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Section 1

Introduction

1.1 Background & Purpose of NCWRP Local Watershed Planning

The NC Wetlands Restoration Program (NCWRP) 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 the **major causes and sources of watershed degradation** (including water quality impairment, aquatic habitat degradation, and flooding problems);
3. prediction of future watershed conditions under **alternative watershed management and land use scenarios**;
4. involvement of **local stakeholder groups** in determining major watershed issues and high-priority focus areas within the watersheds;
5. development of a **consensus-based package of watershed restoration & protection recommendations** to be brought before local decision making bodies, including
 - a. identification of **restoration, enhancement, and preservation opportunities** (project sites with willing landowners) in order to assist the NC Department of Transportation (NCDOT) in meeting future compensatory mitigation needs for stream, riparian buffer and wetland impacts;
 - b. identification of **non-traditional mitigation projects** (e.g., stormwater BMPs, urban retrofits, new/revised ordinances) for targeted sites or sub-watersheds; and
 - c. development of a **long-term follow up strategy** to assist localities in implementation of the specific watershed protection recommendations developed during the planning process.

The NCWRP selected the Clarke Creek and upper Rocky River local watersheds (14-digit Hydrologic Units) as a high-priority area for watershed planning due to three primary factors: (1) documented water quality and 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 and future threats to local watershed health created by agriculture, urban/suburban development, planned highway construction projects, and other possible non-point sources. The specific mitigation project goals for this particular planning effort include the identification of at least 43 acres of suitable wetlands restoration sites and at least 11,000 feet of suitable stream restoration.

The NCWRP Local Watershed Planning (LWP) efforts are moving towards a watershed assessment approach that emphasizes lost or impaired (and restorable) *functions* of key watershed components (streams, riparian buffers, wetlands, and other hydrologic features of the landscape) -- within the context of an integrated ecosystem approach. These functions generally fall into three primary categories: water quality protection; habitat; and floodwater detention. These three functional areas are the focus of watershed assessment and restoration efforts associated with the LWP process.

Whereas the NCWRP has funding to implement specific restoration, enhancement and preservation projects that may receive compensatory mitigation credit, the primary responsibility for watershed solutions that are not traditional mitigation projects (e.g., stormwater management practices) will rest with local governmental entities. As part of the development of Local Watershed Plans, the NCWRP and its consultants have worked with local stakeholder groups to recommend politically and financially feasible watershed solutions, including assistance in identifying possible funding sources for the recommended solutions.

1.2 Major Tasks Conducted by the Watershed Assessment Consultant

The NCWRP retained CDM to conduct a technical assessment of watershed conditions within the LWP Study Area (the Upper Rocky River/Clarke Creek watersheds) and to provide other support services in the development of the final Local Watershed Plan for the study area. CDM's support services to the NCWRP began in December of 2001 and were completed in December of 2003. CDM's primary LWP-related tasks included the following:

1. Compilation and evaluation of all pertinent data and GIS coverages available from federal, state and local agencies and counties/municipalities;
2. Compilation and evaluation of pertinent state and local rules and ordinances related to local watershed protection/restoration (e.g., stormwater management, buffers, zoning, subdivision & site development);
3. Analysis of watershed characteristics, including existing land use and land cover data, and estimation of impervious surface percentages;
4. Screening-level field assessment of stream conditions throughout the watershed, and detailed stream investigations [Rosgen Level II/III] at 30 cross-section sites to provide a framework for future stream restoration;
5. Computer modeling of water quality to estimate nonpoint pollutant loadings and stream erosion potential for existing and future land use scenarios;
6. Identification and analysis of alternative watershed protection measures;
7. Analysis of the costs and benefits of alternative watershed management measures, and recommendation of a comprehensive watershed management plan;

8. Prioritization of capital projects required to implement the recommended watershed management plan;
9. Periodic updates/presentations to the Upper Rocky River/Clarke Creek Local Watershed Planning Group; and
10. Preparation of technical memoranda, GIS map products, and watershed characterization reports.

CDM was supported by Biohabitats, Inc. for the development of the Screening-level field assessment of stream conditions throughout the watershed, and detailed stream investigations [Rosgen Level II/III].

1.3 Purpose of Local Watershed Plan (LWP) Report

The primary purposes of this report are to summarize data collection & analysis conducted so far, to document the key watershed conditions identified to date, and to present recommendations for the Management Plan and Implementation Strategy, including the identification of specific watershed protection and improvement sites. Supporting information used to compile the LWP and develop its recommendations are included in the appendices.

Section 2

Watershed Characterization

2.1 Introduction

This section is intended to summarize the physical, geomorphologic, land use, and demographic characteristics of the two local watersheds. Municipal and county ordinances, watershed infrastructure, and current restoration/preservation efforts were also considered in the Upper Rocky River/Clarke Creek watershed for the purpose of identifying water quality impairments, areas of aquatic habitat degradation, and other significant watershed degradation issues. These characterization data formed the basis for understanding the causes and sources of local watershed degradation, and for recommending the comprehensive strategy for improving overall watershed functioning in these two local watersheds, as discussed in Section 6 of this LWP. An assessment of watershed function included a general analysis of the current (and, to the extent data is available, historical) status of streams, riparian buffers, riparian wetlands, and surrounding land use/land cover conditions within each of the two local watersheds.

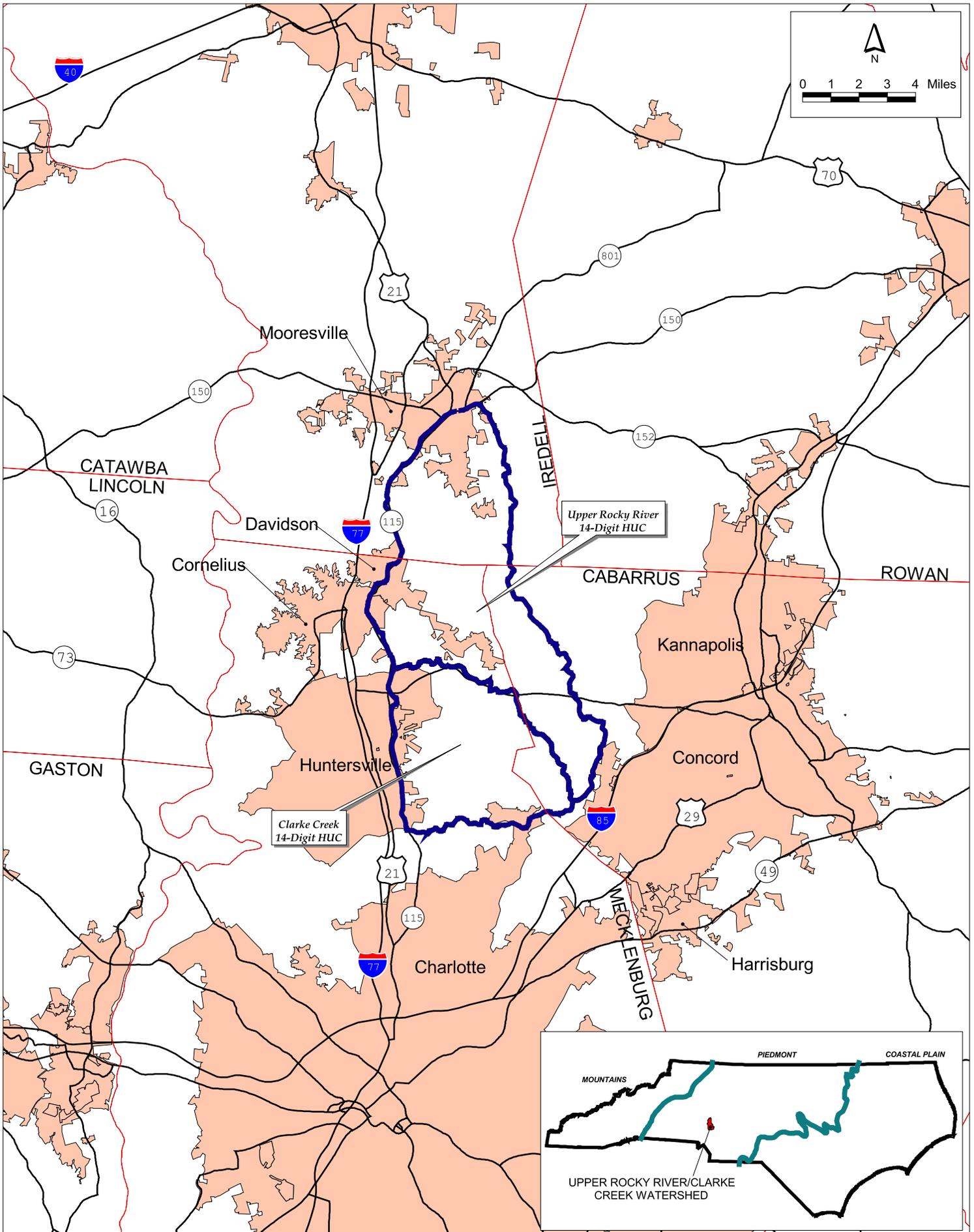
2.2 Description of Study Area

The Upper Rocky River/Clarke Creek watershed consists of two 14-digit Hydrologic Units within the Lower Yadkin River Basin and is located in the southern piedmont region of North Carolina, as shown in **Figure 2-1**. The upper portion of the Rocky River, Hydrologic Unit Code (HUC) 03040105010010, drains approximately 48.5 square miles (31,053 acres) or 63 percent of the entire study watershed. In general, the Upper Rocky River flows in a southeasterly direction until its confluence with Clarke Creek east of state road (SR) 1448 (Cox Mill Road). Clarke Creek, HUC 03040105010020, drains approximately 28.2 square miles (18,054 acres) or 37 percent of the entire study watershed. In general, Clarke Creek flows in an easterly direction until it crosses SR 1449 (Harris Road) at the Cabarrus and Mecklenburg County line, where it dips southward until its confluence with the Upper Rocky River.

Figure 2-2 shows the six major hydrologically-defined subwatersheds comprising the Local Watershed Planning area (ranging in area from approximately 5 to 22 square miles). They are: Clarke Creek, Ramah Creek, Dye Creek, the South Prong of the West Branch of the Rocky River, the West Branch of the Rocky River, and the main stem of the Upper Rocky River. Smaller-scale subwatershed areas of approximately one to three square miles in size will be defined in Section 3 of this LWP for the purposes of watershed modeling and more focused data collection in “pilot areas”.

2.3 Data Collection

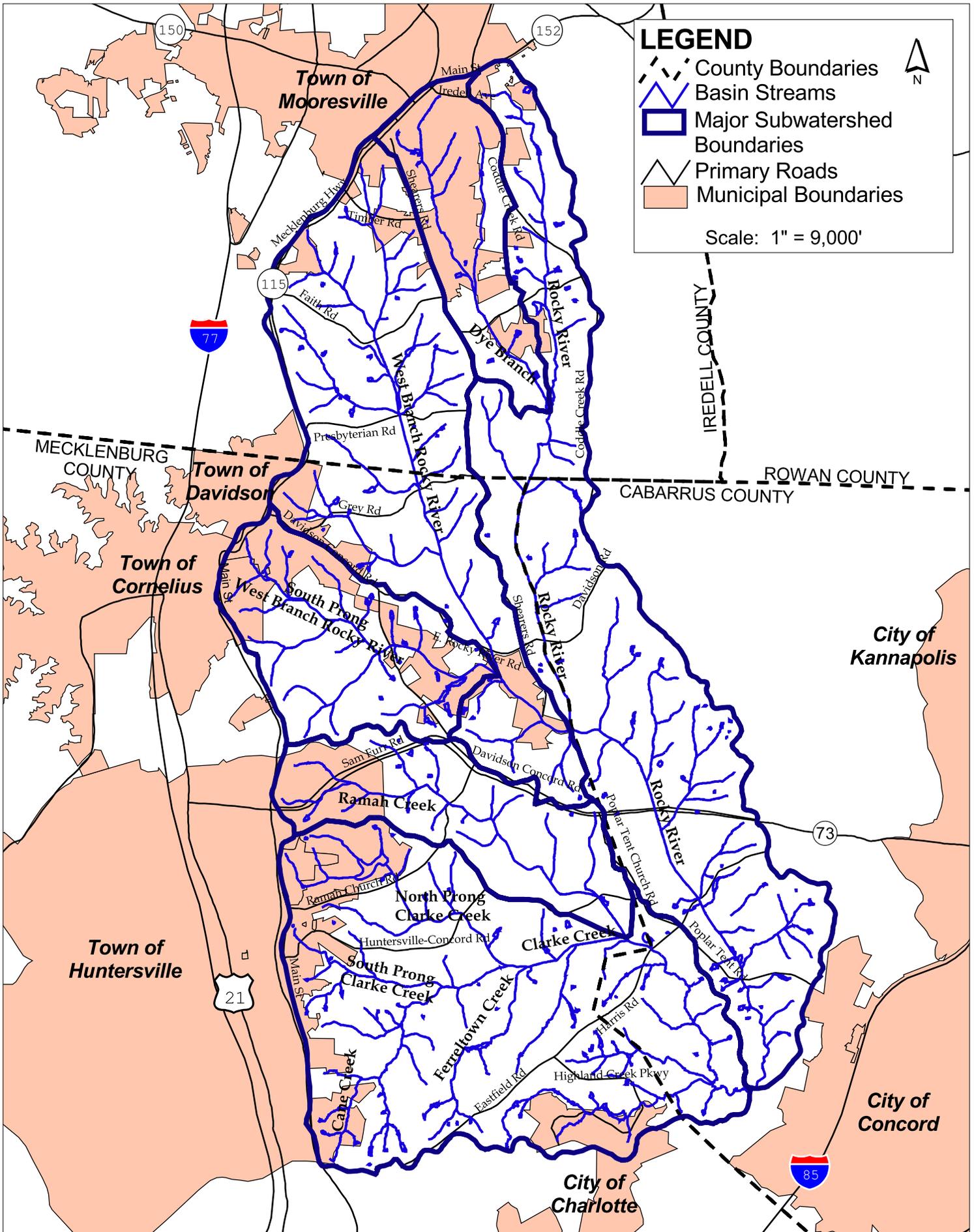
The data collection process was a challenging task due to the constantly evolving local municipal and county ordinances, as well as developing geographic information system (GIS) coverages.



Data Source: NCCGIA 2000 BasinPro

Figure 2-1
 Upper Rocky River/Clarke Creek Local Watershed Plan
 Watershed Regional Location Map





Data Source: NCGIA 2000 BasinPro

Figure 2-2
 Upper Rocky River/Clarke Creek Local Watershed Plan
 Watershed Map with Major Subwatershed Delineations



The data collection phase began in January 2002 when a Request for Information memorandum (provided in Appendix A) was distributed among the members of the Local Watershed Planning Group (LWPG) and continued throughout the project until the end, with the receipt of additional water quality monitoring data. The data collection process included information provided by stakeholders, GIS coverages, windshield surveys, water quality and benthic sampling data from the North Carolina Division of Water Quality (NCDWQ) and the Charlotte-Mecklenburg Land Use and Environmental Services Agency (LUESA), and stormwater and development-related ordinance information provided by members of the LWPG. The following is a description of the major data collection tasks completed for this project.

2.3.1 Stakeholder Input

NCWRP assembled a group of local resource professionals, known as the LWPG, to assist in the development of the LWP. They were utilized as the primary source of data collection due to their extensive knowledge and experience in the watershed. The LWPG is comprised of municipal and county representatives, non-profit agencies, and state agencies that each has a vested interest in the development and implementation of the LWP. A majority of the data was collected through two key sources: (1) the Request for Information memorandum; and (2) LWPG meetings. The following is a brief discussion of each and the associated data collected.

Request for Information Memorandum

In January 2002 a Request for Information memorandum was distributed among the LWPG with the purpose of obtaining information related to water quality, aquatic habitat, land use, hydrology/hydraulics, and local watershed-related ordinances and programs. A majority of the data provided by members of the LWPG in response to the memorandum was associated with land use data in the form of GIS coverages. Data provided included 1999 land use for Mecklenburg County, parcel data for Mecklenburg County, zoning for Cabarrus County, and municipal boundaries for Cabarrus and Mecklenburg Counties. Local ordinance data was also provided, but contained numerous gaps. Additional GIS and local ordinance data gaps were filled through telephone and email correspondence and face-to-face conversations with members of the LWPG as well as representatives of the planning, zoning, land development, stormwater, and GIS departments of the local jurisdictions.

LWPG Meetings

CDM and NCWRP met with members of the LWPG ten times between January 2002 and August 2003 to discuss the progress of work completed and to receive input from the LWPG on information presented at the meeting and to address any of their concerns. Members of the LWPG also provided additional information at the meetings not obtained during the initial data collection phase, including their reactions to information presented by CDM and NCWRP. For instance, during the January 23, 2002 meeting, members of the LWPG were asked to identify portions of the watershed that represent areas that are experiencing or may experience water quality and/or habitat degradation.

Watershed Education for Communities and Local Officials (WECO), a Cooperative Extension Program based at NC State University, began coordinating and facilitating the public involvement portion of the Upper Rocky River Local Watershed Planning process in January, 2003. An outline of the Phase 1 public involvement process from January 2003- August 2003 is provided in Appendix A. Meeting summaries are available on the WECO website at: www.ces.ncsu.edu/WECO/rockriv.html and are also provided in Appendix A of this LWP. Meeting summaries, presentations, hand-outs, and maps were added to the WECO website within 2 weeks following meetings, and the LWPG was provided with the opportunity to review these documents and provide additional feedback directly to CDM, WECO or NCWRP in between meetings.

2.3.2 Geographic Information Survey Coverages

GIS data was used as the primary tool for collecting and evaluating watershed-specific characterization data. Collecting the data proved to be a challenging task due to the considerable difference in the amount and quality of GIS data between jurisdictions. Mecklenburg and Cabarrus counties and the City of Charlotte each have departments dedicated to the development and distribution of GIS data through online services. URL addresses for these department are:

- Mecklenburg County Information Services and Technology Department: <http://www.charmeck.nc.us/Departments/GIS+Application+Development/Home.htm>;
- Cabarrus County GIS Department: <http://166.82.128.222/gis.html>; and
- City of Charlotte GIS Department: <http://www.charmeck.nc.us/Departments/Business+Support+Services/GIS+-+City/Home.htm>.

Iredell County began initializing a GIS database at the time of the start of the project, but very little data had been developed and the coverages that were created had yet to be reviewed for accuracy and completeness. Iredell has since expanded its Mapping Division to include GIS data and has developed numerous coverages that were used in this study. The URL for Iredell County is:

- Iredell County GIS/Mapping Division: <http://www.co.iredell.nc.us/Gismaps.htm>

GIS data was collected not only from local jurisdictions, but also through federal, state, and local agencies including the U.S. Geodata, U.S. Census Bureau, United States Geological Survey (USGS), North Carolina Geographic Information Coordinating Council (NCGICC), North Carolina Center for Geographic Information and Analysis (NCCGIA), NCDOT GIS Distribution Center, GIS Data Depot, Catawba Lands Conservancy, and the North Carolina Natural Heritage Program (NHP). A summary table of all GIS data collected for this study, the date it was obtained, contact information, and a description of the coverage can be found in Appendix A.

2.3.3 Windshield Survey

Several field cruises of the watershed (“windshield surveys”) were conducted for the purpose of identifying watershed-specific data (i.e. new development, BMPs, etc.) that could not be represented through GIS coverages or may have been constructed after the development of the GIS coverage. Examples of the data gathered during the windshield surveys include identifying development not shown on existing land use coverages or aerial photography; changes in hydrology (e.g. recently constructed lakes or significant developments); areas suffering from extensive impacts from heavy sediment loads; jurisdictions currently applying Low Impact Development (LID) design practices; locations where onsite hydrologic controls are being used; poor sediment and erosion control practices; and locations of potential restoration, preservation, and enhancement project sites. This data was used as a verification tool for the water quality modeling and the Subwatershed Ranking Protocol discussed in Section 4.

The windshield surveys were also used to help assess the maturity of residential, commercial, and industrial development for the purpose of linking known stream impairments to increased stream flows and velocities. For example, a mature residential development may have resulted in negative impacts to a downstream channel decades ago, but which has since re-established itself and adjusted to the change in hydrology.

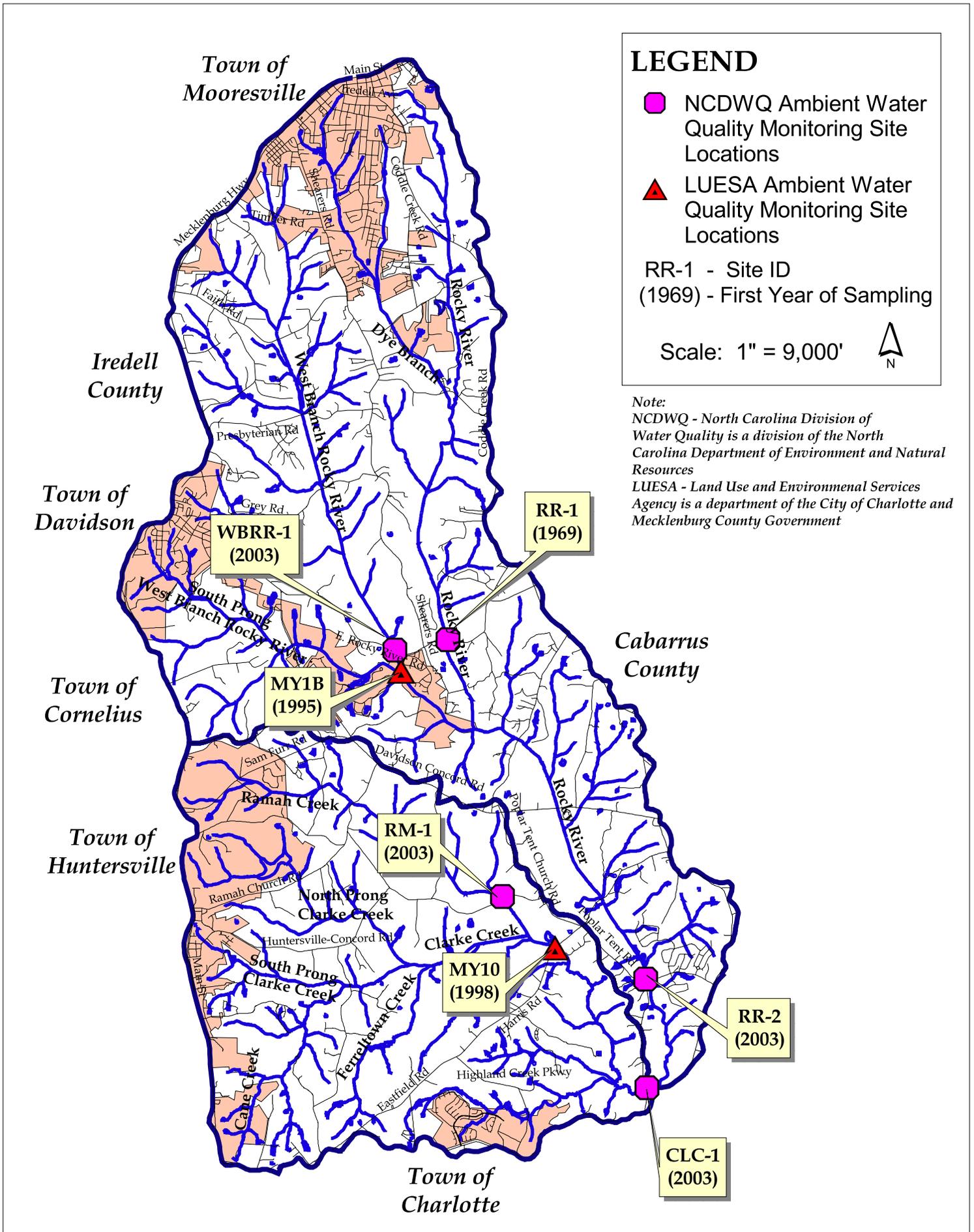
Figure A-1 in Appendix A shows the location of all photographs taken during the windshield surveys and links the identification (ID) numbers shown on the figure to the electronic pictures provided on CD.

2.3.4 Water Quality Monitoring

The NC Division of Water Quality (NCDWQ) and LUESA (formerly the Charlotte-Mecklenburg Environmental Division) have collected water quality monitoring data in the Upper Rocky River/Clarke Creek watershed since 1969 and 1988, respectively. **Figure 2-3** shows the location and date at which monitoring began for each of the water quality monitoring sites. Section 3 of this LWP discusses the trends in water quality observed in the watershed based on the monitoring data. The NCDWQ monitoring data and any North Carolina regulatory limits were plotted for each of the constituents and can be seen in Appendix D.

NCDWQ Monitoring Data

Water quality monitoring data has been collected by NCDWQ at an ambient monitoring station on the Rocky River at SR 2420 (East Rocky River Road) near the Town of Davidson since 1969, as shown on Figure 2-3. The monitoring data was used in the development of the NC Department of Environment and Natural Resources (NCDENR) 1997 Basinwide Water Quality Management Plan for the Yadkin-Pee Dee River Basin and the NCDENR Water Quality 2002 Basinwide Assessment Report on the Yadkin River Basin. The Yadkin-Pee Dee River Basin Association (YPDRBA) also collected water quality data at SR 2420 in support of NCDWQ monitoring. NCDWQ



LEGEND

- NCDWQ Ambient Water Quality Monitoring Site Locations
- ▲ LUESA Ambient Water Quality Monitoring Site Locations

RR-1 - Site ID
(1969) - First Year of Sampling

Scale: 1" = 9,000' ▲
N

Note:
 NCDWQ - North Carolina Division of Water Quality is a division of the North Carolina Department of Environment and Natural Resources
 LUESA - Land Use and Environmental Services Agency is a department of the City of Charlotte and Mecklenburg County Government

Data Source: NCGIA 2000 BasinPro

Figure 2-3
 Upper Rocky River/Clarke Creek Local Watershed Plan
 Water Quality Sampling Location Map



sampled as many as 28 separate constituents at the monitoring site, with numbers of samples collected for each constituent varying from one to 361.

As part of this study NCDWQ is currently collecting water quality data at four additional locations in the Upper Rocky River/Clarke Creek watershed, as shown on Figure 2-3. Sampling began in June 2003 and will include bi-monthly ambient monitoring with occasional storm flow monitoring over a one-year period.

LUESA Monitoring Data

Water quality monitoring data has been and will continue to be collected by LUESA at two locations in the watershed, as shown on Figure 2-3. Monitoring site MY-1B, located on the South Prong West Branch Rocky River at River Ford Road, has been the location of water quality sampling since 1995. Monitoring site MY-10, located on Clarke Creek at SR 1449 (Harris Road), has been the location of water quality sampling since 1988.

2.3.5 Benthic Sampling

NCDWQ and LUESA have also conducted biological monitoring in the Upper Rocky River/Clarke Creek watershed. **Figure 2-4** shows the location and date at which monitoring began for each of the biological monitoring sites. Section 3 of this LWP discusses the results of the biological monitoring and potential causes for reduced benthic macroinvertebrate counts observed in the watershed. The NCDWQ and LUESA monitoring data can be seen in Appendix D.

NCDWQ Monitoring Data

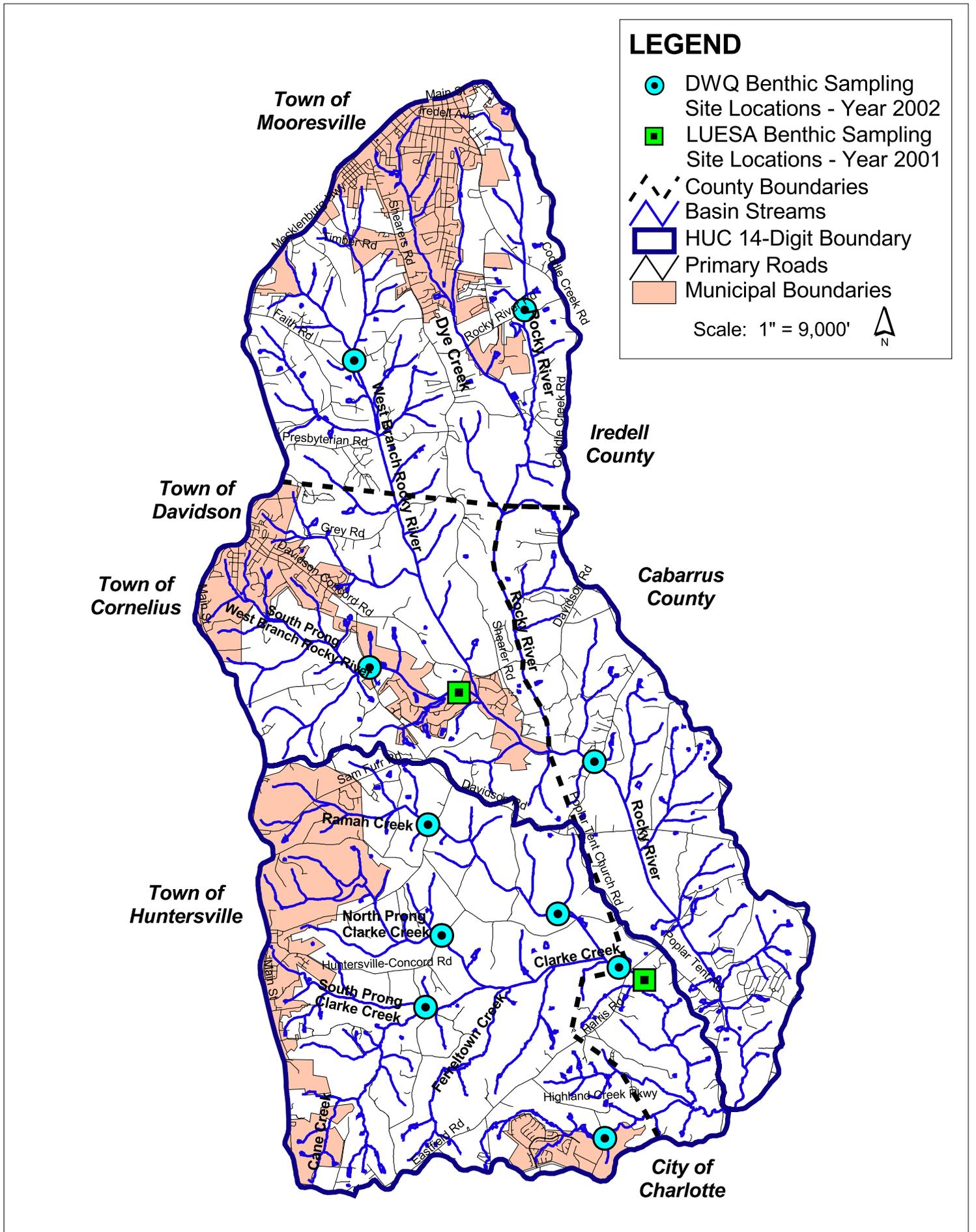
A single benthic macroinvertebrate bioassessment was conducted at ten locations in the Upper Rocky River/Clarke Creek watershed by the Biological Assessment Unit of NCDWQ in May 2002, as shown on Figure 2-4. The monitoring and associated NCDWQ assessment was conducted as part of this study. NCDWQ conducted one previous assessment in June 1985 on the Rocky River in Iredell County, also shown on Figure 2-4.

LUESA Monitoring Data

Fish and benthic macroinvertebrate bioassessment data has been collected annually at up to six different locations in the Upper Rocky River/Clarke Creek watershed, as shown on Figure 2-4, since 1995 using the rapid bioassessment procedures developed by NCDWQ (NCDENR-DWQ, 2001). LUESA conducts the annual assessment as part of their continued countywide water quality evaluation.

2.3.6 Municipal and County Ordinances

A Request for Information memorandum was distributed among the LWPG in an effort to obtain watershed-related information, which included local municipal and county ordinances related to stormwater and development regulations. Considerable data gaps were identified in the information provided by the LWPG and were filled through telephone and email correspondence and face-to-face conversations with



Data Source: NCGIA 2000 BasinPro

Figure 2-4
Upper Rocky River/Clarke Creek Local Watershed Plan
Benthic Sampling Location Map



members of the LWPG as well as representatives of the planning, zoning, land development, and stormwater departments of each jurisdiction. Section 2.7 summarizes the stormwater and development-related ordinances for Cabarrus and Iredell Counties; the Towns of Cornelius, Davidson, Huntersville, and Mooresville; and the City of Charlotte. Local contacts and web links related to the ordinances can be found in Appendix C.

2.3.7 Data Gaps

The data collection process was extended throughout the project due to the continuously evolving local municipal and county ordinances and growing catalog of GIS data. As a result of these changes, a majority of the data gaps associated with GIS and ordinance data were eventually resolved throughout the project.

Mecklenburg and Cabarrus Counties have highly developed GIS departments which made their data readily available for this study. However, Iredell County did not, until recently, have a GIS department or any GIS data. As a result, the portion of the watershed within Iredell County and the Town of Mooresville lacked vital information for completing the GIS analysis described in this LWP. However, a majority of the GIS data required for this study has recently been developed by Iredell County and was integrated into this study at a later date. The major GIS data gaps still outstanding include a soils coverage for Iredell County, detailed water and wastewater distribution systems for the entire watershed, and historic land use for the entire watershed. However, information published by the U.S. Department of Agriculture's Soil Conservation Service (USDA-SCS) and the NCDWQ in the Basinwide Plans provided descriptions of historical land use in the study area.

Keeping up with the evolving stormwater and development-related ordinances for each of the seven jurisdictions proved to be a very challenging task. For instance, since the onset of this study, the Town of Huntersville has adopted a new water quality ordinance and Best Management Practice (BMP) manual and revised their subdivision ordinance; the Town of Davidson is also considering adopting the same water quality ordinance and BMP manual; Cabarrus County has drafted a Unified Development Ordinance (UDO), but has yet to adopt it; Iredell County adopted open space requirements for subdivision development; and the Town of Mooresville is currently re-writing their ordinances to include stormwater runoff and riparian buffer requirements. To date, there are no gaps in local municipal and county ordinance information that CDM is aware of.

2.3.8 Results of the Data Collection Process

The data collection process was challenging due to the constantly evolving local municipal and county ordinances as well as recently developed/improved geographic information survey (GIS) coverages. **Table 2-1** provides a summary of the major subwatershed related characteristics developed from the collected data. The major subwatersheds were delineated based on the following major streams: Clarke Creek, Ramah Creek, Dye Creek, the South Prong of the West Branch of the Rocky

North Carolina Wetlands Restoration Program
Upper Rocky River/Clarke Creek Local Watershed Plan
Table 2-1 - Summary of Watershed Characteristics

Watershed Characteristic	Units	Clarke Creek	Ramah Creek	Dye Creek	South Prong West Branch Rocky River	West Branch Rocky River	Rocky River
Directly Contributing Drainage Area ¹	square-miles	21.6	6.6	5.0	7.1	15.9	20.5
Percent Population Change (1990 - 2000) ²	percent	115%	130%	11%	45%	60%	31%
Stream Length (miles)	1 st order	30.7	8.9	3.9	10.4	22.4	23.4
	2 nd order	12.5	5.5	3.9	4.4	6.9	10.2
	3 rd order	5.6	-	2.0	2.7	6.7	5.6
	4 th order	6.4	-	-	-	3.2	6.3
Percent of Watershed by Municipality	Cabarrus County	16%	< 1%	-	-	< 1%	66%
	Iredell County	-	-	18%	-	41%	18%
	<i>Town of Mooresville</i>	-	-	82%	-	14%	10%
	Mecklenburg County	-	-	-	-	-	-
	<i>Town of Cornelius</i>	-	2%	-	46%	-	-
	<i>Town of Davidson</i>	-	2%	-	54%	45%	6%
	<i>Town of Huntersville</i>	69%	96%	-	< 1%	< 1%	< 1%
	<i>City of Charlotte</i>	15%	-	-	-	-	-
Percent of Watershed by 1999 Land Cover	Single Family Low-Density Residential	9%	34%	4%	15%	8%	3%
	Single Family Medium-Density Residential	2%	3%	1%	-	2%	3%
	Single Family High-Density Residential	7%	6%	-	1%	1%	-
	Rural Agricultural	1%	29%	-	30%	-	41%
	Rural Residential	25%	-	39%	4%	39%	16%
	Industrial/Office/Institutional	2%	1%	1%	3%	2%	2%
	Commercial	-	4%	-	2%	1%	-
	Road	1%	-	3%	-	1%	-
	Multi-Family Residential	-	-	-	-	-	-
	Woods/Brush	54%	-	53%	39%	47%	33%
	Open Space	-	23%	-	6%	-	2%

North Carolina Wetlands Restoration Program
Upper Rocky River/Clarke Creek Local Watershed Plan
Table 2-1 (continued) - Summary of Watershed Characteristics

Watershed Characteristic	Units	Clarke Creek	Ramah Creek	Dye Creek	South Prong West Branch Rocky River	West Branch Rocky River	Rocky River
Future Land Cover (Build-Out Scenario)	Single Family Low-Density Residential	8%	-	2%	1%	14%	4%
	Single Family Medium-Density Residential	70%	53%	87%	10%	30%	47%
	Single Family High-Density Residential	16%	24%	-	67%	-	-
	Rural Agricultural	-	17%	-	18%	-	39%
	Rural Residential	-	-	2%	-	36%	-
	Industrial/Office/ Institutional	-	1%	-	3%	2%	3%
	Commercial	4%	4%	10%	1%	4%	4%
	Road	2%	-	-	-	-	-
	Multi-Family Residential	-	-	-	-	14%	3%
	Woods/Brush	-	-	-	-	-	-
	Open Space	-	-	-	-	-	-
Percent Impervious - Future Land Cover	percent	35%	36%	36%	24%	33%	39%
Water Quality Sampling Data ³		MCDEP	N/A	N/A	N/A	MCDEP	DWQ
Public Land	acres	473	166	1	69	246	80
Natural Heritage Sites ⁴	number	9	-	-	-	3	-
National Wetlands Inventory (Total Area) ⁵	acres	958	256	32	314	306	963
2000 Use Support Part 4 ⁶	-	-	-	-	-	-	9.2 miles of Non-Supporting stream due to Turbidity. Priority-Low

North Carolina Wetlands Restoration Program
Upper Rocky River/Clarke Creek Local Watershed Plan
Table 2-1 (continued) - Summary of Watershed Characteristics

Watershed Characteristic	Units	Clarke Creek	Ramah Creek	Dye Creek	South Prong West Branch Rocky River	West Branch Rocky River	Rocky River
2000 Use Support Part 5 ⁷	-	5.4 miles Not- Evaluated. Priority-Low	-	5.1 miles of Partially & Non- Supporting stream due to Sediment. Priority-Low	-	-	9.2 miles of Non- Supporting stream due to Sediment. Priority-Low
2002 Draft Use Support: Category 5 (Previously Part 1 of the 2000 Use Support) ⁸	-	-	-	-	-	-	Draft TMDL for Fecal Coliform completed 5/02
2002 Draft Use Support: Category 4b (Previously Part 3 of the 2000 Use Support) ⁹	-	-	-	-	-	-	9.2 miles of overall impaired stream due to Turbidity. Priority- Low.
2002 Draft Use Support: Category 6 (Previously Part 5 of the 2000 Use Support) ¹⁰	-	5.4 miles Not- Evaluated. Priority-Low	-	5.1 miles of Partially & Non- Supporting stream due to Sediment. Priority-Low	-	-	9.2 miles of Non- Supporting stream due to Sediment. Priority-Low

North Carolina Wetlands Restoration Program
Upper Rocky River/Clarke Creek Local Watershed Plan
Table 2-1 (continued) - Summary of Watershed Characteristics

Notes:

- 1.) *Directly Contributing Drainage Area represents the area whose runoff flows directly to the stream (e.g. Dye Creek flows into Rocky River, but the Dye Creek drainage area was not accounted for in the above calculated Rocky River drainage area) See Figure 2-2*
- 2.) *Population data obtained from U.S. Census Bureau*
- 3.) *Water quality sampling data was collected by the identified agencies: MCDEP - Mecklenburg County Department of Environmental Protection, DWQ - North Carolina Department of Environment and Natural Resources Division of Water Quality*
- 4.) *Data obtained from North Carolina Natural Heritage Program*
- 5.) *Wetlands Data provided by the National Wetlands Inventory for Iredell, Cabarrus, and Mecklenburg Counties*
- 6.) *The Division of Water Quality identifies waters within Part 4 of the 2000 303d List as "Regulatory controls other than TMDLs expected to result in meeting standards by next listing."*
- 7.) *The Division of Water Quality identifies waters within Part 5 of the 2000 303d List as "Biologically impaired waters. Pollution/pollutant monitoring will place waters on Part 1 or Part 2."*
- 8.) *The Division of Water Quality identifies waters within Category 5 (Previously Part 1 of the 2000 303d List) as waters for which TMDLs are required.*
- 9.) *The Division of Water Quality identifies waters within Category 4b (Previously Part 4 of the 2000 Use Support) as waters for which "Regulatory controls other than TMDLs expected to result in meeting standards by next listing."*
- 10.) *The Division of Water Quality identifies waters within Category 6 (Previously Part 5 of the 2000 Use Support) as "Biologically impaired waters. Pollution/pollutant monitoring will place waters on Category 1 or Category 2."*

River, the West Branch of the Rocky River, and the main stem of the Upper Rocky River.

2.4 Physical Characteristics

The Upper Rocky River/Clarke Creek watershed is comprised of two 14-digit HU's and drains approximately 76.7 square miles (49,107 acres) of predominately residential, agricultural, and forested land use. The following is a description of the key watershed physical characteristics including hydrology, soils, geology, topography, and climate.

2.4.1 Basin Hydrology

The Upper Rocky River/Clarke Creek watershed consists of approximately 182 miles of first through fourth order streams. **Figure 2-5** shows the stream distribution and differentiates between the various stream orders with an attached table summarizing the stream lengths associated with each stream order. There are several named tributaries in the watershed including Ramah, Cane, and Ferreltown Creeks, which drain into Clarke Creek, and Dye Creek which flows southwardly from the Town of Mooresville until its confluence with the Rocky River.

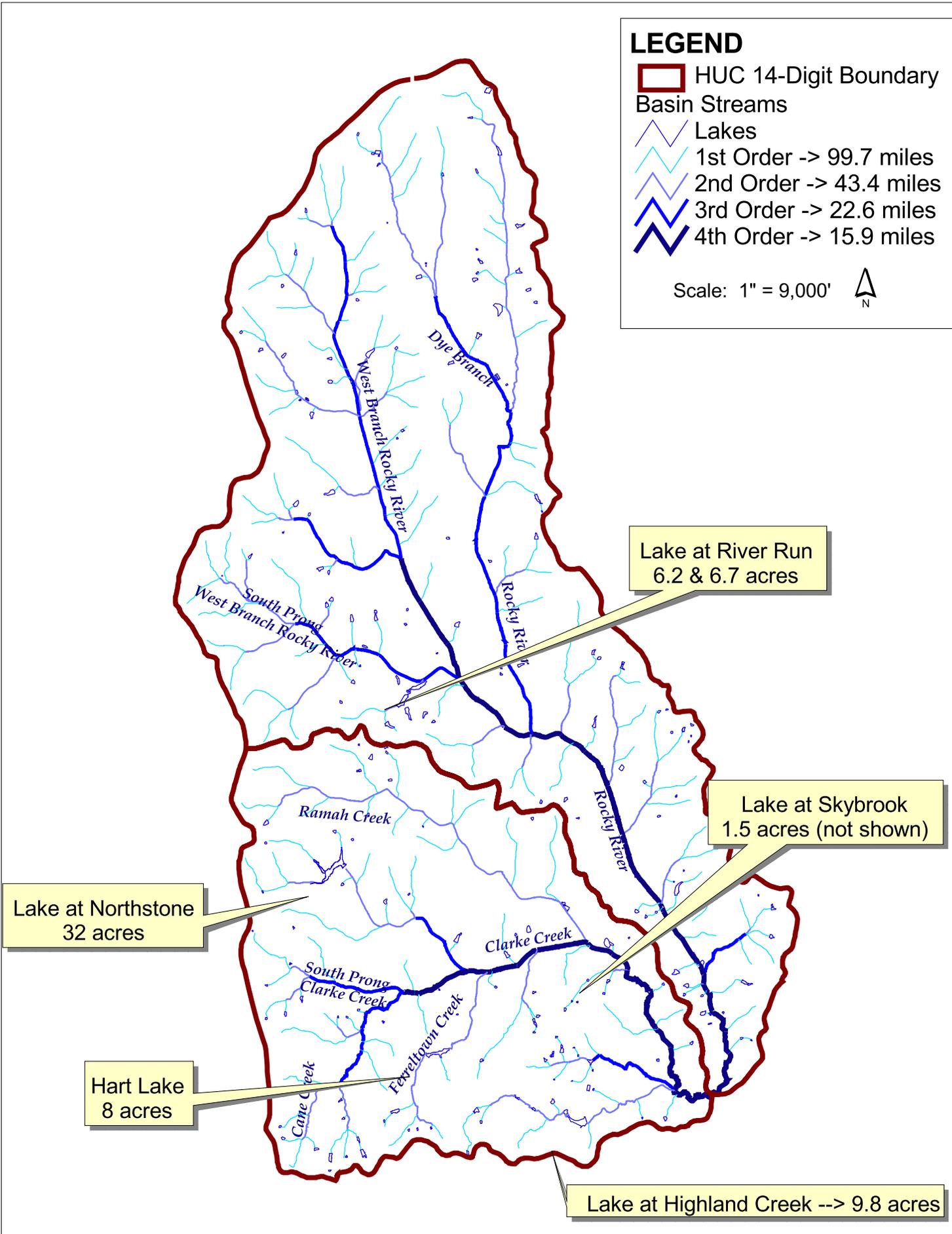
Based on field observations, many of the channels appear to have adjusted or are actively adjusting vertically. This is particularly evident along the mainstem channels; most have adjusted vertically and many appear to still be actively adjusting as a response to land use by dropping in channel bed elevation – a process known as channel incision. This leads to a disassociation of the active channel from the floodplain. A lowering of the bed elevations in the tributaries occurs as an increase in slope condition develops in the vicinity of the confluence of a tributary with an incised mainstem. A steep drop then forms at the confluence as the mainstem bed elevation drops, creating a very steep local slope condition (head-cut). Overtime the head-cut migrates upstream through the tributary until a more stable slope condition is met or an impediment, such as a culvert at a road crossing, prevents further headward migration. The accelerated channel incision contributes significant sediment yield to the downstream areas, leads to vertical containment of flood flows, and typically results in lateral scour and bank erosion, all in an effort to establish a new floodplain at this new lower channel elevation.

There are numerous small lakes and farm ponds located at the headwaters of first order streams. These lakes and ponds help to control downstream hydrology, but are not flood control structures and most likely would not meet NC Dam Safety requirements. The largest lakes in the watershed are manmade ones associated with golf course communities. A 9.8-acre is lake located in the Highland Creek Subdivision in the City of Charlotte and receives runoff from approximately 1,100 acres of dense residential and golf course development. An approximately 32-acre lake is located in the Northstone Subdivision in the Town of Huntersville and receives runoff from approximately 940 acres of predominately dense residential and golf

LEGEND

- HUC 14-Digit Boundary
- Basin Streams
- ~ Lakes
- ~ 1st Order -> 99.7 miles
- ~ 2nd Order -> 43.4 miles
- ~ 3rd Order -> 22.6 miles
- ~ 4th Order -> 15.9 miles

Scale: 1" = 9,000' N
↑



Data Source: NCGIA 2000 BasinPro

Figure 2-5
Upper Rocky River/Clarke Creek Local Watershed Plan
Stream Order Distribution and Primary Lake Locations



course development. There are two lakes in series located in the River Run Subdivision in the Town of Davidson. The 6.2- and 6.7-acre lakes receive runoff from approximately 510 acres of residential and golf course development. A 1.5-acre lake is located in the Skybrook Subdivision in the Town of Huntersville and receives runoff from approximately 10 acres of dense residential and golf course development. There is also an existing lake with a surface area of approximately 8 acres owned by Carolyn Hart in the Town of Huntersville. According to members of the LWPG, the dam is constructed of thousands of tires and receives runoff from approximately 800 acres of forest and rural residential development. Figure 2-5, mentioned above, shows the locations of the primary lakes discussed above.

