Corporation (CCC), submitted a proposal to the USDA to offer financial incentives for agricultural landowners to voluntarily implement conservation practices on agricultural lands through CREP. The goals for this program are to significantly reduce the amount of nutrients entering estuaries from agricultural sources through a voluntary, incentive-based program; to assist North Carolina in achieving the nutrient reduction goals for agriculture in the area; to significantly reduce the amount of sediment entering water courses; to enhance habitat for a range of threatened and endangered species dependent on riparian areas; and to decrease excess pulses of freshwater in primary nursery areas. NC CREP will be part of the USDA's Conservation Reserve Program (CRP). The enrollment of farmland into CREP in North Carolina is expected to improve stream health through the installation of water quality conservation practices on North Carolina farmland.

- **The Soil & Water Conservation Cost-Sharing Program** is available to participants in a Farmland Preservation Program pursuant to the Agriculture Retention and Development Act. A Farmland Preservation Program (FPP) means any voluntary FPP or municipally approved FPP, the duration of which is at least 8 years, which has as its principal purpose as long-term preservation of significant masses of reasonably contiguous agricultural land within agricultural development areas. The maintenance and support of increased agricultural production must be the first priority use of the land. Eligible practices include erosion control, animal waste control facilities, and water management practices. Cost sharing is provided for up to 50% of the cost to establish eligible practices.

Management Strategies

Management measures are "economically achievable measures for the control of the addition of pollutants from existing and new categories and classes of nonpoint and stormwater sources of pollution, which reflect the greatest degree of pollutant reduction achievable through the application of the best available nonpoint and stormwater source pollution control practices, technologies, processes, siting criteria, operating methods, or other alternatives" (USEPA, 1993). Development of effective management measures depends on accurate source assessment. A few projects recently completed, underway and planned are identified below.

Lower Creek and its tributaries are currently the subject of an intensive watershed study under management of the North Carolina Ecosystem Enhancement Program (EEP) with involvement of the Western Piedmont Council of Governments (WPCOG) and MACTEC Engineering and Consulting, Inc. As part of this study, MACTEC will be conducting an extensive data-gathering effort, collecting water quality data, assessing riparian buffers, stream channel alteration, streambank erosion, stormwater runoff and non-point sources of pollution, and summarizing this information in the development of a watershed management plan for the Lower Creek watershed. The final report is envisioned to be the "blueprint" for state and local government and other stakeholders in the Lower Creek watershed when addressing watershed-wide problems such as turbidity. The final report will include recommendations toward selecting and implanting traditional and non-traditional restoration projects and/or actions. Final product deliverables are anticipated to be completed by December 2005.

7.0 Public Participation

The City of Lenoir in Caldwell County was notified of the Lower Creek turbidity TMDL. The TMDL was publicly noticed and comment on the TMDL was requested on February 10, 2005. The comment period was through March 11, 2005. No written comments were received. A copy of the public notification is located in Appendix O.

8.0 Additional Information

Further information concerning North Carolina's TMDL program can be found on the Internet at the Division of Water Quality website:
http://h2o.enr.state.nc.us/tmdl/index.htm

Technical questions regarding this TMDL should be directed to the following members of the DWQ Modeling/TMDL Unit:

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Appendix A. Caldwell County, NC Soils (NRCS, 1991)

Map symbol	Map unit name	Acres	Percent
ApB	Appling sandy loam, 2 to 8 percent slopes	475	0.2
ApD	Appling sandy loam, 8 to 15 percent slopes	1,245	0.4
AsF	Ashe stony sandy loam, 25 to 40 percent slopes	559	0.2
AsG	Ashe stony sandy loam, 40 to 80 percent slopes	1,045	0.3
Bn	Buncombe loamy sand, frequently flooded	1,040	0.3
BtF	Burton stony loam, 25 to 40 percent slopes	1,010	0.3
CeB2	Cecil sandy loam, 2 to 8 percent slopes, eroded	15,056	5.0
CeD2	Cecil sandy loam, 8 to 15 percent slopes, eroded	37,373	12.3
CfB2	Cecil-Urban land complex, 2 to 8 percent slopes, eroded	2,930	1.0
CfD2	Cecil-Urban land complex, 8 to 15 percent slopes, eroded	2,524	0.8
ChG	Chestnut gravelly loam, 50 to 80 percent slopes	37,545	12.4
CKE	Chestnut and edneyville soils, 15 to 25 percent slopes	5,861	1.9
CKF	Chestnut and edneyville soils, 25 to 50 percent slopes	36,352	12.0
Cm	Chewacla loam, occasionally flooded	8,874	2.9
Co	Congaree fine sandy loam, occasionally flooded	4,492	1.5
DnB	Davidson clay loam, 2 to 8 percent slopes	227	<0.1
DnD	Davidson clay loam, 8 to 15 percent slopes	184	<0.1
DoB	Dogue fine sandy loam, 2 to 8 percent slopes	1,084	0.4
EaE	Evard fine sandy loam, 15 to 25 percent slopes	11,044	3.6
EaF	Evard fine sandy loam, 25 to 50 percent slopes	23,179	7.6
ESF	Evard and Saluda fine sandy loams, 25 to 60 percent slopes	12,921	4.3
HaD	Hayesville fine sandy loam, 8 to 15 percent slopes	1,875	0.6
HaE	Hayesville fine sandy loam, 15 to 25 percent slopes	2,203	0.7
HbD	Hibriten very cobbly sandy loam, 8 to 15 percent slopes	1,254	0.4
HbF	Hibriten very cobbly sandy loam, 15 to 60 percent slopes	8,179	2.7
MaB	Masada loam, 2 to 8 percent slopes	2,508	0.8
MaD	Masada loam, 8 to 15 percent slopes	4,015	1.3
PaE	Pacolet fine sandy loam, 15 to 25 percent slopes	34,879	11.5
PaF	Pacolet fine sandy loam, 25 to 40 percent slopes	21,879	7.2
Po	Potomac very cobbly loamy sand, frequently flooded	662	0.2
Pt	Pits, quarries	96	<0.1
RnE	Rion sandy loam, 15 to 25 percent slopes	1,406	0.5
RnF	Rion sandy loam, 25 to 40 percent slopes	5,501	1.8
Ro	Roanoke loam	201	<0.1
RSF	Rock outcrop-Ashe complex, 25 to 80 percent slopes	4,368	1.4
SeB	State loam, 2 to 8 percent slopes	1,077	0.4
TaB	Tate fine sandy loam, 2 to 8 percent slopes	260	<0.1
TaE	Tate fine sandy loam, 8 to 25 percent slopes	2,639	0.9
UaB	Urban land-Arents complex, occasionally flooded	684	0.2
UmC	Urban land-Masada complex, 2 to 15 percent slopes	682	0.2
W	Water	2,112	0.7
Wk	Wehadkee loam, frequently flooded	2,161	0.7

Appendix B. Benthic macroinvertebrate results and site characteristics in the Lower Creek watershed Samples collected September 2002.

Lower Creek at NC 90 = LC1, SR 1303 = LC2, SR 1142 = LC3, SR 1501 = LC4, Zack's Fk at SR 1531 = ZFK1, US 321A = ZF2, Spainhour Cr at Bus 18 = SPH
UT Spainhour Cr = UT SPH, Blair Fk = BFK, Greasy Cr at SR 1305 = GCR1, off Hwy 18 = GCR2, Abingdon Cr = ABCR, Husband Cr at Old NC 18 = HCR1, NC Hwy 18 = HCR2
Celia Cr = CCR, Bristol Cr = BCR, White Mill Cr = WMCR, Gunpowder Cr = GPCR, Smoky Cr = SMCR

Station	LC1	LC2	LC3	LC4	ZFK1	ZFK2	SPH	UT SPH	BFK	GCR1	GCR2	ABCR	HCR1	HCR2	CCR	BCR1	WMCR	GPCR	SMCR
Sample Type	Full	Full	Full	Full	Qual 5	Qual 5	Full	Qual 5	Qual 5	Qual 5	Qual 5	Qual 5	Qual 5	Qual 5	Qual 5	Qual 5	Qual 5	EPT	EPT
Date	9/9/2002	9/10/2002	9/10/2002	9/11/2002	9/9/2002	9/10/2002	9/9/2002	9/9/2002	9/9/2002	9/10/2002	9/10/2002	9/10/2002	9/11/2002	9/11/2002	9/11/2002	9/11/2002	9/11/2002	8/21/02	8/21/02
Ephemeroptera	5	9	5	5	9	4	12	6	3	6	6	11	11	7	7	5	5	14	12
Plecoptera	0	0	0	2	3	0	0	2	0	2	1	3	5	3	1	2	2	3	3
Trichoptera	4	4	6	7	7	2	3	5	3	5	7	6	8	4	2	5	7	6	11
Coleoptera	4	7	4	2	4	4	5	3	2	3	6	6	6	4	3	6	2	-	-
Odonata	6	5	6	8	6	5	6	7	5	5	4	4	6	4	4	7	6	-	-
Megaloptera	1	1	2	1	1	0	1	0	0	2	1	1	3	0	1	3	1	-	-
Diptera: Chironomidae	19	21	16	20	15	9	15	3	6	15	13	15	11	10	12	14	9	-	-
Misc. Diptera	3	3	1	3	6	4	5	1	2	6	3	6	3	2	3	4	3	-	-
Oligochaeta	1	4	3	2	1	2	1	3	1	2	2	4	1	0	1	2	1	-	-
Crustacea	0	1	1	1	0	1	0	1	1	1	0	1	1	1	1	1	1	-	-
Mollusca	2	2	5	3	3	1	1	1	2	1	1	1	0	1	3	5	2	-	-
Other	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	0	-	-
Total Taxa Richness	45	57	60	55	54	32	49	32	24	47	45	57	55	36	39	55	37	-	-
EPT Richness	9	13	11	14	19	6	15	13	5	13	14	20	24	14	10	12	14	23	26
EPT Abundance	40	28	62	82	74	21	61	28	5	66	47	67	93	61	33	63	38	111	111
Biotic Index	6.47	6.68	6.53	6.15	5.68	6.88	6.46	4.55	6.42	4.88	5.71	5.61	5.26	5.25	5.79	5.56	4.87	-	-
Bioclassifiction	Poor	Fair	Fair	Fair	NI*	NR*	Fair	NR*	NR*	Fair	NR*	NI*	NI*	NR*	NR*	NR*	NR*	Good-Fair	Good-Fair
Width (m)	4	5	10	9	2	2	4	1	2	4	2	2	2	3	3	1	1	9	4
Drainage area (sq. miles)	10.6	40	63.7	82.8	8	13.3	8.7	2.3	2.7	4	4.9	5.4	8.3	16.3	5.4	9.1	4.4	19	7.8
Depth (Avg)	0.2	0.2	0.4	0.3	0.2	0.2	0.2	0.1	0.2	0.2	0.1	0.2	0.2	0.2	0.1	0.2	0.1	0.2	0.2
Canopy (%)	60	50	40	10	90	20	90	90	80	50	70	50	70	75	50	80	80	80	80
Substrate (%)																			
Boulder	0	0	20	0	5	0	15	15	0	5	0	5	0	0	0	0	0	5	15
Rubble	0	0	20	0	5	0	15	20	10	20	0	15	0	0	0	0	0	5	15
Gravel	10	35	10	20	20	10	30	20	0	20	20	15	30	20	30	0	25	0	20
Sand	80	60	40	60	65	90	40	40	60	45	60	55	50	60	50	90	65	80	20
Silt	10	5	10	20	5	0	0	5	30	10	20	10	20	20	20	10	10	10	25
Channel modification	4	3	4	2	5	0	3	4	3	5	5	5	5	5	5	5	5	5	5
Instream habitat	10	11	12	11	12	8	8	10	8	12	8	12	11	12	12	10	11	12	12
Bottom substrate	3	3	6	3	5	3	3	5	3	10	3	6	3	3	3	3	3	3	5
Pool variety	0	4	4	4	4	4	4	4	4	6	4	6	6	6	4	6	6	0	4
Riffle habitats	0	0	0	0	7	0	7	7	7	14	5	7	0	0	0	0	0	3	12
Bank stability and vegetation	4	6	4	6	6	4	6	6	6	6	3	6	6	6	6	10	6	12	6
Light penetration	5	7	7	7	10	3	10	10	10	10	8	7	10	10	7	10	10	10	10
Riparian zone width	3	4	3	5	6	4	2	6	4	7	6	2	0	7	5	0	0	3	0
Total Score (0-100)	**29**	**38**	**40**	**38**	**55**	**26**	**43**	**52**	**45**	**70**	**42**	**51**	**49**	**49**	**42**	**53**	**49**	**48**	**62**
Temperature	19	19	22	21	20	16	22	23	21	19	17	21	17	16	16	24	19	21	21
DO (mg/l)	6.6	9	7.3	5.6	8.5	8.1	7.3	7.3	7.3	7.6	9	7.9	6.4	8	8.4	8	5.9	7.8	9
Conductivity	97	115	167	161	75	1000	103	76	113	51	78	69	63	61	60	57	50	158	42
pH	7.1	7.3	7.2	7.1	7.2	7.3	7.2	7.2	7.3	7.4	7.1	7.6	7.3	7.4	7.2	6.9	6.9	7.6	7.7
County	Caldwell	Caldwell	Caldwell	Burke	Caldwell	Caldwell	Caldwell	Caldwell	Caldwell	Caldwell	Caldwell	Caldwell	Caldwell	Caldwell	Caldwell	Caldwell	Caldwell	Caldwell	Burke
Latitude	355528	355344	355027	354831	355600	355437	355415	355908	355621	355443	355341	355256	355138	355013	355138	354856	354947	355039	354800
Longitude	813017	813335	813659	813810	813129	813147	813333	813253	813306	813424	813407	813503	813732	813729	813807	813918	814036	812610	813619