2.4.2 Basin Soils

Soils within the Upper Rocky River/Clarke Creek watershed are comprised of a mixture of Hydrologic Soil Groups B and C, as defined by the USDA-SCS. They have low to moderate infiltration rates and fine to moderately coarse soil textures. Water transmission rates range from 0.15 to 0.30 inches per hour. [Transmission is the rate at which water moves through soil].

There is considerable variability in soil types along the headwater channels. Monacan (Mo) series soils are found along most of the majority of the mainstem channels throughout the study area including the West Branch Rocky River, South Prong West Branch Rocky River, Ramah Creek, and Clarke Creek. The Monacan series is a loam consisting of poorly drained and moderately permeable soils. These soils are formed in recent alluvium adjacent to stream on floodplains. Slopes range from zero to two percent. Depth to bedrock is typically more than 60 inches.

Chewacla (Ch) series soils are found along much of the lower portion of the mainstem of the Rocky River and the lower portion of Clarke Creek. The Chewacla series is a sandy loam formed in recent alluvium in lowland areas that are frequently flooded. Slopes range from zero to two percent. Typically, depth to bedrock range from five feet to more than ten feet. Wehadkee (We) series is found at the southernmost portion of the Rocky River. The Wehadkee series is formed in alluvium in the lowland areas of stream floodplains that are frequently flooded. Slopes are from zero to two percent.

The erosion hazard indices were measured for each of the soil types using the USDA-SCS Soil Surveys for Cabarrus, Iredell, and Mecklenburg Counties. The erosion hazard indices indicate the risk of loss of soil in well-managed woodlands. The indices were grouped into one of three categories including slight, moderate, and severe. Slight indicates that expected soil loss is low. Moderate indicates some measures are needed to control erosion during logging and road construction. Severe indicates intensive management or special equipment and methods are needed to prevent excessive loss of soil. Based on the results of the SCS soil surveys it was determined that a majority of the soils bordering second order streams and above have moderate erosion hazard indices. The width of the moderate erosion hazard

soils varied along streams. The Clarke Creek watershed showed a greater prevalence of moderate erosion hazard soils than the Upper Rocky River watershed. There were scattered locations of severe erosion hazard soils within the entire Upper Rocky River watershed. In general, development along streams within the watershed can be assumed to occur on moderately erodible soils. (USDA-SCS 1964, 1980, and 1988).

2.4.3 Basin Geology

The watershed is located in the Piedmont Physiographic Province of North Carolina and is characterized by gentle to steep, hilly terrain ranging in elevation from 600 to 900 feet above mean sea level. Based on the *Geologic Map of the Charlotte 1 and 2 Quadrangles* (Goldsmith, 1988) bedrock outcroppings occur by regolith [*regolith is the layer of soil and weathered rock above bedrock*], which consists of soil and saprolite. Saprolite is a clay-rich residual material that is the product of in-place chemical weathering and leaching of bedrock. Saprolite is often characterized by bright colors, preserved structures, and mineral fabric present in the rock before weathering. Soil is present as a thin mantle on top of saprolite or alluvium with a thickness usually on the order of 3 to 8 feet. Beneath the saprolite is a transition zone of weathered bedrock. The thickness of regolith above un-weathered bedrock averages about 52 feet, and in some cases may exceed depths of 100 feet (Goldsmith, 1988).

A majority of the watershed is within the Charlotte belt of the Piedmont Physiographic Province and is generally characterized by large areas of plutonic and metavolcanic igneous rocks, with very few metasedimentary rocks. Igneous lithologies range from ultramafic to felsic, and from coarse-grained plutonic rocks to very fine-grained tuffs and volcanic flow materials. The age of rocks ranges from 700 to less than 300 million years. Rock units mapped in the vicinity of the site include granite of the Salisbury Plutonic Suite, phyllite and schist, metavolcanic rocks, and metamorphosed quartz diorite and tonalite. Several diabase intrusives have also been mapped in an area west of the site (Goldsmith, 1988).

2.4.4 Topography

The topography throughout the watershed varies with the overall change in elevation from 900 feet above sea level in the upper portion of the Rocky River to 600 feet above sea level at the confluence of the Rocky River and Clarke Creek. The relatively gentle topography, particularly in the low-lying valleys along the mainstem channels, has historically promoted extensive agricultural activity. Clarke Creek in the southern portion of the watershed has the steepest slope conditions in the study area. This is particularly evident along the tributaries on the south side of the Clarke Creek mainstem while the topography along the mainstem has broader valley conditions.

2.4.5 Basin Climate

North Carolina lies within a warm temperate zone and generally has a mild, uniform climate compared to other continental locations farther inland at the same latitude. This topographical variety, along with the presence of the Gulf Stream off the coast,

gives North Carolina the largest climate variability of any state east of the Mississippi. Winters are rarely extremely cold; however, summers can be somewhat hot. North Carolina has an abundant and well-distributed rainfall. The greatest rainfall intensities are confined to summer and early fall months, the season for severe hurricanes and severe thunderstorms. Average annual rainfall for the Piedmont region ranges from 44 to 50 inches per year. Average annual temperature for the central region is 60° F (16° C) (NOAA and State Climate Office, 2002).

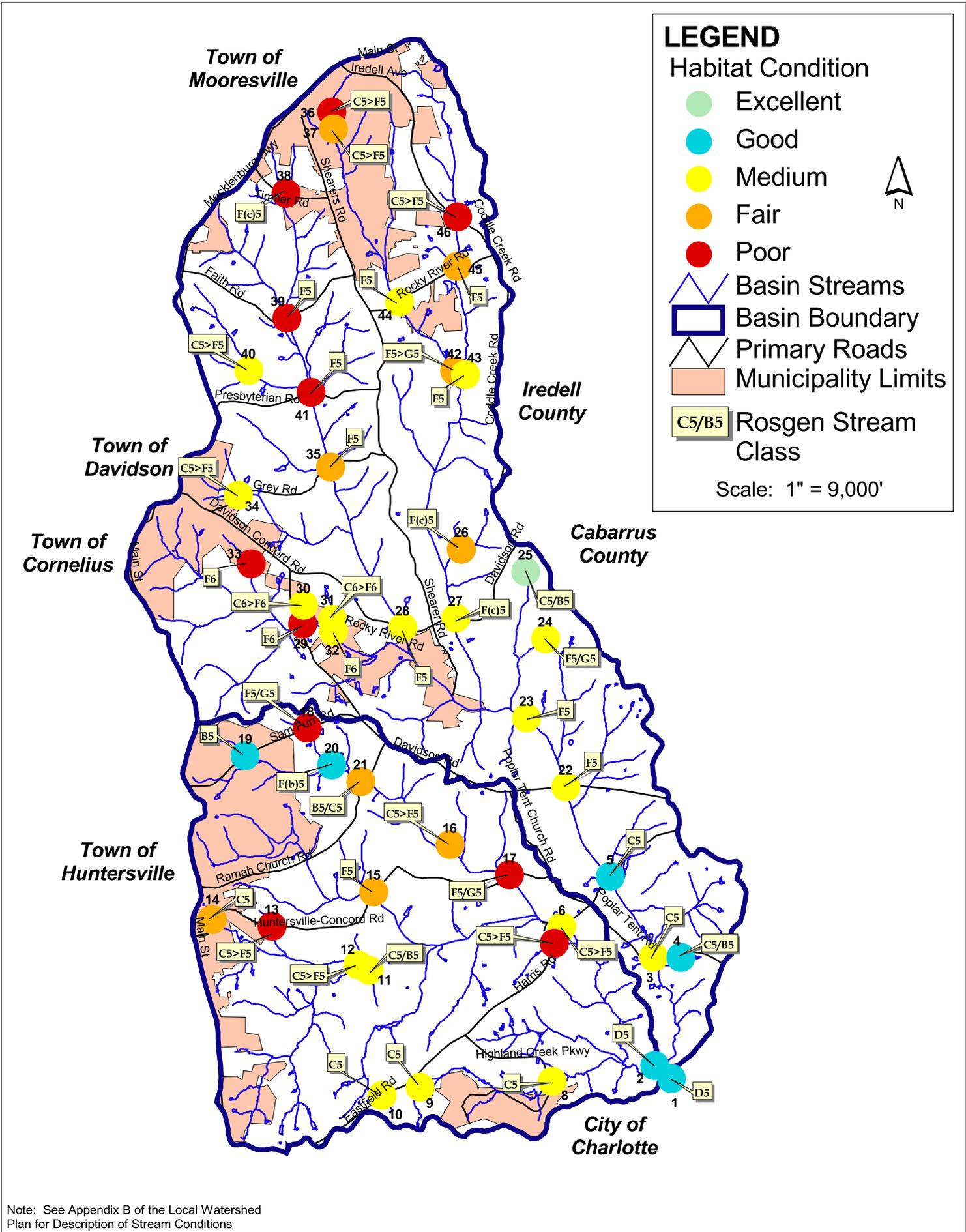
2.5 Geomorphologic Overview

Two tiers of stream channel assessment were conducted within the Upper Rocky River/Clarke Creek watershed. A Rosgen Level I Rapid Stream Reach Assessment and a modified Rosgen Level II and III geomorphic characterization were performed for the purpose of assisting in the hydrologic modeling, characterization of the drainage network, identifying possible causes of stream channel impairment, and providing a preliminary prioritizing of stream reaches that are potential restoration candidates.

2.5.1 Rosgen Level I Rapid Stream Reach Assessment

The rapid stream reach assessment was based on physical data including aerial photography, GIS topographic data, and limited field reconnaissance. The field work was conducted on April 9th and 10th, 2002 and involved a watershed-wide assessment of existing stream channel and riparian buffer conditions. This approach simply involved a visual assessment of conditions at easily-accessed locations spanning the entire watershed. Streams were accessed at 46 individual road crossings, as shown in **Figure 2-6**. Field crews recorded observations at each stream site that included a visual estimate of channel width and depth; stream bed and bank condition (erosion and sedimentation); predominant bed material; condition of the riparian buffer including vegetation and adjacent land use; and potential for restoration or use as a reference reach. No actual physical measurements were taken for this initial assessment phase. Results of the Rosgen Level I rapid stream reach assessment can be found on the CD included in Appendix B.

Table 2-2 summarizes the data collected from each of the 46 stream observation points. The Rosgen Stream Type, column four of the table, shows the Rosgen Stream Classification type assigned to each of the 46 observation sites based on visual estimates of physical dimensions recorded in the field as well as best professional judgment (see Appendix B for the qualitative definitions of each stream classification type). These field observations found that many channels in the watershed have been impacted and are in the process of actively adjusting by widening and/or deepening. Therefore, many of the channels do not necessarily follow all the parameters of a specific Rosgen stream type. In cases where it was difficult to estimate certain dimensions, such as floodprone area, slope, or where the original sinuosity was thought to be disturbed, the channel classification was designated in the table as an “either/or”, such as a “F/C”. In the rankings, most of the adjusting channels were



Note: See Appendix B of the Local Watershed Plan for Description of Stream Conditions

Data Source: NCGIA 2000 BasinPro

Figure 2-6
 Upper Rocky River/Clarke Creek Local Watershed Plan
 Rosgen Level I Habitat Scores



North Carolina Wetlands Restoration Program
Upper Rocky River/Clarke Creek Local Watershed Plan
Table 2-2 - Rosgen Level I Rapid Stream Reach Assessment - Summary of Results

Site #	Stream Name	Location	Rosgen Stream Type	Estimated Channel Dimensions W- at top of bank D- TOB to Bed	Predominant Bed Materials	General Condition & Habitat Value	Surrounding Land Use	Restoration Potential (US = Upstream DS = Downstream)
1	Trib to Rocky River	Derita Rd	F5	W 8'-10' D 6'-8'	sand/silt 15% gravel	Good	Forest	None - woody buffer gives moderate protection & stability
2	Clarke Creek	Cox Mill Rd	D5	W 20'-40' main channel W 250' braided channel	sand/silt	Good-Exc.	Pasture	None - braided channel, beaver dam, wetlands
3	Rocky River	Cox Mill Rd & Poplar Tent Rd	C5	W 30' D 5'-8'	sand/silt	Medium	Pasture	None - too large, relatively stable channel
4	Trib to Rocky River	Scalybark Rd	C5/B5	W 3'-4' D 1'-3'	sand/silt	Good	Dense Residential	None - extensive woody buffer, banks well vegetated
5	Trib to Rocky River	Harris Rd	C5	W 6'-8' D 4'-6'	sand/silt	Good	Forest	None - flows thru mature forest
6	Clarke Creek	Harris Rd	C5>F5	W 4'-6' D 3'-4'	sand/silt 5% gravel	Medium	Pasture	None - stable banks densely vegetated with grasses, mature trees in immediate riparian zone
7	Trib to Clarke Creek	Harris Rd	C5>F5	W 6'-10' D 2'-6'	sand/silt 10% gravel	Poor	Pasture	High - unstable sloughing banks impacted by cattle, meander pattern unstable
8	Trib to Highland Creek/Clarke Creek	Highland Creek Rd	C5	W 4'-5' D 2'-3'	sand/silt 15% cobble/ gravel 1% small boulder	Medium	Golf Course	None - During construction of golf course & subdivision, banks were planted in grass, stabilized in places by large boulders, some forested buffers remain. This is typical of all streams located in the Highland Creek subdivision.
9	Trib to Highland Creek/Clarke Creek	Prosperity Church Rd	C5	backwater of farm pond/ beaver dam wetlands	sand/silt	Medium	Field - agricultural	None - small beaver dam with adjacent wetlands
10	Trib to Clarke Creek	Eastfield Rd	C5	W 10'-15' D 6'-8'	sand/silt	Medium	US: Sparse Residential & new construction adjacent to stream DS: Mature Forest	US: Low to Moderate - reach may be too short DS: None - mature forested buffer
11	Trib to Clarke Creek	Autumncrest Rd	C5/B5	US W 2'-3' US D 1.5'-2' DS W 4'-8' DS D 5'-6'	sand/silt 5% gravel	US: Good DS: Poor	Sparse Residential	US: None - forested DS: High - vertical eroding banks w/sloughing
12	Clarke Creek	Asbury Chapel Rd	C5>F5	W 20'-30' D 8'-10'	sand/silt 10% gravel	Medium	Sparse Residential	Low - large 3rd order stream, forested on one side
13	Trib to Clarke Creek	Huntersville-Concord Rd	C5>F5	W 5'-8' D 3'-4'	sand/silt	Fair to Poor	Sparse Residential	US: Moderate - wide woody/shrubby buffer provides some protection DS: High - no woody buffer, riprap, flows thru pasture
14	headwater trib of Clarke Creek	Huntersville-Concord Rd	C5	W 2' D 1'	sand/silt	Fair	Dense Residential - urban neighborhood	Low - very small channel; restoration would consist mainly of invasive species control & replanting of buffer
15	North Prong of Clarke Creek	Huntersville-Concord Rd	F5	W 15'-25' D 10'-15'	sand/silt 5% gravel/cobble	Fair	Forest, Crop land, Pasture	Low to Moderate - deeply incised but banks well-vegetated & sparse to dense woody buffer
16	Ramah Creek	McCauley Rd/SR 2425	C5>F5	US W 10'-12' US D 3'-4' DS W 15'-20' DS D 10'-12'	sand/silt	Fair	US: Forest DS: Pasture	US: None - forested - sign on bridge says "Watershed Protection Funded by NC Clean Water Management Trust Fund" DS: High - deeply incised, sloughing banks
17	Ramah Creek	Huntersville-Concord Rd	F5/G5	W 12'-15' D 15'-20'	sand/silt	Poor	Fields - plus commercial buildings & parking lot in one DS quadrant	High - extremely incised, straightened channel; extensive invasives & early successional woodies; beaver pond wetland adjacent to channel

**North Carolina Wetlands Restoration Program
Upper Rocky River/Clarke Creek Local Watershed Plan
Table 2-2 (continued) - Rosgen Level I Rapid Stream Reach Assessment - Summary of Results**

Site #	Stream Name	Location	Rosgen Stream Type	Estimated Channel Dimensions W- at top of bank D- TOB to Bed	Predominant Bed Materials	General Condition & Habitat Value	Surrounding Land Use	Restoration Potential (US = Upstream DS = Downstream)
18	Trib to Ramah Creek	Sam Furr Rd/Hwy 73 (3rd trib east of Old Statesville Rd/Hwy 21; just west of SR 2428)	F5/G5	W 12'-18' D 10'-15'	sand/silt	Poor	Pasture	High - severe bank erosion, channelized, riprap
19	Trib to Ramah Creek	Sam Furr Rd/Hwy 73 (2nd trib east of Old Statesville Rd/Hwy 21)	B5	W 2'-3' D 1'-2'	sand/silt	Good to Excellent	Forest	None - possibly could serve as a Reference Reach
20	Ramah Creek	Black Farm Rd	F(b)5	W 25'-30' D 15'-18'	sand/silt 5% cobble/small boulder	Good	Forest	None - 4th order; large influx of sand but channel appears relatively stable
21	Ramah Creek	Ramah Church Rd	B5/C5	W 15'-20' D 8'-10'	sand/silt	Fair	Forest	Low to Moderate - steep eroded banks but forest buffer, possible stream bank stabilization
22	Rocky River	Davidson Concord Rd	F5	W 50'-60'	sand/silt 15% gravel/cobble 5% sm-lg boulder	Medium	Forest w/new subdivision under construction within 1/8 mile	None - large high order stream, mainstem Rocky River
23	Rocky River	Shiloh Church Rd/ Stanley McElreath Rd	F5	W 40'-50' D 15'-20'	sand/silt	Medium	Forest with sewer line adjacent to channel	None - large high order stream, mainstem Rocky River; banks at 45 degrees and well vegetated
24	Trib to Rocky River	Kingsview Rd	F5/G5	W 10'-15' D 8'-12'	silt/sand/clay 20% gravel 10% cobble	Medium to Fair in upper reach; Poor in lower reach	Upper Reach: New subdivision on left bank, mature forest on right bank; Lower Reach: -New subdivision on left bank, old field on right bank	Excellent on lower reach at end of Kingsview Rd & by old field
25	Trib to Rocky River	Sudbury Rd	C5/B5	W 3'-4' D 1'-2'	sand/silt	Excellent	Forest	None - in excellent condition but channel probably too small for use as a Reference Reach
26	Trib to Rocky River	Terrel Ridge Dr	F(c)5	W 25'-30' D 8'-10'	sand/silt 20% gravel/cobble	Fair	Dense Residential - suburban upscale neighborhood	Low to None - forested buffer in many areas, too close to houses
27	Rocky River	Davidson Rd at county line	F(c)5	W 80'-100' D 10'-15'	sand/silt	Medium	Forest & New Residential	None - large high order stream, mainstem Rocky River
28	West Branch	Davidson Rd/Rocky River Rd (west of Shearer Rd)	F5	W 50'-60' D 15'-20'	sand/silt	Medium	Forest	None - many mature trees in buffer, banks well vegetated
29	South Prong	Davidson Concord Rd	F6	W 15'-20' D 8'-10'	silt/sand 5% gravel	Poor	US: Forest-many invasives DS: Crop land	US: High - straightened channel w/poor quality, narrow buffer- potential wetland restoration ~ 20 ac. DS: Low - forested & not as badly degraded
30	Trib to South Prong	Robert Walker Rd (closest to entrance of subdivision)	C6>F6	W 15'-18' D 6'-8'	silt/sand	Medium	US: Forest (except for ~125' closest to road crossing) DS: Dense Residential - upscale golf community	None - US: impacted reach is stable & only 125' in length DS: banks are stable & well vegetated, straightened channel too close to houses to increase sinuosity via restoration
31	Trib to South Prong	Robert Walker Rd (in same subdivision as #30 & #32)	C6>F6	W 15'-18' D 6'-8'	silt/sand	Medium	Dense Residential & Golf Course	Low - poor habitat value but banks are grassed so erosion potential is low, channel is semi-landscaped thru golf course
32	South Prong	River Crossing Rd (in same subdivision as #30 & #31)	F6	W 10'-12' D 6'-8'	silt/sand	Medium	Golf Course	Low - poor habitat value but banks are grassed so erosion potential is low, channel is semi-landscaped thru golf course
33	Trib to South Prong	Hudson Rd (at west end at cul de sac)	F6	W 10'-15' D 8'-10'	silt/sand 5% gravel	Poor	US: Dense Residential DS: Forest	US: None - too close to houses DS: Low to Moderate - channel is highly degraded but flows thru extensive mature forest, many invasives in floodplain
34	Trib to South Prong	Grey Rd	C5>F5	W 5'-6' D 3'-5'	sand/silt	Medium	Forest - a sign near stream indicates stream & floodplain are within Davidson College Ecological Preserve	Low to Moderate - flows thru mature forest but is densely overgrown with invasives

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Table 2-2 (continued) - Rosgen Level I Rapid Stream Reach Assessment - Summary of Results

Site #	Stream Name	Location	Rosgen Stream Type	Estimated Channel Dimensions W- at top of bank D- TOB to Bed	Predominant Bed Materials	General Condition & Habitat Value	Surrounding Land Use	Restoration Potential (US = Upstream DS = Downstream)
35	West Branch	Grey Rd	F5	W 20'-25' D 12'-18'	sand	Fair	Pasture	Moderate to Fair - deeply incised but bank well vegetated so erosion potential is not high
36	Dye Creek	Cabarrus Rd (this reach is DS of #37)	C5>F5	US W 15'-25' US D 15'-20' DS W 5'-7' DS D 2'-3'	sand	Poor	US: Dense Residential DS: Turf in urban park	US: High - channel behind houses extremely unstable; eroding far into backyards DS: High - channel thru park has no woody buffer; eroding, unstable banks
37	Dye Creek	East Iredale Rd (this reach is US of #36)	C5>F5	US W 3'-6' US D 3'-4' DS W 10'-15' DS D 6'-8'	sand	Fair to Poor	Flows thru Liberty Park - sparsely wooded/sparse ground layer then flows thru extensive mature forest. After crossing under Center St, it flows thru open disturbed area which is eroding, most woodies gone, many invasives	Moderate in Park Low in wooded area High in open disturbed area
38	West Branch - headwater trib	Timber Rd	F(c)5	W 15'-20' D 10'-12'	sand/silt	Poor	Open - covered with kudzu	None - too small to cause much erosion; transmission line crosses stream
39	West Branch	Faith Rd	F5	W 12'-15' D 10'-12'	sand/silt 10% gravel/cobble	Poor	Pasture	High - steep eroding banks; cattle impact; buffer is mostly grass. Could be potential Wetland Restoration/Creation site
40	West Branch	Midway Lake Rd	C5>F5	W 8'-10' D 3'-6'	sand	Medium to Fair in upper reach; Poor in lower reach	Pasture	Low to Moderate - channel is very small; potential only to plant woody buffer. Could be potential Wetland Restoration/Creation site
41	West Branch	Presbyterian Rd	F5	W 15-20' D 10'-15'	sand	Poor	Pasture	High - steep eroding banks; low sinuosity; narrow woody buffer with invasives
42	Dye Creek (close to confluence with Rocky River)	Johnson Dairy Rd	F5/G5	W 15'-25' D 10'-15'	sand 2% bedrock	Fair	Forest; Field; Planted Pine (adjacent to Rocky River Wastewater Treatment Plant)	Moderate to High - deeply incised; some raw, eroding banks; very poor buffer (transmission line crosses at angle; would need to investigate effects of discharges from wastewater treatment plant on water quality & on channel stability)
43	Rocky River	Johnson Dairy Rd	F5	W 15'-30' D 8'-10'	sand	Medium	Forest - young growth	Low - channel not highly degrade; protected by dense vegetation of regrowth forest
44	Dye Creek	Rocky River Rd	F5	W 20'-30' D 8'-12'	sand	Fair to Medium	Pasture	Moderate to High - straightened channel with vertical banks; narrow woody buffer
45	Rocky River	Rocky River Rd	F5	W 15'-30' D 8'-10'	sand/silt	US: Poor DS: Fair to Medium	Pasture	US: Moderate to High - severe cattle impact to 150' of channel then woody buffer protects it DS: Low - steep banks but good wide woody buffer. Overall not a high priority site.
46	Rocky River	Coddle Creek Rd	C5>F5	W 10'-15' D 6'-8'	sand	Poor	Pasture	High - straightened channel; cattle impact; very sparse woodies in buffer with some bare ground

classified as a “C” evolving to an “F”, signified in the table as “C>F”. Figure 2-6 shows the Rosgen Stream Classification type assigned to each of the 46 observation sites. Precise and accurate Rosgen Stream Classification typing requires actual surveyed field measurements including calibrated estimates of bankfull discharge and channel dimensions; these were not performed area-wide during the rapid stream reach assessment.

The General Condition and Habitat Value parameter was found to be directly related to the physical condition of the stream channel and riparian zone. For example, in many of the channels observed, the streambanks were steep with very little vegetative root mass. The poor soil stabilization resulted in erosion and sloughing of the streambanks. Accelerated streambank erosion increases the volume of sedimentation deposited in the channel, which in turn, smothers the macroinvertebrate population and buries gravel bars where many fish species spawn. Another typical disturbance found was the lack of mature woody species in the riparian zone. When forested riparian buffers are destroyed, as they were in many cattle pastures, water temperatures can rise significantly, resulting in serious impacts to fish and macroinvertebrate survival (CWP, 2000). Also, previous clearing or disturbance of the riparian buffers often sets the stage for an extensive invasion of non-native species such as multi-flora rose or Chinese privet. These non-native plant species tend to out-compete the native species important to non-aquatic animals. Because of this direct correlation between physical condition and habitat value, both parameters are combined into one ranking in Table 2-2. Each site was assigned a score of excellent, good, medium, fair, or poor (from best to worst) based on the condition of the stream and riparian buffer. The habitat scores are identified for each of the 46 observation sites on Figure 2-6. The parameters used to classify the stream conditions and associated scores can be found on the CD in Appendix B.

2.5.2 Rosgen Level II-III Geomorphologic Assessment

Stream morphology, as defined by Level II criteria, serves as the basic physical stream categorization. There are a number of other factors that influence the overall state or condition of a stream in addition to channel morphology. These factors include hydrologic, biological, ecological, and human factors. Level III analyses incorporate these other factors in addition to the morphological template to further describe the existing stream condition of the stream channel.

The watershed land use characteristics, channel conditions, and habitat observations collected during the rapid stream reach assessment were incorporated into the selection of two pilot areas for the purpose of conducting a more detailed study, including Rosgen Level II and III geomorphic assessments. The following is a summary of the Rosgen Level II and III assessments. Additional supporting information and detailed calculations, graphs, and figures can be found in Appendix B of this LWP.

Selection of Pilot Areas for More Detailed Analysis

Figure 2-7 shows the location of the two pilot areas selected for more detailed studies including Rosgen Level II and III geomorphic assessments. These areas are considered to be representative of the diverse existing and proposed future land uses found within the Upper Rocky River/Clarke Creek watershed. One pilot area was designated on the West Branch Rocky River in the Town of Mooresville and Iredell County jurisdictions. The area drains 3.6 square miles (2,282 acres) and is comprised of approximately 10.0 miles of first through third order streams. The second pilot area was designated on the South Prong West Branch Rocky River in the Towns of Davidson and Cornelius. The area drains 2.9 square miles (1,862 acres) and is comprised of approximately 8.5 miles of first through third order streams.

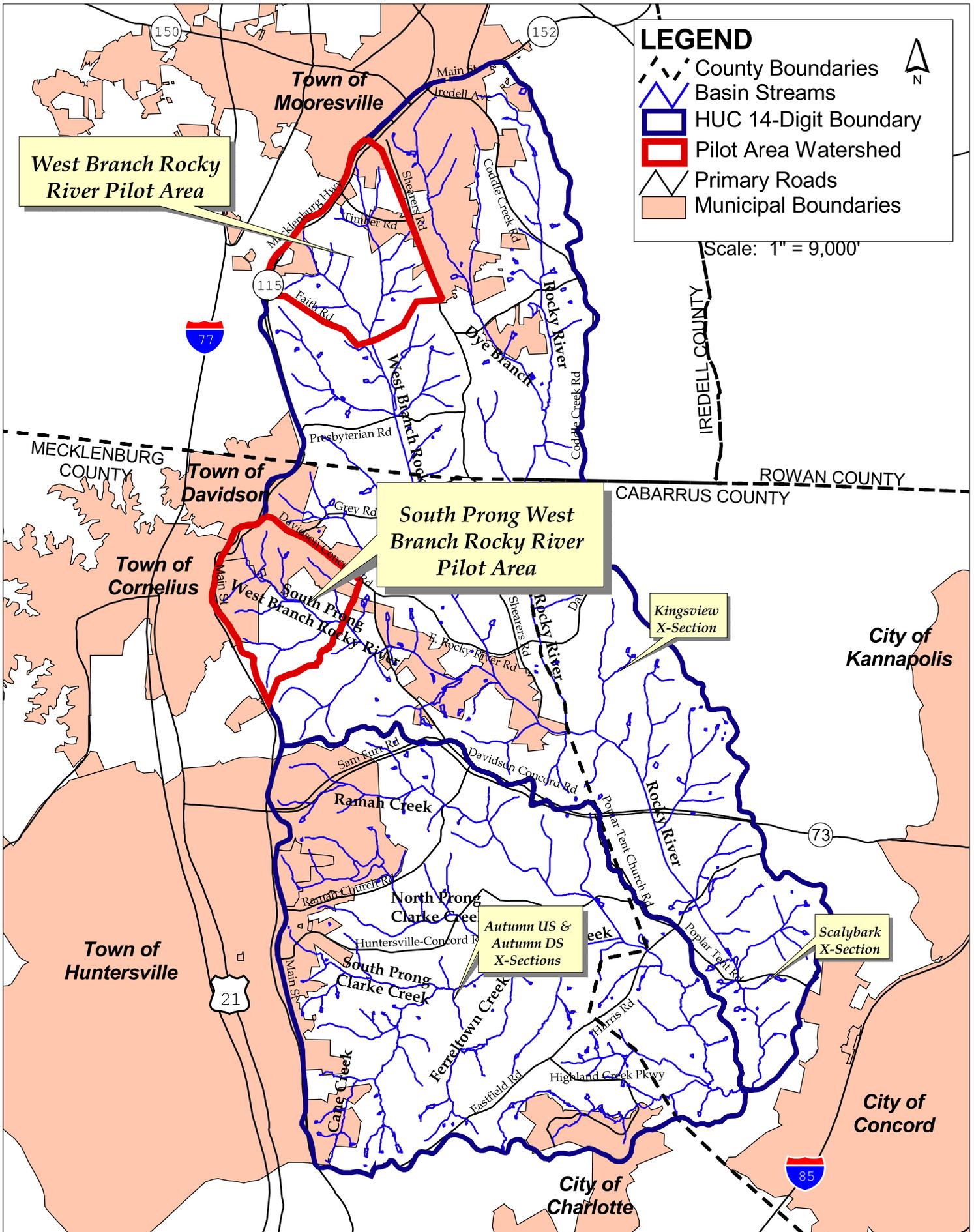
Four additional cross-sections were selected outside of the pilot areas, as shown on Figure 2-7, for additional detailed analysis. These sites were spread across the southern portion of the watershed and were specifically set outside the pilot areas to help determine if there is more variability in stream condition and classification in the watershed as a whole.

Rosgen Level II Assessment

The Rosgen Level II assessment included field measurements taken at cross-section locations and then compared with the parameters in the Rosgen classification system to determine channel type. **Figures II.1a** and **II.1b** in Appendix B show the locations of the cross-sections for both pilot areas. Channel and floodway measurements were taken in the field at each cross-section location and include the following:

- Bankfull width
- Bankfull depth
- Floodprone area width
- Water surface slope range
- Sinuosity range
- Channel bed material

These measurements were used for the purpose of determining the four parameters used by this study to define the appropriate Rosgen channel type (entrenchment ratio, width-to-depth ratio, sinuosity, and channel gradient). **Table 2-3** shows the numerical values for each of the four parameters and the associated channel type.



Data Source: NCGIA 2000 BasinPro

Figure 2-7

Upper Rocky River/Clarke Creek Local Watershed Plan Pilot Area Watersheds and Additional Rosgen II/III Sites



Table 2-3 - Rosgen Stream Classification Parameters

Channel Type	Entrenchment Ratio	Width/Depth Ratio	Sinuosity	Channel Gradient
A	< 1.4	< 12	Low (< 1.2)	4 to 10%
B	1.4 to 2.2	> 12	Moderate (> 1.2)	2 to 4%
C	> 2.2	> 12	High (> 1.4)	< 2%
D	N/A	> 40	Low (<1.2)	< 4%
E	> 2.2	< 12	Very High (> 1.5)	< 2%
F	< 1.4	> 12	High (> 1.4)	< 2%
G	< 1.4	< 12	Moderate (> 1.2)	2 to 4%

Table was adapted from Rosgen, 1994 and Rosgen, 1996.

The channel types were further classified based upon the median particle size of the bed material. Numbers one through six correspond to different sediment size ranges as follows:

- | | |
|-------------|-------------|
| 1 - Bedrock | 2 - Boulder |
| 3 - Cobble | 4 - Gravel |
| 5 - Sand | 6 - Silt |

Summary sheets were developed for each of the cross-section locations and can be found in Appendix B. Each summary sheet shows the cross-section, profile, site-specific information related to Rosgen stream type classification, and streamflow calculations. Three digital photographs were also taken at each cross-section location: one looking upstream, one looking downstream, and one looking perpendicular to the channel from one bank to the other, also included in Appendix B.

Once the channel type was determined for each cross-section location, **Table 2-4** can be used to help understand and predict the stream's response to natural or imposed disturbances (Rosgen, 1996). This is important to (1) assess past impacts, (2) anticipate consequences of proposed management strategies, (3) evaluate the potential for recovery without intervention, (4) better understand the processes of channel adjustment, (5) determine the feasibility and prioritization of restoration, and (6) develop restoration designs to replicate natural stable tendencies. The tables provided in Section II.3 in Appendix B show the assigned channel type at each cross-section location. Actual channel cross-section data was also used in the hydraulic modeling performed in the pilot areas to represent typical channel section in the model (See Section 3.4).

Rosgen Level III Assessment

The Level III field inventory used for this study included visual observations of parameters beyond the Level II morphologic assessment. The approach specifically included assessments of the following stream characteristics: (1) presence of woody debris, (2) sediment supply, (3) reach bed stability, (4) degree of bank erosion, (5) extent of vertical raw bank, (6) evidence of altered hydrology, (7) direct human

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Table 2-4 - Management Interpretations of Various Stream Types (Rosgen, 1996)**

Stream Type	Sensitivity To Disturbance	Recovery Potential^b	Sediment Supply^c	Streambank Erosion Potential	Vegetation Controlling Influenced
A1	Very low	Excellent	Very low	Very low	Negligible
A2	Very low	Excellent	Very low	Very low	Negligible
A3	Very high	Very poor	Very high	Very high	Negligible
A4	Extreme	Very poor	Very high	Very high	Negligible
A5	Extreme	Very poor	Very high	Very high	Negligible
A6	High	Poor	High	High	Negligible
B1	Very low	Excellent	Very low	Very low	Negligible
B2	Very low	Excellent	Very low	Very low	Negligible
B3	Low	Excellent	Low	Low	Moderate
B4	Moderate	Excellent	Moderate	Low	Moderate
B5	Moderate	Excellent	Moderate	Moderate	Moderate
B6	Moderate	Excellent	Moderate	Low	Moderate
C1	Low	Very good	Very low	Low	Moderate
C2	Low	Very good	Low	Low	Moderate
C3	Moderate	Good	Moderate	Moderate	Very high
C4	Very high	Good	High	Very high	Very high
C5	Very high	Fair	Very high	Very high	Very high
C6	Very high	Good	High	High	Very high
D3	Very high	Poor	Very high	Very high	Moderate
D4	Very high	Poor	Very high	Very high	Moderate
D5	Very high	Poor	Very high	Very high	Moderate
D6	High	Poor	High	High	Moderate
Da4	Moderate	Good	Very low	Low	Very high
DA5	Moderate	Good	Low	Low	Very high
DA6	Moderate	Good	Very low	Very low	Very high
E3	High	Good	Low	Moderate	Very high
E4	Very high	Good	Moderate	High	Very high
E5	Very high	Good	Moderate	High	Very high
E6	Very high	Good	Low	Moderate	Very high
F1	Low	Fair	Low	Moderate	Low
F2	Low	Fair	Moderate	Moderate	Low
F3	Moderate	Poor	Very high	Very high	Moderate
F4	Extreme	Poor	Very high	Very high	Moderate
F5	Very high	Poor	Very high	Very high	Moderate
F6	Very high	Fair	High	Very high	Moderate
G1	Low	Good	Low	Low	Low
G2	Moderate	Fair	Moderate	Moderate	Low
G3	Very high	Poor	Very high	Very high	High
G4	Extreme	Very poor	Very high	Very high	High
G5	Extreme	Very poor	Very high	Very high	High
G6	Very high	Poor	High	High	High

Notes:

A Includes increases in streamflow magnitude and timing and/or sediment increases.

B Assumes natural recovery once cause of instability is corrected.

C Includes suspended and bedload from channel-derived sources and/or from stream adjacent slopes.

D Vegetation that influences width/depth ratio-stability.

channel impacts, (8) culverts, (9) utilities, (10) fish barriers, (11) riparian composition, (12) riparian width, (13) canopy cover, and (14) reference reach potential. These parameters all influence the current stream condition and potential for recovery to an optimum condition. As such, the Rosgen Level III assessment helped describe channel conditions as they related to stream stability, potential, and function. The parameters taken at each of the cross-sections for the Level III analysis include the following:

Channel Disturbance

- Altered hydrology
- Direct human channel impacts
- Culvert (type, shape, estimated span, edge of pool conditions)
- Utilities

Channel Stability

- Woody debris
- Sediment supply
- Reach bed stability (aggradation/degradation and boundaries)
- Degree of bank erosion
- Extent of vertical raw bank
- Depositional features

Riparian Conditions

- Riparian composition
- Riparian width
- Canopy cover (percent over channel)

Channel Habitat

- Fish barriers (chronic)

The integration of companion inventories with the additional variables that influence stream state is particularly important in the development of a watershed-wide management plan. This holistic approach integrates both physical and biological function, within a watershed context, providing a wide range of interpretations for management applications. The following channel and riparian buffer characteristics were determined at each cross-section: sediment supply, reach bed stability, degree of bank erosion, extent of vertical raw bank, riparian conditions, Rosgen sensitivity to disturbance, Rosgen recovery potential, buffer width and riparian composition, and

comments and other observations. A description of each of the characteristics listed above can be found in Appendix B.

The tables provided in Section II.3 in Appendix B, show the results of the Rosgen Level II and III analyses for each cross-section for both pilot areas and the four additional cross-sections. Results and conclusions are discussed in detail in Section 3.2.3.3.

2.6 Land Use and Demographic Trends

The Upper Rocky River/Clarke Creek watershed is currently evolving from a watershed dominated by agricultural development and forest cover to one experiencing intense urban, predominately residential, development pressures. It is important to understand not only future development, but what the historic land uses were and what stream and habitat impacts resulted from them. The purpose of this section is to describe the historic land use, existing land use, and predicted future land use based on zoning.

2.6.1 Jurisdictional Boundaries

Jurisdictional boundaries have had little impact on the types of development historically observed within this watershed, but have a considerable impact on the type and degree of development expected in the future. The Upper Rocky River/Clarke Creek watershed drains portions of Cabarrus, Iredell, and Mecklenburg Counties and includes the Towns of Cornelius, Davidson, Huntersville, and Mooresville and the City of Charlotte. **Table 2-5** shows the portion of the watershed within each jurisdiction and the associated percentage of watershed area within each.

Table 2-5 - Jurisdictional Breakdown

Jurisdiction	Area	
	(square-miles)	(% of Study Watershed)
Mecklenburg County	<i>see note below</i>	<i>see note below</i>
<i>Town of Cornelius</i>	3.4	4%
<i>Town of Davidson</i>	12.2	16%
<i>Town of Huntersville</i>	21.3	28%
<i>City of Charlotte</i>	3.2	4%
Cabarrus County	1.7	23%
Iredell County	11.1	14%
<i>Town of Mooresville</i>	8.4	11%
Total =	76.9	100%

It should be noted that the portion of the watershed within Mecklenburg County is fully encompassed within the Towns of Davidson, Cornelius, Huntersville, and the City of Charlotte’s “Sphere of Influence” and was therefore not shown in the table. The Sphere of Influence is a term identified by Mecklenburg County as the area currently outside of a municipality’s Extraterritorial Jurisdiction (ETJ), but dedicated

by the county to be incorporated within their ETJ in the future. **Figure 2-8** shows the Sphere of Influence boundaries for the municipalities in Mecklenburg County and ETJ for the Town of Mooresville in Iredell County.

2.6.2 Historic Land Use and Watershed Growth

It has been documented that streams in the southern Piedmont, including this area of North Carolina, were intensely affected by the erosive farming practices of cotton and tobacco cultivation from the 1700's to the 1930's (Trimble, 1974). According to Trimble, because land was cheap, the farming approach was to plant crops until the soil was depleted and then abandon the fields and clear more woodlands to plant. Agricultural farming may have been the predominant land use from the 1930's and before, but cattle and horse farming has accounted for a majority of the non-forested land use over a minimum of the past 30 years. This is reflected in NCDWQ's land use breakdown for subbasin 11, which includes the portion of the Rocky River down to its confluence with Reedy Creek in Cabarrus County, presented in their 1998 Yadkin River Basin Plan and as shown below.

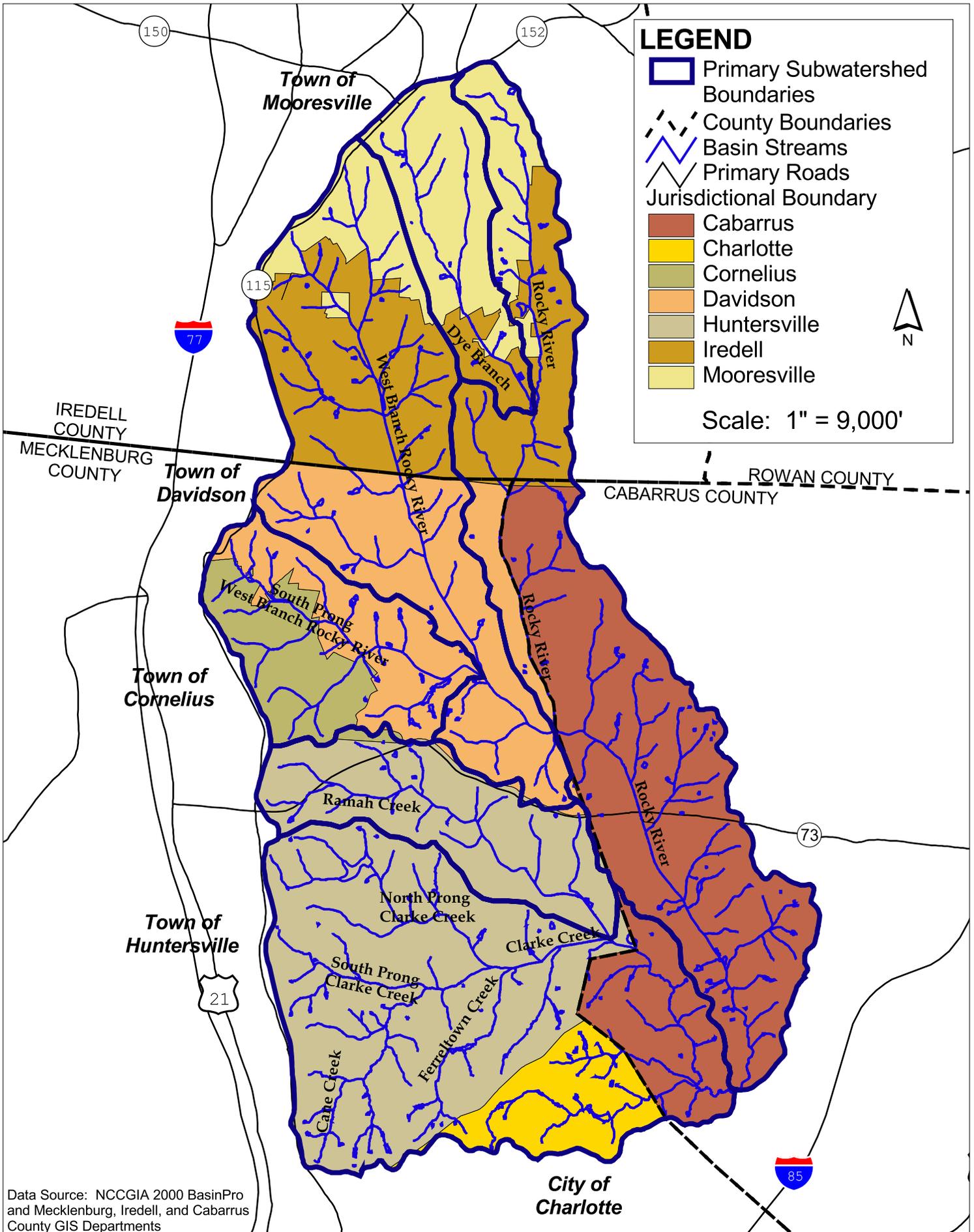
- Cultivated Crop - 3 percent
- Forest - 60.9 percent
- Pasture - 29.4 percent
- Urban - 6.1 percent
- Water - 0.5 percent

The values are based on the NCCGIA land use coverage from 1993 to 1995. Aerial photographs, taken in 1973, were also obtained for the Clarke Creek watershed and compared to the 1999 aerial photographs used for this study. There were very few changes in land use observed between the two photographs.

Based on the mature forest cover observed during site visits, 1973 aerial photography, and 1993-1995 NCCGIA land use coverages, it can be assumed that the watershed has maintained a relatively non-urban landscape with the primary land use types consisting of forest and pasture land. The residential and industrial development in the Town of Mooresville and residential and commercial development in the downtown Davidson appear to be the most mature urban development observed in the watershed. There are also small portions of the Towns of Huntersville and Cornelius in the watershed that appear to be mature urban development.

2.6.3 Existing Land Use

A GIS existing land use coverage was developed for this study using 1999 digital aerial photography, 1999 GIS land use coverage for Mecklenburg County, and 2002 tax parcel information. This coverage was used as a basis for further evaluations including water quality, hydrology, and habitat assessments; development of the subwatershed ranking protocol; and the recommended watershed protection and



Data Source: NCCGIA 2000 BasinPro and Mecklenburg, Iredell, and Cabarrus County GIS Departments

Figure 2-8
Upper Rocky River/Clarke Creek Local Watershed Plan
Jurisdictional Boundaries

improvement project site identification. Impervious area calculations were developed from the resulting existing land use coverage for inclusion in the water quality modeling. See Appendix E for a description of the impervious area calculations. The existing land use was determined based on county-wide assessments and is described below.

2.6.3.1 Development

Cabarrus and Iredell Counties

A GIS existing land use coverage was not available for Cabarrus or Iredell counties. Digital aerial photography from 1999 was used to develop a GIS existing land use coverage based on 12 land use types including open space, forest, pasture, agriculture, commercial, shopping center, industrial, institutional, office, rural residential, manufactured homes, and residential development. The GIS land use coverage for residential development was divided into more discrete categories by the average number of units per acre (e.g. 2 units-per-acre residential).