* Qual 5 sample ratings are based on EPT richness of sample with wash excluded. NI = Not Impaired (at least Good-Fair)
NR = Not Rated (Fair or Poor classification)

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Appendix C. NC DWQ Ambient Monitoring Results for TSS and Turbidity at Station C1750000

DATE	TOTAL NONFILTRABLE RESIDUE MG/L (method 00530)	TURBIDITY, NEPHELOMETRIC TURBIDITY UNITS NTU (method 82079)
1/14/97	33	21
2/25/97	34	27
3/31/97	3	19
4/22/97	60	38
5/27/97	49	30
6/25/97	48	35
7/29/97	68	52
8/26/97	22	19
9/30/97	29	27
10/28/97	22	27
11/18/97	7	5.7
12/10/97	11	9.7
1/21/98	26	24
2/17/98	580	610
3/24/98	28	22
4/21/98	110	90
5/13/98	42	34
6/17/98	140	140
7/14/98	24	24
8/25/98	10	9.9
9/29/98	68	130
11/18/98	6	6.4
12/16/98	13	14
1/19/99	33	31
2/10/99	13	9.5
3/24/99	13	9.9
4/21/99	8	11
5/5/99	110	1400
6/16/99	50	22
7/28/99	22	21
8/11/99	22	9.9
10/20/99	210	170
12/14/99	60	390
1/19/00	6	11
2/29/00	14	9.3
3/28/00		14
4/12/00	15	16
5/17/00	15	7.9
6/28/00		38
7/26/00		20
8/15/00		9.5
9/5/00		200
10/18/00		5.2
12/6/00	3	5.4
1/10/01		13

DATE	TOTAL NONFILTRABLE RESIDUE MG/L (method 00530)	TURBIDITY, NEPHELOMETRIC TURBIDITY UNITS NTU (method 82079)
2/7/01	9	14
4/3/01	30	33
5/31/01		18
6/26/01	110	110
7/12/01	19	18
8/15/01		47
9/27/01	24	14
10/23/01	8	7.6
11/7/01		4.6
12/4/01		4.4
2/13/02		16
3/26/02	16	20
4/25/02		25
5/31/02		110
6/18/02		27
7/2/02		140
8/20/02		67
9/18/02	25	36
10/23/02		18
11/4/02		9.7
12/17/02	16	20
1/22/03		9.2
2/25/03		55
3/10/03	18	23
4/23/03		31
5/7/03		60
6/4/03	150	160
7/16/03		80
8/12/03		60
9/9/03	12	16
10/14/03		9.9
11/13/03		12
12/2/03	9	11
1/7/04		10
2/10/04		35
3/3/04	12	15

Appendix D. Data Sources

The NCDENR's Geographic Information System (GIS) was used extensively to describe the Lower Creek watershed characteristics. The following is general information regarding the data used to describe the watershed:

- **Ambient chemical monitoring locations**: NC DENR Div of Water Quality, Water Quality Section, 9/30/2000, Ambient Water Quality Monitoring Sites: NC DENR Div of Water Quality, Water Quality Section, Raleigh, North Carolina.
- **Biological monitoring locations**: NC DENR Clean Water Management Trust Fund, NC DENR - Div. of Water Quality, Biological Assessment Unit, 11/15/2000, Benthic monitoring results: NC DENR - Div. of Water Quality, Biological Assessment Unit, Raleigh, North Carolina.
- **City of Lenoir Boundary**: NC Department of Transportation-GIS Unit, 2002, Municipal Boundaries - Powell Bill 1999: NC Department of Transportation, Raleigh, North Carolina.
- **County boundaries**: information NC Center for Geographic Information & Analysis, 12/01/1998, Boundaries - County (1:100,000): NC Center for Geographic Information & Analysis, Raleigh, North Carolina.
- **Detailed stream coverage**: North Carolina Center for Geographic Information and Analysis, 4/19/2001, Hydrography (1:24,000): North Carolina Center for Geographic Information and Analysis, Raleigh, NC.
- **Hydrologic Units**: USDA, Natural Resources Conservation Service, 12/01/1998, Hydrologic Units - North Carolina River Basins: USDA, Natural Resources Conservation Service, Raleigh, North Carolina.
- **Land use/Land cover information**: Earth Satellite Corporation (EarthSat), 6/12/1998, Statewide Land Cover - 1996: EarthSat, Raleigh, North Carolina.
- **NPDES Permitted Facilities**: NC DENR Division of Water Quality, Planning Branch, 10/11/2000, National Pollutant Discharge Elimination System Sites: NC DENR Division of Water Quality, Planning Branch, Raleigh, North Carolina.
- **Roads**: NC Department of Transportation - GIS Unit, 9/21/1999, Transportation - NCDOT Roads (1:24,000): NC Department of Transportation, Raleigh, NC.
- **Stream Gaging Stations**: NC DENR-Division of Water Resources, 12/01/1998, Stream Gaging Stations: NC DENR-Division of Water Resources, Raleigh, North Carolina.
- **Streamflow gage data** was obtained online from the United States Geological Survey (USGS) at: http://nc.water.usgs.gov/.

Appendix E. Monthly average effluent TSS concentrations (mg/L) at the City of Lenoir - Lower Creek WWTP during years 1999-2003.

City of Lenoir - Lower Creek WWTP (**NC0023981**)

	1999	2000	2001	2002	2003
January	20.9	14.6	8.4	10.7	5.8
February	40.2	13.7	16.0	7.6	69.4
March	28.3	12.1	74.6	9.6	14.7
April	75.9	8.7	7.1	8.3	9.8
May	103.4	6.6	7.1	9.4	7.6
June	76.1	10.0	7.6	13.1	14.1
July	28.8	5.1	7.4	6.5	7.9
August	7.6	7.3	7.5	5.9	6.3
September	6.6	8.4	7.9	5.1	
October	8.4	8.2	8.0	8.5	
November	8.1	10.7	8.0	5.8	
December	13.5	9.3	8.5	6.2	

Appendix F. General Permitees located within the Lower Creek watershed.

Permit Number	Facility Name	DWQ Description
NCG020026	Vulcan Construction Materials LP - Vulcan Construction Materials - Lenoir Quarry	Mining Activities Stormwater Discharge COC
NCG030148	Neptco Inc - Neptco Incorporated	Metal Fabrication Stormwater Discharge COC
NCG050023	Meridian Automotive Systems - Meridian Automotive Systems	Apparel/Printing/Paper/Leather/Rubber Stormwater Discharge COC
NCG050229	Sealed Air Corporation - Sealed Air Corporation	Apparel/Printing/Paper/Leather/Rubber Stormwater Discharge COC
NCG080186	United Parcel Service - United Parcel Service-Lenoir	Transportation w/Vehicle Maintenance/Petroleum Bulk/Oil Water Separator Stormwater Discharge COC
NCG080260	Caldwell Freight Lines Inc - Caldwell Freight Lines Incorporated	Transportation w/Vehicle Maintenance/Petroleum Bulk/Oil Water Separator Stormwater Discharge COC
NCG120060	Republic Services Of NC LLC - Republic Services Of NC LLC - Lenoir	Landfill Stormwater Discharge COC
NCG140097	Hamby Brothers Concrete Inc - Hamby Brothers Concrete Incorporated	Ready Mix Concrete Stormwater/Wastewater Discharge COC
NCG170313	American & Efird Inc - American & Efird Incorporated-Nelson	Textile Mill Products Stormwater Discharge COC
NCG180080	Broyhill Furniture Industries Inc - Broyhill Furniture Ind-Whitnel	Furniture and Fixtures Stormwater Discharge COC
NCG180081	Broyhill Furniture Industries Inc - Broyhill Furniture Ind- Harp	Furniture and Fixtures Stormwater Discharge COC
NCG180082	Broyhill Furniture Industries Inc - Broyhill Furniture Ind-Caldwel	Furniture and Fixtures Stormwater Discharge COC
NCG180084	Broyhill Furniture Industries Inc - Broyhill Furniture Ind Incorporated	Furniture and Fixtures Stormwater Discharge COC
NCG180101	Kincaid Furniture Co - Kincaid Furniture Co-Plant #5	Furniture and Fixtures Stormwater Discharge COC
NCG180152	Bernhardt Furniture Co - Bernhardt Furniture Co-Cen Lum	Furniture and Fixtures Stormwater Discharge COC
NCG180153	Bernhardt Furniture Co - Bernhardt Furniture Co-Plt 5	Furniture and Fixtures Stormwater Discharge COC
NCG180154	Bernhardt Furniture Co - Bernhardt Furniture Co-Plt 7	Furniture and Fixtures Stormwater Discharge COC
NCG180155	Bernhardt Furniture Co - Bernhardt Furniture Co-Plt 3	Furniture and Fixtures Stormwater Discharge COC
NCG180156	Bernhardt Furniture Co - Bernhardt Furniture Co-Plt 2	Furniture and Fixtures Stormwater Discharge COC
NCG180157	Bernhardt Furniture Co - Bernhardt Furniture Co-Plt 1	Furniture and Fixtures Stormwater Discharge COC
NCG180169	Thomasville Furniture Industries, Inc. - Thomasville Furniture Ind., Inc. - Lenoir Plant	Furniture and Fixtures Stormwater Discharge COC
NCG180189	Fairfield Chair Co - Fairfield Chair Co-Plnt #2	Furniture and Fixtures Stormwater Discharge COC
NCG180190	Fairfield Chair Co - Fairfield Chair Co-Plt #1	Furniture and Fixtures Stormwater Discharge COC
NCG180230	Broyhill Furniture Industries Inc - Broyhill Plant 54 & 123	Furniture and Fixtures Stormwater Discharge COC
NCG210133	H Parsons Inc - H Parsons Incorporated	Timber Products Stormwater Discharge COC
NCG500072	Thomasville Furniture Industries, Inc. - Thomasville Furniture Co - Lenoir	Non-contact Cooling, Boiler Blowdown Wastewater Discharge COC
NCG500178	Broyhill Furniture Industries Inc - Broyhill-Miller Hill Complex	Non-contact Cooling, Boiler Blowdown Wastewater Discharge COC
NCG500179	Broyhill Furniture Industries Inc - Broyhill - Virginia Street Complex	Non-contact Cooling, Boiler Blowdown Wastewater Discharge COC
NCG550801	Blessed Hope Church - Blessed Hope Church	Single Family Domestic Wastewater Discharge COC
NCG550977	Mountain View Pediatrics - Mountain View Pediatrics	Single Family Domestic Wastewater Discharge COC
NCS000066	Neptune Inc - Neptune Inc	Stormwater Discharge, Individual

Appendix G. Methodology for developing the Load Duration Curve

The load duration curve method is based on comparison of the frequency of a given flow event with its associated water quality load. In the case of applying the NTU criteria, a correlation is necessary between NTU and TSS to allow for calculation of a load in mass per time units. Data from the Lower Creek ambient station (Station Q3735000) was used in this TMDL resulted in the below equation:

TSS concentration (mg/L) = (1.3772* Turbidity (NTU)^0.8938)
$R^2 = 0.8435$

A LDC can be developed using the following steps:

1. Plot the Flow Duration Curve, Flow vs. % of days flow exceeded.
2. Develop TSS-turbidity correlation.
3. Translate turbidity values to equivalent TSS values using the linear regression equation from the correlation.
4. Translate the flow-duration curve into a LDC by multiplying the water quality standard (as equivalent TSS concentration), the flow and a units conversion factor; the result of this multiplication is the maximum allowable load associated with each flow.
5. Graph the LDC, maximum allowable load vs. percent of time flow is equaled or exceeded.
6. Water quality samples, expressed as estimated TSS values, are converted to loads (sample water quality data multiplied by daily flow on the date of sample).
7. Plot the measured loads on the LDC

Appendix H. Calibrated soil layer parameters in WARMF.