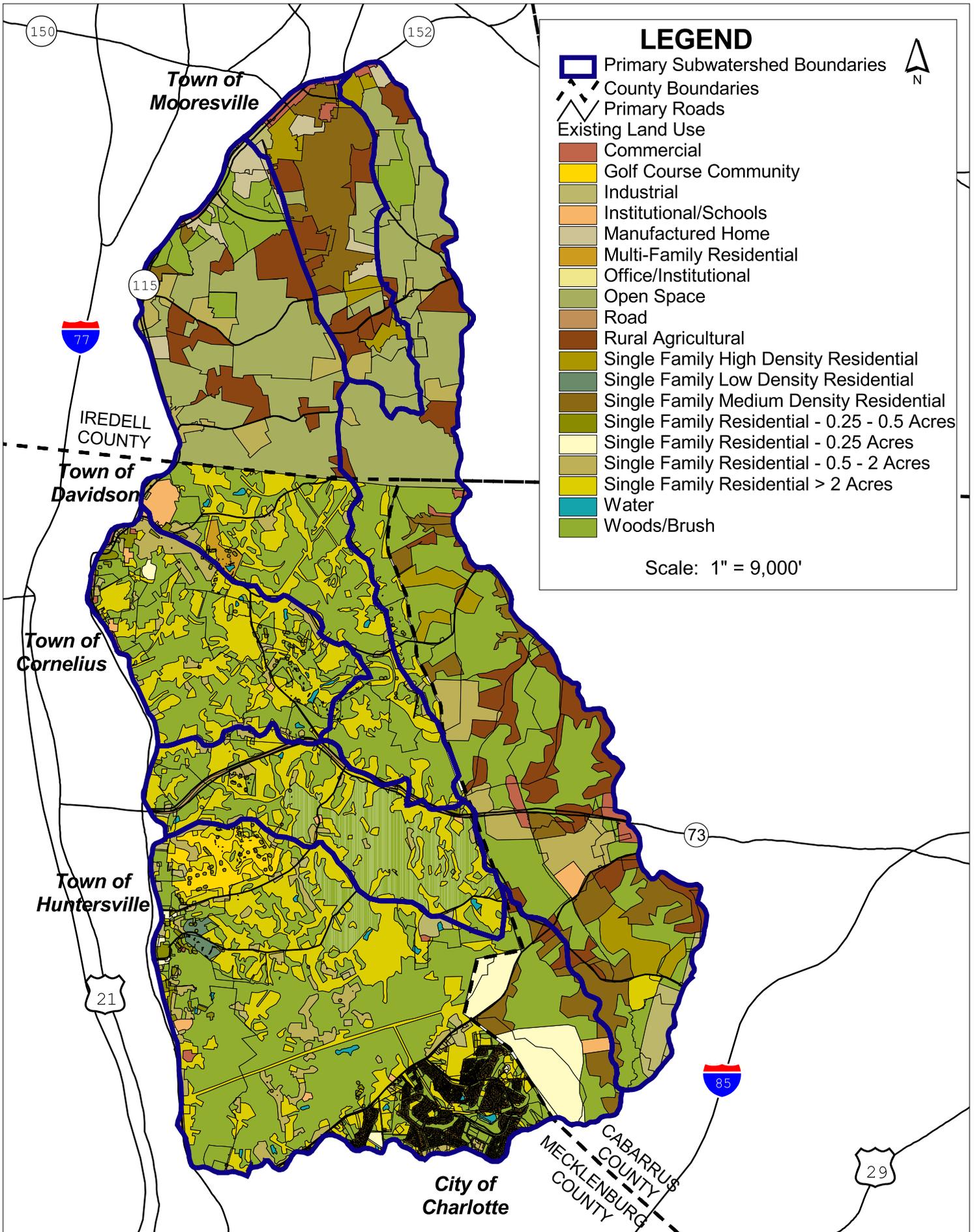
The 1999 existing land use coverages were compared to the 2002 GIS tax parcel data to determine what, if any, large development changes had occurred over the three year period. The GIS tax parcel coverage revealed locations of several newly-constructed residential developments. It was determined that the watershed had experienced intense urban residential development and that the existing land use coverages would have to be revised accordingly to properly represent the urban development impacts currently being experienced in the watershed.

Mecklenburg County

A GIS land use coverage was obtained from the Mecklenburg County Information Service and Technology Department for the portion of the watershed in Mecklenburg County, which encompasses the Towns of Cornelius, Davidson, and Huntersville and the City of Charlotte (52 percent of the entire watershed). This coverage appears to be based on aerial photography from 1999 and was therefore considered comparable to the existing land use coverages developed for Cabarrus and Iredell counties. As discussed above, 2002 GIS tax parcel data was used to account for the recent influx of urban residential development, predominately golf course communities, observed throughout the watershed.

2.6.3.2 Verification and Results

The revised existing land use coverage was verified through windshield surveys conducted throughout the project. **Figure 2-9** shows the final existing land use coverage developed for the Upper Rocky River/Clarke Creek watershed using 1999 GIS land use coverages and aerial photography, 2002 GIS tax parcel data, and windshield surveys conducted throughout the project. **Table 2-6** shows the distribution of each of the land use types. The land use types shown in the table and on the figure were developed for use in the watershed assessment and are discussed in Section 3. Table 2-1 in Section 2 also shows the existing land use breakdown for each of the major hydrologic subwatersheds (e.g. Clarke Creek, Dye Creek, Ramah



Data Source: Data obtained from municipal GIS/Planning Departments and modified by CDM
 See Appendix E for further description)

Figure 2-9
 Upper Rocky River/Clarke Creek Local Watershed Plan
 Existing Land Use Distribution



**North Carolina Wetlands Restoration Program
Upper Rocky River/Clarke Creek Local Watershed Plan
Table 2-6 - Existing Land Use Distribution**

General Land Use Type	Area	Percent of Watershed
	(acres)	(%)
Commercial	426	1%
Golf Course Community	409	1%
Industrial	623	1%
Institutional/Schools	359	1%
Manufactured Home	529	1%
Multi-Family Residential	101	0%
Office/Institutional	0	0%
Open Space	6,436	13%
Road	199	0%
Rural Agricultural	3,388	7%
Single Family High Density Residential	1,063	2%
Single Family Low Density Residential	94	0%
Single Family Medium Density Residential	3,569	7%
Single Family Residential - 0.25 - 0.5 Acres	369	1%
Single Family Residential - 0.25 Acres	983	2%
Single Family Residential - 0.5 - 2 Acres	3,071	6%
Single Family Residential > 2 Acres	8,345	17%
Water	115	0%
Woods/Brush	18,986	39%
Grand Total	49,107	100%

Note: General land use types were determined for the water quality modeling performed using WMM. See Appendix E for a description of the analysis.

Creek, etc.). For additional information regarding the existing land use coverage see Appendix E.

Extensive land use changes have occurred in the watershed since the development of the 1993-1995 GIS land use coverage developed by NCCGIA. **Table 2-7** compares the land use distribution from 1993-1995 to that of the existing land use coverage developed for this study. It can be seen that there has been a significant decrease in forest cover and even greater increase in urban development.

Table 2-7: Land Use Comparison

Land Use Type	1993-1995 DWQ Land Use Distribution ¹	1999-2002 CDM Developed Land Use Distribution ²
	(Percent)	(Percent)
Cultivated Crop	3	5.5
Forest	60.9	39.7
Pasture	29.4	12.7
Urban	6.1	41.9
Water	0.5	0.2

Note:

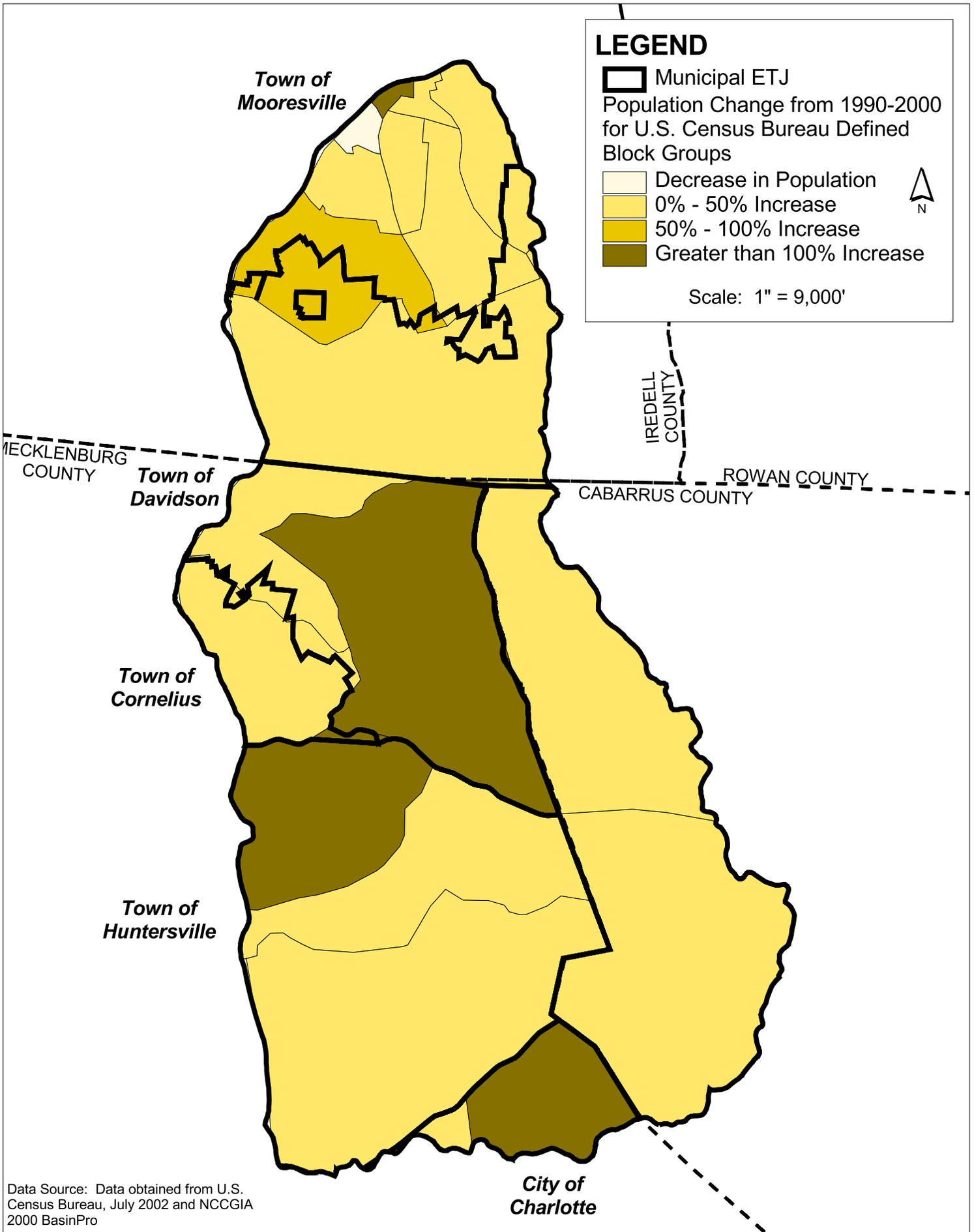
1. Values represent percent distribution for subbasin 11 of the Yadkin River Basin
2. Values represent percent distribution for the Upper Rocky River/Clarke Creek Watershed

It should be noted that the 1993-1995 land use coverage is for subbasin 11 of the Yadkin River Basin (277 square miles) which contains the Upper Rocky River/Clarke Creek watershed (77 square miles). Therefore, a direct correlation can not be made between the two land use percentage breakdowns. The urban development land use type includes development types such as commercial, residential, industrial, etc.

The increase in urban development within the watershed can be correlated to the increase in population experienced between 1990 and 2000. Based on data obtained from the U.S. Census Bureau, the overall population within the watershed increased from approximately 19,300 persons in 1990 to 31,100 persons in 2000, a 61 percent increase. **Figure 2-10** shows the percent increase in population for each of the U.S. Census Bureau defined block groups based on the change in 1990 to 2000 populations.

2.6.4 Future Land Use

A future land use GIS coverage was developed for this study using the GIS zoning coverages for Iredell and Cabarrus Counties, the Towns of Cornelius, Davidson, Huntersville, and Mooresville, and the City of Charlotte as well as the existing land use coverage developed for this study. This coverage, like the existing land use coverage, was used as a basis for further evaluations including water quality, hydrology, and habitat assessments; development of the subwatershed ranking protocol; and the recommended watershed protection and improvement project site identification. Impervious area calculations were developed from the resulting future



Data Source: Data obtained from U.S. Census Bureau, July 2002 and NCCGIA 2000 BasinPro

Figure 2-10
 Upper Rocky River/Clarke Creek Local Watershed Plan
 Percent Change in Population from 1990 to 2000

land use coverage for inclusion in the water quality modeling. See Appendix E for a description of the impervious area calculations.

2.6.4.1 Development

The future land use coverage was created using a combination of zoning coverages and existing land uses with the goal to develop a scenario where all parcels have the potential to be, or have been, developed. The resulting future land use coverage is a combination of jurisdictional zoning codes and current urban development. In areas where urban development has been solidified (e.g. commercial, industrial, dense residential, etc.) the existing land use was maintained and the zoning coverage not used. In areas where there is little or no development (e.g. pasture, forest, rural residential, etc.) the zoning coverage was used.

The purpose of incorporating the existing land use data in the future land use coverage was to minimize the amount of zoning data used for the development of a more detailed water quality model and resulting watershed assessment. For example, the Northstone Golf Course Community in the Town of Huntersville is zoned as General Residential (GR). The GR zoning code permits uses such as single family homes, cemeteries, parks, schools, duplexes, and golf courses (see page 23 of the Town of Huntersville Zoning Ordinance <http://www.huntersville.org/>). It was assumed that development such as this is unlikely to be removed and will maintain its current density and percentage of impervious area.

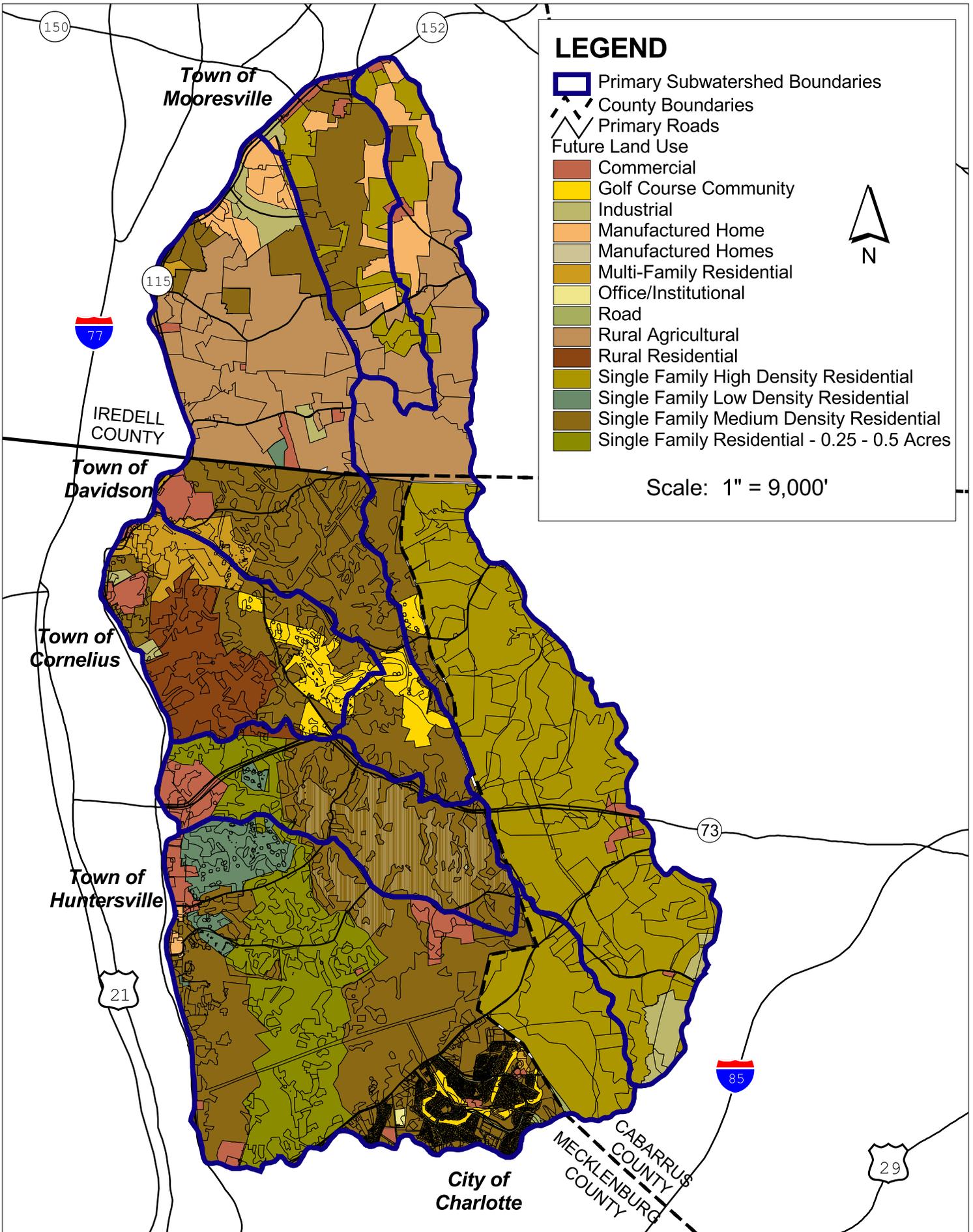
2.6.4.2 Verification and Results

Telephone conversations were conducted with each of the seven jurisdictions in April 2003 to determine if there were any significant re-zoning changes within the watershed; none were identified. It is therefore assumed that the zoning coverages included herein reflect the most up-to-date information available at the time of this study.

Figure 2-11 shows the final future land use coverage developed for the Upper Rocky River/Clarke Creek watershed using GIS zoning data and the existing developed lands coverage created for this study. **Table 2-8** shows the distribution for each of the future land use types. The land use types shown in the table and on the figure were developed for use in the water quality modeling and watershed assessment and are discussed in Section 3. Table 2-1 in Section 2-3 also shows the future land use breakdown for each of the major hydrologic subwatersheds (e.g. Clarke Creek, Dye Creek, Ramah Creek, etc.). For additional information regarding the future land use coverage see Appendix E.

2.6.5 Predicted Watershed Growth

An increase in population can be correlated to an increase in urban development. For that reason, projected population increases were evaluated for the watershed. Several data sources were consulted including the U.S. Census Bureau's projected county population increase, the Cabarrus County Water and Wastewater Master Plan for



LEGEND

- Primary Subwatershed Boundaries
- County Boundaries
- Primary Roads
- Future Land Use**
- Commercial
- Golf Course Community
- Industrial
- Manufactured Home
- Manufactured Homes
- Multi-Family Residential
- Office/Institutional
- Road
- Rural Agricultural
- Rural Residential
- Single Family High Density Residential
- Single Family Low Density Residential
- Single Family Medium Density Residential
- Single Family Residential - 0.25 - 0.5 Acres



Scale: 1" = 9,000'

Data Source: Data obtained from municipal GIS/Planning Departments and modified by CDM
See Appendix E for further description)

Figure 2-11
Upper Rocky River/Clarke Creek Local Watershed Plan
Future (Build-Out) Land Use Breakdown



**North Carolina Wetlands Restoration Program
Upper Rocky River/Clarke Creek Local Watershed Plan
Table 2-8 - Future (Build-Out) Land Use Breakdown**

General Land Use Type	Area	Percent of Watershed
	(acres)	(%)
Commercial	1,846	4%
Golf Course Community	1,307	3%
Industrial	863	2%
Manufactured Home	1,452	3%
Manufactured Homes	2	0%
Multi-Family Residential	972	2%
Office/Institutional	21	0%
Road	265	1%
Rural Agricultural	6,889	14%
Rural Residential	1,695	3%
Single Family High Density Residential	11,800	24%
Single Family Low Density Residential	993	2%
Single Family Medium Density Residential	16,995	35%
Single Family Residential - 0.25 - 0.5 Acres	4,064	8%
Grand Total	49,107	100%

Note: General land use types were determined for the water quality modeling performed using WMM. See Appendix E for a description of the analysis.

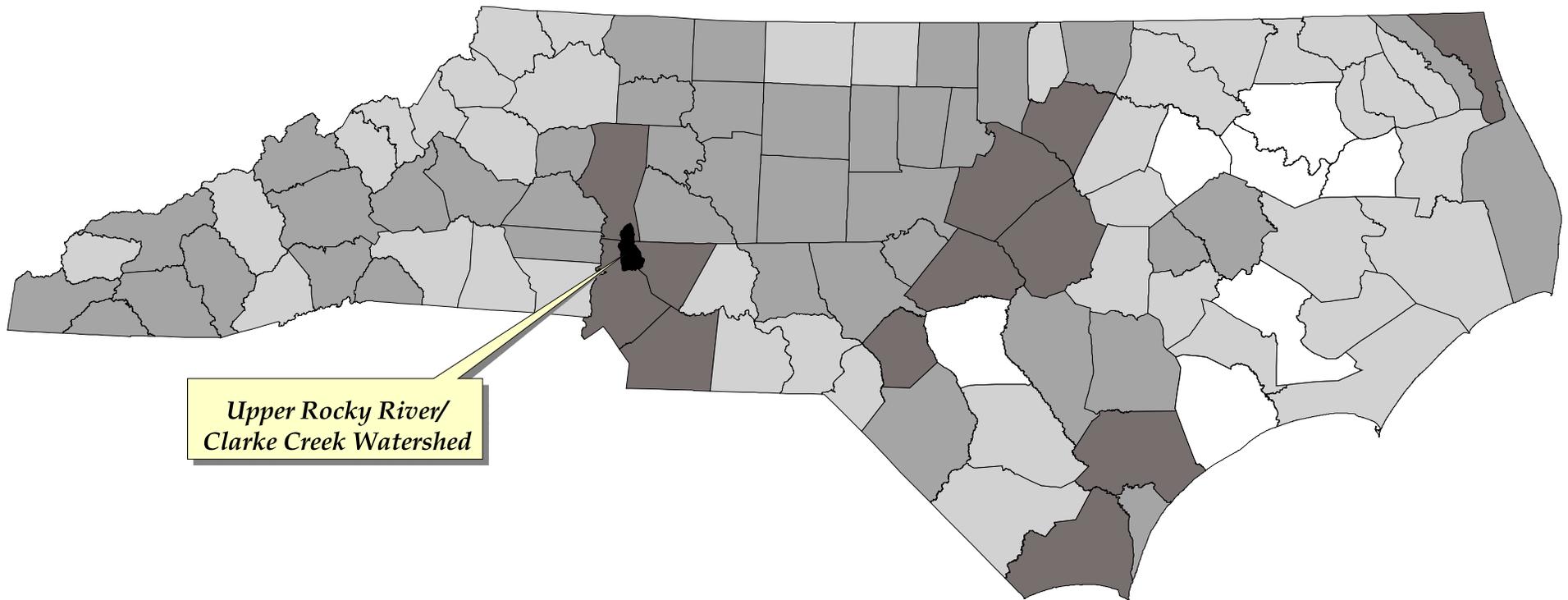
December 2001, and the 1998 and draft 2002 DWQ Yadkin River Basin Plans. Regardless of the source, all indications lead to intense urban development in the near future for the watershed. It can be seen on **Figure 2-12** that each of the counties comprising the Upper Rocky River/Clarke Creek watershed fall within the largest growth categories identified in the state by the U.S. Census Bureau. Based on average population densities, the Cabarrus County Master Plan projects as much as a 95% increase in population within the basin from 2000 to 2010. The 1996 Yadkin River Basin Plan identifies projected population increases for Iredell, Cabarrus, and Mecklenburg Counties of 32.3, 37.1, and 68.3 percent from 1990 to 2020, respectively (NCDENR-DWQ, 1998).

Development pressures observed within the watershed may be attributed, in part, to its being made up of multiple jurisdictions including Cabarrus, Iredell, and Mecklenburg Counties; the Towns of Cornelius, Davidson, Huntersville, and Mooresville; and the City of Charlotte. The continued rapid growth observed within the City of Charlotte has led to the need for surrounding municipalities to accommodate residential development. As each municipality's ability to provide public water and sewer increases, so does development within those areas (see Section 2.8 for a description of the existing and predicted water and sewer infrastructure).

Additional development surrounding the watershed should also lead to an increase in the demand for residential and commercial development within. **Figure 2-13** presents locations of proposed or ongoing development changes within or just outside of the watershed that may have significant impacts on development by 2010. Such items include the proposed Charlotte North Light Rail Corridor running from the Town of Mooresville to the City of Charlotte along State Route 115, Lowes Home Improvement Headquarters bound by State Route 115 and Interstate 77 near the Town of Mooresville, and several of the NCDOT 2004-2010 Transportation Improvement Program (TIP) projects. Also shown on Figure 2-13 are residential developments identified by members of the LWPG that are currently being constructed, approved for construction, or in the planning stages within the watershed. These developments, if all are constructed, will result in the addition of approximately 12,500 new homes.

2.6.6 Conclusions

The Upper Rocky River/Clarke Creek watershed has experienced intense urban growth development within the past ten years resulting in a 61 percent increase in population. The increase in urban development and associated population can be attributed to the transition from rural residential and agriculture to low and medium density residential development, which has been fueled by the continued rapid growth of the City of Charlotte and surrounding municipalities. **The rate of development observed within the watershed can be expected to continue and possibly increase over the next ten years.** The U.S. Census Bureau has grouped Mecklenburg, Cabarrus, and Iredell Counties in its highest tier of projected growth



*Upper Rocky River/
Clarke Creek Watershed*

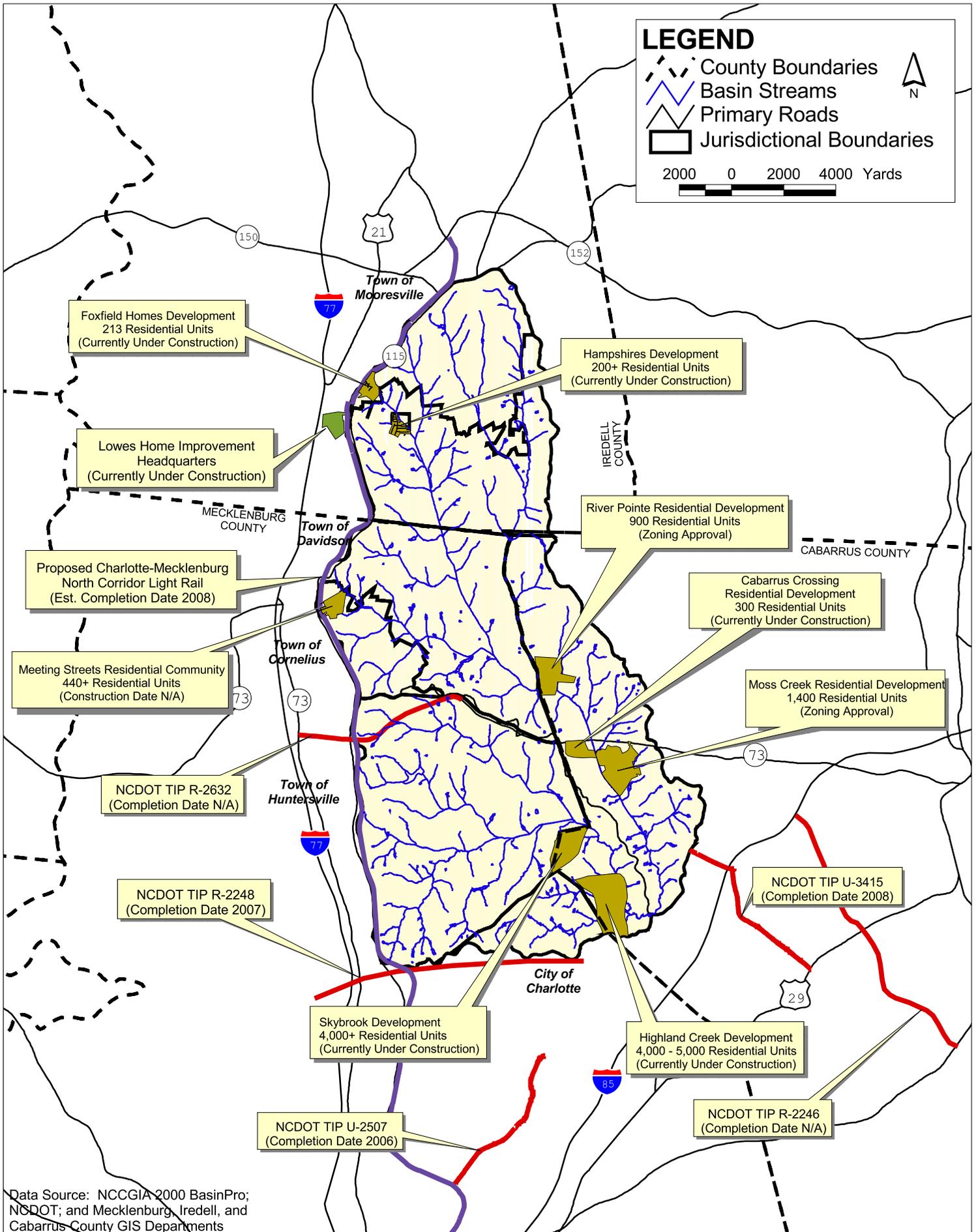
LEGEND

-  Basin Boundary
- Projected Population Growth 2000-2010
-  Population Loss - Net Out-Migration
-  Low Growth - Net In-Migration
-  Medium Growth - Net In-Migration
-  High Growth - High Net In-Migration



Data Source: GIS coverage provided by NCCGIA 2000 BasinPro.
Population Data obtained from U.S. Census Bureau, July 2002

Figure 2-12
Upper Rocky River/Clarke Creek Local Watershed Plan
Projected Population Increase for 2000 - 2010



Data Source: NCCGIA 2000 BasinPro; NCDOT; and Mecklenburg, Iredell, and Cabarrus County GIS Departments

Figure 2-13
Upper Rocky River/Clarke Creek Local Watershed Plan
Potential Development Impacts



within the State of North Carolina from 2000 to 2010. Additional data sources including the DWQ 1998 Yadkin River Basin Plan and 2001 Cabarrus County Water and Wastewater Master Plan identify similar intense development trends within the watershed. Development changes within and/or surrounding the watershed are also expected to have significant impacts within the next ten years including the Charlotte North Light Rail Corridor, Lowes Home Improvement Headquarters, and multiple NCDOT TIP Projects, as shown in Figure 2-13.

2.7 Municipal and County Ordinance Summary

This section is intended to summarize the stormwater and development-related ordinances identified within the Upper Rocky River/Clarke Creek local watershed planning area, as codified by the following jurisdictions: Cabarrus and Iredell Counties, the Towns of Cornelius, Davidson, Huntersville, and Mooresville, and the City of Charlotte. It should be noted that Mecklenburg County was not included in the ordinance review due to the entire portion of the watershed within the County is included in the Town of Cornelius, Davidson, or Huntersville's Sphere's of Influence (see Section 2.6.1 and Figure 2-8 for a further description of the Sphere's of Influence).

Six key watershed-related ordinances were evaluated to determine if a group of optimal stormwater and development-related ordinances could be adopted by the governing jurisdictions to strengthen the existing ordinances in a cost-effective and feasible manner. This technical memorandum provides a brief description of the data collection process and findings for each jurisdiction's regulations regarding: (1) open space requirements; (2) sedimentation and erosion control regulations; (3) water quality BMP implementation and design criteria; (4) stream buffer requirements; (5) floodplain regulations; (6) and stormwater runoff regulations.

The initial data collection process began with the Request for Information memorandum sent out at the beginning of the project (see Section 2.3.1). Data gaps were filled by accessing ordinances through each of the county/municipality government websites and by telephone conversations with members of the LWPG and/or local planning, stormwater, and land development representatives. The following is a brief description of each of the jurisdiction's regulations. Local contacts and web links related to the ordinances can be found in Appendix C.

2.7.1 Open Space Requirements

In order to depict the open space requirements for each jurisdiction in a comparative manner, a sample study was performed based on a *hypothetical 100-acre development* with 300 single-family homes. A brief description of the method and required open space is identified below.

- **Town of Cornelius** - Cornelius uses a matrix based on the average number of units per acre, estimated number of bedrooms within the development, and a factor to determine the amount of open space. The open space required for the hypothetical

100-acre development is 12.5 acres, which results in a density of 3.4 units per acre for the developable land.

- **Town of Davidson** – Davidson’s existing open space requirement is 50 percent for subdivisions averaging 2 units per acre with an additional 0.10 residential units per acre allowed for every one percent increase in required open space. The increase in density from two units per acre to three units per acre desired for the hypothetical development results in 60 of the 100 acres set aside as open space and a density of 7.5 units per acre for the remaining 40 acres of developable land.

The Town of Davidson’s open space requirement is a dynamic regulation, reducing by one percentage point for every 50 acres of publicly purchased open space accessible to the community. The minimum open space requirement is 35 percent, regardless of the public purchase of open space. Based on the current open space regulations the hypothetical development would be required to set aside 60 acres of open space. With the continued purchase of publicly accessible open space owned and maintained by the Town of Davidson, the required open space for the hypothetical development may reduce down to, but not below, 45 acres.

- **Town of Huntersville** – The Town of Huntersville’s current open space requirement is based on varying densities. The maximum allowable density is 1.2 units/acre for the entire development (100-acres). The required open space for a density of 1.2 units/acre is 45 percent. Therefore, for the hypothetical development scenario there would be 45 acres of open space with the remaining 55 acres containing 120 residential lots. The resulting density is 2.2 units/acre for the 55 acres of developable land.

Based on the Town of Huntersville’s open space requirement, a 300-unit residential development would not be permitted on a 100-acre tract. The minimum total tract area is 250 acres, with 45 percent of that (or 112.5 acres) dedicated as open space. The remaining developable land is 137.5 acres, resulting in a density of 2.2 units/acre for the developable land.

- **Town of Mooresville** – Mooresville uses a matrix based on the average number of units per acre, estimated number of bedrooms within the development, and a factor to determine the amount of open space. For the hypothetical development, the open space required is 12.5 acres and resulting density is 3.4 units per acre for the remaining 87.5 acres of developable land.
- **City of Charlotte** – The City of Charlotte requires between 50 and 65 percent open space for single-family residential subdivisions, depending on the density. This open space includes yards, landscaping, etc. and is not a calculated value. It is up to the planner’s judgment to determine whether the development approaches the required value. The recently adopted Charlotte Tree Ordinance requires 10 percent of a development to be a “Tree Save Area”. Because the open space requirement is not calculated, the Tree Save Area requirement of 10 percent was used to calculate the hypothetical required open space. The open space requires is 10 acres and

resulting density is 3.3 units per acre for the remaining 90 acres of developable land.

- **Cabarrus County** – Cabarrus requires 218 square-feet of open space per person in a traditional residential subdivision. For the hypothetical development, CDM assumed 2.4 persons-per-unit, resulting in an estimated 720 persons for the 100-acre development. The required open space would be 3.6 acres with an average density of 3.1 units per acre for the remaining 96.4 acres of developable land. This represents the least stringent (least protective of the watershed) open space requirement of all the jurisdictions within the two local watersheds of interest.
- **Iredell County** – Iredell County uses an open space table based on the number of developable lots in a subdivision, up to 100 lots. An additional 0.5 acres of open space is required for every 10 additional lots. For the hypothetical development, the required open space is five acres for the initial 100 lots and an additional 10 acres for the remaining 200 lots. The total required open space is 15 acres with an average density of 3.5 units per acre for the remaining 85 acres of developable land.

2.7.2 Sedimentation and Erosion Controls

- **Town of Cornelius** - The Mecklenburg County LUESA monitors and enforces all sediment and erosion control within the Town of Cornelius' ETJ. Mecklenburg County requires a sediment and erosion control plan for the disturbance of one acre or more of land and/or the disturbance of 2,000 square feet within a watershed area on a tract requiring a stream buffer.
- **Town of Davidson** – The Town of Davidson sedimentation and erosion control regulations are the same as the Town of Cornelius'.
- **Town of Huntersville** – The Town of Huntersville sedimentation and erosion control regulations are the same as the Town of Cornelius'.
- **Town of Mooresville** – The NCDENR Division of Land Resources monitors and enforces all sediment and erosion control plans within the Town of Mooresville. A regional office, located within the Town of Mooresville, reviews all sediment and erosion control plans for the disturbance of one or more acres.
- **City of Charlotte** – The City of Charlotte Land Development Division monitors and enforces all sediment and erosion control within the City of Charlotte's ETJ and uses the same requirements as the Town of Cornelius.
- **Cabarrus County** – Cabarrus County monitors and enforces all sediment and erosion control within the County. A sediment and erosion control plan must be submitted to the County when land disturbance activities occur on one or more acres. The county follows the North Carolina Sedimentation and Erosion Control Manual with no additional regulations set forth.
- **Iredell County** – The NCDENR Division of Land Resources monitors and enforces all sediment and erosion control within the unincorporated portions of Iredell County (i.e. outside of municipal ETJs). The NCDENR Mooresville Regional Office

is located within the Town of Mooresville and receives all sediment and erosion control plans for the disturbance of one or more acres.

2.7.3 Stormwater BMPs Implementation and Design Criteria

For the purpose of the local watershed planning effort in the Upper Rocky River / Clarke Creek watershed, stormwater BMPs are defined as the practices or structures intended to maintain or improve water *quality*, particularly in water supply watersheds designated by the state. Runoff volume control (i.e., retention or detention) requirements are identified as stormwater runoff regulations (see Section 2.7.6).

The Town of Huntersville is the only jurisdiction that requires BMPs for residential and non-residential development. A copy of Huntersville's water quality ordinance and BMP manual can be obtained at <http://www.charmeck.org/Departments/LUESA/Water+and+Land+Resources/Programs/Water+Quality/Huntersville+Ordinance/Home.htm>. None of the remaining municipalities or counties in the study area requires the use of stormwater BMPs outside of water supply watersheds. No portions of the Upper Rocky River/Clarke Creek watershed are classified by the state as surface water supply watersheds. It should be noted that the Town of Davidson is currently in the process of considering adopting the same water quality ordinance and BMP manual as the Town of Huntersville.

2.7.4 Stream Buffer Requirements

- **Town of Cornelius** – Cornelius adopted the Mecklenburg County Surface Water Improvement and Management (S.W.I.M.) stream buffer guidelines. **Table 2-9** provides a summary of the S.W.I.M. stream buffer requirements for each of the municipalities within Mecklenburg County.
- **Town of Davidson** – The Town of Davidson has adopted the Mecklenburg County S.W.I.M. stream buffer guidelines (see Table 2-9).
- **Town of Huntersville** – The Town of Huntersville has adopted the Mecklenburg County S.W.I.M. stream buffer guidelines (see Table 2-9).
- **Town of Mooresville** – The Town of Mooresville currently does not have any stream buffer requirements. Telephone conversations with representatives of the Town indicate that the municipal ordinances are currently in the process of being revised and that stream buffer requirements may be included in the new ordinances by the end of 2003.
- **City of Charlotte** – The City of Charlotte has adopted the Mecklenburg County S.W.I.M. stream buffer guidelines (see Table 2-9).
- **Cabarrus County** – The Cabarrus County River/Stream Overlay District requires a minimum stream buffer width of 50 feet from the centerline of a USGS 7.5 minute topographic map defined stream (“blue line”) plus four times the average percent

TABLE 2-9

*Appendix A**Summary of Mecklenburg County S.W.I.M. Stream Buffer Requirements
(incorporated into existing Zoning Ordinances)*

August 5, 2002

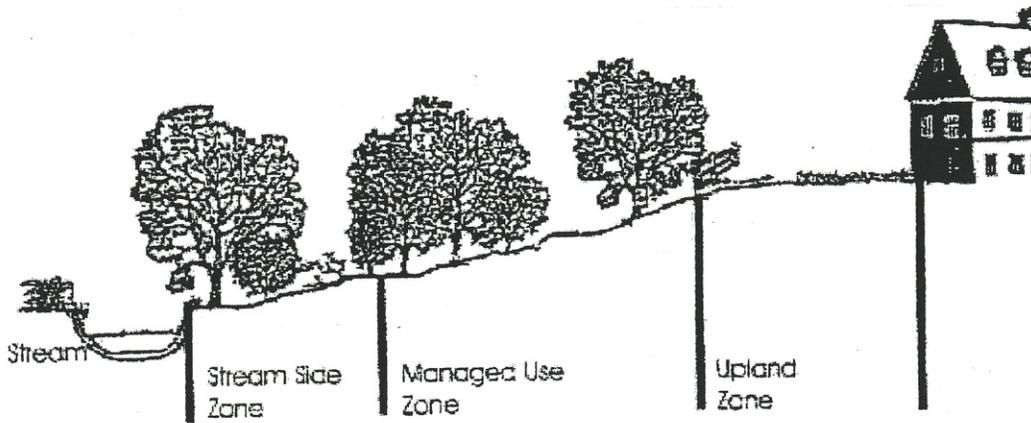
<i>Jurisdiction</i>	<i>Date Ordinance Adopted</i>	<i>Total Buffer Widths</i>			
		<i>≥ 640 acres</i>	<i>≥ 300 acres</i>	<i>≥ 100 acres</i>	<i>≥ 50 acres</i>
Mecklenburg County(1) unincorporated	11/9/99	total = 100 ft + 50% of area of floodfringe beyond 100 ft streamside=30ft. managed use=45ft. upland=25ft +50% of area of floodfringe beyond 100 ft	total = 50 ft streamside=20ft managed use =20ft. upland=10ft	total = 35 ft streamside=20ft managed use =none upland=15ft	No Buffer Requirements
Charlotte(1)	11/15/99	same as Mecklenburg County	same as Mecklenburg County	same as Mecklenburg County	same as Mecklenburg County
Cornelius(2)	12/6/99	total = entire floodplain but no less than 100 feet	total = 50 feet no zones	total = 35 ft no zones	
Huntersville(1)	10/19/99	total = floodway + 100% of floodfringe but no less than 100 ft streamside=30ft managed use=45 ft upland=remainder	total = 50 feet streamside=20ft managed use =20ft. upland=10ft	total = 35 ft streamside=20ft managed=none upland=15ft	
Matthews(1)	2/14/2000	same as Huntersville	same as Huntersville	same as Huntersville	
Davidson(1)		Town of Davidson recently adopted Charlotte-Mecklenburg S.W.I.M. Stream Buffer Rules			
Mint Hill	Town Board has directed staff to move forward with ordinance development - It is anticipated that the ordinance will be adopted in the spring of 2000				
Pineville	Town Board has directed staff to move forward with ordinance development - It is anticipated that the ordinance will be adopted in the spring of 2000				

All buffers are measure horizontally on a line perpendicular to the surface water, landward from the top of the bank on each side of the stream.

- (1) Function, vegetative targets and uses for each of the buffer zones correspond to the buffer plan developed by the S.W.I.M. Panel dated April 20, 1999 (see back of this sheet).
- (2) No buffer zones have been designated. The entire buffer area is designated in the Ordinance as "UNDISTURBED."

Note: Adopted from Mecklenburg County Department of Environmental Protection
S.W.I.M. Stream Buffer Implementation Guidelines (April 12, 2000)

TABLE 2-9 (CONTINUED)



Buffer function, vegetation and use vary according to the different buffer zones as described in the following table.

Characteristics	Stream Side Zone	Managed Use Zone	Upland Zone
Function	Protect the integrity of the ecosystems	Provide distance between upland development and the stream side zone	Prevent encroachment and filter runoff
Vegetative Targets ⁽¹⁾	Undisturbed (no cutting or clearing allowed) - If existing tree density is inadequate, reforestation is encouraged	Limited clearing - Existing tree density must be retained to a minimum of 8 healthy trees of a minimum 6 inch caliper per 1000 square feet - If existing tree density is inadequate, reforestation is encouraged	Grass or other herbaceous ground cover allowed - Forest is encouraged
Uses ⁽²⁾	Very restricted - Permitted uses limited to: flood control structures and bank stabilization as well as installation of utilities and road crossings with stabilization of disturbed areas as specified in Section 12.806.2	Restricted - Permitted uses limited to: all uses allowed in the Stream Side Zone, as well as storm water best management practices (BMPs), bike paths, and greenway trails (not to exceed 10 feet in width)	Restricted - Permitted uses limited to: all uses allowed in the Stream Side and Managed Use Zones, as well as grading for lawns, gardens, and gazebos and storage buildings (non-commercial and not to exceed 150 square ft)

Footnotes:

⁽¹⁾ Re-vegetation of disturbed buffers is required as specified in the Charlotte-Mecklenburg Land Development Standards Manual when such disturbances result in the failure of the buffer system to comply with the vegetative targets specified above. The manual also contains recommended tree densities for each zone for voluntary reforestation efforts.

⁽²⁾ Fill material can not be brought into the buffer. Grading is allowed only in the Upland Zone. Commercial buildings or occupied structures are not allowed in the buffer. Permitted uses within the buffer zones should be coordinated to ensure minimal disturbance of the buffer system. For example, if it is necessary to install utilities within the buffer, every attempt should be made to build greenway trails so they follow the cleared areas instead of requiring additional clearing.

Note: Adopted from Mecklenburg County Department of Environmental Protection S.W.I.M. Stream Buffer Implementation Guidelines (April 12, 2000)

of land slope as measured from top of bank, up to 120 feet. Stream buffers are not required for streams not identified on a USGS topographic map.

- **Iredell County** – There are currently no stream buffer requirements in Iredell County. Telephone conversations with representatives of the County indicate that there are no plans to incorporate such regulations in the future.

2.7.5 Floodplain Regulations

- **Town of Cornelius** – No development is allowed within the FEMA-defined 100-year floodplain without the Town of Cornelius Zoning Administrator’s approval that the activity mitigates the potential adverse impact of flood hazard.
- **Town of Davidson** – No development is allowed within the FEMA-defined 100-year floodplain and uplands (see Table 2-9 for a description of what constitutes an upland zone).
- **Town of Huntersville** – No new construction is allowed within any of the stream buffer zones identified by the Town of Huntersville S.W.I.M. buffer regulations (as adopted from Mecklenburg County). For streams with drainage areas greater than one square mile, the minimum required stream buffer width is 100 feet plus the area inundated by the 100-year storm event beyond 100 feet.
- **Town of Mooresville** – No inhabitable structures are allowed within the FEMA-defined 100-year floodplain.
- **City of Charlotte** – No new development is allowed to have the lowest floor level (including the basement) elevated less than one foot above the Flood Land Use Map (FLUM) base flood elevation. The FLUM base flood elevation, developed by the City of Charlotte, is the elevation of the 100-year storm under future land use conditions. Development is not allowed within a distance of the stream bank equal to one times the width of the stream at the top of bank or 20 feet each side from top of bank, whichever is greater for streams not having a previously-defined base flood elevation. Development may occur if it can be shown that there would be no increase in flood levels during the FLUM base flood discharge.
- **Cabarrus County** – No fill placement is allowed within the FEMA-defined 100-year flood zone and no development may occur within two vertical feet of the flood zone. Developers wishing to develop parcels adjacent to streams not included in a FEMA flood study may be unofficially required to perform a hydrologic/hydraulic flood study for the 100-year storm event to ensure no encroachment within two feet of the floodplain.
- **Iredell County** – Iredell County follows North Carolina’s model “Flood Damage Prevention Ordinance.” All new construction must have the lowest floor at or above the base flood elevation.

2.7.6 Stormwater Runoff Regulations

For the purpose of the local watershed planning effort in the Upper Rocky River / Clarke Creek watershed, it has been assumed that stormwater *runoff* regulations are intended to provide runoff volume control. Ordinances intended to improve water quality, such as those required in water supply watersheds, are considered stormwater BMP ordinances and are addressed in the appropriate section above.

- **Town of Cornelius** - LUESA monitors and enforces all stormwater runoff requirements within the Town of Cornelius' ETJ. Mecklenburg County requires stormwater runoff detention for non-single family residential development resulting in greater than 20,000 square-feet of impervious area and not bordered by a FEMA defined floodplain. Detention facilities must detain the 2- and 10-year design storms and release the runoff over a 24- to 72-hour period and "safely pass" the 50-year storm event.
- **Town of Davidson** - The Town of Davidson follows the requirements of LUESA, which monitors and enforces all stormwater runoff requirements within the Town of Davidson's ETJ.
- **Town of Huntersville** - The Town of Huntersville's new Water Quality Protection Ordinance requires that new development control and treat the first inch of runoff. Post-development runoff conditions must match pre-development runoff conditions for the one-year, 24-hour storm event or the two-year, 24-hour storm event, depending on the zoning category. A copy of the new Water Quality Protection Ordinance can be obtained at the web site provided in Section 2.7.3.
- **Town of Mooresville** - There are currently no stormwater runoff detention requirements within the Town of Mooresville's portion of the Upper Rocky River/Clarke Creek local watershed planning area. Telephone conversations with representatives of the Town indicate that the municipal ordinances are currently in the process of being revised and that stormwater runoff requirements may be included in the new ordinances by the end of 2003.
- **City of Charlotte** -The City of Charlotte Land Development Department monitors and enforces all stormwater runoff within the City of Charlotte's ETJ. Charlotte's stormwater runoff ordinances are consistent with those of Mecklenburg County [see regulations identified for the Town of Cornelius].
- **Cabarrus County** - There are currently no stormwater runoff detention requirements within Cabarrus County's portion of the Upper Rocky River/Clarke Creek local watershed planning area.
- **Iredell County** - There are currently no stormwater runoff detention requirements within Iredell County's portion of the Upper Rocky River/Clarke Creek local watershed planning area. Telephone conversations with representatives of the County indicate that there are no plans to incorporate such regulations in the future.