Subwatershed	Soil Layer	Area (m2)	Thickness (cm)	Initial Moisture	Field Capacity	Sat. Moisture	Horizontal Cond.	Vertical Cond.	Root Distribution	Density g/cm3	Soil Tortuosity
1	1	34165000	65	0.3	0.3	0.42	10020	8.5	0.75	0.2	10
	2	34165000	27.5	0.3	0.26	0.47	1320	51	0.1	1.3	10
	3	34165000	102.499	0.3	0.32	0.548	1000	99.5	0.1	1.3	10
	4	31895000	109.999	0.3	0.28	0.44	300	300	0.05	1.5	10
2	1	33897000	65	0.3	0.3	0.42	10020	8.2	0.75	0.2	10
	2	33897000	27.5	0.3	0.26	0.47	1320	50	0.1	1.3	10
	3	33897000	102.499	0.3	0.32	0.548	1000	98	0.1	1.3	10
	4	31647000	109.999	0.3	0.28	0.44	300	300	0.05	1.5	10
3	1	11808000	65	0.3	0.3	0.42	10020	8.2	0.75	0.2	10
	2	11808000	27.5	0.3	0.26	0.47	1320	50	0.1	1.3	10
	3	11808000	102.499	0.3	0.32	0.548	1000	100	0.1	1.3	10
	4	11808000	109.999	0.3	0.28	0.44	300	300	0.05	1.5	10
4	1	22815000	65	0.3	0.3	0.42	10020	7.5	0.75	0.2	10
	2	22815000	27.5	0.3	0.26	0.47	1320	50	0.1	1.3	10
	3	22815000	102.499	0.3	0.32	0.548	1000	98	0.1	1.3	10
	4	22815000	109.999	0.3	0.28	0.44	300	300	0.05	1.5	10
5	1	12295000	65	0.3	0.3	0.42	10020	8.5	0.75	0.2	10
	2	12295000	27.5	0.3	0.26	0.47	1320	50	0.12	1.3	10
	3	12295000	102.499	0.3	0.32	0.548	1000	101	0.1	1.3	10
	4	12295000	109.999	0.3	0.28	0.44	300	300	0.03	1.5	10
6	1	843051	65	0.1	0.3	0.42	10020	10	0.75	0.2	10
	2	843051	27.5	0.2	0.26	0.47	1320	49.5	0.1	1.3	10
	3	843051	102.499	0.28	0.32	0.548	1000	100	0.1	1.3	10
	4	843051	109.999	0.23	0.28	0.44	300	300	0.05	1.5	10

Subwatershed	Soil Layer	Area (m2)	Thickness (cm)	Initial Moisture	Field Capacity	Sat. Moisture	Horizontal Cond. cm/d	Vertical Cond. **cm/d**	Root Distribution	Density g/cm3	Soil Tortuosity
7	1	15621000	62.5	0.31	0.203	0.5	10220	10	0.75	0.2	10
	2	15621000	57.5	0.31	0.2	0.41	1460	48	0.1	1.3	10
	3	15621000	207.5	0.33	0.23	0.39	1200	98	0.1	1.3	10
	4	15621000	405	0.355	0.2	0.355	525	300	0.05	1.5	10
8	1	7525800	62.5	0.31	0.203	0.5	10220	10	0.75	0.2	10
	2	7525800	57.5	0.31	0.35	0.41	1460	50.5	0.1	1.3	10
	3	7525800	207.5	0.33	0.23	0.39	1200	100	0.1	1.3	10
	4	7525800	405	0.355	0.2	0.355	525	300	0.05	1.5	10
9	1	14150000	62.5	0.31	0.203	0.5	10220	10	0.75	0.2	10
	2	14150000	57.5	0.31	0.25	0.41	1460	50	0.1	1.3	10
	3	14150000	207.5	0.33	0.23	0.39	1200	99	0.1	1.3	10
	4	14150000	405	0.355	0.2	0.355	525	300	0.05	1.5	10
10	1	10651000	62.5	0.31	0.203	0.5	10220	10	0.75	0.2	10
	2	10651000	57.5	0.31	0.25	0.41	1460	49	0.1	1.3	10
	3	10651000	207.5	0.33	0.23	0.39	1200	100	0.1	1.3	10
	4	10651000	405	0.355	0.2	0.355	525	300	0.05	1.5	10
11	1	21611000	62.5	0.31	0.203	0.5	10220	10	0.75	0.2	10
	2	21611000	57.5	0.31	0.15	0.41	1460	48	0.1	1.3	10
	3	21611000	207.5	0.33	0.23	0.39	1200	99	0.1	1.3	10
	4	21611000	405	0.355	0.2	0.355	525	300	0.05	1.5	10
12	1	15144000	62.5	0.31	0.203	0.5	10220	10	0.75	0.2	10
	2	15144000	57.5	0.31	0.2	0.41	1460	49	0.1	1.3	10
	3	15144000	207.5	0.33	0.23	0.39	1200	99	0.1	1.3	10
	4	15144000	405	0.355	0.2	0.355	525	300	0.05	1.5	10
13	1	5697900	62.5	0.31	0.203	0.5	10220	10	0.75	0.2	10
	2	5697900	57.5	0.31	0.15	0.41	1460	48	0.1	1.3	10
	3	5697900	207.5	0.33	0.23	0.39	1200	98	0.1	1.3	10
	4	5697900	405	0.355	0.2	0.355	525	300	0.05	1.5	10