2.7.7 Conclusions and Recommendations

Table 2-10 provides a summary of each jurisdiction's regulations for the six stormwater and development-related ordinances. It can be seen from the table that each jurisdiction has its strengths and weaknesses in regards to stream and habitat degradation control and prevention. Due to the large number of jurisdictions (seven) whose ordinances have direct influence on stream and habitat protection, it can be difficult to develop a unified set of ordinances to govern the entire watershed with the goal of providing a complete and overarching set of regulations. Reviewing/revising jurisdictional ordinances individually is an alternative that can be an equally effective method to help ensure the protection of the watershed, assuming every municipality and county adopt/strengthen their regulations where appropriate.

The ordinance summary presented above outlined the current jurisdictional regulations, but did not rate their effectiveness in terms of controlling/preventing stream and habitat degradation. The Local Watershed MP&IS, discussed in Section 6 of this LWP, provides numerous recommendations for improving local ordinances. Specific elements of the strategies may already be included in the watershed management-related ordinances and regulations of the jurisdictions. In that case, it will be incumbent upon the jurisdiction to determine if revisions to their existing ordinances and regulations are warranted to achieve their desired goals.

As part of the implementation process, the jurisdictions are encouraged to perform a comprehensive self-assessment of all codes, ordinances, policies, and regulations that may be directly or implicitly impacting watershed health. The Center for Watershed Protection (CWP) provides a *Codes and Ordinances Worksheet* with the purpose of helping municipalities and counties assess the effectiveness of their ordinances and identify specific items that can be improved (the worksheet is included in Appendix C). There are also several model ordinances related to stormwater and land development available to municipalities and counties. The following is a list of potential model ordinances and key resources that can be used for assessing/revising local ordinances and regulations.

- The EPA provides "Model Ordinances to Protect Land Resources" which includes ordinances related to aquatic buffers, erosion and sediment control, open space development, stormwater control operation and maintenance, illicit discharges, post-construction controls, source water protection, and other miscellaneous ordinances. <http://www.epa.gov/owow/nps/ordinance/>
- The CWP provides model and existing ordinances related to post-construction runoff, erosion and sediment control, operations and maintenance, and others to help municipalities and counties custom-design stormwater ordinances. The ordinances can be accessed at either of the two following websites www.stormwatercenter.net and www.cwp.org. Additional ordinance information can be obtained from the CWP's *Rapid Watershed Planning Handbook*, October 1998.

**North Carolina Wetlands Restoration Program
Upper Rocky River / Clarke Creek Local Watershed Plan
Table 2-10 - Key Watershed Related Ordinances**

Jurisdiction	Key Watershed Related Ordinances								
	Stormwater Runoff	Sediment & Erosion Control	Stream Buffer				Open Space (see notes)	Stormwater BMP	Floodplain
			≥ 640 acres	≥ 300 acres	≥ 100 acres	≥ 50 acres			
Town of Cornelius	All regulations and enforcement are through the Mecklenburg County Land Use Environmental Services Agency	All regulations and enforcement through the Mecklenburg County Land Use and Environmental Services Agency	total = entire floodplain but no less than 100 feet	total = 50 feet	total = 35 feet no zones		12.5 acres	Not Required	No development shall occur within the FEMA defined floodplain.
Town of Davidson	All regulations and enforcement are through the Mecklenburg County Land Use Environmental Services Agency	All regulations and enforcement through the Mecklenburg County Land Use and Environmental Services Agency	total = 100 feet plus 50% of area of floodfringe beyond 100 feet	total = 50 feet	total = 35 feet	Not Required	45 - 60 acres	Not Required	No development shall occur within the FEMA defined floodplain or uplands.
Town of Huntersville	All regulations and enforcement are through the Mecklenburg County Land Use Environmental Services Agency	All regulations and enforcement through the Mecklenburg County Land Use and Environmental Services Agency	total = 100 feet plus 100% of area of floodfringe beyond 100 feet	total = 50 feet	total = 35 feet		See Note	Required	No development shall occur within Stream Buffers
City of Charlotte	All regulations and enforcement are through the City of Charlotte Land Development Division	All regulations and enforcement through the City of Charlotte Land Development Department	total = 100 feet plus 50% of area of floodfringe beyond 100 feet	total = 50 feet	total = 35 feet	Not Required	10 acres	Not Required	No development shall occur within the FLUM base flood elevation
Iredell County	Not Required	All regulations and enforcement through the State.	Not Required				15 acres	Not Required	No development shall occur within the FEMA defined floodplain.
Town of Mooresville	Not Required	All regulations and enforcement through the State.	Not Required				12.5 acres	Not Required	No habitable structures are allowed within the FEMA defined floodplain.
Cabarrus County	Not Required	All regulations and enforcement through the County	Total = Between 50 & 120 feet (see notes)				3.6 acres	Not Required	No development shall occur within the FEMA defined floodplain.

Last updated 11/9/2003

Note: Open Space - Minimum required open space for hypothetical 100-acre development with 300 dwelling units, used for comparison of open space requirements from different jurisdictions.
 Open Space - City of Charlotte 10-acres open space requirement refers to the recently adopted "City of Charlotte Tree Ordinance"
 Open Space - The Town of Huntersville's open space requirements have a maximum residential lot density of 1.2 units/acre. The hypothetical development (300 units on a 100-acre lot) would therefore not be permitted. The required lot area to develop 300 units is 250 acres.
 Stream Buffer - Cabarrus County requires a minimum 50-foot stream buffer plus four times the land slope as measured from top-of-bank, up to 120-feet (see Appendix B for further information).

- The NCDWQ provides model water supply watershed protection ordinances that can be used by the municipalities and counties in this watershed to further protect its valuable natural resources, regardless of classification. See Section 6 of this LWP for further recommendations on adopting water supply watershed regulations. <http://h2o.enr.state.nc.us/wswp/factform.html>
- The Low Impact Development Center provides numerous publications on LID design techniques that can be included in local municipal and county ordinances. <http://www.lowimpactdevelopment.org/publications.htm>
- The Town of Huntersville water quality ordinance and BMP manual, developed by Mecklenburg County, was adopted in an effort to control and prevent surface water degradation. The Town of Davidson is also considering adopting the ordinance and manual. <http://www.charmeck.org/Departments/LUESA/Water+and+Land+Resources/Programs/Water+Quality/Huntersville+Ordinance/Home.htm>

Presenting the most up-to-date stormwater and development-related ordinances for each of the seven jurisdictions proved to be a challenging task. The ordinances were dynamic due to the increasing awareness of and associated level of importance related to stormwater and development control. Several revisions and even new ordinances were developed during this study, including the Town of Huntersville's new water quality ordinance and BMP manual as well as revisions to their subdivision ordinance (the Town of Davidson is also considering adopting the same water quality ordinance and BMP manual); Cabarrus County has drafted a Unified Development Ordinance (UDO), but has yet to adopt it; Iredell County adopted open space requirements for subdivision development; and the Town of Mooresville is currently re-writing their ordinances to include stormwater runoff and riparian buffer requirements. The local ordinances should be checked periodically and updated in this LWP.

2.8 Watershed Infrastructure

The purpose of this section is to describe the water and wastewater distribution and collection systems within the Upper Rocky River/Clarke Creek watershed. The watershed is currently undergoing a transition from rural residential and forest cover to one experiencing intense urban (predominately residential) development pressures, as described in Section 2.6. That transition is leading to the expansion of both water and wastewater systems. The following is a summary of the infrastructure currently observed within the watershed as well as the planned future expansions of both water and wastewater systems.

2.8.1 Wastewater

Before 1990, the Upper Rocky River/Clarke Creek watershed was relatively undeveloped and as a result, a majority of the watershed did not have wastewater collection systems. Residential development was widely dispersed, with the

exception of the Town of Mooresville and a portion of the Town of Davidson, and therefore relied primarily onsite septic systems. Since 1990, the intense urban growth pressure experienced by the City of Charlotte has led to the overflow of residential development into the Towns of Davidson and Huntersville, and with it, wastewater collection system expansion and onsite wastewater package plants. The watershed's wastewater infrastructure now consists of a mixture of onsite septic tanks, onsite treatment package plants, and municipal collection systems.

Septic tanks are a reliable means of wastewater treatment in areas where development densities are within regulatory requirements, soils are appropriate for the use of septic tanks, and the systems are well maintained. (Rules for the siting, construction, and operation of sewage treatment and disposal systems such as septic tanks and other on-site alternatives may be found in Title 15A Subchapter 18A of the North Carolina Administrative Code, Section .1900 – Sewage Treatment and Disposal Systems, or at http://www.deh.enr.state.nc.us/oww/Rulelaw/Current_Rules.pdf.) However, information compiled by the State of North Carolina suggests that as many as 14 percent of all septic tanks in use in North Carolina, on average, are not performing as intended due to structural degradation, non-existent or infrequent maintenance, or the inability of the surrounding soil to infiltrate and treat the effluent (personal communication with Peter Whittaker, NCDENR Division of Environmental Health). Effluent from these “failing” septic tanks then enters the stream network of the watershed, introducing fecal coliform bacteria. The potential sources of fecal coliform bacteria in streams of the watershed may include not only failing septic tanks, but also uncontrolled sanitary sewer overflows (SSOs) from collection system manholes due to blockages, structural pipe failures, or inadequate capacity; or from effluent that enters streams from leaking pipe joints.

Since centralized treatment and disposal can be costly on a per customer basis, it has not traditionally been utilized in predominantly rural areas such as the Upper Rocky River/ Clarke Creek watershed. As the area continues to develop, however, alternative methods of wastewater collection and treatment including on-site treatment package plants and centralized treatment and disposal of wastewaters will be implemented throughout the watershed.

2.8.1.1 On-site Systems

The number of septic tanks could not be directly determined due to insufficient data. Therefore, the approximate number of septic tanks was determined using the GIS tax parcel databases.

The Mecklenburg County GIS tax parcel coverage consisted of a field identifying when a parcel has a building number associated with it. Therefore, it was assumed that if there was a building number associated with the parcel there was a possibility of it having a septic tank. The parcels were then screened based on the presence of sanitary sewer overflows (SSO), sanitary sewer lines, lift stations, or NPDES permits (signifying an onsite package plant if it's near a large dense residential development)

at or near the parcel to determine if wastewater collection has been available. The resulting number of parcels in Mecklenburg County and in the Upper Rocky River/Clarke Creek watershed predicted to have onsite septic tanks is 1,170.

The Cabarrus County GIS tax parcel coverage consisted of a field which identified the value of any building on the property. Therefore, it was assumed that if there was a building value associated with the parcel there was a possibility of it having a septic tank. The parcels were then screened based on the presence of NPDES permits (signifying an onsite package plant if it's near a large dense residential development) to determine which properties were expected to have septic tanks. Cabarrus County recently constructed an eight-inch interceptor which runs up the Rocky River and intersects the Mecklenburg and Cabarrus County borders after crossing SR 1600 (Shiloh Church Road). Because the interceptor was installed in approximately 1998, it was assumed that any development not recently constructed was not hooked onto the interceptor. The resulting number of parcels in Cabarrus County and in the Upper Rocky River/Clarke Creek watershed predicted to have onsite septic tanks is 800.

The Iredell GIS tax parcel coverage did not have attributes that could be used to identify parcels with buildings located on them. All parcels located within the Town of Mooresville's ETJ were assumed to be part of the local wastewater collection system, based on telephone conversations with town representatives. All parcels within the unincorporated portion of Iredell County were assumed to potentially have septic tanks. The parcels were then screened based on the following two criteria: (1) the presence of NPDES permits - signifying an onsite package plant if it's near a large dense residential development, and (2) if a large, dense residential development was located on the Town of Mooresville's ETJ border and did not have an NPDES permit, it was assumed that the development contributed to the Town of Mooresville's collection system. The remaining parcels were then screened based on the average percentage of parcels with buildings determined for Mecklenburg and Cabarrus Counties. The percentage of parcels having buildings for Mecklenburg and Cabarrus Counties was determined to be 84 and 63 percent, respectively, by comparing data contained in the GIS for the total number of parcels with buildings versus the total number of parcels. The average of the two counties was (74 percent) used to approximate the number of septic tanks in the watershed in Iredell County. The resulting number of parcels in Iredell County and in the Upper Rocky River/Clarke Creek watershed predicted to have onsite septic tanks is 950.

The estimated total number of onsite septic tanks for Cabarrus, Iredell, and Mecklenburg Counties is 2,920. Based on a telephone conversation with Peter Whittaker with NCDENR in the Asheville Regional Office, a study conducted by NCDENR on the western part of NC, including Cabarrus, Mecklenburg, and Iredell Counties revealed that approximately 10 to 14 percent of all septic tanks are currently failing. Based on this estimate, it can be assumed that between 290 and 410 of the septic tanks in the Upper Rocky River/Clarke Creek watershed are failing.

2.8.1.2 Treatment and Collection Systems

Only a small portion of the watershed is currently provided with wastewater collection systems or onsite package plants. However, that small portion accounts for a majority of the population in the watershed. The largest urbanized areas consist of the Town of Mooresville, downtown Davidson, and the subdivisions in the Town Huntersville and City of Charlotte. These areas all contribute to wastewater collection systems. There are also several subdivisions located in the watershed, several of which have onsite wastewater package plants. **Figure 2-14** shows the portions of the watershed assumed to have sanitary sewer collection systems or onsite wastewater package plants. The residential developments shown on Figure 2-13 that are currently being constructed, approved for construction, or in the planning stages will result in the addition of approximately 12,500 new homes, all which will be served by centralized wastewater collection systems.

The Town of Mooresville wastewater treatment plant (WWTP) is located just upstream of the SR 1142 (Johnson Dairy Road) and Dye Creek crossing, also shown on Figure 2-14. The WWTP discharges into Dye Creek and has an NPDES permitted flow of 5.2 million gallons per day (MGD). A further discussion on the impacts of the WWTP is presented in Section 3.

2.8.1.3 Sanitary Sewer Overflows

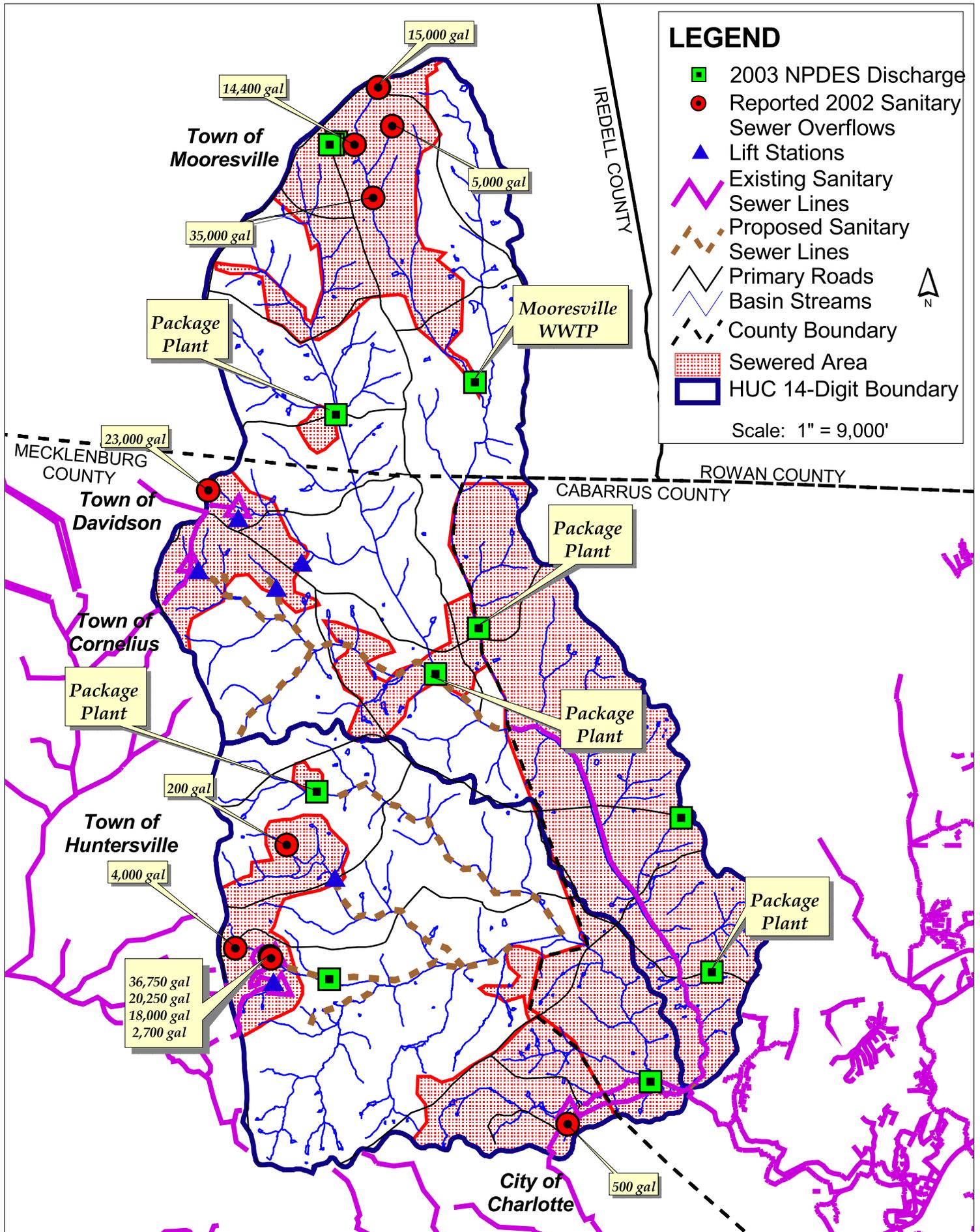
Figure 2-14 shows the location and associated overflow volume for the 12 SSO's reported in 2002 in the Upper Rocky River/Clarke Creek watershed. All spills were reported to have entered into the nearest stream or tributary. There were not any reported overflows in Cabarrus County in 2002.

2.8.1.4 Wastewater System Planning

Telephone and face-to-face conversations were conducted with municipal and county representatives to determine if and when wastewater collection system expansion would occur in the watershed. Based on the information provided, it can be assumed that all new development in the Upper Rocky River/Clarke Creek watershed, with the exception of the unincorporated portion of Iredell County, will have the opportunity to provide sanitary sewer service to its residents. The following is a brief summary of the information collected.

Iredell County

There are currently no plans for Iredell County or the Town of Mooresville to expand their wastewater collection systems into the unincorporated portion of the County in the watershed. A meeting with representatives of the Town of Davidson indicated that there is currently a prohibitive agreement that states that the Charlotte-Mecklenburg Utilities (CMU) will not expand its water or wastewater systems into Iredell County. Therefore, it can be assumed that the unincorporated portion of Iredell County in the Upper Rocky River/Clarke Creek watershed will remain septic.



Data Source: NCGIA 2000 BasinPro, Mecklenburg, Iredell, and Cabarrus County GIS

Figure 2-14
Upper Rocky River/Clarke Creek Local Watershed Plan
Wastewater Infrastructure



Cabarrus County

The construction of the eight-inch interceptor running up the Rocky River, see Figure 2-14, will enable new construction access to the County's wastewater collection system. It was assumed for this study that no existing developments contribute to the interceptor, but that all new development will.

Mecklenburg County

CMU provided a GIS coverage showing the location of proposed sanitary sewer lines included in their 2003 to 2007 Capital Improvement Plan (CIP) budget. It can be seen from Figure 2-14 that the proposed sewer lines will receive flow from a majority of the watershed in Mecklenburg County. Based on telephone conversations with representatives of CMU, areas not directly served by the proposed sewer lines will have the opportunity to hook on to the collection system if desired.

2.8.2 Water Supply

The water supply system in the Upper Rocky River/Clarke Creek watershed is comprised of a mixture of community and non-community water wells and municipal/county distribution systems. Similarly to sanitary sewer, as urban development pressures from the City of Charlotte has forced residential development into the Towns of Davidson and Huntersville, so has the expansion of drinking water distribution systems.

2.8.2.1 Drinking Water Wells

Private Wells

Based on telephone conversations with representatives of the local jurisdictions, it is reasonable to assume that where there is municipal or county sanitary sewer systems there is public drinking water systems. The same theory applies to where there are onsite septic systems, there most likely are drinking water wells. Based on that assumption, there are approximately 2,920 drinking water wells in the Upper Rocky River/Clarke Creek watershed in Cabarrus, Iredell, and Mecklenburg Counties.

Community Wells

The Public Water Supply Section of NCDENR provided information for all community, non-transient non-community, and transient non-community drinking water wells in the Upper Rocky River/Clarke Creek watershed. The Public Water Supply Section defines the three well types as follows:

- Community water system: A public water system which serves at least 15 service connections used by year-round residential or regularly serves at least 25 year-round residents.
- Non-transient non-community water system: A public water system that is not a community water system and that regularly serves at least 25 of the same persons over 6 months per year.

- **Transient non-community water system:** A non-community water system that does not regularly serve at least 25 of the same persons over six months per year.

A GIS coverage was created using the latitudinal and longitudinal coordinates provided, as shown on **Figure 2-15**. The drinking water wells are estimated to serve a total of 2,740 persons, with the largest individual well serving 1,001 persons.

2.8.2.2 Distribution Systems

Figure 2-15 shows the public drinking water distribution system for Cabarrus and Mecklenburg Counties. GIS data was not provided by Iredell County. Based on telephone conversations with representatives of the Town of Mooresville, it is reasonable to assume that where there are municipal sanitary sewer systems (as shown on Figure 2-14) there are public drinking water systems.

2.8.2.3 Water Supply Planning

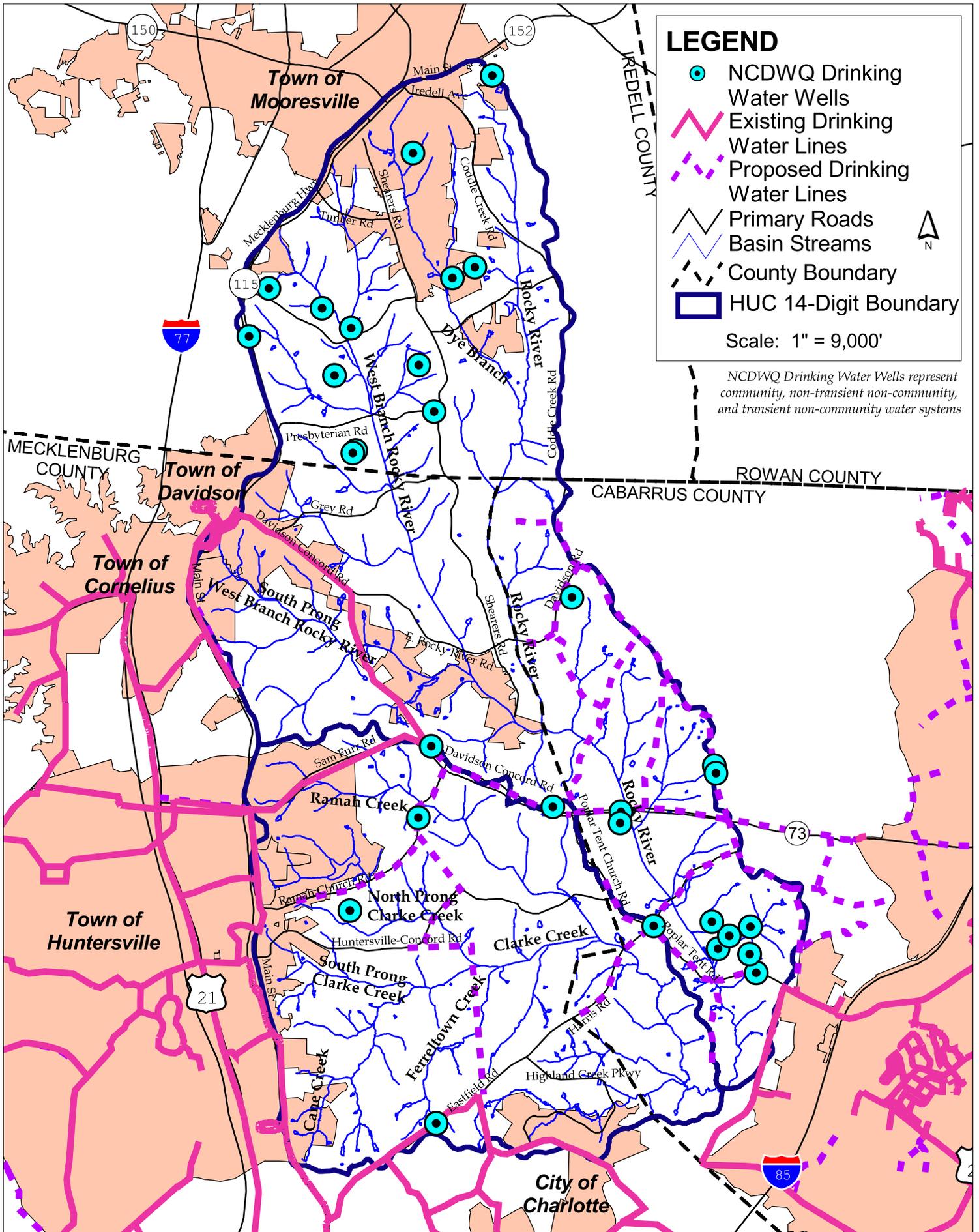
Cabarrus and Mecklenburg Counties provided GIS coverages of their existing and planned water distribution systems, as shown on Figure 2-15. The Cabarrus County proposed water distribution system expansion was identified for their 2015 capital improvement program (CIP). The Mecklenburg County proposed water distribution system expansion was identified for their 2004 CIP. It can be seen that the proposed water distribution systems follow similar growth patterns as that of the wastewater distribution systems, shown on Figure 2-14. Iredell County and the Towns of Mooresville and Davidson have no plans at this time to expand their water distribution systems into the unincorporated portions of Iredell County.

2.9 Current Restoration and Preservation Efforts

Land and habitat preservation and restoration is becoming increasingly more recognized for its effective role in preserving and restoring key natural resources in watersheds. Local non-profit land trusts and state agencies such as the NCWRP and North Carolina Wildlife Resources Commission (NCWRC) recognize the significant number of existing and lost natural resources in the watershed. They also recognize the significant urban development pressures currently being experienced in the watershed. There has been some effort to preserve/restore key natural resources, but that level of effort must be increased before development eliminates the opportunities in the watershed. The following is a description of the preservation and restoration efforts currently being conducted in the Upper Rocky River/Clarke Creek watershed.

2.9.1 Land and Habitat Preservation

Land preservation provides a multitude of benefits towards protecting and preserving everyday functions of the watershed and its natural resources as well as preserving areas of significant habitat and/or species. By preserving lands through non-profit land trusts or municipal land trusts it can be assumed that the amount of development and associated impervious area is maintained at a very low level, thus ensuring the benefits typically associated with forest or open space lands. Land and



LEGEND

- NCDWQ Drinking Water Wells
- Existing Drinking Water Lines
- - - Proposed Drinking Water Lines
- Primary Roads
- Basin Streams
- - - County Boundary
- HUC 14-Digit Boundary

Scale: 1" = 9,000'

NCDWQ Drinking Water Wells represent community, non-transient non-community, and transient non-community water systems

Data Source: NCGIA 2000 BasinPro, Mecklenburg, Iredell, and Cabarrus County GIS

Figure 2-15
Upper Rocky River/Clarke Creek Local Watershed Plan
Drinking Water Infrastructure



habitat preservation is currently being conducted in the Upper Rocky River/Clarke Creek watershed through the Catawba Lands Conservancy, Davidson Lands Conservancy, public greenways and parks, and state land trusts. **Figure 2-16** shows the lands currently being preserved in the watershed. Stream buffer zones were not included in the figure. The following is a brief description and local contact for each land preservation organization.

2.9.1.1 Catawba Lands Conservancy

The Catawba Lands Conservancy is a non-profit land trust and member of the Land Trust Council of North Carolina and the national Land Trust Alliance. Their purpose is to protect lands having significant water and wildlife resources in the Southern Piedmont and Lower Catawba River Basin. They have been instrumental in the preservation of 910 acres of lands having significant natural resources in the watershed, as shown on Figure 2-16. Based on telephone conversations with the Catawba Lands Conservancy, they are currently in the process of coordinating with local land owners to ensure the preservation of an additional 950 acres within the watershed. For additional information regarding the program visit their website at <http://www.catawalands.org/index.asp>.

2.9.1.2 Davidson Lands Conservancy

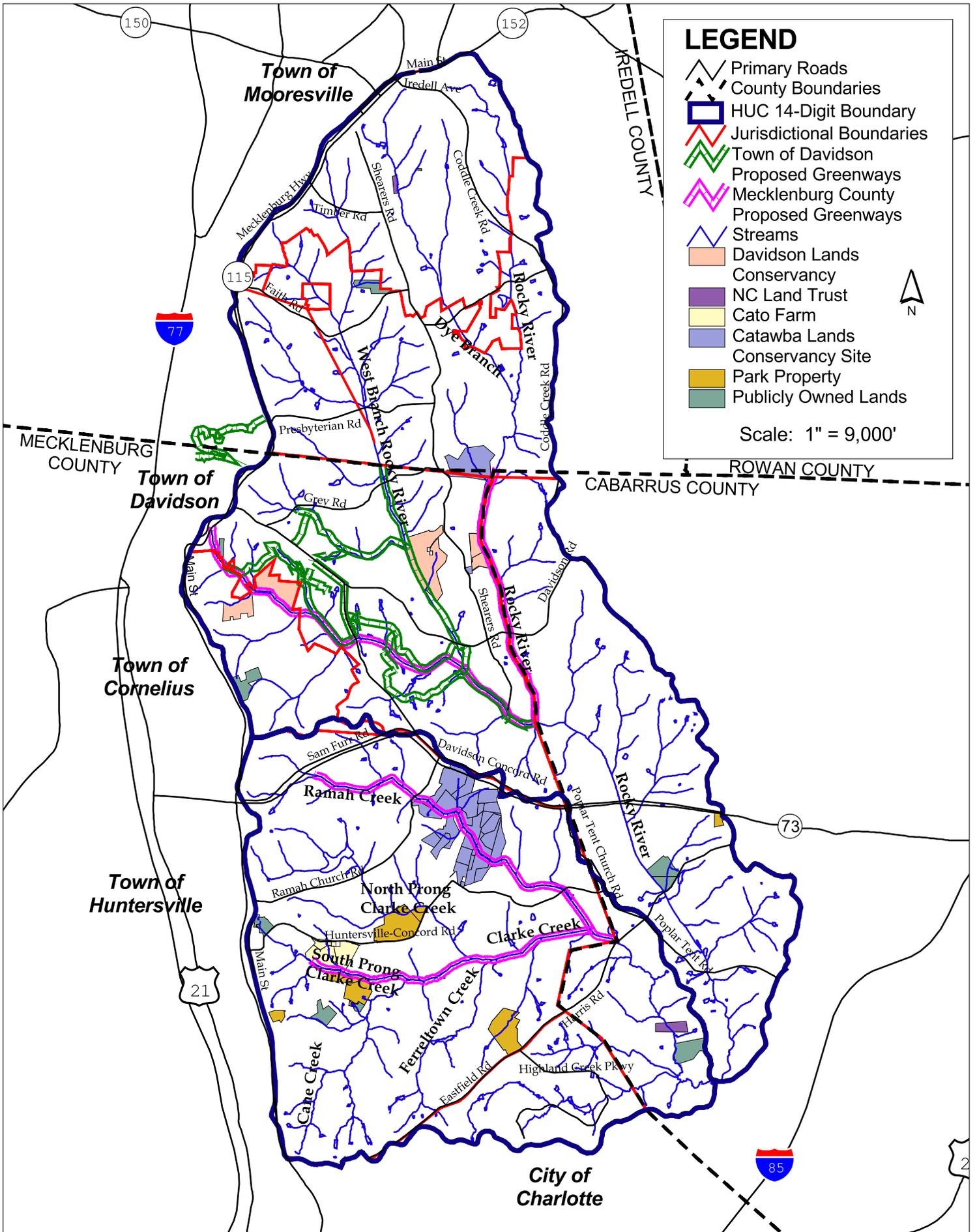
The Davidson Lands Conservancy is a non-profit community-based land trust founded in 2000 in the Town of Davidson. Their purpose is to protect lands having significant water and wildlife resources in the Town of Davidson and neighboring communities in Mecklenburg, Cabarrus, and Iredell Counties. They have been instrumental in the preservation of 453 acres of lands having significant natural resources in the watershed, as shown on Figure 2-16. For additional information regarding the program visit their website at <http://www.davidsonlands.org/index.html>.

2.9.1.3 Land Trust for Central North Carolina

The Land Trust for Central North Carolina is a non-profit land trust operation in ten counties in central North Carolina, including Cabarrus and Iredell Counties, for the purpose of protecting lands having significant water and wildlife resources. They have been instrumental in the preservation of 58 acres of lands having significant natural resources in the watershed, as shown on Figure 2-16. An additional 41 acres in Iredell County in the watershed are listed as planned conservation gifts. Based on telephone conversations with the Land Trust for Central North Carolina there are no plans to pursue additional lands in the Upper Rocky River/Clarke Creek watershed at this time. For additional information regarding the program visit their website at <http://www.landtrustcnc.org/index.html>.

2.9.1.4 Public Lands, Greenways, and Parks

There are 1,378 acres of publicly owned lands in the Upper Rocky River/Clarke Creek watershed, of which, 1,036 acres contain or border 5.5 miles of intermittent or



Data Source: NCGIA 2000 BasinPro, Mecklenburg, Iredell, and Cabarrus County GIS

Figure 2-16
 Upper Rocky River/Clarke Creek Local Watershed Plan
 Existing or Planned Land
 Preservation & Stream Restoration Sites



perennial streams, as shown on Figure 2-16 [based on 2002 GIS tax parcel data]. The Town of Davidson recently received funding for the purchase of 20.2 miles of greenway and bike trails, also shown on Figure 2-16. Mecklenburg County is currently in the process of obtaining 19.4 miles of park greenway along perennial streams including the Rocky River, South Prong Rocky River, Ramah Creek, and Clarke Creek, also shown on Figure 2-16.

2.9.2 Existing Restoration Projects

There is currently one restoration project in the Upper Rocky River/Clarke Creek watershed. Cato Farms stream restoration project was funded by NCWRP and is shown on Figure 2-16. The project consists of the restoration of approximately 3,000 linear feet of the South Prong Clarke Creek.

Section 3

Comprehensive Watershed Assessment

3.1 Introduction

CDM used the watershed characterization data compiled from the members of the LWPG, the NCDENR Division of Water Quality, and various GIS data sources to develop a comprehensive watershed assessment for the Upper Rocky River / Clarke Creek watershed. This information was used to identify general trends in observed water quality and habitat conditions throughout the watershed, in part to develop a comprehensive watershed assessment that served as the basis for the development of the subwatershed ranking protocol discussed in Section 4. Key components of the comprehensive watershed assessment included 1) review and assessment of available water quality data and benthic macroinvertebrate surveys, 2) development of a water quality model for the entire watershed, and 3) development of hydrologic and hydraulic models for selected portions of the watershed. Each activity is discussed in detail below.

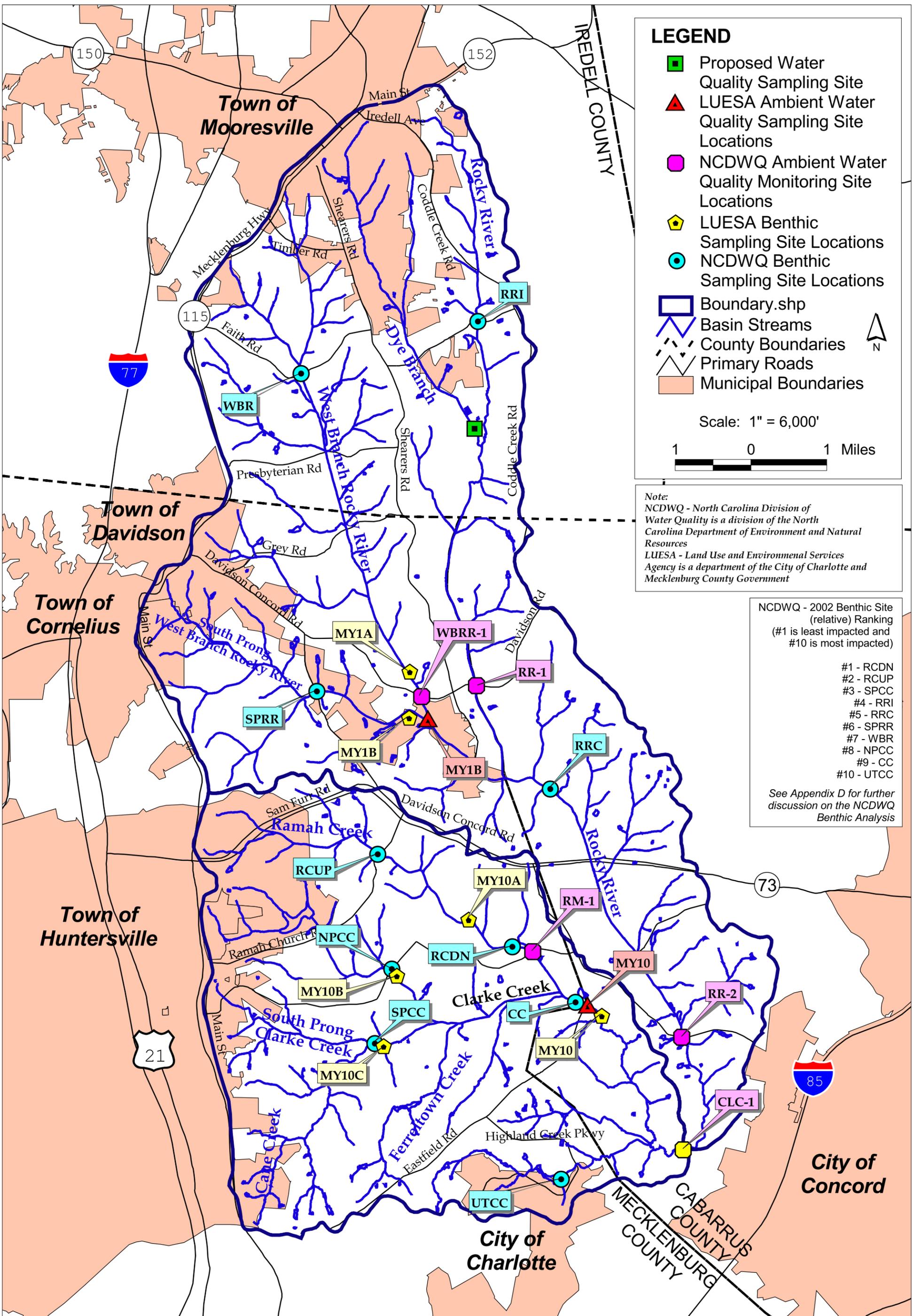
3.2 Water Quality Monitoring

As part of the technical assessment of the Upper Rocky River / Clarke Creek watershed, CDM obtained and reviewed data from a number of historical and ongoing water quality monitoring initiatives undertaken by state and local programs. Data related to historical and existing water quality included:

- Water quality assessments including two Basinwide Assessments prepared by the NCDENR Division of Water Quality and long-term monthly water quality data obtained from the Division of Water Quality's Environmental Services Branch,
- Monthly water quality data collected by the LUESA (formerly the Charlotte-Mecklenburg Environmental Protection Department) at two monitoring locations in the watershed, and
- Chemical/physical water quality monitoring data collected in the watershed by the Division of Water Quality in support of the ongoing local watershed planning effort.

The locations of monitoring stations identified with each of these water quality monitoring efforts are shown on **Figure 3-1**. Specific conclusions concerning observed water quality in the watershed derived from these efforts are discussed below.

A benthic macroinvertebrate community survey was also conducted by the Division of Water Quality's Biological Assessment Unit in support of the local watershed planning effort. Information collected and preliminary conclusions reached from this effort are also discussed below.



LEGEND

- Proposed Water Quality Sampling Site
- ▲ LUESA Ambient Water Quality Sampling Site Locations
- NCDWQ Ambient Water Quality Monitoring Site Locations
- ⬠ LUESA Benthic Sampling Site Locations
- NCDWQ Benthic Sampling Site Locations
- Boundary.shp
- Basin Streams
- County Boundaries
- Primary Roads
- Municipal Boundaries

Scale: 1" = 6,000'

1 0 1 Miles

Note:
 NCDWQ - North Carolina Division of Water Quality is a division of the North Carolina Department of Environment and Natural Resources
 LUESA - Land Use and Environmental Services Agency is a department of the City of Charlotte and Mecklenburg County Government

NCDWQ - 2002 Benthic Site (relative) Ranking (#1 is least impacted and #10 is most impacted)

- #1 - RCDN
- #2 - RCUP
- #3 - SPCC
- #4 - RRI
- #5 - RRC
- #6 - SPRR
- #7 - WBR
- #8 - NPCC
- #9 - CC
- #10 - UTCC

See Appendix D for further discussion on the NCDWQ Benthic Analysis

Data Source: NCCGIA 2000 BasinPro and Mecklenburg, Iredell, and Cabarrus County GIS Departments

Figure 3-1
 Upper Rocky River/Clarke Creek Local Watershed Plan
 Water Quality Sampling Site Locations (Chemistry and Benthics)



3.2.1 Water Quality Monitoring Data Sources

DWQ Basinwide Assessments

Information contained in the NCDENR Division of Water Quality's 2002 Basinwide Assessment Report on the Yadkin River Basin, published in June 2002, and the 1997 Basinwide Water Quality Management Plan for the Yadkin-Pee Dee River Basin proved especially valuable in identifying water quality trends and sources of concern from the regulatory perspective. These reports were developed by the Division of Water Quality as part of a systematic assessment of the state's seventeen major river basins. Thirty years of monthly water quality sampling data taken at an ambient monitoring station on the Rocky River at SR 2420 was obtained from the Division of Water Quality's Environmental Services Branch in an effort to identify any long-term trends related to water quality. This ambient monitoring station is the only state-maintained water quality monitoring station identified in the 77-square-mile study area, and was used by the Division of Water Quality in their assessment of water quality conditions in this part of the watershed.

Water quality data for the 2002 report was routinely collected by the state at the ambient monitoring station on the Rocky River at SR 2420 near Davidson between September 1, 1996 and August 31, 2001. Water quality data for the 1997 report was collected at the same ambient monitoring station from 1992 through 1996, unless otherwise stated. Another organization, the Yadkin Pee Dee River Basin Organization (YPDRBA), also collected water quality data in the watershed area at SR 2420. The YRDRBA is a coalition of NPDES point source discharge permit holders who have organized in an effort to more cost-effectively collect water quality data for NPDES permit compliance. The 2002 Basinwide Report indicates that the data collected at the monitoring station was obtained by the Division of Water Quality during the development of the 2002 plan but was not used in the assessment of water quality in the watershed because the YPDRBA data sampled over the same period of record as the North Carolina Department of Water Quality data.

Charlotte-Mecklenburg EPD Monitoring

Water quality data collected by the Charlotte-Mecklenburg EPD (now known as the Land Use and Environmental Services Agency, or LUESA) at two locations in the Mecklenburg County portion of the watershed was also included in the assessment. The water quality sampling stations are located on Clarke Creek (station MY-10) and on the south prong of the West Branch of the Rocky River near Davidson (station MY-1B). The location of the stations can be seen in Figure 3-1. Monthly water quality data for a number of parameters has been collected at the two locations since 1988 and 1994, respectively. The primary parameters that were sampled include nutrients, metals, dissolved oxygen, fecal coliform, and solids.

Ongoing DWQ Chemical/Physical Water Quality Monitoring

The DWQ is conducting an ongoing chemical/physical water quality monitoring program in support of the local watershed planning effort. The monitoring program is assessing ambient water quality at five locations in the Upper Rocky River/Clarke

Creek watershed as shown in Figure 3-1. The purpose of the ongoing monitoring is to assist with the identification of factors that are influencing current water quality in the watershed. This information can be used to assist in the characterization of water quality conditions and identification of specific sources of pollutants, as well as for the calibration of water quality model refinements, if warranted.

The sampling program was developed by DWQ with input from CDM regarding the recommended sampling locations. Locations were selected based on observed watershed land use patterns and degradation as well as anecdotal evidence of water quality impairments relayed by the Local Watershed Planning Group. The DWQ is planning on collecting baseflow and stormflow data for a period of at least six months. To date, the DWQ has performed three baseflow samplings and one stormflow sampling. The DWQ is sampling a limited selection of parameters required to develop use support decisions for 305(b)/303(d) reporting. Results of the sampling performed as of November 2003 are included in Appendix D.

The compiled data set was unavailable during the evaluation of the subwatersheds, but was reviewed following the development of the subwatershed prioritization to determine if observed water quality conditions were in agreement with those areas that were predicted to be impaired by other observations and water quality modeling.

3.2.2 Summary of Water Quality Monitoring Results

3.2.2.1 Long-Term Water Quality Trends

According to the 1997 and 2002 Basinwide Reports prepared by the Division of Water Quality, the main water quality concerns in the Yadkin-Pee Dee river basin as a whole are increasing nutrient loadings, land use changes (increased development in once rural areas), sediment in streams from nonpoint sources, and in-stream impacts from permitted municipal and industrial dischargers. The 2002 Basinwide Report does not identify specific nonpoint and point sources of these water quality stressors in subbasin 11, other than specific mention of the Rocky River WWTP, the largest point source located in the subbasin. Of note, the most degraded water quality was found in Forsyth, Rowan, Iredell, Cabarrus, and Davidson counties. The reports indicate that the monitoring stations that detected high levels of nutrients (nitrogen and phosphorus) were all located downstream of wastewater treatment facilities having NPDES discharge permits. The 2002 report notes the potential to downplay the role of nonpoint source pollution and over-state the role of point source pollution as contributory to water quality degradation because 2001 was a drought year. Accordingly, the Division of Water Quality cautions against making conclusions about point versus nonpoint source pollution as increasing or decreasing without considering the drought.