Subwatershed	Soil Layer	Area (m2)	Thickness (cm)	Initial Moisture	Field Capacity	Sat. Moisture	Horizontal Cond. cm/d	Vertical Cond. **cm/d**	Root Distribution	Density g/cm3	Soil Tortuosity
14	1	9346200	62.5	0.31	0.203	0.5	10220	10	0.75	0.2	10
	2	9346200	57.5	0.31	0.101	0.41	1460	50	0.1	1.3	10
	3	9346200	207.5	0.33	0.23	0.39	1200	100	0.1	1.3	10
	4	9346200	405	0.355	0.2	0.355	525	300	0.05	1.5	10
15	1	29122000	65	0.25	0.2	0.45	10000	7.5	0.75	0.2	10
	2	29122000	50	0.3	0.2	0.35	1300	50	0.1	1.3	10
	3	29122000	200	0.35	0.2	0.45	1000	100	0.1	1.3	10
	4	29122000	400	0.35	0.12	0.35	500	300	0.05	1.5	10
16	1	4267000	65	0.25	0.2	0.45	10000	10	0.75	0.2	10
	2	4267000	50	0.3	0.2	0.35	1300	50	0.1	1.3	10
	3	4267000	200	0.35	0.2	0.45	1000	100	0.1	1.3	10
	4	4267000	400	0.35	0.12	0.35	500	300	0.05	1.5	10

Appendix I. Streambank erosion values and total TSS loading values for years 92-97 (calibration dataset), 97-03 period, and TMDL period (based on 97-03 period) for each subwatershed in the Lower Creek Basin.

streambank erosion values from WARMF output
Values are in kg/day

Subwatershed	92-97	97-03	TMDL
1	181	36	10
2	164	25	7
3	3,170	999	279
4	93	32	9
5	3.80	0.30	0.08
6	6,880	2,210	619
7	149	41	11
8	11,800	3,710	1,040
9	31,600	9,010	2,520
10	41,100	11,400	3,190
11	304	77	22
11	13	649	182
12	138	36	10
14	122,000	31,500	8,840
15	418	78	22
16	179,000	43,400	12,200
Entire watershed	**397,013**	**103,204**	**28,961**

total TSS Loading values from WARMF output
Values are in kg/day

Subwatershed	92-97	97-03	TMDL
1	676	144	40
2	573	140	39
3	3,380	1,200	336
4	399	177	50
5	80.30	17.80	4.98
6	6,890	2,220	623
7	368	209	58
8	12,000	3,860	1,080
9	32,000	9,280	2,600
10	41,600	11,600	3,260
11	707	423	119
12	338	215	60
13	2,560	713	200
14	122,000	31,600	8,860
15	741	238	67
16	179,000	43,400	12,200
Entire watershed	**403,312**	**105,437**	**29,597**

Appendix J. Nonpermitted stormwater loading was identified in subwatersheds 14 and 16 based on the excessive streambank erosion load. Current condition 97-03 scenarios were compared to scenarios within WARMF in which all urban areas were converted to mixed forest. The percent change in loading between these scenarios became the bases for choosing the percent of current streambank erosion loading that is attributable to stormwater loading. Currently, no MS4 area is contained within either of the two subwatersheds.

	Subwatershed 14 with no Urban loading (LC9703_NPS)		**Subwatershed 16 with no Urban loading (LC9703_NPS)**	
	97-03 current conditions	97-03, urban LULC changed to mixed forest	97-03 current conditions	97-03, urban LULC changed to mixed forest
Managed Flow	0	0	0	0
Groundwater Pumping	0	0	0	0
Deciduous Forest	258	446	279	470
Evergreen Forest	181	267	209	299
Mixed Forest	182	403	206	434
Pasture	276	387	294	407
Cultivated	363	576	399	616
Recr. Grasses	6.13	17.3	6.36	17.6
Water	0	0	0	0
Barren	26.3	51.6	32.1	57.9
Low Int. Develop.	377	0	399	0
High Int. Develop.	155	0	156	0
Comm / Industrial	296	0	300	0
Wetlands	0	0	0	0
General Nonpoint Sources	0	0	0	0
Stream Bank Erosion	59700	24200	103000	48600
Direct Precipitation	0	0	0	0
Direct Dry Deposition	0	0	0	0
Type 1 Septic System	0	0	0	0
Type 2 Septic System	0	0	0	0
Type 3 Septic System	0	0	0	0
Unpermitted Surface Mines	0	0	0	0
Unpermitted Deep Mines	0	0	0	0
Permitted Surface Mines	0	0	0	0
Permitted Deep Mines	0	0	0	0
General Point Sources	0	0	0	0
TOTAL	61900	26300	106000	50900
Attributable to the Stormwater		**59%**		**53%**

Appendix K. TSS loading output from the WARMF model during the 1997-2003 for the MS4 ("Hickory Urbanized Area" within the Lower Creek watershed) area identified by landuse within each subwatershed..

MS4 Allocation - Load kg/day	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Managed Flow	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Groundwater Pumping	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Deciduous Forest	0.04	0.04	0.00	0.10	0.03	0.00	1.12	19.32	14.61	4.46	0.82	0.00	0.21	0.00	0.00	0.00
Evergreen Forest	0.03	0.03	0.00	0.05	0.02	0.00	0.38	6.47	7.33	1.45	0.52	0.00	0.17	0.00	0.00	0.00
Mixed Forest	0.02	0.03	0.00	0.06	0.02	0.00	0.38	8.98	7.32	2.11	0.37	0.00	0.13	0.00	0.00	0.00
Pasture	0.70	0.19	0.00	0.53	0.13	0.00	3.27	15.64	34.86	21.28	0.97	0.00	1.20	0.00	0.00	0.00
Cultivated	1.21	0.86	0.00	2.58	0.35	0.00	12.44	37.54	66.25	18.37	4.67	0.00	1.86	0.00	0.00	0.00
Recr. Grasses	0.10	0.14	0.00	0.39	0.10	0.00	0.34	0.42	4.55	0.00	0.00	0.00	0.19	0.00	0.00	0.00
Water	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Barren	0.08	0.04	0.00	0.13	0.10	0.00	0.00	4.49	4.74	0.60	0.36	0.00	0.11	0.00	0.00	0.00
Low Int. Develop.	12.03	48.84	34.15	58.81	10.17	3.25	3.72	15.38	33.44	6.99	0.00	0.00	7.00	0.00	0.00	0.00
High Int. Develop.	3.49	42.25	27.39	44.45	4.22	4.41	1.88	4.15	4.83	0.00	0.00	0.00	0.09	0.00	0.00	0.00
Comm / Industrial	17.66	61.06	71.04	40.22	5.67	3.51	1.10	28.50	11.57	2.35	0.00	0.00	2.81	0.00	0.00	0.00
Wetlands	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
General Nonpoint Sources	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Stream Bank Erosion	5	6	999	11	0	2210	2	3710	6287	1469	1	0	3	0	0	0
Direct Precipitation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Direct Dry Deposition	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Type 1 Septic System	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Type 2 Septic System	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Type 3 Septic System	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unpermitted Surface Mines	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unpermitted Deep Mines	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Permitted Surface Mines	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Permitted Deep Mines	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
General Point Sources	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MS4 Load per watershed (kg/day)	**40**	**160**	**1,132**	**158**	**21**	**2,221**	**27**	**3,851**	**6,477**	**1,527**	**9**	**0**	**17**	**0**	**0**	**0**
Total MS4 load (kg/day)	**15,639**															

Appendix L. TMDL scenario using TSS loading output from the WARMF model during the 1997-2003 period for the MS4 ("Hickory Urbanized Area" within the Lower Creek watershed) area identified by landuse within each subwatershed..

MS4 Allocation - Load kg/day	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Managed Flow	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Groundwater Pumping	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Deciduous Forest	0.01	0.01	0.00	0.03	0.01	0.00	0.31	5.43	4.08	1.25	0.23	0.00	0.06	0.00	0.00	0.00
Evergreen Forest	0.01	0.01	0.00	0.01	0.00	0.00	0.11	1.81	2.04	0.41	0.15	0.00	0.05	0.00	0.00	0.00
Mixed Forest	0.01	0.01	0.00	0.02	0.01	0.00	0.11	2.51	2.05	0.59	0.10	0.00	0.04	0.00	0.00	0.00
Pasture	0.20	0.05	0.00	0.15	0.04	0.00	0.92	4.37	9.75	5.96	0.27	0.00	0.34	0.00	0.00	0.00
Cultivated	0.34	0.24	0.00	0.72	0.10	0.00	3.48	10.51	18.53	5.11	1.31	0.00	0.52	0.00	0.00	0.00
Recr. Grasses	0.03	0.04	0.00	0.11	0.03	0.00	0.10	0.12	1.27	0.00	0.00	0.00	0.05	0.00	0.00	0.00
Water	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Barren	0.02	0.01	0.00	0.04	0.03	0.00	0.00	1.26	1.33	0.17	0.10	0.00	0.03	0.00	0.00	0.00
Low Int. Develop.	3.37	13.69	9.56	16.45	2.85	0.91	1.04	4.32	9.38	1.96	0.00	0.00	1.96	0.00	0.00	0.00
High Int. Develop.	0.98	11.84	7.64	12.46	1.18	1.23	0.53	1.16	1.35	0.00	0.00	0.00	0.03	0.00	0.00	0.00
Comm / Industrial	4.94	17.13	19.89	11.21	1.59	0.98	0.31	8.00	3.24	0.66	0.00	0.00	0.79	0.00	0.00	0.00
Wetlands	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
General Nonpoint Sources	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Stream Bank Erosion	1.43	1.69	279.00	3.08	0.02	619.00	0.55	1040.00	1758.45	411.16	0.26	0.00	0.97	0.00	0.00	0.00
Direct Precipitation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Direct Dry Deposition	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Type 1 Septic System	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Type 2 Septic System	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Type 3 Septic System	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unpermitted Surface Mines	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unpermitted Deep Mines	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Permitted Surface Mines	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Permitted Deep Mines	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
General Point Sources	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MS4 Load per watershed (kg/day)	**11**	**45**	**316**	**44**	**6**	**622**	**7**	**1,079**	**1,811**	**427**	**2**	**0**	**5**	**0**	**0**	**0**
Total MS4 load (kg/day)	**4,377**															

Appendix M. TSS loading output from the WARMF model during the 1997-2003 for nonpoint sources (non- MS4, "Hickory Urbanized Area" and non permitted loading within the Lower Creek watershed) area identified by landuse within each subwatershed..

NPS Allocation - Load kg/year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Managed Flow	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Groundwater Pumping	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Deciduous Forest	0.42	0.44	0.00	0.56	0.20	0.00	41.74	0.00	6.95	46.59	68.63	27.57	3.57	19.56	21.31	0.00
Evergreen Forest	0.18	0.15	0.00	0.23	0.08	0.00	19.25	0.00	5.64	27.08	57.67	37.91	4.84	17.31	28.46	0.04
Mixed Forest	0.16	0.18	0.00	0.37	0.13	0.00	26.79	0.00	4.66	23.85	51.85	39.90	4.16	15.93	27.68	0.00
Pasture	3.89	0.54	0.00	0.35	0.63	0.00	12.12	0.00	9.30	49.05	58.00	26.08	7.79	12.70	17.67	0.00
Cultivated	4.06	1.01	0.00	2.50	0.66	0.00	36.86	0.00	10.26	48.82	58.93	32.69	16.34	20.58	31.99	0.01
Recr. Grasses	0.05	0.00	0.00	0.04	0.03	0.00	0.81	0.00	0.77	0.00	0.00	0.00	0.45	0.98	0.30	0.00
Water	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Barren	0.16	0.03	0.00	0.26	0.05	0.00	2.62	0.00	1.50	2.04	2.26	1.88	1.66	0.72	1.05	0.01
Low Int. Develop.	9.97	4.09	0.00	4.97	4.34	0.00	17.24	0.00	5.91	14.67	37.76	1.08	23.35	15.07	24.78	0.00
High Int. Develop.	0.24	0.60	0.00	0.62	3.52	0.00	3.01	0.00	0.01	1.22	1.72	0.18	0.28	0.81	0.37	0.00
Comm / Industrial	23.47	0.61	0.00	4.13	1.74	0.00	3.58	0.00	1.66	6.85	5.87	0.00	3.06	4.57	7.02	0.00
Wetlands	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
General Nonpoint Sources	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Stream Bank Erosion	31	19	0	21	0	0	39	0	2723	9931	76	649	33	12915	78	20398
Direct Precipitation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Direct Dry Deposition	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Type 1 Septic System	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Type 2 Septic System	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Type 3 Septic System	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unpermitted Surface Mines	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unpermitted Deep Mines	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Permitted Surface Mines	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Permitted Deep Mines	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
General Point Sources	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NPS Load per watershed (kg/day)	**74**	**27**	**-**	**35**	**12**	**-**	**203**	**-**	**2,769**	**10,151**	**419**	**816**	**98**	**13023**	**239**	**20398**
Total NPS load (kg/day)	**48,264**															

Appendix N. TMDL scenario using TSS loading output from the WARMF model during the 1997-2003 for nonpoint sources (non- MS4, "Hickory Urbanized Area" and non permitted loading within the Lower Creek watershed) area identified by landuse within each subwatershed..