Ambient water quality data obtained at the Upper Rocky River monitoring station located at SR 2420 are shown in **Table 3-1**. The table also compares the findings of the 2002 report with findings from the 1997 report, regulatory standards for the Class C waters found in the local watershed planning area, and approximately 30 years of

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**Table 3-1 - Comparison of Regulatory Standards and Water Quality Data in the Study Area
at the Ambient Monitoring Station at SR 2420**

Parameter	Reported Percentile Pollutant Concentrations						Typical Concentrations ⁸	Trend ²	Regulatory Standard	Meets Regulatory Standard?
	1997 Basinwide Report			2002 Basinwide Report						
	25th	Median	75th	25th	Median	75th				
Field Measurements										
Dissolved Oxygen (mg/l)	7.5	8.3	9.8	7.6	8.8	10	3 - 9	no trend	See note 4	yes
Conductivity (umhos/cm)	475	575	740	247	341	435	N/A	inconclusive	NR	NR
Temperature (degrees C)	-	-	-	10	16	22	Variable	no trend	See note 5	no conclusion
pH (s.u.)	7.5	7.6	7.8	7.2	7.3	7.5	4.5 - 8.5	no trend	6 - 9	yes
Physical Measurements										
Turbidity (NTU)	-	-	-	8	12	15	N/A	increasing	50 NTU	yes
TSS (mg/l)	-	-	-	9	14	22	10 - 110	increasing	NR	NR
Bacterial Testing										
Fecal Coliform*	200	790	1400	105	290	500	N/A	no trend	See note 6	no
Metals										
Aluminum (ug/l)	-	-	-	395	620	970	50	inconclusive	NR	NR
Arsenic (ug/l)	-	-	-	BRL	BRL	BRL	2	no trend	50	yes
Cadmium (ug/l)	-	-	-	BRL	BRL	BRL	≈ 0 - 5	inconclusive	2	yes
Chromium (ug/l)	-	-	-	BRL	BRL	BRL	1	inconclusive	50	yes
Copper (ug/l)	-	-	-	2	5	6	10	inconclusive	7	no
Iron (ug/l)	-	-	-	785	1000	1350	0.04	increasing	1000	no
Lead (ug/l)	-	-	-	BRL	BRL	BRL	1	no trend	25	yes
Mercury (ug/l)	-	-	-	BRL	BRL	BRL	1	inconclusive	12	no conclusion
Nickel (ug/l)	-	-	-	BRL	BRL	BRL	2.2	no trend	88	yes
Zinc (ug/l)	-	-	-	19	29	51	30	inconclusive	50	no conclusion
Nutrients										
NH3 as N (mg/l)	-	-	-	0.01	0.05	0.11	0.01 - 10	decreasing	NR	NR
TKN as N (mg/l)	-	-	-	0.4	0.6	0.75	N/A	decreasing	NR	NR
NO2 + NO3 as N (mg/l)	-	-	-	2.1	4.8	8.75	0.24 - 0.73	increasing	NR	NR
Total Nitrogen (mg/l)	3.5	4.5	6	2.5	5.4	9.5	0.1 - 10	increasing	NR	NR
Total Phosphorus (mg/l)	1.25	1.55	2	0.64	1	1.45	0.02 - 6	no trend	NR	NR

General Notes:

1. Data obtained from 1997 and 2002 Basinwide Assessment Reports for the Yadkin River Basin Prepared by NCDENR Division of Water Quality. The 1997 Basinwide Report did not include the summary of all water quality parameters found in the 2002 report.
2. Trend is defined as Increasing, Decreasing, Inconclusive, or No Trend based on a review of Ambient Monitoring Station Data from 1972 to 2001.
3. BRL = Most all samples collected for these metals had concentrations below the reporting level. In cases where samples were above the reporting level, there were too few samples to make statistical conclusions so this data was not interpreted.
4. Not less than a daily average of 5 mg/l with a minimum instantaneous value not less than 4.0 mg/l.
5. Temperature shall not exceed 2.8 degrees Celsius above the natural water temperature, and shall in no case exceed 32 degrees Celsius.
6. Geometric mean shall not exceed 200/100ml (MF count) based on at least 5 consecutive samples within 30 days nor exceed 400/100ml in over 20 percent of the samples.
7. NR = Not Regulated
8. Typical concentrations for streams and rivers in the United States obtained from Maidment's Handbook of Hydrology, 1993.

*Interpreted from graph, therefore value is approximate.

ambient monitoring data taken from the station at SR 2420 to identify temporal trends, if any. Typical concentrations for freshwater streams and rivers are included in Table 3-1 as well for general information purposes. These background concentrations should be evaluated from measured baseflow concentrations obtained for the watershed of interest as sufficient data is collected in the future.

Table 3-1 indicates that concentrations of **ammonia** and **total kjeldahl nitrogen (TKN)** have decreased since monitoring began in 1972. At the same time, **nitrate and nitrite** concentrations in the river have increased over the last thirty years. The increase began after 1981 and continues through the present day. Summary data for ammonia as nitrogen, TKN, and nitrates and nitrites was not included in the 1997 Basinwide Report. However, the median concentration of total nitrogen was observed to increase between the 1997 and 2002 Basinwide Reports.

The relatively short period of record available for the two Charlotte-Mecklenburg EPD monitoring stations makes long-term trend determinations for nutrients infeasible. However, values for all sampled nutrients except for nitrates and nitrites appear consistent with data compiled from the Division of Water Quality's ambient monitoring station at SR 2420. Values for these parameters at SR 2420 are significantly higher than the data collected at the Charlotte-Mecklenburg EPD monitoring stations. These higher values are thought to be a result of the point source discharge of the Mooresville Wastewater Treatment Plant located on Dye Creek above the SR 2420 monitoring station.

Similar trends for **total phosphorus** were identified when comparing monitoring data from the ambient monitoring station at SR 2420 to the Charlotte-Mecklenburg EPD data. Phosphorus concentrations have remained steady in the Upper Rocky River over the last 30 years, occasionally increasing or decreasing but not indicating a trend in either direction. The median total phosphorus value was observed to decrease at SR 2420 between the 1997 and 2002 Basinwide Reports.

Of the regulated metals, **copper, iron, and zinc** exceeded the regulatory limits at the Division of Water Quality's ambient monitoring station between 1997 and 2002. However, the median was still below the detection limit in all three cases. **Copper** concentrations appear to reflect a downward trend over time as measured at the monitoring station at SR 2420, but due to limits of the testing or sampling apparatus and the lack of exact data prior to 1988, it is not possible to conclude for certain that copper concentrations have decreased in the watershed in the last thirty years. Data collected at the Charlotte-Mecklenburg EPD monitoring stations for copper were observed to be below the detection level of the testing or sampling apparatus and no conclusion was drawn from this data.

Iron concentrations have increased in the Upper Rocky River since 1973. Elevated levels of iron have been recorded beginning in 1994, despite the fact that iron concentrations have exceeded the action level of 1000 ug/l throughout the thirty-year

monitoring period. According to the 2002 Basinwide Report, the median iron concentration observed at SR 2420 is at the regulatory limit. Charlotte-Mecklenburg EPD data for iron indicates that the median values for both monitoring stations are just below the regulatory limit but are higher than the regulatory limit when expressed as annual averages over the period of record.

Over the course of thirty years, **zinc** concentrations have periodically risen and fallen over three to five year periods in the Upper Rocky River at SR 2420. The cause for this temporal variability in the zinc levels observed in the stream at SR2420 is unknown at present. A review of the data does seem to indicate a significant drop in zinc concentrations to below the regulatory limit during the drought years of 1998 to 2001, indicating that the zinc observed in the Upper Rocky River may be attributable to nonpoint sources. Since 1999, zinc concentrations have been below the action level. However, there is insufficient data to conclude that zinc levels are presently meeting the regulatory standard. Charlotte-Mecklenburg EPD data for zinc indicates that the median values for both monitoring stations are just below the regulatory limit but are at the regulatory limit for monitoring station MY-10 when expressed as annual averages over the period of record.

Nickel and **lead** exceeded reporting limits at many stations within this hydrologic unit but were not reported as a problem at SR2420. In general, the Charlotte-Mecklenburg EPD sites were observed to meet the regulatory limits, but in some cases the reporting limit of the testing or data collection apparatus may have been inadequate to analyze or sample to the regulatory level, and no conclusion was drawn from the testing.

Temporal trends for **cadmium**, **chromium**, **mercury**, and **nickel** concentrations at the monitoring station at SR 2420 are inconclusive over the last 30 years. **Arsenic** and **lead** were also found to not show any temporal patterns. In general, the reporting limit of the testing or data collection apparatus may have been inadequate to analyze or sample to the regulatory level, and no conclusion can be drawn from the testing. **Aluminum** data is also inconclusive due to the lack of data prior to 1990. Charlotte-Mecklenburg EPD monthly data for aluminum, arsenic, cadmium, chromium, lead, mercury, and nickel appear to be below regulatory limits or below the detection limit of the testing or sampling apparatus at monitoring stations MY-1B and MY-10.

Dissolved oxygen concentrations were never detected below 5 mg/l at the ambient monitoring station at SR 2420, nor was an instantaneous reading below 4 mg/l ever detected at SR2420. Dissolved oxygen levels have historically been about the same as they were in recent years. Dissolved oxygen was not monitored by the Charlotte-Mecklenburg EPD at either of the water quality monitoring sites located in the watershed.

Fecal coliform concentrations were observed to be in excess of the regulatory standard for the Division of Water Quality's ambient monitoring station at SR2420

and for both of the Charlotte-Mecklenburg EPD monitoring stations in the watershed. In the 2002 Basinwide Report, the ambient monitoring station at SR2420 was just one of 13 stations in the Yadkin-Pee Dee River Basin where the median value of the measured fecal coliform levels was above the regulatory limit. There is no trend in fecal coliform concentration despite the fact that the geometric mean in the 1997 report is 500 points higher than the geometric mean in the 2002 report. The Division of Water Quality has placed the Upper Rocky River from its origin to SR 2420 on the 2002 303(d) list as a waterbody incapable of supporting its intended uses due to fecal coliform contamination. The Division of Water Quality has initiated the development of a total maximum daily load (TMDL) allocation and model for this portion of the Upper Rocky River, and has identified nonpoint sources from agriculture and urban runoff via municipal storm sewers as the primary sources of the fecal coliform contamination.

The concentration of **total suspended solids (TSS)** in the Upper Rocky River, particularly when it rained, was identified by the Division of Water Quality as problematic in the 2002 Basinwide Report. According to the 2002 Basinwide Report, **turbidity** standards are presently being exceeded in the study area in 10 percent of the samples taken between 1997 and 2001. While the total suspended solids and turbidity values measured at the ambient monitoring station at SR2420 and at the Charlotte-Mecklenburg EPD monitoring stations appear to be below typical average values for regional and national watersheds, the Division of Water Quality did observe significant erosion and sediment deposits in many portions of the watershed while performing additional benthic macroinvertebrate sampling in support of the ongoing Upper Rocky River/Clarke Creek Local Watershed Plan. Turbidity and total suspended solids loads in the watershed can be expected to increase with changes in land use, the addition of more impervious area that adds nonpoint sources of solids and also alters the hydrology of the watershed, increasing the frequency of bankfull storm events and causing scour and erosion of the natural stream channels in the watershed.

3.2.2.2 Recent Water Quality Data

The DWQ provided a summary of three baseflow sampling events conducted in June, August, and October 2003 and a stormflow sampling event conducted on July 2, 2003. The stormflow sampling was conducted on July 2, 2003 following a rain event having 24-hour rainfall totals reported by the National Oceanic and Atmospheric Administration (NOAA) to be between 0.26 inches (as reported at Lake Norman/Davidson), 1.33 inches (Charlotte Douglas International Airport) and 1.85 inches (Concord). General trends and observations noted by the DWQ are provided below. The reported data and related bar charts are included in Appendix D.

Baseflow Data

According to the DWQ, a number of trends are developing in the data obtained from the three baseflow sampling events,. It should be noted that while the data are

believed to be accurate, the sample size is still inadequate to draw any statistically-valid conclusions.

Dissolved oxygen was observed to be depressed by almost half of reported values at station CLC-1 (Clarke Creek) when compared to the other stations. Station CLC-1 is downstream of a sizeable wetland complex, which could be affecting measured levels. Baseflow values for specific conductance were observed to be higher than those observed in the July stormwater sample, with the highest values found at locations downstream of the Rocky River Wastewater Treatment Plant (station RR-2) and in Clarke Creek (CLC-1). Relatively higher values of nitrate and nitrite and total phosphorus (when compared to the other four monitoring stations) were also found at RR-2. Fecal coliform samples were observed to have higher single-measurement values than the state water quality standards for Class C waters (a geometric mean of 200 organisms per 100 milliliters (200/100mL) over five consecutive samples taken in a 30-day period) in three of the four stations sampled including those on the West Branch of the Rocky River (WBRR-1), Ramah Creek (RM-1) and the Rocky River (RR-2). Samples in August and October averaged almost 800/100 mL.

Metals – including **aluminum, copper, iron, lead, and zinc** – were found to be below reporting limits or below US EPA action levels. **Manganese** was observed to be an average of five times higher at Clarke Creek (CLC-1) than at the other four stations.

Stormflow Data

Stormflow data was collected on July 2, 2003 following a rainfall event that appears to be in excess of 1.33 inches of rain. No rain gauges have been installed by DWQ in the watershed as part of this effort, so exact rainfall is unknown and the possibility of spatial and temporal variations in the amount of rainfall exists. However, DWQ sampling protocols mandate that samples be obtained prior to the passage of the peak discharge at each station, and DWQ reports having likely met this expectation for the July 2, 2003 storm based on observed water levels at the time of sampling.

At each of the five stations sampled July 2, the following parameters were consistently higher than in the baseflow sampling events: **biochemical oxygen demand (BOD5), turbidity, suspended residue, iron, aluminum, zinc, copper, manganese, ammonia, total Kjeldahl nitrogen, total phosphorus, and grease and oil**. Significant spikes in **suspended residue, turbidity, aluminum, and iron** (on the order of 40 to 80 times baseflow values) were observed in data from stations at the West Branch of the Rocky River (WBRR-1) and the Rocky River (RR-1 and RR-2). Elevated levels of **lead** were observed at both stations on the Rocky River.

Specific conductance, chloride, pH, and nitrates and nitrites were observed to be lower during stormflow when compared to baseflow. No conclusion was drawn regarding **fecal coliform**, since no samples were taken in the July 2, 2003 storm event due to the unavailability of laboratory personnel to process the samples over the July 4 holiday weekend. Additional stormflow sampling will include fecal coliform.

3.2.2.3 Preliminary Conclusions Regarding Observed Water Quality

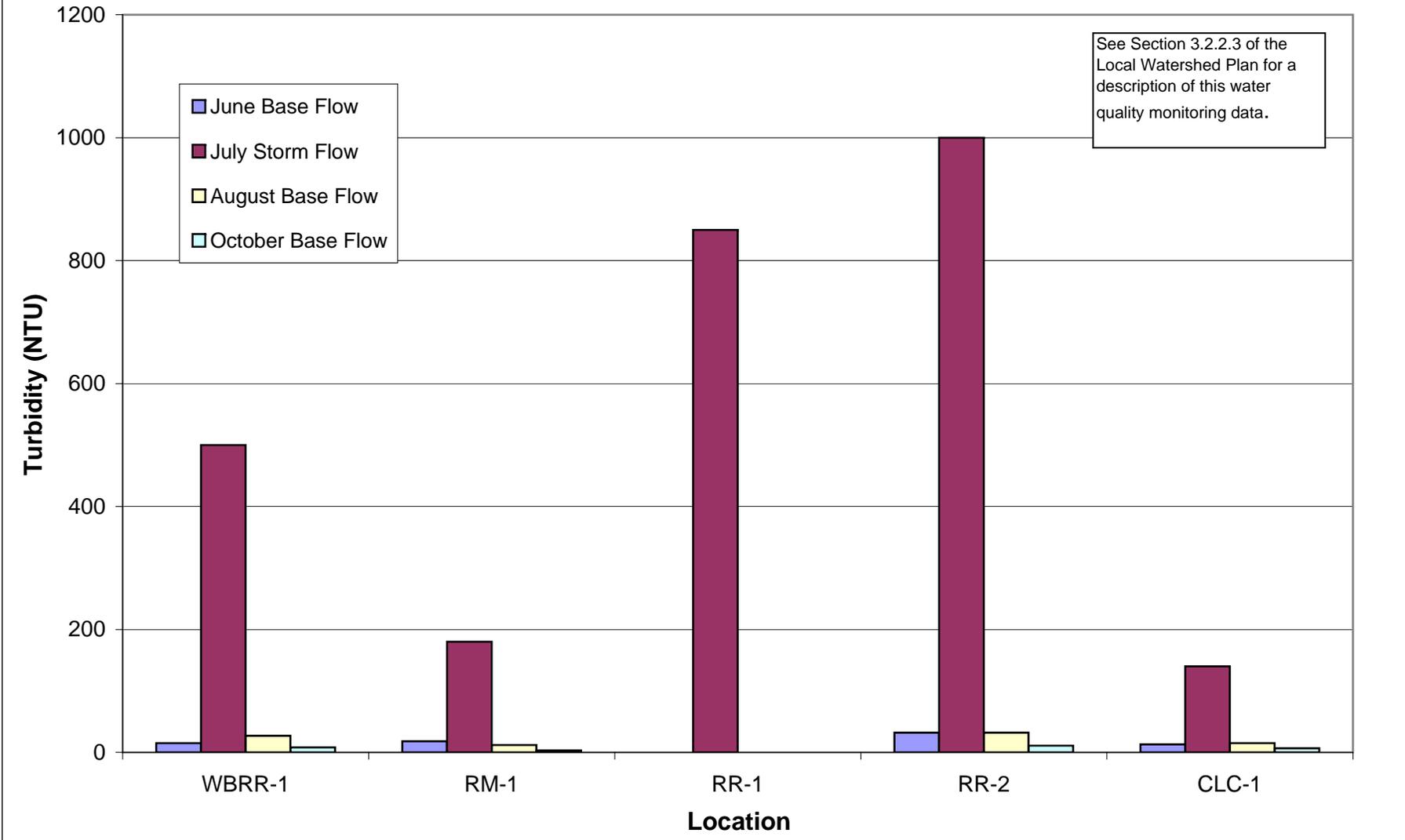
The findings of the 1997 and 2002 Basinwide Reports prepared by the Division of Water Quality indicates that the main water quality concerns in the Yadkin-Pee Dee river basin as a whole are increasing nutrient loadings, land use changes (increased development in once rural areas), sediment in streams from nonpoint sources, and in-stream impacts from permitted municipal and industrial dischargers.

These general conclusions appear applicable to the smaller scale Upper Rocky River / Clarke Creek watershed, where most subwatersheds are in various stages of transition from rural agricultural areas to more suburban-type land uses, unless previously developed. As an example, the turbidity levels observed in the stream network during stormflows can be attributed in part to this development pressure, but not completely.

Figure 3-2 provides a comparison of the turbidity measured at the five monitoring stations in the July 2, 2003 storm and in the three baseflow sampling events. The discrepancy in stormflow turbidity levels observed at RR-1 and RR-2 when compared to samples taken at the other three stations does not appear to be correlated solely to land use expressed as imperviousness. As an example, the average existing impervious values for the subwatersheds draining to CLC-1 is one percent larger than the impervious values for RR-2's contributing watershed, yet the measured turbidity at CLC-1 is almost one-eighth that observed at RR-2. There also does not appear to be a wide-reaching correlation between land disturbance activities ongoing at the time of sampling as shown on Figure 2-13 in Section 2 and the observed stormflow turbidity measurements. Monitoring stations RR-2 and CLC-1 are both located immediately downstream of large subdivisions that are currently under construction, but samples taken at these stations were observed to very different turbidity measurements that did not appear to correlate well with observed land uses. It is hoped that this relationship will become clear as additional data is collected.

Preliminary data does suggest that the observed difference in turbidity between stations having similar imperviousness may be attributable to the loss of stream buffer and possibly past channelization or other degradation of the stream network. Buffer disturbance in the subwatersheds draining to stations RM-1 and CLC-1 (those having the lowest measured stormflow turbidity) was estimated to be an average of 37 percent less than that found in subwatersheds draining to stations RR-1 and RR-2. Land use in the Rocky River under existing conditions is predominantly agricultural (approximately 41 percent of the land use was classified as rural agricultural), and it is possible that the observed stream straightening, channelization, and buffer disturbances that accompanied the agricultural land uses play a role in the observed turbidity levels in these streams. In any case, additional stormflow sampling data is needed before more tangible inferences can be made regarding the likely causes of observed water quality monitoring results.

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Figure 3-2 - NCDWQ Turbidity Sampling



The observed spikes in aluminum and iron that were shown to accompany high turbidity measurements are likely a function of soil chemistry and are therefore likely not attributable to definitive point sources such as industrial discharges or even runoff from urban land uses. In general, suspended matter is typically aluminum silicates with iron, which leads to high concentrations of aluminum, iron, and silica when dissolved. Measuring suspended solids in terms of concentration rather than nephelometric units (NTUs) can provide a more qualitative analysis of the constituents.

Finally, the fact that specific conductance and associated nitrate and nitrite, total phosphorus, and chloride are lower in stormflows than in baseflow and were shown to be particularly pronounced downstream of the wastewater treatment plant discharge on the Rocky River (at station RR-2) seems to indicate that the plant effluent is having an effect on water quality in the receiving streams. This effect is likely allowed within the facility's NDPES permit limits. The facility should be monitored for compliance. No action is likely necessary at this time, though process improvements at the plant may be warranted at the plant in the future to provide nutrient reduction. Certainly, as the watershed continues to grow and wastewater demand increases, the impacts of additional effluent could become an issue.

3.2.3 Habitat Assessments

3.2.3.1 DWQ Benthic Macroinvertebrates Sampling

As part of DWQ's efforts in support of the Upper Rocky River / Clarke Creek local watershed planning effort, the DWQ Biological Assessment Unit (BAU) conducted a survey of benthic macroinvertebrate communities at ten sites located throughout the watershed. The sites are identified in Figure 3-1. The survey was conducted in May 2002 using procedures outlined in the Standard Operating Procedures for Benthic Macroinvertebrates published by the DWQ Biological Assessment Unit in April 2001. CDM and NCWRP identified candidate sites for the surveys based on watershed data compiled as of that date and on the recommendations of the BAU. The survey was conducted at the height of a record four-year drought that began in 1998 and ended in the fall of 2002. BAU staff noted in their assessment that the drought likely had some impact on the streams that were surveyed. Results of the survey, as excerpted from a Technical Memorandum prepared by Eric Fleek of the BAU in October 2002, are provided below. The complete memorandum can be found in Appendix D.

Conclusions and Between-Site Comparisons

(from DWQ BAU Technical Memorandum Dated October 28, 2002)

"The most obvious problems among the study streams generally came from habitat degradation, as evidenced by severe bank erosion, poor riparian buffer zones, and heavy sediment loads. Many of the problems shown by the benthic macroinvertebrate community, however, may be caused by changes in water chemistry. To quickly compare water quality between streams, we have used specific conductance as a general indicator of water quality problems. It should be noted that

none of the specific conductance values measured for this study should be considered indicative of unimpacted water quality. However, specific conductance comparisons between sites generally correlate with biotic index and EPT taxa richness. For example, the highest measured specific conductivity at UT Clarke Creek (204 $\mu\text{mos}/\text{cm}$) was associated with the highest measured biotic index (7.80) and the lowest measured EPT taxa richness (2). Conversely, the second lowest specific conductance (145 $\mu\text{mos}/\text{cm}$ – Ramah Creek SR 2426) and third lowest specific conductance (154 $\mu\text{mos}/\text{cm}$ – Ramah Creek SR 2427) correlated with the lower biotic index value (5.66 and 5.88) and the higher EPT taxa richness (16 and 15). All types of land disturbance and development were associated with elevated specific conductance values, indicating that nonpoint source runoff affects both habitat and water chemistry.

“Four sites in particular harbored taxa indicative of organic inputs: West Branch Rocky River (SR 1136), Clarke Creek (SR 1449), North Prong Clarke Creek (SR 2442), South Prong Rocky River (SR 2693) and UT Clarke Creek (SR 2461). Of these sites, only the West Branch of the Rocky River had obvious indications of what the source of the organic enrichment was – in this case livestock. Reconnaissance of the remaining catchments is needed to determine the nature of their organic inputs.

“The best water quality was found at the two Ramah Creek sites (SR 2426 and SR 2427). However, “best water quality” *only* applies within the data set generated for this study. If the metrics of these two sites were to be compared to a regional reference site they would be seen as degraded in comparison. For example, a regional reference stream in 1997 (Gar Creek SR 2074, Mecklenburg County) had 21 EPT species present. The best site in this data set (Ramah Creek at SR 2427) had only 16 EPT in comparison.

“Areas in this study which fell between the range of the worst sites (UT Clarke Creek, Clarke Creek, North Prong Clarke Creek) and “better” sites (Ramah Creek SR 2426, Ramah Creek SR 2427, South Prong Clarke Creek) included the Rocky River (SR 1142), Rocky River (SR 1600), South Prong Rocky River (SR 2693), and West Branch Rocky River (SR 1136).

“These sites, (in addition to the three aforementioned worst sites) should be included as priorities for corrective management activities. However, as noted previously, even the three “best” sites assessed for this study should still be considered impacted and therefore deserving of corrective management activities as well.”

3.2.3.2 Mecklenburg County LUESA Habitat Surveys

The Mecklenburg County LUESA has conducted fish and benthic macroinvertebrate bioassessments generally on an annual basis at six locations in the West Branch of the Rocky River and Clarke Creek. They use protocols developed by the DWQ’s BAU to perform these analyses. LUESA provided CDM with the results of benthic macroinvertebrate sampling that took place in the vicinity of monitoring station MY-

1B between June 1995 and July 2001 and fish and benthic macroinvertebrate sampling at station MY-10 between August 1995 and August 2001. At station MY-1B, five benthic macroinvertebrate surveys were performed that had scores ranging from fair to good, with no discernible trend. Fish scores from four samples at station MY-10 ranged from poor to fair-good with an improving trend. Benthic macroinvertebrate scores at station MY-10 ranged from poor to good-fair with a slight degrading trend. The data from the surveys is included in Appendix D.

3.2.3.3 Geomorphologic Assessments

Biohabitats, Inc. performed Rosgen Level I, II, and III geomorphological assessments of the streams in the Upper Rocky River / Clarke Creek watershed as subcontractor to CDM. The field observations were performed in two stages as discussed in Section 2. Stage 1 included a Rosgen Level I rapid stream reach assessment, which was utilized to identify general trends of stream behavior and habitat conditions on a large scale at the beginning of the data collection and watershed assessment. Stage 2 included a more rigorous modified Rosgen Level II and III geomorphologic characterization that was performed to assist in the hydrologic modeling, characterization of the drainage network from a watershed perspective, the identification of possible causes of stream channel impairment, and a preliminary look at prioritizing stream reaches as potential restoration candidates.

The field observations performed as part of the Rosgen Level I assessment found that many channels in the watershed have been impacted and are in the process of actively adjusting – widening and/or deepening. Therefore, many of the channels do not necessarily follow all the parameters of a specific Rosgen stream type. In many of the channels observed, the streambanks were steep with very little vegetative root mass. The poor soil stabilization resulted in erosion and sloughing of the streambanks. Accelerated streambank erosion increases the volume of sedimentation deposited in the channel, which, in turn, smothers the macroinvertebrate population and buries gravel bars where many fish species spawn. Another typical disturbance found was the lack of mature woody species in the riparian zone. When forested riparian buffers are destroyed, as they were in many cattle pastures, water temperatures can rise as much as 10-15 degrees. Temperature changes of only 4-10 degrees can seriously impact macroinvertebrate survival. Also, previous clearing or disturbance of the riparian buffers often sets the stage for an extensive invasion of non-native species such as multi-flora rose or Chinese privet. These non-native plant species tend to out-compete the native species important to non-aquatic animals.

The watershed characteristics, channel conditions, and observations collected during the rapid stream reach assessment were used to help select two pilot areas for the purpose of conducting a more detailed study including Rosgen Level II and III geomorphic assessments (see Figure 2-7). These areas are considered to be representative of the diverse land uses (i.e. agriculture, rural residential, etc.) found within the Upper Rocky River/Clarke Creek watershed. One pilot area was designated on the West Branch Rocky River in the Town of Mooresville and Iredell

County jurisdictions. The area drains 3.6 square miles (2,282 acres) and is comprised of approximately 10.0 miles of first through third order streams. The second pilot area was designated on the South Prong West Branch Rocky River in the Towns of Davidson and Cornelius. The area drains 2.9 square miles (1,862 acres) and is comprised of approximately 8.5 miles of first through third order streams.

Four additional channel sections outside of the pilot areas were also selected for more detailed analysis. These sites were spread across the southern portion of the watershed and were specifically set outside the pilot areas to help determine if there is more variability in stream condition and classification in the watershed as a whole.

Based on the results presented in the tables in Section II.3 of Appendix B, many of the channels measured have been determined to currently be F or G stream types. In addition, a majority of the other streams appear to be in a state of evolution from previously stable C and E stream type geometries to G and F stream type geometries. The stream reaches that are currently in G and/or progressing to F stream type channel morphology, exhibiting signs of channel incision with a loss of adequate floodprone area and/or the occurrence of over-widening, are the areas of the most concern.

Channel instability is inherent with these stream types and further channel adjustment will occur over time increasing sediment yield to the downstream areas resulting in additional channel instability and adjustment in those areas. Rosgen type G channels are highly entrenched systems which have a low to moderate gradient (two to four percent), moderate sinuosity (greater than 1.2), and low width-to-depth ratio (less than 12). Type G streams are entrenched to such a degree that even low-frequency flood flows (high discharge) are contained within the channel and therefore, do not have access to a wide floodplain for volume storage, energy dissipation, and sediment deposition. Consequently, storm flow velocities tend to be high within the channel itself which, combined with the alluvial substrate and debris dams, results in severe bank erosion and sediment accumulation within the channel. Type F channel morphology is characterized by high entrenchment and a moderate to high width-to-depth ratio. These channels have a moderate to high sediment supply and depositional bars within the channel are common. Streambank erosion rates are high in these channels because of bank slope rejuvenation and mass wasting processes, the channels are already deeply incised and now are in the process of widening. Many of the channels that have already converted to an F stream type though incision and over-widening have flows that are beginning to develop in the floodplain area and are resembling C channels, signified in the table as "F(c)". This fluvial geomorphic process of re-creating a new floodplain at the new lower bed elevation allows the channel to develop a completely functional floodplain re-established within the confines of the deeply incised and over-widened F channel.

The expectation prior to field investigations was that there would be considerable variability in stream classification and overall channel stability within each pilot area

based on the many variables collected including geology, topography, riparian condition, and proximity to developed areas. The results of the field investigation did not support this theory, instead they showed a high percentage of channels in a subwatershed exhibiting signs of channel instability and accelerated adjustment regardless of adjacent land use conditions.

The majority of the tributaries to the South Prong West Branch Rocky River and West Branch Rocky River appear to have incised as a result of the incision of the mainstem channels. The land use changes over the last century, from expansive agricultural activity to altered hydrology from increased impervious area, and current agricultural practices involving the removal of riparian buffers and livestock access to stream channels have caused the mainstem channels to incise. This lowering in channel bed elevation has migrated or is currently migrating headward through a majority of the tributaries. Therefore, even the tributaries with forested drainage areas are unstable, becoming fully entrenched, and progressing from a Rosgen stream type G to an F channel.

3.2.4 Recommendations for Additional Water Quality Monitoring

The DWQ has provided an initial water quality monitoring program in support of the Upper Rocky River / Clarke Creek local watershed planning effort and has committed to provide near-monthly baseflow sampling and quarterly stormflow monitoring for six months to a year. However, additional long-term sampling and data collection will be needed to continue to develop a catalog of water quality data that can be used to refine the watershed management efforts undertaken by the Local Watershed Planning Group in the years to come. Specific recommendations for additional water quality monitoring and data collection to support decision-making tools are listed below.

- Continue to sample baseflows monthly and stormflows quarterly (or as frequently as practicable) at the identified DWQ monitoring stations for the long term to develop a catalog of data and identify watershed trends.
- Consider adding an additional monitoring station at the confluence of Dye Branch and the Rocky River south of Mooresville to provide better resolution of land uses in the upper reaches of the watershed.
- Conduct benthic macroinvertebrate surveys every two to three years at the ten established survey stations in the watershed to develop a catalog of data and to monitor the effects of land use changes and the implementation of watershed management strategies.
- Sample Charlotte-Mecklenburg LUESA's monitoring stations MY-1B and MY-10 during the same baseflow and stormflow events as the DWQ stations using the same methods and, if possible, the same personnel.
- Install streamflow gages and rain gages at each DWQ monitoring station to provide streamflow data and spatial rainfall data.

- Implement a Weather-Tracker program in the watershed to have interested residents record weather information that can be used for the refinement and calibration of hydrologic and water quality models.
- Consider sampling for pesticides at least biannually after performing cursory research into the types actively used in the watershed.
- Conduct a Bacterial Source Tracking (BST) effort using antibiotic resistance methods to identify potential fecal coliform contamination sources to support the implementation of effective and appropriate management strategies.

3.3 Water Quality Modeling

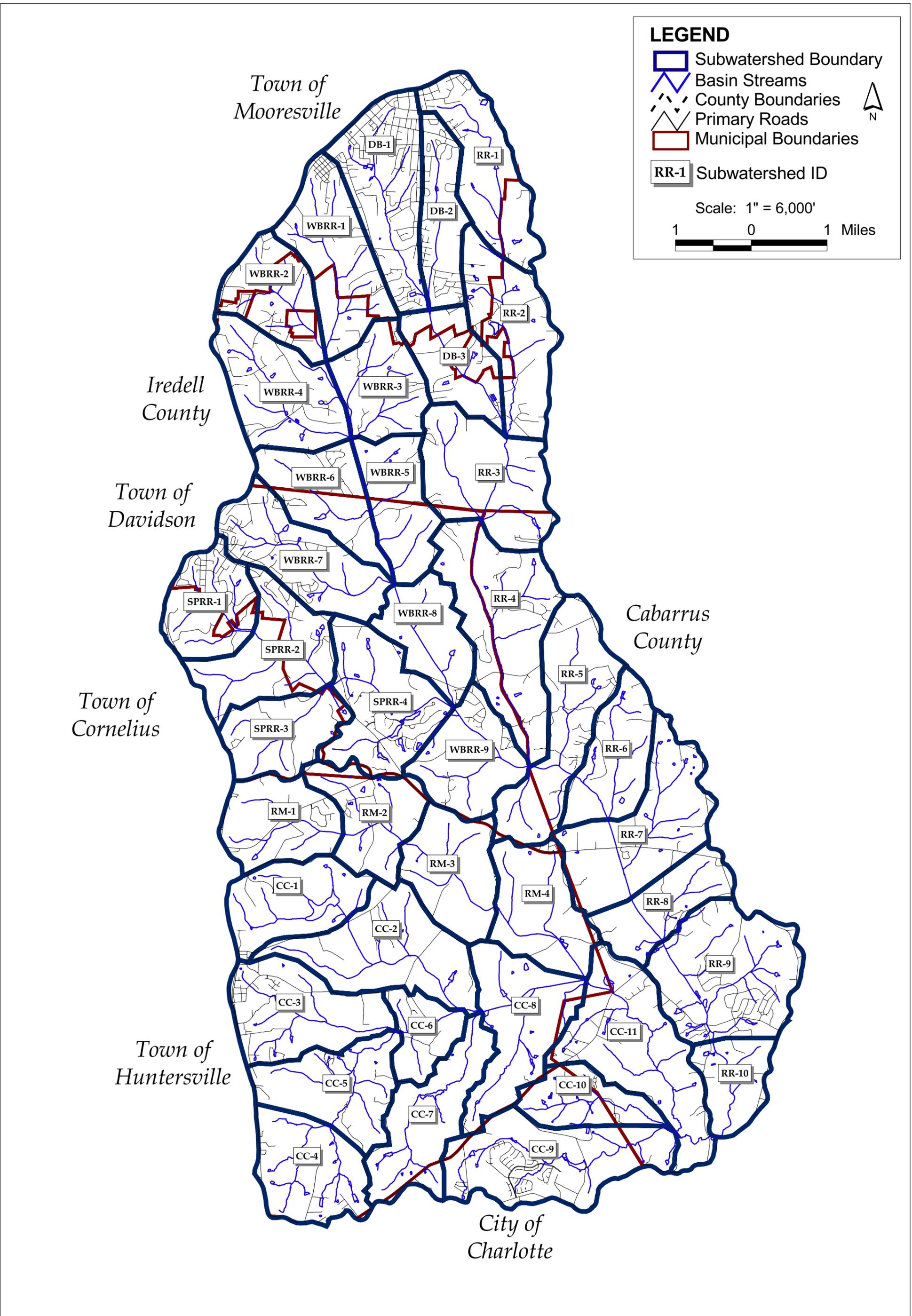
Water quality modeling was performed for the purpose of determining pollutant loading from nonpoint sources in the entire 77-square mile watershed, allowing for the identification of critical areas in the watershed to be included in the subwatershed ranking protocol, described in Section 4 of this LWP. The Watershed Management Model (WMM) was used to determine the nonpoint source pollutant loading on a subwatershed scale using various watershed-specific characteristics including land use, baseflow, and event mean concentrations (EMCs). A detailed description of the model, input parameters (including EMCs used in the modeling), and results can be found in Appendix E of this LWP. The following is a brief description of the model, modeling scenarios, and results determined for this study.

3.3.1 Introduction to the Watershed Management Model

Water quality modeling was performed using the public domain WMM to simulate the generation rate of non-point source pollutants in the Upper Rocky River/Clarke Creek watershed. WMM was developed by CDM for the U.S. EPA as a database-driven water quality model capable of estimating annual and seasonal pollutant loads from point and nonpoint sources in a watershed (Rouge River, 1998). The model requires various input parameters including EMCs, land use types and their associated average percentage of impervious area, annual baseflow, average baseflow concentrations, pervious and impervious runoff coefficients, and pollutant delivery ratio. The model is capable of analyzing numerous pollutant constituents including various heavy metals, nutrients, biological oxygen demand, and total suspended solids on a subwatershed specific level (Rouge, 1998).

3.3.2 Subwatershed Delineation

The Upper Rocky River/Clarke Creek watershed is a 77-square mile watershed comprised of two 14-digit HUCs. The watershed was delineated into 41 subwatersheds ranging in size from approximately one to three square miles in area, as shown on **Figure 3-3**. The subwatersheds were delineated based on hydrologic boundaries using GIS topography obtained from the NCDOT. Each subwatershed was identified based on the primary stream it contained, as shown below.



Data Source: NCCGIA 2000 BasinPro and Mecklenburg, Iredell, and Cabarrus County GIS Departments

Figure 3-3
Upper Rocky River/Clarke Creek Local Watershed Plan
Subwatershed Delineation



- RR – Rocky River
- CC – Clarke Creek
- RM – Ramah Creek
- DB – Dye Branch
- WBRR – West Branch Rocky River
- SPRR – South Prong Rocky River

These subwatersheds were used to compare the difference in measured physical parameters between subwatersheds in an effort to determine when and what types of management strategies should be applied by members of the LWPG to arrest existing and protect from future watershed degradation.

3.3.3 Model Input Parameters

WMM requires a number of watershed and subwatershed-specific input parameters including subwatershed area, EMCs, land use types and associated percent average imperviousness, pervious and impervious runoff coefficients, annual precipitation, baseflow, baseflow concentrations, delivery ratio, and suspended fraction percentages. These parameters were determined using a combination of watershed-specific GIS data and past CDM experience with water quality modeling. A description of how each input parameter was determined and the associated values can be found in Appendix E.

3.3.4 Modeling Scenarios

Three modeling scenarios were considered for this study: (1) existing land use, (2) future (build-out) land use, and (3) change in land use. The existing land use scenario was used to determine current pollutant loading problems in each subwatershed, while also providing a baseline for the future land use scenario. The future land use scenario, or build-out scenario, was used to determine which subwatersheds are predicted to experience excessive pollutant loads. The change in land use scenario was used to determine which subwatersheds are predicted to experience the greatest increase in pollutant loading. The following is a description of each scenario.

3.3.4.1 Existing Land Use

The existing land use scenario was modeled using WMM for the purpose of determining which subwatersheds are currently experiencing excessive pollutant loads from stormwater runoff. The modeling was based on the GIS existing land use coverage developed for this study. Section 2.6.3 describes how the existing land use coverage was created and the assumptions that went into its development. Appendix E describes how the existing land use categories were grouped together and input into WMM. The results of the modeling were input in the subwatershed ranking protocol, described in Section 4, for the purpose of determining in which

subwatersheds stream and habitat restoration, creation, preservation, and enhancement efforts should be concentrated.

3.3.4.2 Future Land Use Scenario

The future land use scenario was modeled using WMM for the purpose of determining which subwatersheds are predicted to generate the greatest pollutant loads from stormwater runoff under build-out land use conditions. The build-out condition assumes that all lands are developed to the maximum extent possible, as determined by 2003 jurisdictional zoning and development ordinances. Section 2.6.4 describes how the future land use coverage was created and the assumptions that went into its development. Appendix E describes how the future land use categories were grouped together and input into WMM. The results of the modeling were input in the subwatershed ranking protocol for the purpose of determining in which subwatersheds stream and habitat restoration, preservation, and enhancement efforts should be concentrated.

3.3.4.3 Change in Land Use Scenario

The future land use and existing land use scenarios were also used to determine the predicted change in pollutant loading for each subwatershed. This scenario emphasizes subwatersheds that experience significant changes in land use. For example, a subwatershed that is currently undeveloped with pasture and forest land cover may be zoned for commercial and high-density residential development, resulting in a significant increase in impervious area. Another subwatershed that is currently highly developed will not experience a significant change in land use and associated impervious area under future conditions. The predicted change in pollutant loading from existing to future land use conditions under these two cases will be significantly different. The types of recommended subwatershed improvements will also be significantly affected by cases such as these.

3.3.5 Modeling Results and Recommendation for Future Modeling

The results of the WMM modeling for each of the subwatersheds and the twelve constituents evaluated for this study can be seen in **Tables E-7** through **E-9**, in Appendix E. Total nitrogen (TN), total suspended solids (TSS), and total phosphorus (TP) were identified from the water quality analysis performed in this study and by members of the LWPG as potential watershed concerns and were included in the subwatershed ranking protocol for the purpose of identifying critical areas in the watershed to concentrate stream and habitat restoration, preservation, and enhancement projects, discussed in Section 4 of this LWP. Copper (Cu) was also included in the modeling as a surrogate for other metals. In addition, the WMM should be refined using the results from the ongoing NCDWQ water quality monitoring and available streamflow data, when available. The WMM provides a simple mechanism for identifying the impact of planned development on water quality. The WMM can be easily modified to account for land use changes and

should be utilized as a planning level tool to predict impacts to water quality before using more comprehensive models.

3.4 Water Quantity Modeling

3.4.1 Hydrologic and Hydraulic Modeling Approach

CDM's initial approach for identifying watershed stressors as part of the Upper Rocky River / Clarke Creek local watershed planning effort revolved around the identification and evaluation of representative "pilot areas" that generally reflected conditions observed in the watershed, as well as existing and future land uses that were found elsewhere in the watershed. The general approach included the following key tasks:

1. Identification of key watershed and water quality stressors through the 1998 and 2002 Basinwide Water Quality Reports for the Yadkin-Pee Dee River Basin, 30-year monthly DWQ ambient monitoring station data, and monthly water quality data compiled for two ambient monitoring stations by MCDEP;
2. Compilation of existing and future land use, population, transportation improvements, existing and proposed sanitary sewer systems, natural resource, topographic, and soils information in ArcView GIS format;
3. Identification of watershed impairments, candidate preservation and restoration opportunities, and pending large-scale land use changes by the local planning group, populated by members of the local resource and municipal planning groups;
4. Preliminary identification of critical subwatersheds, classified by potential land use change allowed by zoning; stream habitat impairments identified by Rosgen Level I assessments of the entire watershed's stream network as evidenced at a number of accessible road crossings; and
5. Selection of two pilot areas for detailed hydrologic, hydraulic, and water quality modeling; Rosgen Level II/III assessments; and watershed management alternative evaluations to determine the most suitable combination of best management practices for the watershed, as well as to identify indicators of watershed impairment that can be extrapolated to the entire watershed.

CDM was able to compile sufficient watershed data to identify two three-square-mile pilot areas that were representative of the existing and future conditions anticipated for the watershed. Pilot areas in the Towns of Davidson and Mooresville were selected for further evaluation using the Rosgen Level II/III geomorphological techniques identified in Section 2 and hydrologic and hydraulic models developed by the US Army Corps of Engineers (USACE). The hydrologic and hydraulic models of the pilot areas were developed for existing and future conditions using the USACE's HEC-1 hydrologic and HEC-RAS hydraulic models (comprehensive information on the uses and limitations of these models can be found at the US Army Corps of Engineers' Hydrologic Engineering Center web page - www.hec.usace.army.mil).

Streamflow records were not available in the pilot areas, so an attempt to calibrate the models was made using the USGS Regression Equations and regional curves prepared by Biohabitats based on their Rosgen Level II/III stream assessments. These models were used to predict in-stream velocities during frequent, bankfull storm events for comparison with the physical data on streambank stability and sedimentation collected during the Level II/III stream assessment.

The intent of the pilot area approach was to identify a correlation between existing land use and observed changes in stream geomorphology that could be extrapolated from the pilot areas to the larger watershed. Results of this analysis did not provide a good correlation between observed stream geomorphology and land use conditions. CDM therefore abandoned the pilot area approach in favor of a more comprehensive watershed assessment approach that made use, in part, of hydrologic estimates developed using USGS regression equations to predict peak discharges in each of the subwatersheds for the purposes of assessing erosion potential under existing and future land uses.

CDM used an erosion potential screening model based on hydraulic geometry relationships for stream channels developed by Leopold and Maddock (Leopold and Maddock, 1953). The method was used in conjunction with subwatershed-specific estimates of streamflow to evaluate relative increases in streambank erosion potential based on comparisons of the 2-year peak flows (assumed to be approximately equal to bankfull events) for pre-development and future land use conditions.

The erosion potential model is based on relationships that reflect changes in channel width caused by changes in the 2-year or bankfull flow resulting from land use changes. The width is proportional to Q^n , where the value of the exponent “n” varies from stream to stream, typically within the range of 0.35 to 0.5 (Leopold and Maddock, 1953). Channels in this study that were observed to be transitioning from Rosgen Stream Class B or C to an F (approximately vertical side walls) generally have an “n” value of 0.5. (Note: the “n” value should not be confused with Manning’s “n” value as used in hydraulic engineering.)

The basis of the erosion potential model is the erosion ratio, $(Q_2/Q_1)^n$, which is used to compare post-development flows or existing land use flows (Q_2) to undeveloped flows (Q_1). The analysis was performed for both existing and future land use to assess impacts to the stream when compared to the undeveloped condition of the subwatersheds. The USGS regression equation for urban watersheds was used to determine these flows by varying imperviousness to reflect the three different land use conditions.

The erosion ratio was used to categorize increases in stream channel erosion potential as follows:

- Minimum erosion potential: Erosion ratio less than 1.25 (i.e., less than a 25% increase in stream width compared to natural channel conditions).

- Moderate erosion potential: Erosion ratio between 1.25 and 1.50 (i.e., a 25% to 50% increase in stream width compared to natural channel conditions.)
- Excessive erosion potential: Erosion ratio greater than 1.50 (i.e., more than 50% increase in stream width compared to natural channel conditions.)

The results of the erosion potential calculations for each of the 41 subwatersheds delineated for the evaluation of the Upper Rocky River/Clarke Creek watershed are provided in **Tables 3-2** and **3-3**.

3.4.2 Recommendations for Additional Water Quantity Modeling

While the pilot area assessment approach was abandoned after it was determined to be inadequate to represent the relationships between the stream geomorphology and the anticipated stormwater discharges, the hydrologic and hydraulic models were completed and can be combined with other HEC-based models to aid in the development of watershed-wide hydrologic and hydraulic models. Expanding these models would allow the municipalities of the Local Watershed Planning Group to prepare detailed models of the impact that the type and location of a given development will have on downstream culverts, stream channels, and other systems in a variety of storm events. These models can be maintained by planning departments and updated to include new developments. Rainfall and streamflow gauging stations should be installed in each of the named tributaries in the watershed as part of the comprehensive water quantity modeling effort, if attempted, to allow for calibration of the hydrologic and hydraulic models to the collected historical streamflow data.

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Table 3-2 - Existing Land Use Erosion Potential Calculation**

USGS Urban Regression Equation --> $Q = C(DA)^f I^d$

Storm Event	C	f	d
2	33.3	0.681	0.686
5	78.9	0.655	0.572
10	122	0.611	0.515
25	228	0.602	0.436
50	296	0.593	0.396
100	374	0.593	0.358

Notes:

- 1.) Urban Equation and values shown in table above from (USGS, 2002). See Section 9 for a complete list of references.
- 2.) Urban Equation represents the USGS Urban flood-frequency equations for the Blue Ridge-Piedmont.
- 3.) In the Urban Equation shown above (DA) is drainage area in square miles and I is average percentage of impervious coverage.

Erosion Potential Equation = $(Q_{pre}/Q_{ex})^n$

Subwatershed ID ²	Contributing Drainage Area ³ (sq-miles)	Existing Development Average Percent Impervious Area ⁴	Peak Discharge Estimate for the 2-year Design Storm Event		Erosion Ratio ⁷	Erosion Potential ⁸
			Pre-Development ⁵	Existing Development ⁶		
CC-1	1.7	12%	80	270	1.84	Excessive
CC-2	4.2	5%	140	250	1.34	Moderate
CC-3	2.1	8%	90	220	1.56	Excessive
CC-4	1.8	5%	80	140	1.32	Moderate
CC-5	3.7	6%	130	260	1.41	Moderate
CC-6	6.6	6%	190	430	1.50	Excessive
CC-7	1.9	5%	80	160	1.41	Moderate
CC-8	14.9	9%	340	920	1.64	Excessive
CC-9	2.7	23%	110	560	2.26	Excessive
CC-10	1.1	21%	60	290	2.20	Excessive
CC-11	25.4	12%	480	1,620	1.84	Excessive

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Table 3-2 (continued) - Existing Land Use Erosion Potential Calculation

Erosion Potential Equation = $(Q_{pre}/Q_{ex})^n$

Subwatershed ID ²	Contributing Drainage Area ³ (sq-miles)	Existing Development Average Percent Impervious Area ⁴	Peak Discharge Estimate for the 2-year Design Storm Event		Erosion Ratio ⁷	Erosion Potential ⁸
			Pre-Development ⁵	Existing Development ⁶		
DB-1	2.3	29%	90	590	2.56	Excessive
DB-2	1.3	20%	60	310	2.27	Excessive
DB-3	5.0	10%	160	480	1.73	Excessive
RM-1	1.6	7%	70	170	1.56	Excessive
RM-2	3.1	5%	120	220	1.35	Moderate
RM-3	4.8	4%	160	240	1.22	Minimal
RM-4	6.6	5%	190	370	1.40	Moderate
RR-1	1.9	9%	80	230	1.70	Excessive
RR-2	4.0	4%	140	210	1.22	Minimal
RR-3	11.3	4%	280	430	1.24	Minimal
RR-4	14.3	7%	330	770	1.53	Excessive
RR-5	39.1	5%	650	1,230	1.38	Moderate
RR-6	40.6	3%	670	910	1.17	Minimal
RR-7	43.2	8%	700	1,810	1.61	Excessive
RR-8	44.6	14%	710	2,720	1.96	Excessive
RR-9	47.5	11%	740	2,460	1.82	Excessive
RR-10	48.5	25%	750	4,260	2.38	Excessive
SPRR-1	1.5	11%	70	230	1.81	Excessive
SPRR-2	3.5	5%	130	230	1.33	Moderate
SPRR-3	1.4	4%	70	100	1.20	Minimal
SPRR-4	7.1	6%	200	430	1.47	Moderate

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Table 3-2 (continued) - Existing Land Use Erosion Potential Calculation**

Erosion Potential Equation = $(Q_{pre}/Q_{ex})^n$

Subwatershed ID ²	Contributing Drainage Area ³ (sq-miles)	Existing Development Average Percent Impervious Area ⁴	Peak Discharge Estimate for the 2-year Design Storm Event		Erosion Ratio ⁷	Erosion Potential ⁸
			Pre-Development ⁵	Existing Development ⁶		
WBRR-1	2.1	8%	90	230	1.60	Excessive
WBRR-2	1.4	9%	70	190	1.65	Excessive
WBRR-3	5.0	4%	160	250	1.25	Moderate
WBRR-4	5.7	5%	170	310	1.35	Moderate
WBRR-5	8.6	3%	230	280	1.10	Minimal
WBRR-6	8.7	5%	230	420	1.35	Moderate
WBRR-7	2.1	10%	90	270	1.73	Excessive
WBRR-8	13.6	3%	320	440	1.17	Minimal
WBRR-9	22.4	3%	440	610	1.18	Minimal

Notes:

- 1.) Erosion Potential equation referenced from (Leopold, 1953). See Section 9 for a complete list of references.
- 2.) See Figure 3-3 of the LWP for the subwatershed locations.
- 3.) Values obtained using GIS data.
- 4.) See Appendix E for a description of how the average impervious area values were estimated.
- 5.) A pre-development (or wooded) average impervious area of 2 percent for each of the subwatersheds was assumed.
Values obtained using USGS Urban Regression Equation shown above.
- 6.) Values obtained using the USGS Urban Regression Equation shown above.
- 7.) Value obtained using Erosion Potential equation shown above. Assumed an "n" value of 0.5 for streams transitioning from a B or C to an F (which is the case for this watershed).
- 8.) If Erosion Ratio is less than 1.25 assume "Minimal".
If Erosion Ratio is 1.25 or greater and less than 1.5 assume "Moderate".
If Erosion Ratio is 1.5 or greater assume "Excessive".

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Table 3-3 - Future Land Use Erosion Potential Calculation**

USGS Urban Regression Equation --> $Q = C(DA)^f I^d$

Storm Event	C	f	d
2	33.3	0.681	0.686
5	78.9	0.655	0.572
10	122	0.611	0.515
25	228	0.602	0.436
50	296	0.593	0.396
100	374	0.593	0.358

Notes:

- 1.) Urban Equation and values shown in table above from (USGS, 2002). See Section 9 for a complete list of references.
- 2.) Urban Equation represents the USGS Urban flood-frequency equations for the Blue Ridge-Piedmont.
- 3.) In the Urban Equation shown above (DA) is drainage area in square miles and I is average percentage of impervious coverage.

Erosion Potential Equation = $(Q_{pre}/Q_{ex})^n$

Subwatershed ID ²	Contributing Drainage Area ³ (sq-miles)	Predicted Future Development Average Percent Impervious Area ⁴	Peak Discharge Estimate for the 2-year Design Storm Event		Erosion Ratio ⁷	Erosion Potential ⁸
			Pre-Development ⁵	Future Development ⁶		
CC-1	1.7	28%	80	470	2.42	Excessive
CC-2	4.2	13%	140	510	1.91	Excessive
CC-3	2.1	29%	90	550	2.47	Excessive
CC-4	1.8	33%	80	550	2.62	Excessive
CC-5	3.7	27%	130	780	2.45	Excessive
CC-6	6.6	13%	190	680	1.89	Excessive
CC-7	1.9	14%	80	310	1.97	Excessive
CC-8	14.9	30%	340	2,140	2.51	Excessive
CC-9	2.7	39%	110	820	2.73	Excessive
CC-10	1.1	32%	60	390	2.55	Excessive
CC-11	25.4	40%	480	3,770	2.80	Excessive

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Table 3-3 (continued) - Future Land Use Erosion Potential Calculation**

Erosion Potential Equation = $(Q_{pre}/Q_{ex})^n$

Subwatershed ID ²	Contributing Drainage Area ³ (sq-miles)	Predicted Future Development Average Percent Impervious Area ⁴	Peak Discharge Estimate for the 2-year Design Storm Event		Erosion Ratio ⁷	Erosion Potential ⁸
			Pre-Development ⁵	Future Development ⁶		
DB-1	2.3	40%	90	740	2.87	Excessive
DB-2	1.3	36%	60	460	2.77	Excessive
DB-3	5.0	36%	160	1,160	2.69	Excessive
RM-1	1.6	45%	70	620	2.98	Excessive
RM-2	3.1	12%	120	400	1.83	Excessive
RM-3	4.8	18%	160	700	2.09	Excessive
RM-4	6.6	20%	190	930	2.21	Excessive
RR-1	1.9	36%	80	610	2.76	Excessive
RR-2	4.0	31%	140	900	2.54	Excessive
RR-3	11.3	31%	280	1,840	2.56	Excessive
RR-4	14.3	38%	330	2,470	2.74	Excessive
RR-5	39.1	39%	650	5,020	2.78	Excessive
RR-6	40.6	41%	670	5,340	2.82	Excessive
RR-7	43.2	37%	700	5,170	2.72	Excessive
RR-8	44.6	38%	710	5,330	2.74	Excessive
RR-9	47.5	42%	740	6,040	2.86	Excessive
RR-10	48.5	53%	750	7,120	3.08	Excessive
SPRR-1	1.5	47%	70	610	2.95	Excessive
SPRR-2	3.5	23%	130	670	2.27	Excessive
SPRR-3	1.4	5%	70	120	1.31	Moderate
SPRR-4	7.1	27%	200	1,210	2.46	Excessive

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Table 3-3 (continued) - Future Land Use Erosion Potential Calculation**

Erosion Potential Equation = $(Q_{pre}/Q_{ex})^n$

Subwatershed ID ²	Contributing Drainage Area ³ (sq-miles)	Predicted Future Development Average Percent Impervious Area ⁴	Peak Discharge Estimate for the 2-year Design Storm Event		Erosion Ratio ⁷	Erosion Potential ⁸
			Pre-Development ⁵	Future Development ⁶		
WBRR-1	2.1	38%	90	680	2.75	Excessive
WBRR-2	1.4	32%	70	460	2.56	Excessive
WBRR-3	5.0	29%	160	1,000	2.50	Excessive
WBRR-4	5.7	29%	170	1,100	2.54	Excessive
WBRR-5	8.6	33%	230	1,590	2.63	Excessive
WBRR-6	8.7	34%	230	1,620	2.65	Excessive
WBRR-7	2.1	46%	90	750	2.89	Excessive
WBRR-8	13.6	33%	320	2,150	2.59	Excessive
WBRR-9	22.4	28%	440	2,690	2.47	Excessive

Notes:

- 1.) Erosion Potential equation referenced from (Leopold, 1953). See Section 9 for a complete list of references.
- 2.) See Figure 3-3 of the LWP for the subwatershed locations.
- 3.) Values obtained using GIS data.
- 4.) See Appendix E for a description of how the average impervious area values were estimated.
- 5.) A pre-development (or wooded) average impervious area of 2 percent for each of the subwatersheds was assumed.
Values obtained using USGS Urban Regression Equation shown above.
- 6.) Values obtained using the USGS Urban Regression Equation shown above.
- 7.) Value obtained using Erosion Potential equation shown above. Assumed an "n" value of 0.5 for streams transitioning from a B or C to an F (which is the case for this watershed).
- 8.) If Erosion Ratio is less than 1.25 assume "Minimal".
If Erosion Ratio is 1.25 or greater and less than 1.5 assume "Moderate".
If Erosion Ratio is 1.5 or greater assume "Excessive".

Section 4

Development of Subwatershed Ranking Protocol

4.1 Introduction and Purpose

The Subwatershed Ranking Protocol (SRP) was developed in an effort to identify the subwatersheds observed or predicted to be in the most critical need of attention based on a comparison of collected physical data and watershed management information (e.g. zoning, water and wastewater infrastructure, etc.). The SRP presented below was utilized to present an unbiased assessment of the subwatersheds on the basis of collected data that was grouped into three broad categories – Current Natural Resources and Habitat Value, Current Watershed Health, and Future Risk to watershed function. The results of the SRP were utilized in the Upper Rocky River/Clarke Creek Local Watershed Plan to help identify and prioritize recommended watershed protection and improvement project sites (identified in Section 7) to most efficiently address existing or predicted watershed concerns. The SRP was also intended to be a dynamic tool that can be updated by the Local Watershed Planning Group to reconsider subwatershed priorities in response to changes in subwatershed conditions.

4.2 Subwatershed Classifications

The SRP includes 23 qualitative and quantitative physical parameters (such as land use, percent of buffer disturbance, qualitative habitat condition, among others) that were used to categorize observed or predicted conditions in each subwatershed within a consistent rating system. The parameters were grouped into three broad categories - Current Natural Resources and Habitat Value, Current Watershed Health, and Future Risk to watershed function. Each parameter was assigned a score on the same scale of 0 to 4. The meaning of the assigned scores varied depending on the category. The three categories and parameters are presented in **Table 4-1** and are described below.

4.2.1 Current Natural Resources and Habitat Value

The current natural resources and habitat value of the subwatersheds was determined based on a compilation of GIS data showing the location and extent of various natural resources and information provided by resource professionals in the Local Watershed Planning Group. High scores in the Current Natural Resources and Habitat Value category indicated the presence of a comparatively high number of natural resources and/or critical habitat suitable for preservation. A description of the parameters included in this category is presented below.

Natural Resource Sites

The presence of natural resource sites (i.e. significant managed areas, heritage areas, and element occurrences identified by the NHP) both within and downstream of the

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Table 4-1 - Subwatershed Prioritization Ranking Protocol Categories, Parameters, and Associated Scoring Breakdown

Category	Item	Parameter	Units	Scoring Breakdown				
				0	1	2	3	4
Current Natural Resources and Habitat Value	1	Natural Resource Sites (NRS)	#/location	No sites		Downstream		Onsite
	2	Existing Wetlands	acres	0	< 50	51-100	101-150	> 150
	3	Land Preservation Areas						
		Existing	acres	0	< 50	51 - 150	151 - 300	> 300
		Proposed	acres	0	< 50	51 - 150	151 - 300	> 300
4	Potential Riparian Buffer Preservation Opportunities	ft	0	2,000 - 2,500	2,501 - 3,000	> 3,000	Upstream of NRS	
5	Water Supply Wells	MGD	0	< 0.1	0.1 - 0.25	0.26 - 0.5	> 0.50	
Current Watershed Health	6	Existing Impervious Cover	%	< 5%	6% - 10%	11% - 15%	16% - 25%	> 25%
	7	Floodplain Development/Flooding Potential	\$	0	< \$250k	\$250k - \$500k	\$500k - \$750k	> \$750
	8	Buffer Disturbance - Deforestation	%	0	< 10%	11 - 25%	26% - 50%	> 50%
	9	Buffer Disturbance - Impervious Area	%	0	< 1%	1% - 3%	3% - 5%	> 5%
	10	Wetland Disturbance	%	0	< 25%	26% - 50%	50% - 75%	> 75%
	11	Erosion Potential - Pre-development to Existing Land Use	-	Slight		Moderate		Excessive
	12	Rosgen Level I Scores	-	Excellent	Good	Medium	Fair	Poor
	13	303(d) Listed Stream	-	No	Low	Medium	High	TMDL
	14	Nonpoint Source Pollution Loadings - Current Land Use						
		<i>Total Suspended Solids (TSS)</i>	mg/l	< 15	16 - 25	26 - 35	36 - 45	> 45
		<i>Total Nitrogen (TN)</i>	lbs/acre	≤ 3.7	3.8 - 5	5.1 - 7	7.1 - 9	> 9
		<i>Total Phosphorus (TP)</i>	mg/l	< 0.01	0.01 - 0.035	0.035 - 0.065	0.065 - 0.1	> 0.1
		<i>Copper (Cu)</i>	mg/l	< 0.0035		0.0035 - 0.01		> 0.01
	15	Wastewater Management Systems	-	Municipal WWTP	Municipal/Package	Package WWTP	Package/Septic	Onsite septic
16	Wastewater Discharge/Overflows	#	0	1	2	3	> 3	
Future Risk to Watershed Functions	17	Future Impervious Cover	%	< 5%	6% - 10%	11% - 15%	16% - 25%	> 25%
	18	Impervious Cover (Change)	%	< 5%	6% - 10%	11% - 15%	16% - 25%	> 25%
	19	NCDOT Transportation Improvement Projects (TIPs)	location	No TIP's		Bordering a TIP		Containing a TIP
	20	Soil Erodibility Index	-	Slight	Slight-Mod	Moderate	Mod-Severe	Severe
	21	Erosion Potential - Pre-development to Future Zoning	-	Slight		Moderate		Excessive
	22	Nonpoint Source Pollution Loadings - Future Zoning						
		<i>Total Suspended Solids (TSS)</i>	mg/l	< 15	16 - 25	26 - 35	36 - 45	> 45
		<i>Total Nitrogen (TN)</i>	lbs/acre	< 3.7	3.8 - 5	5.1 - 7	7.1 - 9	> 9
		<i>Total Phosphorus (TP)</i>	mg/l	< 0.01	0.01 - 0.035	0.035 - 0.065	0.065 - 0.1	> 0.1
		<i>Copper (Cu)</i>	mg/l	< 0.0035		0.0035 - 0.01		> 0.01
	23	Nonpoint Source Pollution Loadings - Change in Land Use						
		<i>Total Suspended Solids (TSS)</i>	mg/l	< 15	16 - 25	26 - 35	36 - 45	> 45
		<i>Total Nitrogen (TN)</i>	lbs/acre	< 3.7	3.8 - 5	5.1 - 7	7.1 - 9	> 9
	<i>Total Phosphorus (TP)</i>	mg/l	< 0.01	0.01 - 0.035	0.035 - 0.065	0.065 - 0.1	> 0.1	
	<i>Copper (Cu)</i>	mg/l	< 0.0035		0.0035 - 0.01		> 0.01	

subwatersheds was determined using GIS. This information was used to determine which subwatersheds require attention to ensure that irreplaceable natural resources (preserved lands, the habitats of endangered species, and other critical natural systems) are protected by appropriate best management practices.

Existing Wetlands

The acreage of existing wetlands located within each subwatershed was determined using the National Wetlands Inventory (NWI) GIS coverage. It should be noted that the data included in the NWI dates from the 1970s and may not accurately reflect current conditions observed in the watershed, but generally represents the best data set available at the time of this evaluation.

Land Preservation Areas

Publicly-owned lands and tracts of land that have been or will be permanently preserved (protected from development) by land trusts and conservation groups such as the Catawba Lands Conservancy, Davidson Lands Conservancy, North Carolina Land Trust and other organizations are included in this category. This information was obtained through a combination of GIS coverages and correspondence with the conservation groups.

Potential Riparian Buffer Preservation Opportunities

Opportunities for contiguous riparian buffer preservation were identified using aerial photos in GIS. A 2000-foot-long undisturbed buffer width of 300 feet was required on both sides of first, second, or third order streams for a potential opportunity to be considered.

Water Supply Wells

Groundwater usage from community, non-community, and private drinking water wells was determined for each subwatershed in an effort to determine where groundwater protection is most critical. The locations and average daily demand of community and non-community groundwater wells (expressed in millions of gallons per day) was determined from GIS coverages provided by NCDENR's Public Water Supply Section. Private residential well usage was estimated by an average demand per residence and by assuming that areas not provided with sanitary sewer service are also not provided with drinking water from surface-fed water treatment plants.

4.2.2 Current Watershed Health

The current watershed health of the subwatersheds was determined based on a compilation of GIS data showing the location and extent of various existing land uses, documented loss of natural habitat, observed and modeled watershed impairments, presence and quality of wastewater management systems, and information provided by resource professionals in the Local Watershed Planning Group. High scores in the Current Watershed Health category indicated that the watershed is likely expected to have a high degree of general impairment when compared to other subwatersheds in

the study area. A description of the parameters included in this category is presented below.

Existing Impervious Cover

The percentage of impervious land cover in the subwatersheds was determined using 1999 land use data updated based on observation and information provided by members of the Local Watershed Planning Group to include large developments constructed since 1999. Scores for impervious cover as a percentage of total land area are based on literature values relating imperviousness to the potential for stream degradation as identified by the Center for Watershed Protection (CWP, 2003).

Floodplain Development/Flooding Potential

The presence of structures within the FEMA-defined 100-year floodplain was determined for each subwatershed using GIS to predict the potential for property damage due to flooding and to identify subwatersheds that would benefit from keeping development out of low-lying areas. Typical property values were developed to represent potential damages. Low scores would indicate that development does not encroach on the floodplain.

Buffer Disturbance – Deforestation

The amount of undisturbed, mature buffer within a defined 100-foot width on both sides of the stream was measured for each subwatershed for current land uses. This parameter was derived from aerial photos and expressed as a percentage of the buffer zone.

Buffer Disturbance – Impervious Area

In addition to deforested buffer zone, the impervious area located within the defined 100-foot-wide buffer zone was measured and expressed as a percentage.

Wetland Disturbance

The amount of wetlands that have been lost due to agricultural practices and development, as evidenced by comparing the areal extent of hydric soils to the National Wetlands Inventory database, was measured for each subwatershed. Losses of wetlands were expressed as a percentage.

Erosion Potential Ratio – Pre-development to Current Zoning

The erosion potential ratio for the downstream-most stream segment of each subwatershed was calculated to estimate the potential impacts to the stream network that may be attributable to existing development. The erosion potential ratio is calculated using pre-development and existing 2-year discharges determined from USGS regression equations and a parameter that approximates current stream cross-section. The erosion potential is expressed as ranging from minimal to excessive; low scores indicate minimal erosion potential. Determination of the erosion potential ratio is discussed in Section 3.4.1.

Rosgen Level I Habitat Scores

The general condition of the stream habitat for each subwatershed was estimated using the general classifications assigned to the sections visited during the Rosgen Level I rapid stream assessments. Stream habitat for subwatersheds not observed during the rapid stream assessment was approximated by using data obtained at the nearest upstream and downstream observation points. Habitat scores based on benthic macroinvertebrate data collected by the NC DENR Division of Water Quality during the summer of 2002 was not included in this parameter due to the relatively small sample size and potential impact of the drought on quality of data.

Non-Supporting Streams Downstream

The presence of stream reaches within or immediately downstream of a given subwatershed that do not support their intended uses as determined by the 2000 303(d) list were identified.

Nonpoint Source Pollution Loading Under Current Land Use Conditions

Predicted nonpoint source pollution loads were determined for four representative nonpoint pollutants identified as being problematic in the watershed by the NC DWQ. The concentrations of the four constituents – total suspended solids, total nitrogen, total phosphorus, and copper – were predicted from land use and scored based on comparisons to other subwatersheds, concentrations predicted to result in water quality degradation, or regulatory standards for Class C waters. Values were obtained from the WMM modeling and can be found in Appendix E.

Wastewater Management Systems

The predominant types of wastewater management systems were identified for each of the subwatersheds. The three classes of wastewater management systems represented in the analysis included centralized/regional wastewater treatment plants, community package wastewater treatment plants, and on-site septic systems. Areas served by centralized treatment were identified by the presence of sanitary sewer interceptors; package plants were identified by the location of NDPEs-permitted wastewater outfalls; and areas served by on-site septic systems were deduced by the absence of other means of wastewater disposal. The lowest scores were given to subwatersheds relying wholly on centralized treatment. Scores for subwatersheds that rely on a combination of technologies were determined by the relative size of each technology's service area.

Wastewater Discharges/Overflows

Uncontrolled discharges of wastewater from sanitary sewers were identified for each of the subwatersheds based on records maintained by the water and sewer authorities that have jurisdiction in the various subwatersheds. All available information was obtained from the NC DENR Mooresville Regional Office. Scores were based on the total number of documented discharges over a given timeframe as compared to all of the subwatersheds.

4.2.3 Future Risk to Watershed Function

The future risk to watershed function of the subwatersheds was determined based on a compilation of GIS data showing the location and extent of various future land uses based on currently-adopted zoning, predicted changes in land use and related increases in nonpoint source pollution loadings, and information provided by resource professionals in the Local Watershed Planning Group. High scores in the Future Risk to Watershed Function category indicated that the watershed is likely expected to have a high degree of general impairment when compared to other subwatersheds in the study area. A description of the parameters included in this category is presented below.

Future Impervious Cover

Impervious cover under future land use conditions as determined by currently-adopted zoning was used to predict where changes in watershed health and habitat may be expected based on this development. Scores for impervious cover as a percentage of total land area are based on literature values relating imperviousness to the potential for stream degradation.

Changes in Impervious Cover

The change in impervious cover allows for the identification of subwatersheds that are particularly susceptible to watershed, stream, and habitat degradation with continued development, based on the relationship between current land use and the maximum amount of development allowed by zoning. Low scores would indicate that the subwatershed is not expected to experience significant additional development based on current zoning. Scores for the change in impervious cover as a percentage of total land area are based on literature values relating imperviousness to the potential for stream degradation.

NCDOT Transportation Improvement Program (TIP) Projects

The proximity of planned NCDOT TIP projects for the 2004-2010 planning period to the subwatersheds were determined based on GIS coverages and data provided by NCDOT. Low scores indicate that a planned TIP is not planned in the vicinity of the subwatershed.

Soil Erodibility Index

The soil erodibility index of soils found within the subwatersheds was used to estimate the potential for sediment transport that could accompany development (and general land cover disturbances) if the appropriate best management practices were not implemented. This information was obtained from soil surveys prepared by the USDA's Natural Resource Conservation Service (NRCS, formerly the SCS) and included three classifications of soil erodibility: slight, moderate, and severe. Weighted scores for each subwatershed were calculated by assigning a value of 1 for slight, 3 for moderate, and 5 for severe soil erodibility potential.

Erosion Potential Ratio – Pre-development to Future Zoning

The erosion potential ratio for the downstream-most stream segment of each subwatershed was calculated to estimate the potential impacts to the stream network that may be attributable to future planned development. The erosion potential ratio is calculated using pre-development and predicted future 2-year discharges determined from USGS regression equations and a parameter that approximates current stream cross-section. The erosion potential is expressed as ranging from minimal to excessive; low scores indicate minimal erosion potential. Determination of the erosion potential ratio is discussed in Section 3.4.1.

Nonpoint Source Pollution Loading Under Future Land Use Conditions

Predicted nonpoint source pollution loads were determined for four representative nonpoint pollutants identified as being problematic in the watershed by the NC DWQ. The concentrations of the four constituents – total suspended solids, total nitrogen, total phosphorus, and copper – were predicted from future land use and scored based on comparisons to other subwatersheds, concentrations predicted to result in water quality degradation, or regulatory standards. See Sections 3.3.4, 3.3.5, and Appendix E for additional information on the water quality modeling and results.

Change in Nonpoint Source Pollution Loading from Current to Future Land Use Conditions

The predicted change in key the four key modeled nonpoint source pollutants anticipated to accompany development was determined and categorized relative to the appropriate standards. This parameter was used to help identify subwatersheds where watershed management strategies will need to be implemented if the development that is expected to trigger these changes in nonpoint source pollution loads is allowed to take place.

4.3 Parameter Scoring

A scoring system that assigns from 0 to 4 points for each parameter was developed in order to quantitatively compare each of the subwatersheds based on the three broad categories described above. The scoring system was based on a unique range of values for each of the parameters. The range of values assigned to each point varies with the parameter being evaluated based on the observed range of data for all subwatersheds in the study or an estimate of the values that could result in detrimental impacts to the subwatershed's overall health. The scoring system specific to each parameter is presented in Table 4-1.

The scores for each parameter were summed to develop a composite score for each subwatershed in each of the three categories; only whole numbers were used in the scoring. The Local Watershed Planning Group elected not to selectively weight any of the scores more to give more bias to that parameter, which can be done to place emphasis on parameters that are of particular importance to the group.

Efforts were made to determine if the SRP was properly identifying subwatersheds that intuitively should have been prioritized based on collected data and discussions with the Local Watershed Planning Group. CDM staff conducted additional field cruises of those subwatersheds identified as Tier I and Tier II as well as those known to possess significant natural resources or watershed stressors. These efforts led to adjustments to the manner in which sanitary sewer overflows were incorporated into the scoring protocol (scoring was changed to be based on the number of documented overflows rather than the total volume of overflows in order to place more emphasis on persistent problems) as well as adjustments to some of the ranges of scores in other categories.

4.4 Results of Subwatershed Rankings

The results of the subwatershed prioritization ranking protocol for each of the 41 subwatersheds in the Upper Rocky River/Clarke Creek watershed are shown in **Tables 4-2** through **4-7**. The total scores for each of the subwatersheds were used to identify the most critical subwatersheds for the implementation of watershed management strategies, including specific protection and improvement project sites. The subwatersheds were prioritized by determining the highest total scores in each category and assigning the subwatersheds to one of two tiers based on these scores – Tier 1 (first priority) and Tier 2 (second priority). The range of total scores included in each tier were determined arbitrarily after reviewing the distribution of the scores in each category. Total scores for each of the three broad categories are presented in **Table 4-8**. **Figures 4-1** through **4-3** show the Tier one and two subwatersheds for the Current Watershed Health, Current Natural Resources and Habitat Value, and Future Risk scoring categories, respectively. **Figure 4-4** also shows the Tier one and two subwatersheds for each of the scoring categories on a single figure. Specific recommended watershed protection and improvement project sites were prioritized using the results of the SRP and are discussed in detail in Section 7.

**North Carolina Wetlands Restoration Program
Upper Rocky River/Clarke Creek Local Watershed Plan
Table 4-2 - Ramah Creek Subwatershed Prioritization Ranking Protocol Scoring Results**

Category ¹	Parameter ²	Units	RM-1 ⁵		RM-2		RM-3		RM-4	
			value ³	score ⁴	value	score	value	score	value	score
Current Natl Resources and Habitat Value	1 Natural Resource Sites	#/location	0	0	0	0	0	0	4 (d)	2
	2 Existing Wetlands	acres	7.5	1	7.4	1	76.7	2	157.3	4
	3 Land Preservation Areas									
	<i>Existing</i>	acres	0	0	0	0	1,044	4	1	1
	<i>Proposed</i>	acres	0	0	0	0	107	2	374	4
	4 Potential Riparian Buffer Preservation Opportunities	ft	0	0	0	0	0	0	0	0
5 Water Supply Wells	MGD	0.04	1	0.02	1	0.01	1	0.02	1	
<i>Current Natural Resources and Habitat Value Score:</i>				2		2		9		12
Current Watershed Health	1 Existing Impervious Cover	%	7%	1	5%	0	4%	0	5%	0
	2 Floodplain Development/Flooding Potential	\$K	0	0	0	0	0	0	0	0
	3 Buffer Disturbance - Deforestation	%	18%	2	38%	3	14%	2	24%	2
	4 Buffer Disturbance - Impervious Area	%	0.6%	1	3.9%	3	0%	0	0.8%	1
	5 Wetland Disturbance	%	92%	4	92%	4	76%	4	61%	3
	6 Erosion Potential Ratio (Qe/Qf)									
	<i>Pre-development to Existing Land Use</i>	-	Excessive	4	Moderate	2	Slight	0	Moderate	2
	7 Rosgen Level I Habitat Scores	-	Good	1	Good	1	Fair	3	Poor	4
	8 Non-Supporting Streams Downstream (303 (d) list)	-	-	0	-	0	-	0	-	0
	9 Nonpoint Source Pollution Loadings - Current Land Use									
	<i>Total Suspended Solids (TSS)</i>	mg/L	21	1	33	2	27	2	27	2
<i>Total Nitrogen (TN)</i>	lbs/acre	3.9	1	3.6	0	3.4	0	3.5	0	
<i>Total Phosphorus (TP)</i>	mg/L	0.095	3	0.15	4	0.13	4	0.126	4	
<i>Copper (Cu)</i>	mg/L	0.004	2	0.006	2	0.004	2	0.004	2	
10 Wastewater Management Systems	-	Public	0	Septic	4	Septic	4	Septic	4	
11 Wastewater Discharges/Overflows	#	0	0	0	0	0	0	0	0	
<i>Current Watershed Health Score:</i>				20		25		21		24
Future Risk to Watershed Functions	1 Future Impervious Cover	%	45%	4	12%	2	18%	3	20%	3
	2 Change in Impervious Cover	%	38%	4	16%	3	14%	2	15%	2
	3 NCDOT Transportation Improvement Projects (TIPs)	location	within	4	within	4	none	0	none	0
	4 Soil Erodibility Index by Area									
	<i>Slight</i>	%	23%		53%		73%		67%	
	<i>Moderate</i>	%	77%		46%		27%		33%	
	<i>Severe</i>	%	0%		0%		0%		0%	
	<i>Weighted Average</i>	-	Moderate	2	Slight-Mod	1	Slight-Mod	1	Slight-Mod	1
	5 Erosion Potential Ratio (Qe/Qf)									
	<i>Pre-development to Future Zoning</i>	-	Excessive	4	Excessive	4	Excessive	4	Excessive	4
	6 Nonpoint Source Pollution Loadings - Future Land Use									
	<i>Total Suspended Solids (TSS)</i>	mg/L	48	4	59	4	57	4	54	4
	<i>Total Nitrogen (TN)</i>	lbs/acre	7.9	3	8	3	8.4	3	8.4	3
<i>Total Phosphorus (TP)</i>	mg/L	0.198	4	0.311	4	0.29	4	0.28	4	
<i>Copper (Cu)</i>	mg/L	0.01	2	0.013	4	0.011	4	0.011	4	
7 Change in Nonpoint Source Pollution Loadings - Current to Future Land Uses										
<i>Total Suspended Solids (TSS)</i>	mg/L	27	2	26	2	30	2	27	2	
<i>Total Nitrogen (TN)</i>	lbs/acre	4	1	4.4	1	5	1	4.9	1	
<i>Total Phosphorus (TP)</i>	mg/L	0.103	4	0.16	4	0.164	4	0.154	4	
<i>Copper (Cu)</i>	mg/L	0.006	2	0.007	2	0.007	2	0.007	2	
<i>Future Risk to Watershed Functions Score:</i>				40		38		34		34

Notes

- 1.) See Section 4 for a description of the Categories.
- 2.) See Table 4-1 and Section 4 for a description of the Parameters.
- 3.) See Section 4 for a description of how the values were determined.
- 4.) See Table 4-1 for a description of how scores were assigned.
- 5.) See Figure 3-3 for the subwatershed delineations.

**North Carolina Wetlands Restoration Program
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Table 4-3 - Clarke Creek Subwatershed Prioritization Ranking Protocol Scoring Results**

Category ¹	Parameter ²	Units	CC-1 ⁵		CC-2		CC-3		CC-4		CC-5		CC-6	
			value ³	score ⁴	value	score	value	score	value	score	value	score	value	score
Current Natl Resources and Habitat Value	1 Natural Resource Sites	#/location	0	0	0	0	0	0	0	0	2	4	1	4
	2 Existing Wetlands	acres	2.5	1	23.4	1	26.0	1	9.3	1	29.8	1	18.7	1
	3 Land Preservation Areas													
	Existing	acres	0	0	290	3	304	4	0	0	100	2	7	1
	Proposed	acres	0	0	0	0	0	0	0	0	0	0	0	0
	4 Potential Riparian Buffer Preservation Opportunities	ft	0	0	0	0	1,998	1	2,089	1	0	0	0	0
5 Water Supply Wells	MGD	0	0	0.02	1	0.01	1	0.02	1	0.02	1	0.01	1	
<i>Current Natural Resources and Habitat Value Score:</i>				1		5		7		3		8		7
Current Watershed Health	1 Existing Impervious Cover	%	12%	2	5%	0	8%	1	5%	0	6%	1	6%	1
	2 Floodplain Development/Flooding Potential	\$K	0	0	0	0	0	0	0	0	0	0	150	1
	3 Buffer Disturbance - Deforestation	%	11%	2	50%	3	14%	2	9%	1	17%	2	49%	3
	4 Buffer Disturbance - Impervious Area	%	0.0%	1	0.3%	1	1.6%	2	0.0%	0	0.1%	1	0.0%	0
	5 Wetland Disturbance	%	98%	4	91%	4	77%	4	90%	4	80%	4	88%	4
	6 Erosion Potential Ratio (Qe/Qf)													
	Pre-development to Existing Land Use	-	Excessive	4	Moderate	2	Excessive	4	Moderate	2	Moderate	2	Excessive	4
	7 Rosgen Level I Habitat Scores	-	Fair	3	Fair	3	Fair	3	Medium	2	Medium	2	Medium	2
	8 Non-Supporting Streams Downstream (303 (d) list)	-	Low	1	Low	1	Low	1	Low	1	Low	1	Low	1
	9 Nonpoint Source Pollution Loadings - Current Land Use													
	Total Suspended Solids (TSS)	mg/L	31	2	29	2	27	2	21	1	25	1	34	2
Total Nitrogen (TN)	lbs/acre	4.2	1	3.4	0	4.1	1	3.4	0	3.5	0	3.6	0	
Total Phosphorus (TP)	mg/L	0.13	4	0.14	4	0.12	4	0.099	3	0.11	4	0.15	4	
Copper (Cu)	mg/L	0.02	4	0.005	2	0.005	2	0.003	0	0.003	0	0.006	2	
10 Wastewater Management Systems	-	Public	0	Septic	4	Public-Septic	1	Septic	4	Septic	4	Septic	4	
11 Wastewater Discharges/Overflows	#	1	1	0	0	5	4	0	0	0	0	0	0	
<i>Current Watershed Health Score:</i>				29		26		31		18		22		28
Future Risk to Watershed Functions	1 Future Impervious Cover	%	28%	4	13%	2	29%	4	33%	4	27%	4	13%	2
	2 Change in Impervious Cover	%	15%	2	16%	3	20%	3	28%	4	22%	3	15%	2
	3 NCDOT Transportation Improvement Projects (TIPs)	location	none	0	none	0	none	0	bordering	2	none	0	none	0
	4 Soil Erodibility Index by Area													
	Slight	%	30%		62%		64%		30%		60%		54%	
	Moderate	%	69%		37%		33%		67%		39%		46%	
	Severe	%	0%		0%		0%		2%		0%		0%	
	Weighted Average	-	Slight-Mod	1	Slight-Mod	1	Slight-Mod	1	Slight-Mod	1	Slight-Mod	1	Slight-Mod	1
	5 Erosion Potential Ratio (Qe/Qf)													
	Pre-development to Future Zoning	-	Excessive	4	Excessive	4	Excessive	4	Excessive	4	Excessive	4	Excessive	4
	6 Nonpoint Source Pollution Loadings - Future Land Use													
	Total Suspended Solids (TSS)	mg/L	44	3	58	4	43	3	43	3	43	3	63	4
	Total Nitrogen (TN)	lbs/acre	5.7	2	7.9	3	7.6	3	8	3	7.8	3	7.9	3
Total Phosphorus (TP)	mg/L	0.18	4	0.302	4	0.218	4	0.218	4	0.225	4	0.303	4	
Copper (Cu)	mg/L	0.023	4	0.012	4	0.009	2	0.009	2	0.009	2	0.012	4	
7 Change in Nonpoint Source Pollution Loadings - Current to Future Land Uses														
Total Suspended Solids (TSS)	mg/L	13	0	29	2	16	1	22	1	18	1	29	2	
Total Nitrogen (TN)	lbs/acre	1.5	0	4.5	1	3.5	0	4.6	1	4.3	1	4.3	1	
Total Phosphorus (TP)	mg/L	0.05	2	0.163	4	0.096	3	0.119	4	0.115	4	0.154	4	
Copper (Cu)	mg/L	0.003	0	0.007	2	0.004	2	0.006	2	0.006	2	0.006	2	
<i>Future Risk to Watershed Functions Score:</i>				26		34		30		35		32		33

Notes

- 1.) See Section 4 for a description of the Categories.
- 2.) See Table 4-1 and Section 4 for a description of the Parameters.
- 3.) See Section 4 for a description of how the values were determined.
- 4.) See Table 4-1 for a description of how scores were assigned.
- 5.) See Figure 3-3 for the subwatershed delineations.

**North Carolina Wetlands Restoration Program
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Table 4-3 (continued) - Clarke Creek Subwatershed Prioritization Ranking Protocol Scoring Results**

Category ¹	Parameter ²	Units	CC-7 ⁵		CC-8		CC-9		CC-10		CC-11	
			value ³	score ⁴	value	score	value	score	value	score	value	score
Current Natl Resources and Habitat Value	1 Natural Resource Sites	#/location	0	0	0	0	0	0	0	0	4	4
	2 Existing Wetlands	acres	32.0	1	325.4	4	57.8	2	27.2	1	413.2	4
	3 Land Preservation Areas <i>Existing</i>	acres	2	1	229	3	0	0	0	0	101	2
	<i>Proposed</i>	acres	69	2	0	0	0	0	0	0	6	1
	4 Potential Riparian Buffer Preservation Opportunities	ft	3,513	3	2,552	2	2,485	1	2,682	2	2,237	1
	5 Water Supply Wells	MGD	0.02	1	0.01	1	0.02	1	0.002	1	0.03	1
<i>Current Natural Resources and Habitat Value Score:</i>				8		10		4		4		13
Current Watershed Health	1 Existing Impervious Cover	%	5%	0	9%	1	23%	3	21%	3	12%	2
	2 Floodplain Development/Flooding Potential	\$K	0	0	0	0	0	0	0	0	150	1
	3 Buffer Disturbance - Deforestation	%	11%	2	25%	2	32%	3	38%	3	23%	2
	4 Buffer Disturbance - Impervious Area	%	0%	1	3.5%	3	2.5%	2	0.0%	0	0.3%	1
	5 Wetland Disturbance	%	88%	4	42%	2	91%	4	89%	4	41%	2
	6 Erosion Potential Ratio (Qe/Qf) <i>Pre-development to Existing Land Use</i>	-	Moderate	2	Excessive	4	Excessive	4	Excessive	4	Excessive	4
	7 Rosgen Level I Habitat Scores	-	Medium	2	Medium	2	Medium	2	Medium	2	Medium	2
	8 Non-Supporting Streams Downstream (303 (d) list)	-	Low	1	Low	1	Low	1	Low	1	Low	1
	9 Nonpoint Source Pollution Loadings - Current Land Use											
	<i>Total Suspended Solids (TSS)</i>	mg/L	30	2	27	2	32	2	33	2	24	1
	<i>Total Nitrogen (TN)</i>	lbs/acre	3.5	0	3.9	1	6.4	2	5.9	2	4.6	1
<i>Total Phosphorus (TP)</i>	mg/L	0.14	4	0.118	4	0.16	4	0.163	4	0.117	4	
<i>Copper (Cu)</i>	mg/L	0.004	2	0.004	2	0.006	2	0.007	2	0.003	0	
10 Wastewater Management Systems	-	Septic	4	Septic	4	Public	0	Public	0	Septic	4	
11 Wastewater Discharges/Overflows	#	0	0	0	0	1	1	0	0	0	0	
<i>Current Watershed Health Score:</i>				24		28		30		27		25
Future Risk to Watershed Functions	1 Future Impervious Cover	%	14%	2	30%	4	39%	4	32%	4	40%	4
	2 Change in Impervious Cover	%	16%	3	21%	3	20%	3	18%	3	28%	4
	3 NCDOT Transportation Improvement Projects (TIPs)	location	bordering	2	none	0	bordering	2	none	0	none	0
	4 Soil Erodibility Index by Area											
	<i>Slight</i>	%	65%		64%		78%		87%		59%	
	<i>Moderate</i>	%	34%		34%		20%		9%		35%	
	<i>Severe</i>	%	0%		2%		1%		4%		6%	
	<i>Weighted Average</i>	-	Slight-Mod	1	Slight-Mod	1	Slight	0	Slight	0	Slight-Mod	1
	5 Erosion Potential Ratio (Qe/Qf) <i>Pre-development to Future Zoning</i>	-	Excessive	4	Excessive	4	Excessive	4	Excessive	4	Excessive	4
	6 Nonpoint Source Pollution Loadings - Future Land Use											
	<i>Total Suspended Solids (TSS)</i>	mg/L	58	4	53	4	47	4	50	4	43	3
	<i>Total Nitrogen (TN)</i>	lbs/acre	8.1	3	8.4	3	9.2	4	8.9	3	9.5	4
	<i>Total Phosphorus (TP)</i>	mg/L	0.305	4	0.247	4	0.233	4	0.243	4	0.225	4
<i>Copper (Cu)</i>	mg/L	0.012	4	0.011	4	0.013	4	0.011	4	0.009	2	
7 Change in Nonpoint Source Pollution Loadings - Current to Future Land Uses												
<i>Total Suspended Solids (TSS)</i>	mg/L	28	2	26	2	15	0	17	1	19	1	
<i>Total Nitrogen (TN)</i>	lbs/acre	4.6	1	4.5	1	2.8	0	3	0	4.9	1	
<i>Total Phosphorus (TP)</i>	mg/L	0.162	4	0.129	4	0.072	3	0.08	3	0.108	4	
<i>Copper (Cu)</i>	mg/L	0.008	2	0.007	2	0.007	2	0.004	2	0.006	2	
<i>Future Risk to Watershed Functions Score:</i>				36		36		34		32		34

Notes

- 1.) See Section 4 for a description of the Categories.
- 2.) See Table 4-1 and Section 4 for a description of the Parameters.
- 3.) See Section 4 for a description of how the values were determined.
- 4.) See Table 4-1 for a description of how scores were assigned.
- 5.) See Figure 3-3 for the subwatershed delineations.

**North Carolina Wetlands Restoration Program
Upper Rocky River/Clarke Creek Local Watershed Plan
Table 4-4 - Dye Branch Subwatershed Prioritization Ranking Protocol Scoring Results**

Category ¹	Parameter ²	Units	DB-1 ⁵		DB-2		DB-3	
			value ³	score ⁴	value	score	value	score
Current Natl Resources and Habitat Value	1 Natural Resource Sites	#/location	0	0	0	0	0	0
	2 Existing Wetlands	acres	7.0	1	5.3	1	18.8	1
	3 Land Preservation Areas							
	<i>Existing</i>	acres	10	1	0	0	0	0
	<i>Proposed</i>	acres	0	0	0	0	0	0
	4 Potential Riparian Buffer Preservation Opportunities	ft	0	0	0	0	0	0
5 Water Supply Wells	MGD	0.00	1	0.03	1	0.07	1	
<i>Current Natural Resources and Habitat Value Score:</i>				3	2	2		
Current Watershed Health	1 Existing Impervious Cover	%	29%	4	20%	3	10%	1
	2 Floodplain Development/Flooding Potential	\$K	6,600	4	0	0	0	0
	3 Buffer Disturbance - Deforestation	%	58%	4	38%	3	67%	4
	4 Buffer Disturbance - Impervious Area	%	25.7%	4	7.5%	4	0.7%	1
	5 Wetland Disturbance	%	98%	4	97%	4	95%	4
	6 Erosion Potential Ratio (Qe/Qf)							
	<i>Pre-development to Existing Land Use</i>	-	Excessive	4	Excessive	4	Excessive	4
	7 Rosgen Level I Habitat Scores	-	Poor	4	Medium	2	Medium	2
	8 Non-Supporting Streams Downstream (303 (d) list)	-	Low	1	Low	1	Low	1
	9 Nonpoint Source Pollution Loadings - Current Land Use							
	<i>Total Suspended Solids (TSS)</i>	mg/L	38	3	31	2	25	1
<i>Total Nitrogen (TN)</i>	lbs/acre	7.0	2	5.9	2	4.4	1	
<i>Total Phosphorus (TP)</i>	mg/L	0.174	4	0.15	4	0.12	4	
<i>Copper (Cu)</i>	mg/L	0.008	2	0.006	2	0.004	2	
10 Wastewater Management Systems	-	Public	0	Public	0	Public-Septic	1	
11 Wastewater Discharges/Overflows	#	6	4	0	0	0	0	
<i>Current Watershed Health Score:</i>				44	31	26		
Future Risk to Watershed Functions	1 Future Impervious Cover	%	40%	4	36%	4	36%	4
	2 Change in Impervious Cover	%	11%	2	16%	3	22%	3
	3 NCDOT Transportation Improvement Projects (TIPs)	location	none	0	none	0	none	0
	4 Soil Erodibility Index by Area							
	<i>Slight</i>	%	28%		25%		39%	
	<i>Moderate</i>	%	72%		75%		61%	
	<i>Severe</i>	%	0%		0%		0%	
	<i>Weighted Average</i>	-	Slight-Mod	1	Slight-Mod	1	Slight-Mod	1
	5 Erosion Potential Ratio (Qe/Qf)							
	<i>Pre-development to Future Zoning</i>	-	Excessive	4	Excessive	4	Excessive	4
	6 Nonpoint Source Pollution Loadings - Future Land Use							
	<i>Total Suspended Solids (TSS)</i>	mg/L	45	3	43	3	45	3
	<i>Total Nitrogen (TN)</i>	lbs/acre	8.5	3	8.1	3	8.6	3
	<i>Total Phosphorus (TP)</i>	mg/L	0.208	4	0.21	4	0.258	4
<i>Copper (Cu)</i>	mg/L	0.009	2	0.01	2	0.022	4	
7 Change in Nonpoint Source Pollution Loadings - Current to Future Land Uses								
<i>Total Suspended Solids (TSS)</i>	mg/L	7	0	12	0	20	1	
<i>Total Nitrogen (TN)</i>	lbs/acre	1.5	0	2.2	0	4.2	1	
<i>Total Phosphorus (TP)</i>	mg/L	0.034	1	0.056	2	0.139	4	
<i>Copper (Cu)</i>	mg/L	0.001	0	0.004	2	0.018	4	
<i>Future Risk to Watershed Functions Score:</i>				24	28	36		

Notes

- 1.) See Section 4 for a description of the Categories.
- 2.) See Table 4-1 and Section 4 for a description of the Parameters.
- 3.) See Section 4 for a description of how the values were determined.
- 4.) See Table 4-1 for a description of how scores were assigned.
- 5.) See Figure 3-3 for the subwatershed delineations.