NPS Allocation - Load kg/year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Managed Flow	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Groundwater Pumping	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Deciduous Forest	0.12	0.12	0.00	0.16	0.05	0.00	11.68	0.00	1.94	13.06	19.17	7.72	1.00	5.47	5.96	0.00
Evergreen Forest	0.05	0.04	0.00	0.06	0.02	0.00	5.38	0.00	1.57	7.61	16.10	10.61	1.36	4.84	7.96	0.01
Mixed Forest	0.04	0.05	0.00	0.10	0.04	0.00	7.49	0.00	1.30	6.69	14.48	11.17	1.17	4.46	7.75	0.00
Pasture	1.09	0.15	0.00	0.10	0.18	0.00	3.39	0.00	2.60	13.75	16.18	7.28	2.18	3.55	4.98	0.00
Cultivated	1.14	0.28	0.00	0.70	0.18	0.00	10.31	0.00	2.87	13.59	16.48	9.15	4.57	5.77	8.97	0.00
Recr. Grasses	0.01	0.00	0.00	0.01	0.01	0.00	0.23	0.00	0.22	0.00	0.00	0.00	0.13	0.27	0.08	0.00
Water	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Barren	0.04	0.01	0.00	0.07	0.01	0.00	0.73	0.00	0.42	0.57	0.63	0.53	0.46	0.20	0.29	0.00
Low Int. Develop.	2.79	1.15	0.00	1.39	1.22	0.00	4.81	0.00	1.66	4.11	10.57	0.30	6.55	4.23	6.95	0.00
High Int. Develop.	0.07	0.17	0.00	0.17	0.98	0.00	0.84	0.00	0.00	0.34	0.48	0.05	0.08	0.23	0.10	0.00
Comm / Industrial	6.56	0.17	0.00	1.15	0.49	0.00	1.00	0.00	0.47	1.92	1.64	0.00	0.86	1.28	1.96	0.00
Wetlands	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
General Nonpoint Sources	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Stream Bank Erosion	8.67	5.40	0.00	5.78	0.07	0.00	10.85	0.00	761.55	2778.84	21.34	182.00	9.23	3624	22.00	5734
Direct Precipitation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Direct Dry Deposition	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Type 1 Septic System	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Type 2 Septic System	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Type 3 Septic System	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unpermitted Surface Mines	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unpermitted Deep Mines	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Permitted Surface Mines	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Permitted Deep Mines	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
General Point Sources	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NPS Load per watershed (kg/day)	**21**	**8**	**-**	**10**	**3**	**-**	**57**	**-**	**775**	**2,840**	**117**	**229**	**28**	**3655**	**67**	**5734**
Total NPS load (kg/day)	**13,542**															

Appendix O. Public Notification of Public Review Draft of Lower Creek Turbidity TMDL .

Lower Creek, Catawba River Basin

Now Available Upon Request

Lower Creek Turbidity Total Maximum Daily Load

Is now available upon request from the North Carolina Division of Water Quality. This TMDL study was prepared as a requirement of the Federal Water Pollution Control Act, Section 303(d). The study identifies the sources of pollution, determines allowable loads to the surface waters, and suggests allocations for turbidity

TO OBTAIN A FREE COPY OF THE TMDL REPORT:

Please contact Ms. Robin Markham (919) 733-5083, extension 558 or write to:

Ms. Robin Markham
Water Quality Planning Branch
NC Division of Water Quality
1617 Mail Service Center
Raleigh, NC 27699-1617

Interested parties are invited to comment on the draft TMDL study by March 4, 2005. Comments concerning the reports should be directed to Narayan Rajbhandari at the above address. The draft TMDL is also located on the following website: *http://h2o.enr.state.nc.us/tmdl/*

PUBLIC NOTICE
STATE OF NORTH CAROLINA
DIVISION OF WATER QUALITY

Availability of the Total Maximum Daily Load (TMDL) for Turbidity for Lower Creek in North Carolina.

You are requested to review the TMDL and mail your comments to NCDWQ-Planning Branch, attn: Ms. Robin Markham, 1617 Mail Service Center, Raleigh, NC 27699-1617. Copies of the TMDL may be obtained by calling Ms. Robin Markham at (919) 733-5083, ext. 558 or on the internet at http://h2o.enr.state.nc.us/tmdl/. Written comments regarding the TMDL will be accepted until March 11, 2005.

February 10

NORTH CAROLINA,
CALDWELL COUNTY,
AFFIDAVIT OF PUBLICATION

Before the undersigned, a Notary Public of said County and State, duly commissioned, qualified, and authorized by law to administer oaths, personally appeared

Brenda W. Penley

who being first duly sworn, deposes and says: that he is Interim Ad Director of The Lenoir News-Topic, engaged in the publication of a newspaper known as Lenoir News-Topic, published, issued, and entered as second class mail in the City of Lenoir, in said County and State; that he is authorized to make this affidavit and sworn statement; that the notice or other legal advertisement, a true copy of which is attached hereto, was published in Lenoir News-Topic on the following dates:

Feb. 10

and that the said newspaper in which such notice, paper, document, or legal advertisement was published was, at the time of each and every publication, a newspaper meeting all of the requirements and qualifications of Section 1-597 of the General Statutes of North Carolina and was a qualified newspaper within the meaning of Section 1-597 of the General Statutes of North Carolina.

This 10th day of February 2005

Brenda W. Penley

Sworn to and subscribed before me, this 10th day of February 2005

Lane Sains

Notary Public

My Commission expires: ....