**North Carolina Wetlands Restoration Program
Upper Rocky River/Clarke Creek Local Watershed Plan
Table 4-5 - Rocky River Subwatershed Prioritization Ranking Protocol Scoring Results**

Category ¹	Parameter ²	Units	RR-1 ⁵		RR-2		RR-3		RR-4		RR-5		RR-6	
			value ³	score ⁴	value	score	value	score	value	score	value	score	value	score
Current Natl Resources and Habitat Value	1 Natural Resource Sites	#/location	0	0	0	0	0	0	1	4	1	4	0	0
	2 Existing Wetlands	acres	4.1	1	61.5	2	40.5	1	71.3	2	27.4	1	86.2	2
	3 Land Preservation Areas <i>Existing</i>	acres	1	1	0	0	145	2	129	2	0	0	0	0
	<i>Proposed</i>	acres	0	0	0	0	0	0	0	0	18	1	0	0
	4 Potential Riparian Buffer Preservation Opportunities	ft	0	0	3,061	3	2,499	1	2,057	1	4,275	3	0	0
5 Water Supply Wells	MGD	0.04	1	0.05	1	0.02	1	0.01	1	0.04	1	0.03	1	
<i>Current Natural Resources and Habitat Value Score:</i>				3		6		5		10		10		3
Current Watershed Health	1 Existing Impervious Cover	%	9%	1	4%	0	4%	0	7%	1	5%	0	3%	0
	2 Floodplain Development/Flooding Potential	\$K	0	0	300	2	0	0	0	0	0	0	0	0
	3 Buffer Disturbance - Deforestation	%	34%	3	42%	3	18%	2	31%	3	20%	2	21%	2
	4 Buffer Disturbance - Impervious Area	%	1.0%	2	1.3%	2	0.0%	0	0.2%	1	0.0%	0	0.3%	1
	5 Wetland Disturbance	%	98%	4	79%	4	95%	4	85%	4	87%	4	55%	3
	6 Erosion Potential Ratio (Qe/Qf) <i>Pre-development to Existing Land Use</i>	-	Excessive	4	Slight	0	Slight	0	Excessive	4	Moderate	2	Slight	0
	7 Rosgen Level I Habitat Scores	-	Poor	4	Fair	3	Fair	3	Medium	2	Medium	2	Medium	2
	8 Non-Supporting Streams Downstream (303 (d) list)	-	TMDL	4	TMDL	4	TMDL	4	TMDL	4	-	0	-	0
	9 Nonpoint Source Pollution Loadings - Current Land Use													
	<i>Total Suspended Solids (TSS)</i>	mg/L	24	1	21	1	21	1	20	1	20	1	18	1
	<i>Total Nitrogen (TN)</i>	lbs/acre	3.9	1	3.4	0	3.2	0	3.8	1	3.5	0	3.2	0
<i>Total Phosphorus (TP)</i>	mg/L	0.106	4	0.10	4	0.10	3	0.098	3	0.09	3	0.08	3	
<i>Copper (Cu)</i>	mg/L	0.003	0	0.003	0	0.002	0	0.003	0	0.003	0	0.002	0	
10 Wastewater Management Systems	-	Septic	4	Septic	4	Septic	4	Septic	4	Septic	4	Septic	4	
11 Wastewater Discharges/Overflows	#	0	0	0	0	0	0	0	0	0	0	0	0	
<i>Current Watershed Health Score:</i>				32		27		21		28		18		16
Future Risk to Watershed Functions	1 Future Impervious Cover	%	36%	4	31%	4	31%	4	38%	4	39%	4	41%	4
	2 Change in Impervious Cover	%	28%	4	27%	4	27%	4	31%	4	34%	4	38%	4
	3 NCDOT Transportation Improvement Projects (TIPs)	location	none	0	none	0	none	0	none	0	none	0	none	0
	3 Soil Erodibility Index by Area													
	<i>Slight</i>	%	25%		26%		29%		13%		22%		31%	
	<i>Moderate</i>	%	75%		74%		71%		86%		78%		67%	
	<i>Severe</i>	%	0%		0%		0%		1%		0%		2%	
	<i>Weighted Average</i>	-	Slight-Mod	1	Slight-Mod	1	Slight-Mod	1	Moderate	2	Moderate	2	Slight-Mod	1
	4 Erosion Potential Ratio (Qe/Qf) <i>Pre-development to Future Zoning</i>	-	Excessive	4	Excessive	4	Excessive	4	Excessive	4	Excessive	4	Excessive	4
	5 Nonpoint Source Pollution Loadings - Future Land Use													
	<i>Total Suspended Solids (TSS)</i>	mg/L	44	3	45	3	44	3	43	3	43	3	44	3
	<i>Total Nitrogen (TN)</i>	lbs/acre	7.8	3	7.1	3	7.4	3	8.9	3	9.2	4	9.5	4
	<i>Total Phosphorus (TP)</i>	mg/L	0.218	4	0.246	4	0.255	4	0.218	4	0.221	4	0.223	4
<i>Copper (Cu)</i>	mg/L	0.015	4	0.024	4	0.025	4	0.01	2	0.009	2	0.009	2	
6 Change in Nonpoint Source Pollution Loadings - Current to Future Land Uses														
<i>Total Suspended Solids (TSS)</i>	mg/L	20	1	24	1	23	1	23	1	23	1	26	2	
<i>Total Nitrogen (TN)</i>	lbs/acre	3.9	1	3.7	0	4.2	1	5.1	2	5.7	2	6.3	2	
<i>Total Phosphorus (TP)</i>	mg/L	0.112	4	0.144	4	0.159	4	0.12	4	0.131	4	0.142	4	
<i>Copper (Cu)</i>	mg/L	0.012	4	0.021	4	0.023	4	0.007	2	0.006	2	0.007	2	
<i>Future Risk to Watershed Functions Score:</i>				37		36		37		35		36		36

Notes

- 1.) See Section 4 for a description of the Categories.
- 2.) See Table 4-1 and Section 4 for a description of the Parameters.
- 3.) See Section 4 for a description of how the values were determined.
- 4.) See Table 4-1 for a description of how scores were assigned.
- 5.) See Figure 3-3 for the subwatershed delineations.

**North Carolina Wetlands Restoration Program
Upper Rocky River/Clarke Creek Local Watershed Plan
Table 4-5 (continued) - Rocky River Subwatershed Prioritization Ranking Protocol Scoring Results**

Category ¹	Parameter ²	Units	RR-7 ⁵		RR-8		RR-9		RR-10	
			value ³	score ⁴	value	score	value	score	value	score
Current Natl Resources and Habitat Value	1 Natural Resource Sites	#/location	0	0	0	0	0	0	0	0
	2 Existing Wetlands	acres	193.0	4	170.3	4	119.3	3	194.9	4
	3 Land Preservation Areas									
	<i>Existing</i>	acres	0	0	78	2	0	0	0	0
	<i>Proposed</i>	acres	168	3	173	3	0	0	0	0
	4 Potential Riparian Buffer Preservation Opportunities	ft	0	0	0	0	2,103	1	0	0
5 Water Supply Wells	MGD	0.03	1	0.01	1	0.12	2	0.01	1	
<i>Current Natural Resources and Habitat Value Score:</i>				8		10		6		5
Current Watershed Health	1 Existing Impervious Cover	%	8%	1	14%	2	11%	2	25%	3
	2 Floodplain Development/Flooding Potential	\$K	0	0	0	0	300	2	0	0
	3 Buffer Disturbance - Deforestation	%	33%	3	31%	3	39%	3	59%	4
	4 Buffer Disturbance - Impervious Area	%	1%	2	1.2%	2	4.0%	3	0.7%	1
	5 Wetland Disturbance	%	70%	3	55%	3	77%	4	32%	2
	6 Erosion Potential Ratio (Qe/Qf)									
	<i>Pre-development to Existing Land Use</i>	-	Excessive	4	Excessive	4	Excessive	4	Excessive	4
	7 Rosgen Level I Habitat Scores	-	Medium	2	Good	1	Medium	2	Medium	2
	8 Non-Supporting Streams Downstream (303 (d) list)	-	-	0	-	0	-	0	-	0
	9 Nonpoint Source Pollution Loadings - Current Land Use									
	<i>Total Suspended Solids (TSS)</i>	mg/L	23	1	28	2	24	1	43	3
<i>Total Nitrogen (TN)</i>	lbs/acre	3.6	0	4.2	1	4.5	1	5.7	2	
<i>Total Phosphorus (TP)</i>	mg/L	0.10	3	0.12	4	0.11	4	0.13	4	
<i>Copper (Cu)</i>	mg/L	0.004	2	0.005	2	0.004	2	0.007	2	
10 Wastewater Management Systems	-	Septic	4	Septic	4	Septic	4	Septic	4	
11 Wastewater Discharges/Overflows	#	0	0	0	0	0	0	0	0	
<i>Current Watershed Health Score:</i>				25		28		32		31
Future Risk to Watershed Functions	1 Future Impervious Cover	%	37%	4	38%	4	42%	4	53%	4
	2 Change in Impervious Cover	%	35%	4	31%	4	31%	4	28%	4
	3 NCDOT Transportation Improvement Projects (TIPs)	location	none	0	none	0	bordering	2	bordering	2
	3 Soil Erodibility Index by Area									
	<i>Slight</i>	%	50%		69%		37%		48%	
	<i>Moderate</i>	%	49%		31%		60%		47%	
	<i>Severe</i>	%	0%		0%		2%		5%	
	<i>Weighted Average</i>	-	Slight-Mod	1	Slight-Mod	1	Slight-Mod	1	Slight-Mod	1
	4 Erosion Potential Ratio (Qe/Qf)									
	<i>Pre-development to Future Zoning</i>	-	Excessive	4	Excessive	4	Excessive	4	Excessive	4
	5 Nonpoint Source Pollution Loadings - Future Land Use									
	<i>Total Suspended Solids (TSS)</i>	mg/L	48	4	49	4	46	4	65	4
	<i>Total Nitrogen (TN)</i>	lbs/acre	9.4	4	9.4	4	9.6	4	9.8	4
	<i>Total Phosphorus (TP)</i>	mg/L	0.236	4	0.239	4	0.222	4	0.214	4
<i>Copper (Cu)</i>	mg/L	0.01	2	0.01	2	0.009	2	0.012	4	
6 Change in Nonpoint Source Pollution Loadings - Current to Future Land Uses										
<i>Total Suspended Solids (TSS)</i>	mg/L	25	1	21	1	22	1	22	1	
<i>Total Nitrogen (TN)</i>	lbs/acre	5.8	2	5.2	2	5.1	2	4.1	1	
<i>Total Phosphorus (TP)</i>	mg/L	0.138	4	0.119	4	0.113	4	0.084	3	
<i>Copper (Cu)</i>	mg/L	0.006	2	0.005	2	0.005	2	0.005	2	
<i>Future Risk to Watershed Functions Score:</i>				36		36		38		38

Notes

- 1.) See Section 4 for a description of the Categories.
- 2.) See Table 4-1 and Section 4 for a description of the Parameters.
- 3.) See Section 4 for a description of how the values were determined.
- 4.) See Table 4-1 for a description of how scores were assigned.
- 5.) See Figure 3-3 for the subwatershed delineations.

**North Carolina Wetlands Restoration Program
Upper Rocky River/Clarke Creek Local Watershed Plan
Table 4-6 - South Prong of the Rocky River Subwatershed Prioritization Ranking Protocol Scoring Results**

Category ¹	Parameter ²	Units	SPRR-1 ⁵		SPRR-2		SPRR-3		SPRR-4	
			value ³	score ⁴	value	score	value	score	value	score
Current Natl Resources and Habitat Value	1 Natural Resource Sites	#/location	0	0	0	0	0	0	0	0
	2 Existing Wetlands	acres	9.1	1	51.3	2	1.2	1	260.3	4
	3 Land Preservation Areas <i>Existing</i>	acres	130	2	79	2	46	1	0	0
	<i>Proposed</i>	acres	0	0	0	0	0	0	0	0
	4 Potential Riparian Buffer Preservation Opportunities	ft	0	0	2,452	1	2,031	1	0	0
5 Water Supply Wells	MGD	0	0	0	0	0	0	0	0	
<i>Current Natural Resources and Habitat Value Score:</i>				3	5	3	4			
Current Watershed Health	1 Existing Impervious Cover	%	11%	2	5%	0	4%	0	6%	1
	2 Floodplain Development/Flooding Potential	\$K	0	0	0	0	0	0	0	0
	3 Buffer Disturbance - Deforestation	%	11%	2	35%	3	14%	2	41%	3
	4 Buffer Disturbance - Impervious Area	%	0.7%	1	0.6%	1	3%	3	1.4%	2
	5 Wetland Disturbance	%	91%	4	71%	3	99%	4	52%	3
	6 Erosion Potential Ratio (Qe/Qf) <i>Pre-development to Existing Land Use</i>	-	Excessive	4	Moderate	2	Slight	0	Moderate	2
	7 Rosgen Level I Habitat Scores	-	Medium	2	Medium	2	Medium	2	Poor	4
	8 Non-Supporting Streams Downstream (303 (d) list)	-	-	0	-	0	-	0	-	0
	9 Nonpoint Source Pollution Loadings - Current Land Use									
	<i>Total Suspended Solids (TSS)</i>	mg/L	23	1	25	1	36	3	24	1
	<i>Total Nitrogen (TN)</i>	lbs/acre	4.3	1	3.4	0	3.3	0	3.6	0
<i>Total Phosphorus (TP)</i>	mg/L	0.102	4	0.11	4	0.17	4	0.114	4	
<i>Copper (Cu)</i>	mg/L	0.004	2	0.004	2	0.005	2	0.004	2	
10 Wastewater Management Systems	-	Public-Septic	1	Septic	4	Septic	4	Private-Septic	3	
11 Wastewater Discharges/Overflows	#	0	0	0	0	0	0	0	0	
<i>Current Watershed Health Score:</i>				24	22	24	25			
Future Risk to Watershed Functions	1 Future Impervious Cover	%	47%	4	23%	3	5%	0	27%	4
	2 Change in Impervious Cover	%	36%	4	18%	3	1%	0	21%	3
	3 NCDOT Transportation Improvement Projects (TIPs)	location	none	0	none	0	none	0	bordering	2
	4 Soil Erodibility Index by Area									
	<i>Slight</i>	%	34%		44%		34%		71%	
	<i>Moderate</i>	%	45%		53%		66%		29%	
	<i>Severe</i>	%	0%		0%		0%		0%	
	<i>Weighted Average</i>	-	Slight-Mod	1	Slight-Mod	1	Slight-Mod	1	Slight-Mod	1
	5 Erosion Potential Ratio (Qe/Qf) <i>Pre-development to Future Zoning</i>	-	Excessive	4	Excessive	4	Moderate	2	Excessive	4
	6 Nonpoint Source Pollution Loadings - Future Land Use									
	<i>Total Suspended Solids (TSS)</i>	mg/L	52	4	46	4	37	3	42	3
	<i>Total Nitrogen (TN)</i>	lbs/acre	8.8	3	6.4	2	3.5	0	6.7	2
	<i>Total Phosphorus (TP)</i>	mg/L	0.204	4	0.204	4	0.175	4	0.199	4
	<i>Copper (Cu)</i>	mg/L	0.01	2	0.011	4	0.009	2	0.023	4
6 Change in Nonpoint Source Pollution Loadings - Current to Future Land Uses										
<i>Total Suspended Solids (TSS)</i>	mg/L	29	2	21	1	1	0	18	1	
<i>Total Nitrogen (TN)</i>	lbs/acre	4.5	1	3	0	0.2	0	3.1	0	
<i>Total Phosphorus (TP)</i>	mg/L	0.102	4	0.09	3	0.01	0	0.085	3	
<i>Copper (Cu)</i>	mg/L	0.006	2	0.007	2	0.004	2	0.019	4	
<i>Future Risk to Watershed Functions Score:</i>				35	31	14	35			

Notes

- 1.) See Section 4 for a description of the Categories.
- 2.) See Table 4-1 and Section 4 for a description of the Parameters.
- 3.) See Section 4 for a description of how the values were determined.
- 4.) See Table 4-1 for a description of how scores were assigned.
- 5.) See Figure 3-3 for the subwatershed delineations.

**North Carolina Wetlands Restoration Program
Upper Rocky River/Clarke Creek Local Watershed Plan
Table 4-7 - West Branch of the Rocky River Subwatershed Prioritization Ranking Protocol Scoring Results**

Category ¹	Parameter ²	Units	WBRR-1 ⁵		WBRR-2		WBRR-3		WBRR-4		WBRR-5		WBRR-6	
			value ³	score ⁴	value	score	value	score	value	score	value	score	value	score
Current Natl Resources and Habitat Value	1 Natural Resource Sites	#/location	0	0	0	0	0	0	0	0	1	4	1	4
	2 Existing Wetlands	acres	9.7	1	1.4	1	8.2	1	43.5	1	13.7	1	14.6	1
	3 Land Preservation Areas <i>Existing</i>	acres	37	1	0	0	0	0	0	0	95	2	0	0
	<i>Proposed</i>	acres	0	0	0	0	0	0	0	0	0	0	0	0
	4 Potential Riparian Buffer Preservation Opportunities	ft	0	0	0	0	2,446	1	2,268	1	2,058	1	0	0
5 Water Supply Wells	MGD	0.03	1	0.10	1	0.04	1	0.09	1	0.02	1	0.04	1	
<i>Current Natural Resources and Habitat Value Score:</i>				3	2	3	3	9	6					
Current Watershed Health	1 Existing Impervious Cover	%	8%	1	9%	1	4%	0	5%	0	3%	0	5%	0
	2 Floodplain Development/Flooding Potential	\$K	450	2	0	0	0	0	0	0	0	0	0	0
	3 Buffer Disturbance - Deforestation	%	36%	3	38%	3	76%	4	32%	3	38%	3	70%	4
	4 Buffer Disturbance - Impervious Area	%	3.7%	3	1.3%	2	0.1%	1	0.7%	1	0.6%	1	0.2%	1
	5 Wetland Disturbance	%	98%	4	99%	4	98%	4	88%	4	97%	4	94%	4
	6 Erosion Potential Ratio (Qe/Qf) <i>Pre-development to Existing Land Use</i>	-	Excessive	4	Excessive	4	Moderate	2	Moderate	2	Slight	0	Moderate	2
	7 Rosgen Level I Habitat Scores	-	Poor	4	Medium	2	Poor	4	Poor	4	Fair	3	Fair	3
	8 Non-Supporting Streams Downstream (303 (d) list)	-	-	0	-	0	-	0	-	0	-	0	-	0
	9 Nonpoint Source Pollution Loadings - Current Land Use													
	<i>Total Suspended Solids (TSS)</i>	mg/L	23	1	25	1	22	1	22	1	20	1	20	1
	<i>Total Nitrogen (TN)</i>	lbs/acre	3.7	0	4	1	3.3	0	3.4	0	3.2	0	3.4	0
<i>Total Phosphorus (TP)</i>	mg/L	0.099	3	0.11	4	0.10	4	0.10	4	0.09	3	0.10	3	
<i>Copper (Cu)</i>	mg/L	0.004	2	0.004	2	0.002	0	0.004	2	0.002	0	0.003	0	
10 Wastewater Management Systems	-	Public-Septic	1	Septic	4	Septic	4	Septic	4	Septic	4	Septic	4	
11 Wastewater Discharges/Overflows	#	0	0	0	0	0	0	0	0	0	0	0	0	
<i>Current Watershed Health Score:</i>				28	28	24	25	19	22					
Future Risk to Watershed Functions	1 Future Impervious Cover	%	38%	4	32%	4	29%	4	29%	4	33%	4	34%	4
	2 Change in Impervious Cover	%	30%	4	23%	3	25%	3	25%	3	30%	4	29%	4
	3 NCDOT Transportation Improvement Projects (TIPs)	location	none	0	none	0	none	0	none	0	none	0	none	0
	3 Soil Erodibility Index by Area													
	<i>Slight</i>	%	42%		33%		40%		36%		28%		22%	
	<i>Moderate</i>	%	58%		67%		60%		64%		71%		74%	
	<i>Severe</i>	%	0%		0%		0%		0%		2%		3%	
	<i>Weighted Average</i>	-	Slight-Mod	1	Slight-Mod	1	Slight-Mod	1	Slight-Mod	1	Slight-Mod	1	Moderate	2
	4 Erosion Potential Ratio (Qe/Qf) <i>Pre-development to Future Zoning</i>	-	Excessive	4	Excessive	4	Excessive	4	Excessive	4	Excessive	4	Excessive	4
	5 Nonpoint Source Pollution Loadings - Future Land Use													
	<i>Total Suspended Solids (TSS)</i>	mg/L	54	4	46	4	46	4	45	3	46	4	43	3
	<i>Total Nitrogen (TN)</i>	lbs/acre	7.7	3	7.7	3	7.1	3	7	2	7.8	3	7.7	3
	<i>Total Phosphorus (TP)</i>	mg/L	0.217	4	0.245	4	0.268	4	0.263	4	0.236	4	0.231	4
<i>Copper (Cu)</i>	mg/L	0.016	4	0.021	4	0.03	4	0.029	4	0.017	4	0.017	4	
6 Change in Nonpoint Source Pollution Loadings - Current to Future Land Uses														
<i>Total Suspended Solids (TSS)</i>	mg/L	31	2	21	1	24	1	23	1	26	2	23	1	
<i>Total Nitrogen (TN)</i>	lbs/acre	4	1	3.7	0	3.8	1	3.6	0	4.6	1	4.3	1	
<i>Total Phosphorus (TP)</i>	mg/L	0.118	4	0.131	4	0.167	4	0.161	4	0.146	4	0.135	4	
<i>Copper (Cu)</i>	mg/L	0.012	4	0.017	4	0.028	4	0.025	4	0.015	4	0.014	4	
<i>Future Risk to Watershed Functions Score:</i>				39	36	37	34	39	38					

Notes

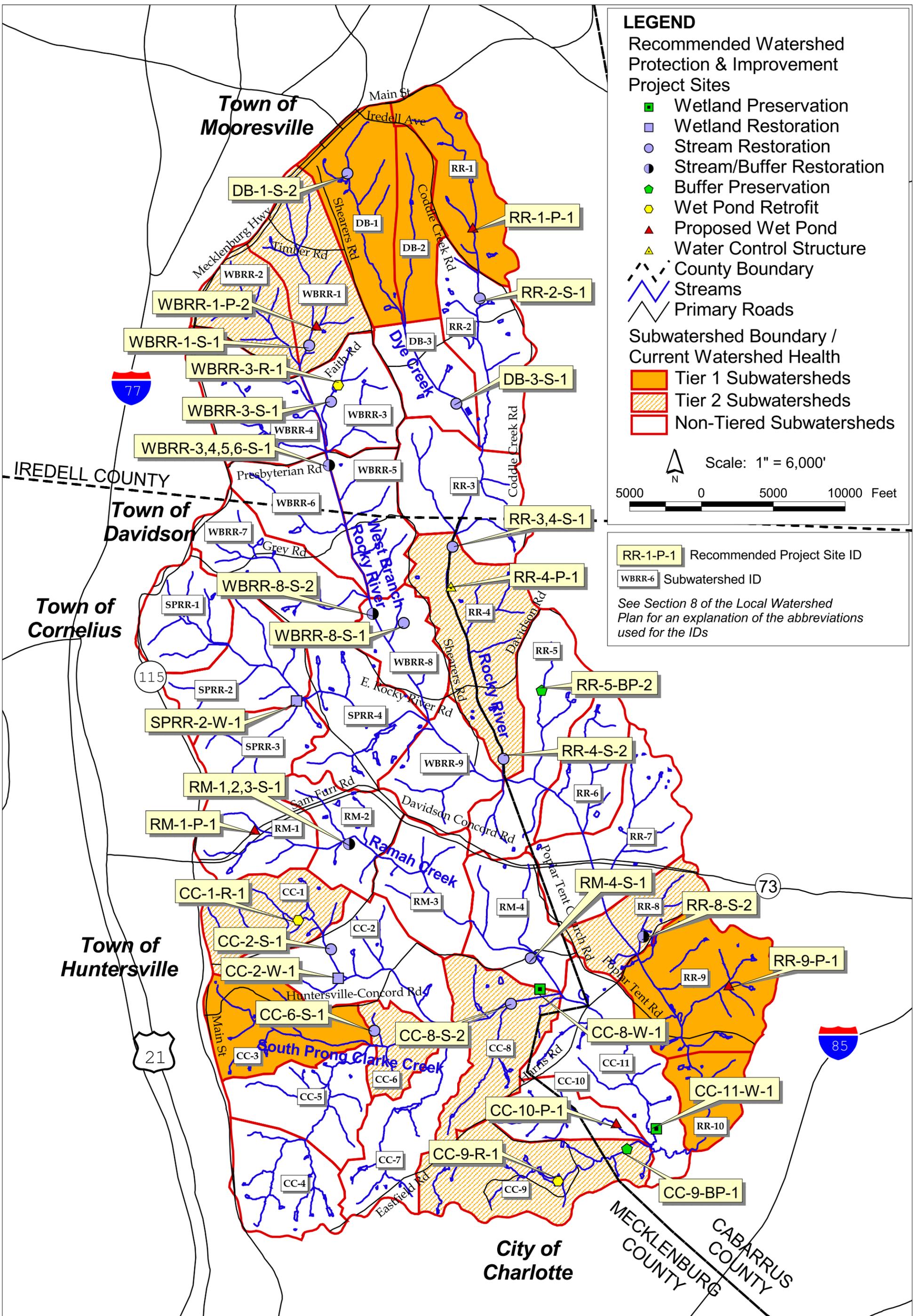
- 1.) See Section 4 for a description of the Categories.
- 2.) See Table 4-1 and Section 4 for a description of the Parameters.
- 3.) See Section 4 for a description of how the values were determined.
- 4.) See Table 4-1 for a description of how scores were assigned.
- 5.) See Figure 3-3 for the subwatershed delineations.

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Table 4-8 - Summary of Category Rankings by Subwatershed

Subwatershed	Subwatershed ID	Current Watershed Health	Current Natural Resources and Habitat Value	Future Risk to Watershed Functions
<i>Clarke Creek</i>	CC-1	29	1	26
	CC-2	26	5	34
	CC-3	31	7	30
	CC-4	18	3	35
	CC-5	22	8	32
	CC-6	28	7	33
	CC-7	24	8	36
	CC-8	28	10	36
	CC-9	30	4	34
	CC-10	27	4	32
	CC-11	25	13	34
<i>Dye Branch</i>	DB-1	44	3	24
	DB-2	31	2	28
	DB-3	26	2	36
<i>Ramah Creek</i>	RM-1	20	2	40
	RM-2	25	2	38
	RM-3	21	9	34
	RM-4	24	12	34
<i>Rocky River</i>	RR-1	32	3	37
	RR-2	27	6	36
	RR-3	21	5	37
	RR-4	28	10	35
	RR-5	18	10	36
	RR-6	16	3	36
	RR-7	25	8	36
	RR-8	28	10	36
	RR-9	32	6	38
	RR-10	31	5	38
<i>South Prong Rocky River</i>	SPRR-1	24	3	35
	SPRR-2	22	5	31
	SPRR-3	24	3	14
	SPRR-4	25	4	35
<i>West Branch Rocky River</i>	WBRR-1	28	3	39
	WBRR-2	28	2	36
	WBRR-3	24	3	37
	WBRR-4	25	3	34
	WBRR-5	19	9	39
	WBRR-6	22	6	38
	WBRR-7	25	8	33
	WBRR-8	17	8	33
	WBRR-9	18	5	34

 = Tier 1 Subwatershed

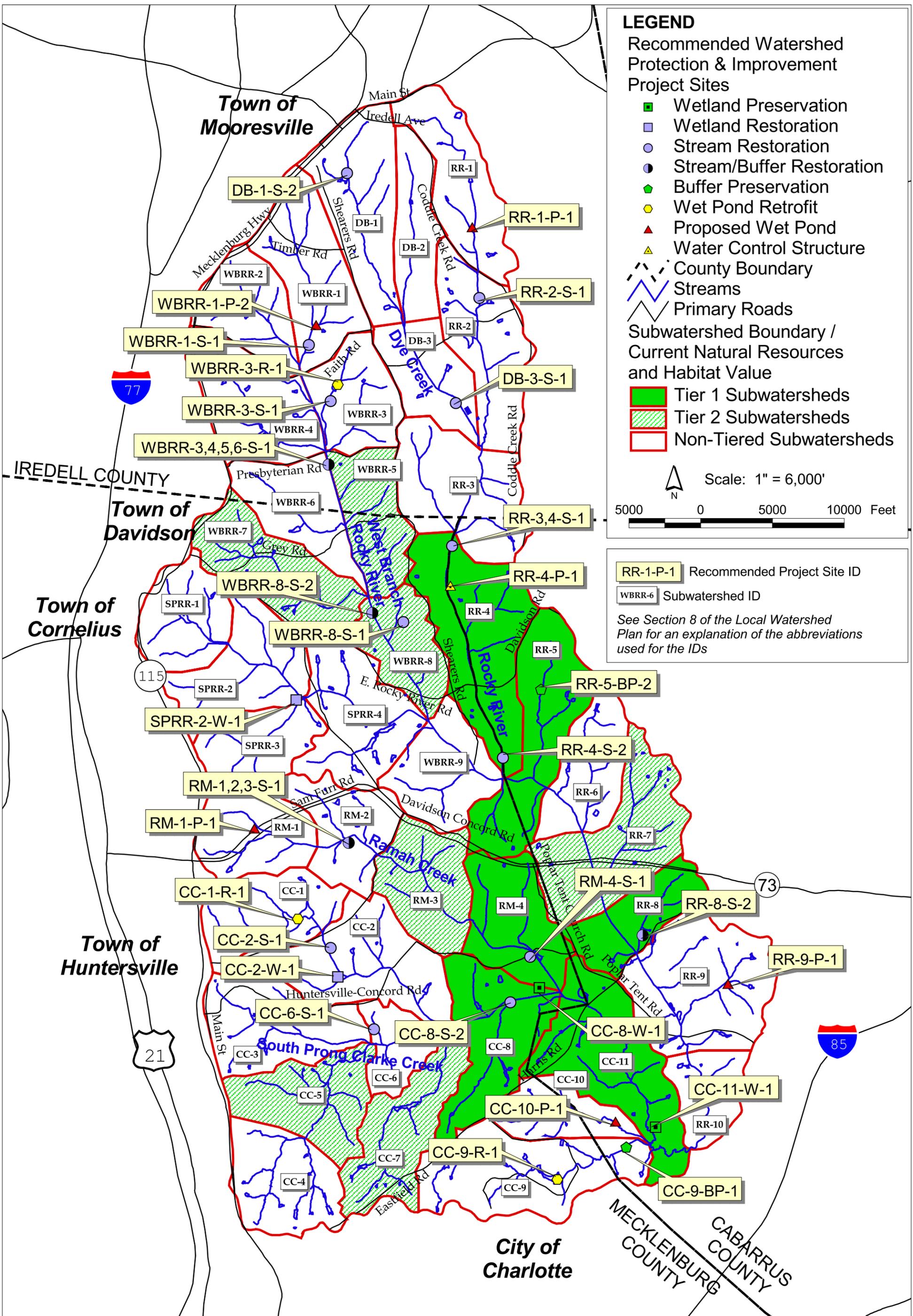
 = Tier 2 Subwatershed



Data Source: NCCGIA 2000 BasinPro and Mecklenburg, Iredell, and Cabarrus County GIS Departments

Figure 4-1
 Upper Rocky River/Clarke Creek Local Watershed Plan
 Current Watershed Health Tier 1 & 2 Subwatersheds and Final Recommended Watershed Protection & Improvement Project Sites

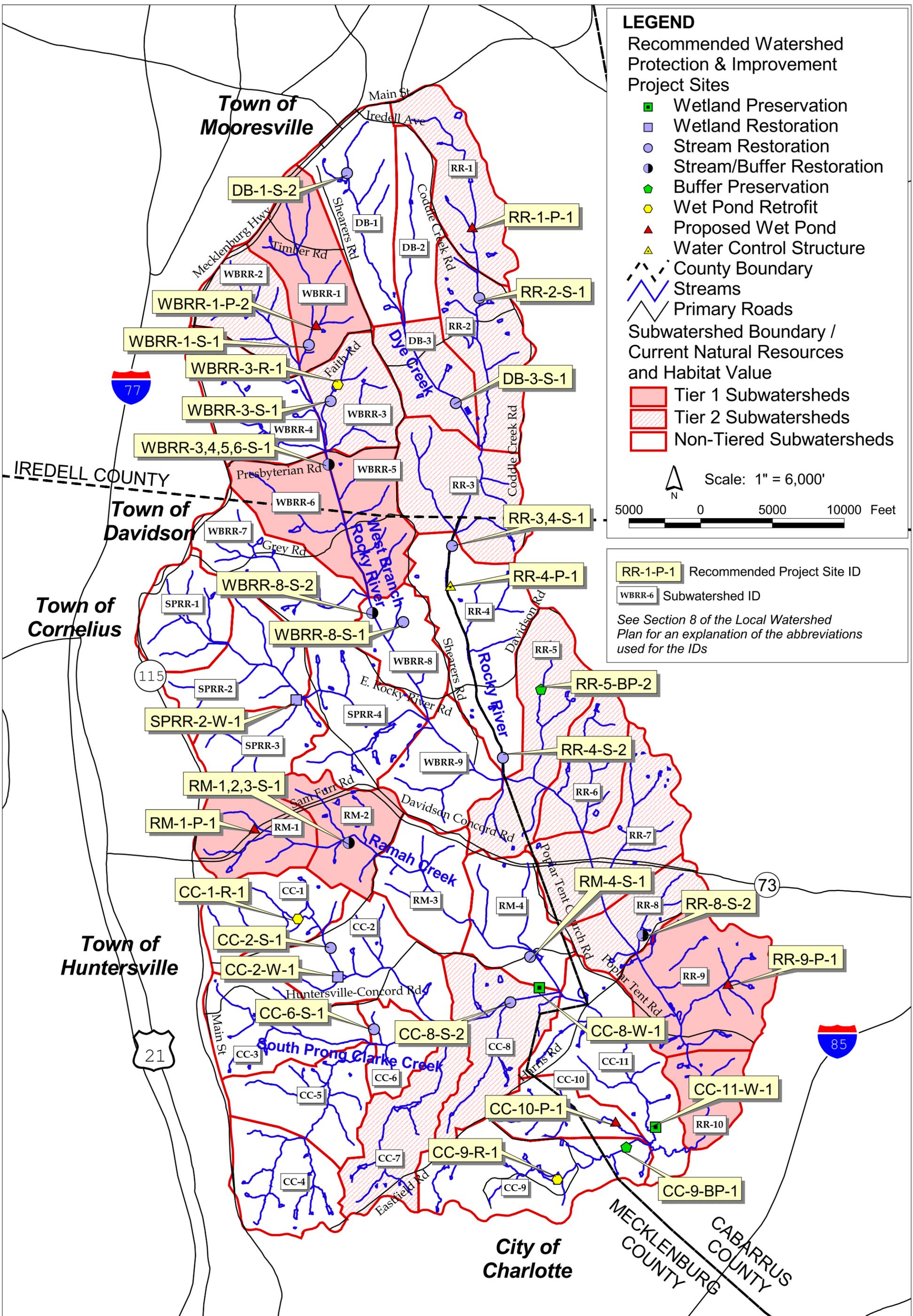




Data Source: NCCGIA 2000 BasinPro and Mecklenburg, Iredell, and Cabarrus County GIS Departments

Figure 4-2
Upper Rocky River/Clarke Creek Local Watershed Plan
Current Natural Resources and Habitat Value Tier 1 & 2 Subwatersheds and
Final Recommended Watershed Protection & Improvement Project Sites

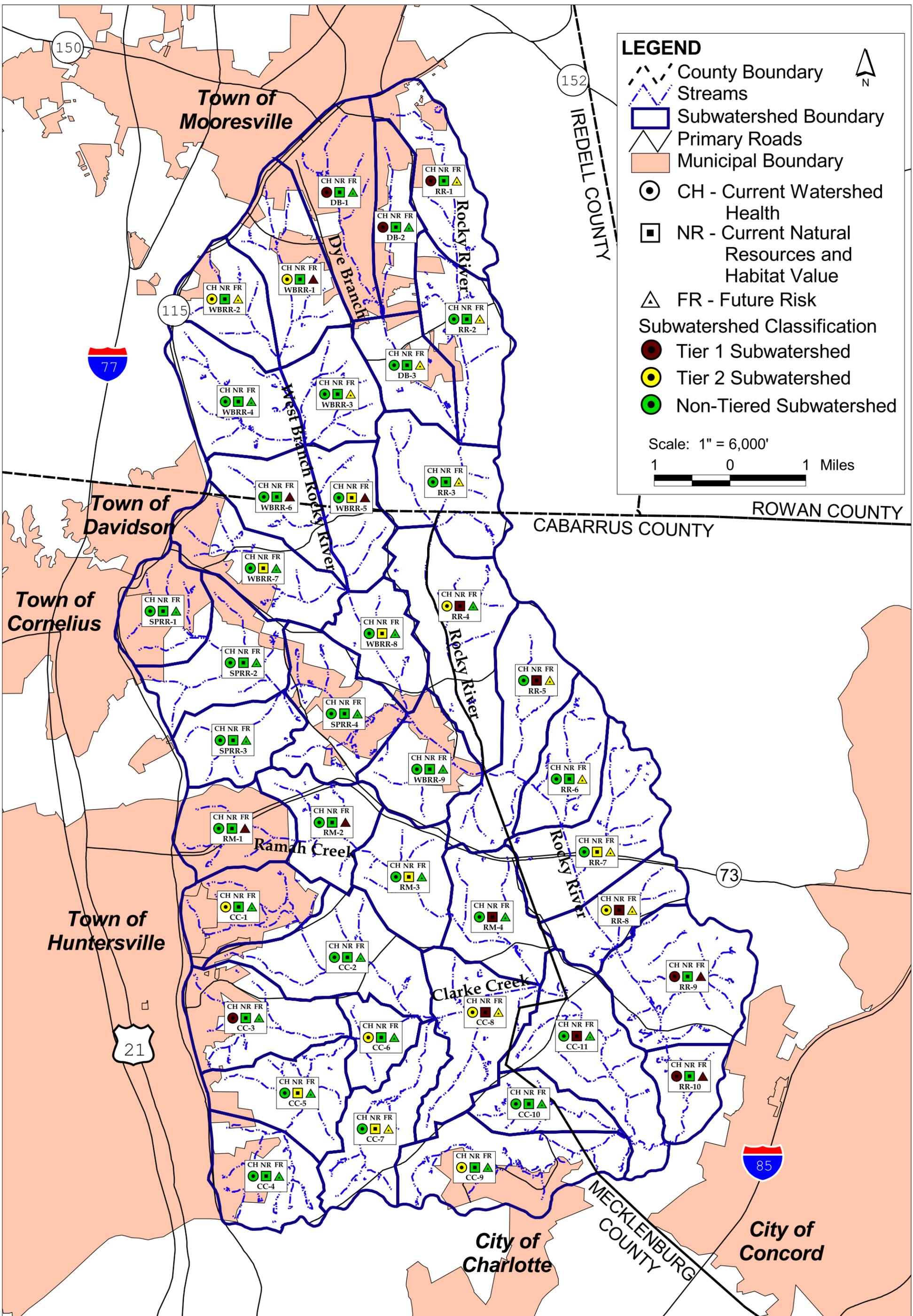




Data Source: NCCGIA 2000 BasinPro and Mecklenburg, Iredell, and Cabarrus County GIS Departments

Figure 4-3
 Upper Rocky River/Clarke Creek Local Watershed Plan
 Future Risk Tier 1 & 2 Subwatersheds and Final Recommended
 Watershed Protection & Improvement Project Sites





Data Source: NCCGIA 2000 BasinPro and Mecklenburg, Iredell, and Cabarrus County GIS Departments

Figure 4-4
Upper Rocky River/Clarke Creek Local Watershed Plan
Tier 1 and 2 Subwatershed Classification



Section 5

Local Watershed Planning Group Goals and Objectives

5.1 Introduction and Purpose

The overall purpose of the goals, objectives, and strategies of this LWP – reflecting the collaborative input of the LWPG membership -- is to identify the most critical existing and potential watershed impairments and to formulate a management plan that will accommodate planned growth in a manner that maintains (or re-establishes) the natural hydrologic characteristics of the watershed-- specifically stream baseflow, stable stream channel (geomorphologic) conditions, flood-carrying capacity of the streams and their floodplains, and surface water quality (and associated aquatic habitat functions) – *to the maximum extent practicable*. Virtually all human uses of the landscape cause impacts to these natural watershed characteristics and functions. Ideally, by meeting the objectives determined by the LWPG (and implementing the associated strategies), those watershed impacts can be minimized to a level that can sustain the integrity of the natural watershed systems, their resources, and the communities that rely upon them.

The qualifying phrase “to the maximum extent practicable “ is simply a reflection of the inevitable constraints or barriers to local watershed protection and improvement that are imposed, to one degree or another, by a lack of state and local resources (including staff, money and technology); considerations of technical feasibility (e.g., site access and physical constraints to project construction); a possible lack of willing/cooperative landowners for easement acquisition and project implementation; certain jurisdictional/bureaucratic hurdles; and a consideration of local political realities. Therefore, a critical prerequisite for the successful implementation of any or all of the recommended management strategies in this LWP is the establishment of a permanent group/committee of individuals – operating through the authority of multi-jurisdictional & multi-agency cooperative agreements - - that can direct the long-term implementation of specific management strategies and watershed improvement projects (and move towards removing any technical, financial, bureaucratic or political barriers to such implementation efforts). Such a group – a Watershed Steering Team – could meet regularly (or as needed) to sustain momentum for implementation of the specific recommendations produced as part of this LWP process. [See Section 6.3, MS-9 for further details regarding this recommendation.]

5.2 Local Watershed Planning Group Goals

On March 13, 2003, CDM, NCWRP, and representatives of WECO met with the LWPG to present a watershed characterization overview and determine what goals should be identified and addressed by the Management Plan and Implementation Strategy (MP&IS). WECO asked each LWPG member to answer the following question: “*Looking into the near future, when this Watershed Plan has been completed and is*

being implemented, you are ecstatic because the Plan has accomplished what...?" Based on the inventory of watershed impairments and conditions presented by CDM and those observed by the LWPG members, 24 specific objectives were identified by the LWPG and were then grouped into seven main goals. The following are the consensus goals of the LWPG for the two local watersheds considered by this planning effort:

- Goal #1: Engage and Educate the Public and Government
- Goal #2: Implement Land Use Planning
- Goal #3: Enhance Recreation and Open Space Preservation
- Goal #4: Improve Water Quality
- Goal #5: Restore Physical Habitat
- Goal #6: Identify Potential Funding Sources
- Goal #7: Follow-up/Implement for the Long Term

The 24 objectives represent specific tasks identified by the LWPG that address a variety of watershed impairments, as well as strategies to protect/maintain ecological diversity in the watershed, as shown in **Table 5-1**. Each of the main goals is identified below, followed by the associated objectives determined by the LWPG -- which are primarily basic tasks, principles or strategies required to achieve each goal. The actual MP&IS presented in Section 6 incorporates these objectives into the appropriate recommended Management Strategies [MSs], as grouped into 10 fundamental categories of watershed protection tools/strategies. The following are the 24 objectives grouped within their respective goals and followed by NCWRP's and CDM's interpretation of the objective as well as the associated MS's recommended to achieve the objective. Several of the goals reference Tier one and two subwatersheds, which can be seen in Figures 4-1 through 4-3. The goals are followed by short tables showing recommended Management Strategies (MS's) pertinent to meeting the objectives. The MS's can be applied to each of the objectives, but were only included if they specifically address the objective.

Goal #1: Engage and Educate Public and Government

The purpose of public education is to engage the community and its businesses in watershed stewardship and (ideally) to obtain their sustained support for the watershed MP&IS developed as part of this LWP and, indeed, for any future planning efforts related to local watershed protection/management. Educating the public about development impacts and poor housekeeping practices (i.e. hazardous waste disposal, lawn maintenance, recycling, septic system maintenance, etc.) involves not only local communities, but large landowners and developers. Demonstrating the negative impacts of development in the watershed through public education should be accompanied with alternative solutions to existing land development applications. Providing developers with alternative/cost-effective site design solutions, homeowners with an understanding of the importance of "good housekeeping"

**North Carolina Wetlands Restoration Program
Upper Rocky River/Clarke Creek Local Watershed Plan
Table 5-1 - Watershed Goals and Objectives**

GOALS	1		2		3		4		5		6		7	
	<i>Engage and Educate the Public and Government</i>		<i>Implement Land Use Planning</i>		<i>Enhance Recreation and Open Space Preservation</i>		<i>Improve Water Quality</i>		<i>Restore Physical Habitat</i>		<i>Identify Potential Funding Sources</i>		<i>Follow-Up/ Implement in the Long Term</i>	
OBJECTIVES	1-1	Provide greater awareness of development impacts	2-1	Prioritize areas with the greatest needs for action	3-1	Establish functioning riparian buffers throughout the watershed	4-1	Reduce sediment input	5-1	Permanently protect threatened streams	6-1	Help localities and other stakeholders identify funding sources	See Note	
	1-2	Educate the public on why change is needed	2-2	Use ranking to establish land uses to protect creeks	3-2	Use subwatershed or project ranking to coordinate town land purchases	4-2	Maintain/upgrade sanitary sewer collection and treatment systems	5-2	Re-establish riparian stream buffers, channelized streams, destroyed wetlands, aquatic communities, and riparian habitat				
			2-3	Find a balance between growth and stream degradation	3-3	Initiate wetland preservation	4-3	Incorporate water quality BMPs into residential development	5-3	Restore and construct additional wetlands				
			2-4	Identify optimal locations for stormwater retrofits and Low Impact Development practices	3-4	Preserve greenway/wildlife corridors	4-4	Develop a detailed water quality model for the watershed						
			2-5	Refine Watershed Master Plan			4-5	Identify specific pollutant concerns in each subwatershed						
			2-6	Open Space Protection			4-6	Storm flow and peak flow reduction						
			2-7	Provide data to be used by municipalities for Water Quality Master Plan			4-7	Improved floodplain function						

Notes:
No specific objectives were identified for the Follow-Up/Implement in the Long Term goal

practices, and governments with the importance of implementing appropriate controls through municipal ordinances or other regulations are key components in the development of an effective watershed education program. Specific objectives identified by members of the LWPG are identified below, followed by short tables showing the recommended Management Strategies (MSs) pertinent to meeting the objectives. An effort has been made to specifically identify those Management Strategies that are of paramount importance to achieve the objectives, however, elements of many of the strategies may also be appropriate. It is left to the reader to review and integrate key elements of the Management Strategies where appropriate to achieve the objectives for the collective good of the watershed.

Objective 1-1: Provide greater awareness of development impacts.

Educate governments, communities, developers, and land owners on the negative impacts that are associated with continued urban growth on the streams and natural resources of the watershed through public education programs, demonstration projects of development impacts, and alternative LID design techniques.

MS-1	Incorporate the Public in Watershed Stewardship and Education	Pg. 6-4
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Objective 1-2: Educate the public on why change is needed.

Educate governments, communities, developers, and land owners on why current development and household practices are degrading the streams and natural resources of the watershed. Recommended key education strategies include stream schools, public education programs, demonstration projects, and multi-jurisdictional public outreach programs, among others.

MS-1	Incorporate the Public in Watershed Stewardship and Education	Pg. 6-4
MS-9	Watershed Based Cooperative Planning	Pg. 6-36

Goal #2: Implement Land Use Planning

Mecklenburg, Cabarrus, and Iredell Counties are predicted to be among the fastest growing counties in the state of North Carolina between 2000 and 2010, as projected by the U.S. Census Bureau (U.S. Census Bureau, 2002). It is therefore imperative to effectively manage the inflow of development in a way that maximizes the preservation of key land resources, protects site hydrology, preserves natural resources, and satisfies community interest in a complimentary and aesthetically pleasing development. The economic benefits of an effective watershed-wide land use management plan include a reduction in stormwater runoff, erosion-sedimentation, and flooding, and enhanced water quality, bio-diversity, landscape aesthetics, property value, aquifer recharge, and baseflow.

Without a watershed-wide land use plan, efforts to protect/preserve natural resources in the watershed may be nullified by upstream development. For instance, if Cabarrus County were to revise their ordinances to implement LID development and onsite hydrologic controls, the positive impacts resulting from those changes may be destroyed by high sediment, nutrient, and/or fecal coliform loads from upstream development.

Objective 2-1: Prioritize areas with the greatest needs for action.

Begin by implementing the restoration, creation, preservation, and enhancement opportunities identified in the recommended watershed protection and improvement project sites. The ranking protocol can also be used to identify subwatersheds that would benefit from additional stormwater management and water quality monitoring/modeling efforts. Figure 4-1 provides a summary of the highest-priority subwatersheds based on currently-available information. As more up-to-date information on land use, water quality monitoring, and other critical items becomes available, use the subwatershed ranking protocol to periodically re-apply the subwatershed ranking protocol and identify locations in the watershed to concentrate stream, wetland, and habitat restoration, preservation, and enhancement projects.

MS-3	Implement Land Preservation Techniques for Protecting Natural Resources	Pg. 6-9
MS-4	Restore Aquatic and Wildlife Habitat	Pg. 6-15
MS-8	Continue Water Quality Monitoring and Modeling	Pg. 6-32

Objective 2-2: Use ranking to establish land uses to protect creeks.

Use the subwatershed ranking protocol to identify locations in the watershed to concentrate urban development and/or preservation efforts to protect aquatic habitat and water quality. Urban development should incorporate LID concepts along with open space and riparian buffer requirements to ensure the protection of significant natural resources (with particular attention to Tier I and II subwatersheds).

MS-3	Implement Land Preservation Techniques for Protecting Natural Resources	Pg. 6-9
MS-9	Watershed-Based Cooperative Planning	Pg. 6-36

Objective 2-3: Find a balance between growth and stream degradation.

Identify subwatersheds in which to concentrate urban development using the lowest scoring Current Natural Resources/Habitat Value subwatersheds (i.e. subwatersheds containing the least amount of natural resources such as wetlands, NHP sites, etc.).

Urban development should incorporate LID concepts including requirements for open space, riparian buffer zones, and matching the post-development to pre-development peak flow condition.

MS-3	Implement Land Preservation Techniques for Protecting Natural Resources	Pg. 6-9
MS-5	Implement New Development Controls	Pg. 6-18
MS-7	Implement Non-Stormwater Discharges Management	Pg. 6-31
MS-9	Watershed-Based Cooperative Planning	Pg. 6-36

Objective 2-4: Identify optimal locations for stormwater retrofits and Low Impact Development practices.

Implement LID design techniques in high scoring Current Natural Resources/Habitat Value subwatersheds (i.e. subwatersheds containing the least amount of natural resources such as wetlands, NHP sites, etc.) where development is inevitable. Prioritize Current Watershed Health and Current Natural Resources/Habitat Value Tier I and II subwatersheds for existing wet pond retrofits. Begin by implementing the opportunities identified in the recommended watershed protection and improvement project sites.

MS-5	Implement New Development Controls	Pg. 6-18
MS-7	Implement Non-Stormwater Discharges Management	Pg. 6-31
MS-10	Identify Funding Opportunities	Pg. 6-37

Objective 2-5: Refine Watershed Master Plan.

Use this LWP as a stepping stone for expanding upon and developing other more detailed local watershed analyses including fecal source tracing studies, continued water quality modeling and benthic monitoring, natural resource identification studies, etc. These analyses can be coordinated through special task forces comprised of members of local jurisdictions who report periodically to the overall Upper Rocky River Watershed (all 6 HUs) Steering Team. [Four additional local watersheds (14-digit HUs) - contiguous to the Clarke Creek and Upper Rocky River watersheds - were added to NCWRP's planning initiative. Together, the four new and two original watersheds constitute subbasin 11 of the lower Yadkin basin. This expanded planning project will build upon CDM's and WECO's LWP efforts to date in the Clarke Creek and Upper Rocky River HUs.] Additional task forces may including habitat restoration and preservation, public education, land use planning, greenway

and natural corridors, water quality, stormwater/floodplain management, and any other aspect that may influence watershed management.

MS-1	Incorporate the Public in Watershed Stewardship and Education	Pg. 6-4
MS-9	Watershed-Based Cooperative Planning	Pg. 6-36
MS-10	Identify Funding Opportunities	Pg. 6-37

Objective 2-6: Open Space Protection.

Review/revise municipal and county ordinances to require open space in residential and non-residential development. Require all significant natural resources (i.e. wetlands, streams, etc.) be included in the open space areas. Work with local non-profit land trusts (e.g. Catawba Lands Conservancy and Davidson Lands Conservancy) to purchase parcels with significant natural resources and/or acquire easements through private parcels. Consider developing a special task force comprised of representatives from each of the local jurisdictions to work with local non-profit land trusts. Concentrate efforts in Current Natural Resources/Habitat Value and Future Risk Tier I and II subwatersheds. Begin by implementing preservation opportunities identified in the recommended watershed protection and improvement project sites list.

MS-3	Implement Land Preservation Techniques for Protecting Natural Resources	Pg. 6-9
MS-5	Implement New Development Controls	Pg. 6-18
MS-9	Watershed-Based Cooperative Planning	Pg. 6-36
MS-10	Identify Funding Opportunities	Pg. 6-37

Objective 2-7: Provide data to be used by municipalities for Water Quality Master Plan.

Incorporate the results of the water quality analysis and modeling efforts included in this study in a watershed-wide Water Quality Master Plan. Implement the additional recommended water sampling sites, frequency, and parameters identified in this study.

MS-8	Continue Water Quality Monitoring and Modeling	Pg. 6-32
MS-9	Watershed-Based Cooperative Planning	Pg. 6-36
MS-10	Identify Funding Opportunities	Pg. 6-37

Goal #3: Enhance Recreation and Open Space Preservation

An important aspect of effectively managing a watershed and its natural resources is the development of stewardship among the community and maintaining their commitment and caring of the resources that comprise the watershed. Engaging the public by connecting them with streams and resources through the creation of public access areas (i.e. parks, greenways, bike trails, etc.) can be a direct and easily incorporated method. Providing access to water-based resources not only provides opportunities but also encourages appreciation for and stewardship of those resources.

The Upper Rocky River/Clarke Creek watershed contains numerous sensitive resources, including approximately 1,600 acres of riparian wetlands, 285 acres of significant natural heritage areas, 12 natural heritage element occurrences, and 30 community groundwater intake wells. These sensitive resources are highly vulnerable to diminished water quality, water supply, water quantity, aquatic integrity, and increased erosion during wet weather conditions and reduced baseflows during extended dry weather conditions. Land preservation is therefore essential for maintaining these valuable resources and for restoring currently degraded streams.

A basic step towards protecting these natural resources in the watershed is reviewing and possibly revising municipal ordinances to require items such as riparian buffers for all intermittent and perennial streams, careful evaluation of the potential impacts to overall watershed health resulting from planned new development, and on-site hydrologic controls. Municipalities can also assist non-profit land trusts dedicated to the preservation of significant aquatic habitat areas through grant funding, landowner contacts, and easement acquisition.

Objective 3-1: Establish functioning riparian buffers throughout the watershed.

Consider developing and/or expanding upon existing riparian buffer requirements based on the NCWRC's recommendations, which include 50-foot buffer on both sides of intermittent streams and 100-foot buffers on both sides of perennial streams.

Consider strengthening riparian buffer requirements in Current Natural Resource/Habitat Value Tier one and two subwatersheds to 100-foot buffers on both sides of intermittent streams and 200-foot buffers on both sides of perennial streams. In areas not having sufficient riparian buffers, consider creating or restoring forested buffers and/or utilize BMPs to take the place of lost riparian buffer functions including pollutant removal, groundwater recharge, reduction in stormwater runoff velocity, and wildlife habitat. Begin by implementing the restoration and preservation/enhancement opportunities identified in the recommended watershed protection and improvement project sites (See Section 7).

MS-3	Implement Land Preservation Techniques for Protecting Natural Resources	Pg. 6-9
MS-4	Restore Aquatic and Wildlife Habitat	Pg. 6-15

Objective 3-2: Use subwatershed or project ranking to coordinate town land purchases.

Prioritize Current Natural Resources/Habitat Value Tier I and II subwatersheds for land preservation efforts. Begin by implementing the preservation opportunities identified in the recommended watershed protection and improvement project sites (See Section 7). Concentrate additional efforts in subwatersheds containing significant natural resources including Natural Heritage Sites (NHP) sites, wetlands, water supply wells, rock outcrops, etc. Also consider purchasing and retrofitting existing lakes and farm ponds at the headwaters of first and second order streams to control downstream flooding, improve pollutant removal capabilities, and create aquatic and wildlife habitat.

MS-3	Implement Land Preservation Techniques for Protecting Natural Resources	Pg. 6-9
MS-6	Reduce Stormwater and Flooding Impacts	Pg. 6-23
MS-10	Identify Funding Opportunities	Pg. 6-37

Objective 3-3: Initiate wetland preservation.

Prioritize Current Natural Resources/Habitat Value and Future Risk Tier I and II subwatersheds for wetland preservation efforts. Concentrating efforts in the Current Natural Resources/Habitat Value Tier I and II subwatersheds preserves the wetlands that provide the most significant protection of key natural resources through water quality, flood control, and aquatic and wildlife habitat capabilities. The Future Risk Tier I and II subwatersheds include wetlands that will be under the greatest pressure to be destroyed by urban development. Begin by implementing the wetland preservation opportunities identified in the recommended watershed protection and improvement project sites (See Section 7).

MS-3	Implement Land Preservation Techniques for Protecting Natural Resources	Pg. 6-9
MS-10	Identify Funding Opportunities	Pg. 6-37

Objective 3-4: Preserve greenway/wildlife corridors.

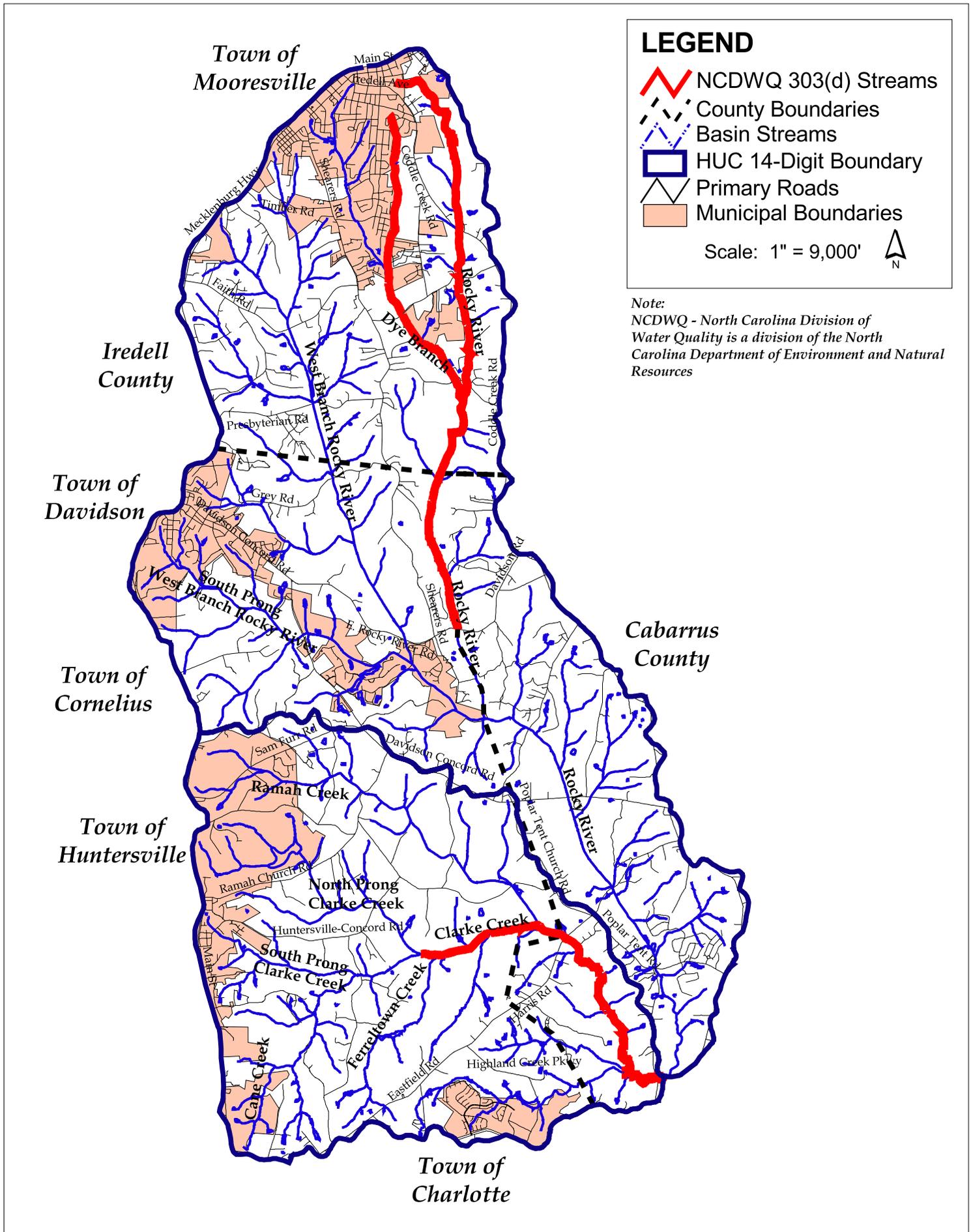
Prioritize Current Natural Resources/Habitat Value and Future Risk Tier one and two subwatersheds for greenway/wildlife corridor preservation efforts. Link the greenways/corridors to residential neighborhoods, commercial developments, and schools in an effort to educate and entertain local residents. Consult local jurisdictions that are currently working towards creating greenways/corridors in the watershed. Mecklenburg County is currently in the process of obtaining 19.4 miles of park greenway along perennial streams including the Rocky River, South Prong Rocky River, Ramah Creek, and Clarke Creek, shown on Figure 2-16. The Town of Davidson recently received funding for the purchase of 20.2 miles of greenway and bike trails, also shown on Figure 2-16.

MS-1	Incorporate the Public in Watershed Stewardship and Education	Pg. 6-4
MS-2	Provide Water-Based Recreation and Cultural Resources	Pg. 6-8
MS-3	Implement Land Preservation Techniques for Protecting Natural Resources	Pg. 6-9
MS-9	Watershed-Based Cooperative Planning	Pg. 6-36
MS-10	Identify Funding Opportunities	Pg. 6-37

Goal #4: Improve Water Quality

This MP&IS prioritizes the need to restore streams within the watershed for the purpose of meeting the state of North Carolina’s water quality standards where they are currently not being met. **Figure 5-1** shows stream segments identified as impaired that have been listed on the state’s “303d” lists (NCDENR-DWQ, 2002) and will require restoration or improvement to existing watershed functions to eliminate the impairments through the Total Maximum Daily Load (TMDL) process under the Federal Clean Water Act. The recommended objectives strive to eliminate the introduction of future contaminants into the environment, improve “management procedures”, avoid the transport of sediment into streams and waterways, and to remove pollutants from stormwater prior to its being discharged into streams.

The LWPG identified “wadable waters,” or what the NCDWQ would classify as Class B waters, as the minimum goal for the Upper Rocky River/Clarke Creek Watershed. The objectives and strategies of this management plan therefore strive to achieve these standards and improve or maintain high water quality standards in waters supporting “sensitive resources.” The recommended strategies for removal of pollutants from stormwater runoff from developed lands stress the need to implement BMPs to remove sediments and nutrients. By using BMPs that provide hydrologic controls to capture and treat the runoff from rainfall events up to the one-



Data Source: NCGIA 2000 BasinPro

Figure 5-1
 Upper Rocky River/Clarke Creek Local Watershed Plan
 NCDWQ Assigned 303(d) Listed Streams



inch storm, between 85 percent and 90 percent of the total annual average rainfall runoff is treated prior to the release to streams (ASCE-WEF, 1998).

Section 6.3 and Section 7 present recommended BMPs that have been shown to achieve significant pollutant reduction. By implementing these recommended BMPs on a watershed-wide basis, a reduction in pollutant loadings and an improvement in water quality may be achieved.

Objective 4-1: Reduce sediment input.

Reduce the volume of sediment transported to streams and lakes from stormwater runoff and streambank erosion. Begin by implementing the stream restoration and riparian buffer restoration projects included in the recommended watershed protection and improvement projects sites (See Section 7). Concentrate additional efforts in Current Watershed Health and Current Natural Resources/Habitat Value Tier I and II subwatersheds. Some non-structural methods include stronger enforcement of sedimentation and erosion control regulations, and the use of minimum disturbance practices in site design. Also, identify primary sources of sediment within the subwatersheds identified as contributing high sediment loads.

MS-4	Restore Aquatic and Wildlife Habitat	Pg. 6-15
MS-5	Implement New Development Controls	Pg. 6-18
MS-6	Reduce Stormwater and Flooding Impacts	Pg. 6-23
MS-8	Continue Water Quality Monitoring and Modeling	Pg. 6-32
MS-10	Identify Funding Opportunities	Pg. 6-37

Objective 4-2: Maintain/upgrade sanitary sewer collection and treatment systems.

Identify sources of pollutant discharge to streams from sanitary sewer collection and treatment systems including SSO's, illicit discharge connections, and failing septic tanks through the development of a watershed-specific monitoring and enforcement program for the above mentioned pollutant sources. Recommended "source studies" include fecal coliform bacteria source tracing and additional water quality monitoring and modeling. Also consider coordinating planning among municipalities, counties, and utilities to ensure consistency of wastewater system development and infrastructure expansion with local land use plans, ordinances, and adopted resource management plans.

MS-7	Implement New Development Controls	Pg. 6-31
MS-8	Continue Water Quality Monitoring and Modeling	Pg. 6-32

MS-9	Watershed-Based Cooperative Planning	Pg. 6-36
MS-10	Identify Funding Opportunities	Pg. 6-37

Objective 4-3: Incorporate water quality BMPs into residential development.

Review and revise municipal ordinances to require stormwater and water quality BMPs in residential and non-residential (i.e. commercial, industrial, agricultural, etc.) development. Implement LID design techniques such as rain barrels, rain gardens, curb and gutter elimination, shorter road widths, etc. Maximize the use of BMP treatment trains such as grassed swales, wet ponds, level spreaders, etc. At a minimum, adopt the North Carolina regulations for class IV water supply watersheds for all areas (refer to the North Carolina Administrative Code 15A NCAC 02B .0100 & .0200 for a complete discussion of the requirements for Class IV Water Supply Watersheds).

MS-5	Implement New Development Controls	Pg. 6-18
MS-6	Reduce Stormwater and Flooding Impacts	Pg. 6-23
MS-9	Watershed-Based Cooperative Planning	Pg. 6-36

Objective 4-4: Develop a detailed water quality model for the watershed.

Refine the water quality model (WMM) used for this study by expanding the catalog of water quality sampling data, include a fecal source tracing study, and identify all industrial and municipal point source discharges. Two key parameters to include in the water quality monitoring are stream flow and precipitation data. Also consider developing a water quality model capable of simulating single storm events (WMM provided seasonal average annual pollutant loading estimates). A special task force can be setup to take responsibility for collecting and identifying funding for additional water quality monitoring as well as refining the model.

MS-8	Continue Water Quality Monitoring and Modeling	Pg. 6-32
MS-9	Watershed-Based Cooperative Planning	Pg. 6-36
MS-10	Identify Funding Opportunities	Pg. 6-37

Objective 4-5: Identify specific pollutant concerns in each subwatershed.

Identify specific pollutant concerns on a subwatershed scale using the results of the water quality modeling conducted for this study. Consider refining the model by

expanding the catalog of water quality sampling data for the watershed. Two key parameters to include in the water quality monitoring are stream flow and precipitation data. Also consider developing a water quality model capable of simulating single storm events. A special task force can be setup to take responsibility for collecting and identifying funding for additional water quality monitoring as well as refining the model.

MS-8	Continue Water Quality Monitoring and Modeling	Pg. 6-32
MS-9	Watershed-Based Cooperative Planning	Pg. 6-36
MS-10	Identify Funding Opportunities	Pg. 6-37

Objective 4-6: Storm flow and peak flow reduction.

Revise municipal and county ordinances to require the use of LID design techniques. Example techniques include reducing and disconnecting impervious cover, infiltrating rainfall or re-using stormwater onsite, minimizing site disturbance, requiring open space areas, etc. Incorporating innovative methods such as these promote infiltration of rainfall that would normally contribute to stormwater runoff and increased storm flows and peak flows. Also consider purchasing and retrofitting lakes and farm ponds at the headwaters of first and second order streams for the purpose of improving/preserving their flood control benefits.

MS-5	Implement New Development Controls	Pg. 6-18
MS-6	Reduce Stormwater and Flooding Impacts	Pg. 6-23
MS-10	Identify Funding Opportunities	Pg. 6-37

Objective 4-7: Improved floodplain function.

Improve floodplain functions through enhancement and restoration projects for the purpose of reducing storm flow peaks and downstream flooding impacts. Enhance the attenuation of flood flows by using level spreaders at outfalls, removing existing structures within the 100-year FEMA-defined floodplain, and widening existing floodplains. Restore floodplain functions through riparian buffer and stream restoration projects. Begin by implementing the riparian buffer and stream restoration opportunities identified in the recommended watershed protection and improvement project sites (see Section 7). Concentrate additional efforts in Current Natural Resources/Habitat Value and Current Watershed Health Tier I and II subwatersheds.

MS-3	Implement Land Preservation Techniques for Protecting Natural Resources	Pg. 6-9
MS-4	Restore Aquatic and Wildlife Habitat	Pg. 6-15
MS-6	Reduce Stormwater and Flooding Impacts	Pg. 6-23
MS-10	Identify Funding Opportunities	Pg. 6-37

Goal #5: Restore Physical Habitat

Aquatic habitat in the Upper Rocky River/Clarke Creek Watershed has been damaged due to man’s activities, including highway and bridge construction, flood control, channel modifications, industrial and residential development, agriculture, irrigation, livestock grazing, and accidental habitat loss. These changes in natural aquatic habitat cannot be reversed or brought back to their natural state, but efforts to mitigate for their negative effects can be accomplished through watershed plans such as this and a collaboration of efforts by the community, municipalities, and NCWRP. Restoration projects identified by this study for the watershed include riparian wetlands restoration, stream restoration, and riparian buffer restoration.

Objective 5-1: Permanently protect threatened streams.

Prioritize Current Watershed Health Tier I and II subwatersheds for preserving lands containing threatened streams. In addition, concentrate efforts in subwatersheds containing NCDWQ-defined 303(d) listed streams. Implement recommended wetland restoration projects, proposed wet ponds, and existing wet pond retrofits identified as recommended watershed protection and improvement project sites for the purpose of controlling downstream hydrology and removing pollutants (see Section 7). Also implement riparian buffer restoration projects along threatened streams.

MS-3	Implement Land Preservation Techniques for Protecting Natural Resources	Pg. 6-9
MS-4	Restore Aquatic and Wildlife Habitat	Pg. 6-15
MS-6	Reduce Stormwater and Flooding Impacts	Pg. 6-23
MS-8	Continue Water Quality Monitoring and Modeling	Pg. 6-32
MS-10	Identify Funding Opportunities	Pg. 6-37

Objective 5-2: Re-establish riparian stream buffers, channelized streams, destroyed wetlands, aquatic communities, and riparian habitat.

Begin by implementing the restoration opportunities identified in the recommended watershed protection and improvement project sites (see Section 7). Concentrate additional efforts in Current Natural Resources/Habitat Value and Current Watershed Health Tier I and II subwatersheds.

MS-4	Restore Aquatic and Wildlife Habitat	Pg. 6-15
MS-10	Identify Funding Opportunities	Pg. 6-37

Objective 5-3: Restore and construct additional wetlands.

Begin by implementing the wetland restoration opportunities identified in the recommended watershed protection and improvement project sites. Concentrate additional efforts in Current Natural Resources/Habitat Value and Current Watershed Health Tier I and II subwatersheds.

MS-4	Restore Aquatic and Wildlife Habitat	Pg. 6-15
MS-10	Identify Funding Opportunities	Pg. 6-37

Goal #6: Identify Potential Funding Sources

Funding the implementation of the key strategies for meeting the goals and objectives identified by the LWPG can be the most difficult aspect of watershed management. The federal, state, and municipal funding mechanisms mentioned below have been shown to be effective in other areas of the country and can be applied to this watershed. See Section 6.3-MS-10 for additional information on funding mechanisms.

Objective 6-1: Help localities and other stakeholders identify funding sources.

Pursue the recommended federal, state, and local funding opportunities (described in Section 6.3, MS-10) for implementation of the recommended watershed protection and improvement project sites. Funding opportunities such as a stormwater utility can also be used to fund the special task forces, additional watershed studies, and additional water quality monitoring.

MS-9	Watershed-Based Cooperative Planning	Pg. 6-36
MS-10	Identify Funding Opportunities	Pg. 6-37

Goal #7: Follow-Up/Implement in the Long Term

To effectively implement this MP&IS, jurisdictions will have to make changes to not only their local ordinances, but find ways to incorporate the public in all aspects of watershed management. Conservation development design and good housekeeping practices are ineffective tools unless the public can buy into the understanding that it takes the direct involvement of all individuals and entities that work, live, or play within the watershed. Public education and involvement of local decision-makers (i.e. town council members, county commissioners, etc.) are also critical elements of this MP&IS.

Revising ordinances to incorporate appropriate controls for stormwater management, water conservation, land development, and natural resources protection is an effective method for ensuring the long-term management of the watershed. Because ordinances and regulations can be changed, the public must be constantly educated/involved with all aspects of watershed management. The role of local jurisdictions is to not only facilitate the process of watershed management, but to lead by example in all levels of government. This includes the active participation in education programs, incorporating the most effective BMP and conservation design techniques in local ordinances, and proper maintenance and protection of local natural resources. Each of the recommended MSs provided in this study can be implemented in the long term and can result in improved water quality, aquatic and wildlife habitat, innovative land use planning and development, continued water quality analysis, and watershed education and stewardship among all watershed residents.

MS-1	Incorporate the Public in Watershed Stewardship and Education	Pg. 6-4
MS-9	Watershed-Based Cooperative Planning	Pg. 6-36
MS-10	Identify Funding Opportunities	Pg. 6-37

Section 6

Local Watershed Management Plan & Implementation Strategy

6.1 Guidance and Recommendations for Implementation

The objective of this Local Watershed MP&IS is to provide a framework for comprehensive watershed management that is able to accommodate existing land uses and planned growth in the entire watershed, while preserving or re-establishing the overall health of the resources in the watershed. Specifically, the Plan should help sustain watershed resources to the extent practicable and meet the seven goals of the LWPG. These goals include the need to:

- Engage and educate the public and government;
- Implement land use planning;
- Enhance recreation and open space preservation;
- Improve water quality;
- Restore lost and impaired physical habitat;
- Identify funding opportunities; and
- Implement the plan for the long-term.

The Upper Rocky River/Clarke Creek watershed is an urbanizing watershed where residential and commercial development pressures can be expected to continue given the amount of developable land remaining in the watershed and recent historical growth trends. This pending development provides an opportunity for the adoption of new ordinances and development techniques, such as those that promote a reduction in impervious area and the infiltration of stormwater runoff into natural areas to reduce stormwater volumes, improve water quality, and enhance groundwater recharge.

The most effective way to balance this growth with the needs of the watershed is to implement an integrated management plan to address concerns on a watershed-specific – not jurisdiction-specific – scale. Implementing the plan on a watershed-wide scale in concert with the other cities, towns, and counties of the watershed provides three key benefits. First, a joint planning and implementation effort eliminates the need for redundant programs and provides economies of scale for management planning, public education and outreach, and program staffing. As an example, the City of Charlotte, the Towns of Cornelius, Davidson, and Huntersville, and Mecklenburg County share pooled resources for management of their collective stormwater utility, with each partner paying for the management and planning of the stormwater-related needs of their community. Second, watershed-wide cooperation provides opportunities for identifying and funding the most strategic projects in the

watershed in terms of overall health of the watershed, regardless of location. This approach places the emphasis on addressing watershed concerns at their source to make a quantifiable difference where needed, as opposed to implementing marginal projects to meet regulatory requirements or to demonstrate that “something” is being done. Finally, watershed-based cooperative planning and implementation minimizes the chance that the good practices incorporated by some municipalities will be degraded by the poor practices of their hydraulically-connected neighbors. For example, the implementation of a stream restoration project on an impaired stream segment in one municipality that is downstream of another that allows high-density development without hydrologic controls could result in the failure of the downstream project and the loss of both financial and natural resources – the restored ecosystem itself. Thoughtful collaborative planning and implementation on a watershed-wide scale can prevent these occurrences and provide a much-improved habitat in a more cost-effective manner.

The ten general watershed management strategies (MSs) presented below are intended to serve as the basis for deciding which specific management options may be implemented individually or jointly by municipalities on a watershed-wide scale. Specific elements of the strategies discussed below may already be included in the watershed management-related ordinances and regulations of the municipalities. In that case, it will be incumbent upon the municipality to determine if revisions to their existing ordinances and regulations are warranted to achieve the desired goals of the LWPG and satisfy their own watershed-related goals and needs. As part of the implementation process, the municipalities in the watershed are encouraged to perform a comprehensive self-assessment of all codes, ordinances, policies, and regulations that may be directly or implicitly impacting watershed health. Refer to Section 2.7.7 for recommendations on how to evaluate existing ordinances as well as model ordinances for revising existing ordinances.

The previous section provided a summary of the goals and objectives identified by members of the LWPG along with which of the MSs would be most appropriate for achieving the objectives. This section is intended to provide the details and implementation requirements of each general management strategy. Each general management strategy is linked with the specific objectives of the LWPG, as shown in **Table 6-1**, to provide an efficient means for identifying the most relevant strategies that may be implemented to address specific planning group objectives.

6.2 Identify Subwatershed Priorities

All municipalities are encouraged to implement strategies from all ten general categories of implementation guidance. However, this clearly requires a substantial effort and it may be helpful to determine if there are critical priorities already identified that should be addressed first. Before deciding what implementation strategies to undertake, determine the following three things for your municipality:

- 1) In what subwatershed(s) is your municipality located?

North Carolina Wetlands Restoration Program
Upper Rocky River/Clarke Creek Local Watershed Plan
Table 6-1 - Management Strategy Recommendations for Addressing LWPG Objectives

#	Local Watershed Planning Group Member Identified Watershed Objectives	MS-1	MS-2	MS-3	MS-4	MS-5	MS-6	MS-7	MS-8	MS-9	MS-10
		<i>Incorporate the Public in Watershed Stewardship and Education</i>	<i>Provide Water-Based Recreation and Cultural Resources</i>	<i>Implement Land Preservation Techniques for Protecting Natural Resources</i>	<i>Restore Aquatic and Wildlife Habitat</i>	<i>Implement New Development Controls</i>	<i>Reduce Stormwater and Flooding Impacts</i>	<i>Implement Non-Stormwater Discharges Management</i>	<i>Continue Water Quality Monitoring and Modeling</i>	<i>Watershed-Based Cooperative Planning</i>	<i>Identify Funding Opportunities</i>
GOAL # 1: ENGAGE AND EDUCATE THE PUBLIC AND GOVERNMENT											
1-1	Provide greater awareness of development impacts	√									
1-2	Educate the public on why change is needed	√								√	
GOAL # 2: IMPLEMENT LAND USE PLANNING											
2-1	Prioritize areas with the greatest needs for action			√							
2-2	Use ranking to establish land uses to protect creeks									√	
2-3	Find a balance between growth and stream degradation			√		√		√		√	
2-4	Identify optimal locations for stormwater retrofits and Low Impact Development practices					√		√			√
2-5	Refine Watershed Master Plan	√								√	√
2-6	Open Space Protection			√		√				√	√
2-7	Provide data to be used by municipalities for Water Quality Master Plan								√	√	√
GOAL # 3: ENHANCE RECREATION AND OPEN SPACE PRESERVATION											
3-1	Establish functioning riparian buffers throughout the watershed			√	√						
3-2	Use subwatershed or project ranking to coordinate town land purchases			√			√				√
3-3	Initiate wetland preservation			√							√
3-4	Preserve greenway/wildlife corridors	√	√	√						√	√

North Carolina Wetlands Restoration Program
Upper Rocky River/Clarke Creek Local Watershed Plan
Table 6-1 (continued) - Management Strategy Recommendations for Addressing LWPG Objectives

#	Local Watershed Planning Group Member Identified Watershed Objectives	MS-1	MS-2	MS-3	MS-4	MS-5	MS-6	MS-7	MS-8	MS-9	MS-10
		<i>Incorporate the Public in Watershed Stewardship and Education</i>	<i>Provide Water-Based Recreation and Cultural Resources</i>	<i>Implement Land Preservation Techniques for Protecting Natural Resources</i>	<i>Restore Aquatic and Wildlife Habitat</i>	<i>Implement New Development Controls</i>	<i>Reduce Stormwater and Flooding Impacts</i>	<i>Implement Non-Stormwater Discharges Management</i>	<i>Continue Water Quality Monitoring and Modeling</i>	<i>Watershed-Based Cooperative Planning</i>	<i>Identify Funding Opportunities</i>
GOAL # 4: IMPROVE WATER QUALITY											
4-1	Reduce sediment input				√	√	√		√		√
4-2	Maintain/upgrade sanitary sewer collection and treatment systems							√	√	√	√
4-3	Incorporate water quality BMPs into residential development					√	√			√	
4-4	Develop a detailed water quality model for the watershed								√	√	√
4-5	Identify specific pollutant concerns in each subwatershed								√	√	√
4-6	Storm flow and peak flow reduction					√	√				√
4-7	Improved floodplain function			√	√		√				√
GOAL # 5: RESTORE PHYSICAL HABITAT											
5-1	Permanently protect threatened streams			√	√		√		√		√
5-2	Re-establish riparian stream buffers, channelized streams, destroyed wetlands, aquatic communities, and riparian habitat				√						√
5-3	Restore and construct additional wetlands				√						√
GOAL # 6: IDENTIFY POTENTIAL FUNDING SOURCES											
6-1	Help localities and other stakeholders identify funding sources									√	√
GOAL # 7: FOLLOW-UP/IMPLEMENT IN THE LONG TERM											
7	Follow-Up/Implement in the Long Term	√								√	√

Notes:
A specific objective for Goal # 7 was not identified by the members of the Local Watershed Planning Group
See Section 5 of the Local Watershed Plan for a description of each of the objectives.

- 2) What subwatershed resources (e.g. water quality, aquatic and wildlife habitat, etc.) are affected by (or affect) your municipality?
- 3) What subwatershed priorities need to be addressed in your subwatershed(s)?

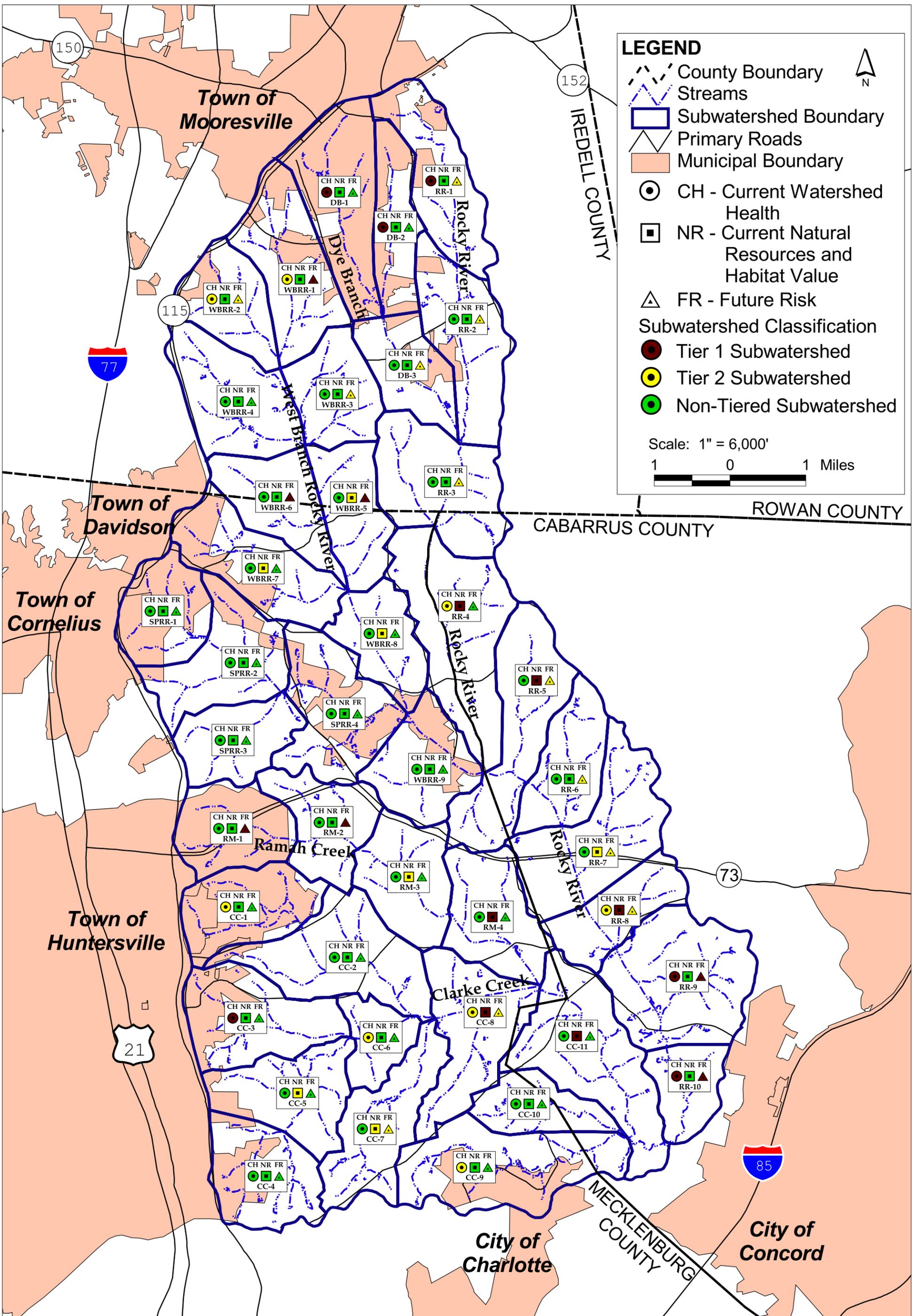
To address these questions, CDM and the LWPG developed the Subwatershed Ranking Protocol. The Subwatershed Ranking Protocol is a quantitative and qualitative system used to categorize each subwatershed within a consistent rating system. It was developed in an attempt to assist LWPG members in determining which subwatersheds were most critical in three key watershed management areas: current health; natural resources and habitat protection; and future risk for stream and habitat degradation. A detailed breakdown of the final prioritization protocol scoring for each of the 41 subwatersheds can be found in Section 4.

Based on this scoring, each subwatershed was assigned one of three classifications for the purpose of prioritizing BMP implementation (Tier 1, Tier 2, or Secondary Implementation). Figures 4-1 through 4-3 show the subwatershed classifications for each of the three scoring categories. **Figure 6-1** combines the subwatershed classifications for each of the scoring categories into a single figure. Current Watershed Health and Future Risk Tier 1 classifications represent the most critical subwatersheds in terms of existing or future impairment, followed by Tier 2, and then Secondary Implementation. The Current Natural Resources/Habitat Value Tier 1 classification represents subwatersheds containing the most extensive collection of natural resources and aquatic/wildlife habitat in the watershed. The prioritization classifications were assigned based on a relative ranking of the subwatersheds and many watershed characterization factors (see Section 4); it was not a rigorous quantitative scoring system. It should be noted that subwatersheds assigned the *Secondary Implementation* classification may have poor current watershed health, be at risk for future impairment, or contain numerous natural resources and aquatic/wildlife habitat areas, but are not predicted to be at as great a risk as Tier 1 and 2 subwatersheds.

6.3 Recommended Management Strategies (MS)

The following management strategies are intended to provide the local jurisdictions of the Upper Rocky River/Clarke Creek watershed with general techniques that can be applied for addressing the goals and objective identified by the members of the LWPG, as described in Section 5 of this MP&IS. These management strategies were tailored to allow each jurisdiction the flexibility to implement the strategies most appropriate for their specific needs. It should be noted that these discussions are not intended to provide a thorough and comprehensive description or design specifications. Rather, they provide the basic information necessary for municipalities to select the most relevant strategies to pursue.

The lists and descriptions of management strategies that follow represent a distillation of watershed BMPs from a variety of sources. Many of the strategies are intuitive,



Data Source: NCCGIA 2000 BasinPro and Mecklenburg, Iredell, and Cabarrus County GIS Departments

Figure 6-1
Upper Rocky River/Clarke Creek Local Watershed Plan
Tier 1 and 2 Subwatershed Classification



and some are unique and innovative. In general, the following sources were indispensable in identifying some of the more innovative strategies that could be implemented with good results in the Upper Rocky River/Clarke Creek watershed and should be consulted for further discussion of the management strategies where appropriate. A complete citation of the references can be found in Section 8.

- American Society of Civil Engineers' (ASCE's) and Water Environment Federation's (WEF's) Urban Runoff Quality Management.
- California Stormwater Quality Association's California Stormwater Best Management Practice Handbooks. www.cabmphandbooks.com.
- Center for Watershed Protection's Rapid Watershed Planning Handbook and their website, www.stormwatercenter.net.
- Chester County, Pennsylvania's Chester County, Pennsylvania Water Resources Compendium – Part I: Technical Report – Assessment of 21 Watersheds Originating in Chester County, Pennsylvania, prepared by Chester County Water Resources Authority in concert with Gaadt Perspectives, Inc. and CDM. http://www.chesco.org/water/Resource_Library/drought_information.html
- David Maidment's Handbook of Hydrology.
- Prince George's County, Maryland Department of Environmental Resources' Low Impact Development Design Manual.

MS-1 Incorporate the Public in Watershed Stewardship and Education

MS-1.1 Develop Public Education

The purpose of public education is to engage the public and its entities in watershed stewardship and develop their sustained support for the MP&IS. Educating the public about development impacts and good housekeeping practices (i.e. hazardous waste disposal, lawn maintenance, recycling, septic system maintenance, etc.) involves not only local communities and developers, but those that work, live, or play in the watershed. An effective public education program reaches not only homeowners and developers, but also commercial, agricultural, industrial, and regulatory communities; and possibly most important, the jurisdictions themselves.

Local jurisdictions should be the primary means by which public education programs are developed and incorporated into the community. Their active participation in these programs is essential in conveying the importance of the practices being presented. This can include the proper maintenance of structural BMP facilities in the watershed; participation in stream school, cleanup, and adoption programs; and development and distribution of newsletters, web links, and mailing inserts.

Other key participants in public education include large landowners and developers. An effective public education program does not discourage continued development in the watershed, but rather conveys to land developers and home owners how new development can be incorporated in a way that best preserves key watershed

functions. Providing developers with alternative/cost-effective site design solutions can be an effective watershed education program.

Residential development is the primary means of growth in the watershed. The active participation of the homeowners and their associations is essential to accomplish the protection and restoration of watershed resources. Public education programs are necessary to ensure that homeowners understand what good housekeeping practices they should incorporate. Due to the high degree of residential development in the watershed, residential landowners may be the single most important audience to educate about easy-to-implement practices for watershed stewardship.

There are numerous topics that can be considered for public education programs. The following is a list of potential activities that can be implemented by local jurisdictions.

- Septic system maintenance
- LID
- Individual well water quality testing and maintenance
- Water conservation
- Riparian stream buffer maintenance
- Demonstration programs for completed restoration projects and existing areas of significant natural resources
- Appropriate use of lawn chemicals
- Lawn/landscape maintenance
- Use of rain barrels and rain gardens
- Recycling
- Household hazardous waste disposal, including used oil recycling, battery recycling, and used paint disposal
- Pet/animal waste disposal
- Residential waste disposal.

There are numerous methods for integrating the public education topics shown above. Many municipalities, including those in this watershed, have extensive experience in the implementation and operation of such programs. The following is a compendium of successful public education programs adapted from the Chester County Water Resources Authority's, 2001 *Chester County, Pennsylvania Water Resources Compendium – Part I: Technical Report – Assessment of 21 Watersheds Originating in Chester County, Pennsylvania* (Chester, 2001), the City of Raleigh's, 2003 *Stormwater Management Funding Study* (City of Raleigh Stormwater Services Department http://www.raleigh-nc.org/engineering/Work_In_Progress/

stormhome.htm), and a Journal of Watershed Protection Techniques article, *On Watershed Education* (The Practice of Watershed Protection, 2000). The recommended programs are discussed below.

- Municipal Newsletters – Include watershed related information including septic system clean-out and management, hazardous waste disposal, care of riparian buffers along privately owned streams, re-routing downspouts, rain barrels, special events, etc. (Chester County)
- Festival and Special Events - Provide a booth or table of handouts and material at fairs, festivals, and other community event to discuss how watersheds work and how residential and commercial land uses can be improved to better protect the streams and groundwater. (Chester County and Watershed Protection Techniques)
- Mailing Inserts – Include information similar to the handouts in local newsletters and send out to land owners and residents. (City of Raleigh)
- Public Signage – Place signs at restoration project sites to educate the public about the importance of watershed projects. (NCWRP)
- Demonstration Projects – Show residents first hand how some watershed stewardship practices can be used including stormwater BMPs, riparian buffers, rain barrels, rain gardens, etc. Also consider demonstration projects illustrating the negative effects of development and resulting deteriorating streams and natural resources. (Chester County)
- Community Stream Days – Keep residents connected to streams by providing community events including stream clean-ups, fish rodeos for children, canoe races, stream walks, and streambank tree plantings. (Chester County)
- Educational Videos - Consider creating educational videos focusing on how individuals can practice good housekeeping techniques, become part of local natural resource protection programs, and help to educate others. (City of Raleigh)
- Multi-Jurisdiction Activities - Work with adjacent municipalities that share the same watershed and streams to bring resources to the forefront and attract more residents and land owners. (Chester County)
- Photo Contests - Host a photography contest with a water resources or environmental theme to help educate the public. (Chester County)
- Internet Website – Create a website dedicated to public education and watershed stewardship and include relevant information such as sign up sheets for ordering brochures and videos and announcements of stream cleanups, classes, etc. (City of Raleigh)
- Speakers at Municipal Meetings – Municipal meetings can be used to provide watershed related information through representatives of NCDWQ, NCWRP, and other state agencies as well as non-profit organizations and public water suppliers. (Chester County)

- Stream Schools – Municipalities can work with watershed associations and schools to host and promote stream and watershed education programs for children and adults. Jurisdictions should consider incorporating local colleges such as Davidson College and the University of North Carolina at Charlotte. (Chester County)
- “Adopt-A-Stream” Programs – Conduct periodic stream cleanup or riparian buffer planning projects (Chester County)

MS-1.2 Advocate Municipal Implementation

Several municipalities within North Carolina have incorporated public education programs in recent years in an attempt to reduce the increasing rate of pollution to streams, rivers, and lakes. A Roper survey conducted in 1999 determined that just 22 percent of Americans understand that stormwater runoff is the primary source of pollution to streams (NEETF, 1999). The desire and ability to reduce stormwater runoff pollution can therefore not be met if the public is not even aware of the source of the problem. For example, recent research is documenting that individuals’ perceptions may over-estimate the actual benefits of their residential environmental stewardship practices, and that their lawn maintenance practices are often detrimental to (rather than protective of) their watershed resources. Results found that in a surveyed population of riparian residential land owners, most described themselves as holding a high level of environmental stewardship, yet 85 percent of surveyed riparian residential properties were categorized as “degrading activities.” When re-surveyed, the landowners overwhelmingly cited “low maintenance” as a priority consideration for lawn practices over ecological considerations (S. Schauman, 2000).

Table 6-2 summarizes some of the various public education options currently being incorporated by municipalities in North Carolina. These municipalities can serve as a learning tool for this watershed for which programs would be the most appropriate for each jurisdiction and the watershed as a whole. The recently-promulgated NPDES Phase II regulations require certain jurisdictions to provide watershed related public education. Of the eight municipalities within the study watershed (see Table 6-4 for a list of the jurisdictions), six are subject to the NPDES Phase II regulations – Cabarrus and Mecklenburg Counties; the Towns of Cornelius, Davidson, and Huntersville; and the City of Charlotte. The NPDES Phase II rules are discussed in Section 6.4.

There are several resources available to assist the municipalities and counties in the development and incorporation of public education programs regarding watershed protection. The following is a list of potential sources:

- “On Watershed Education” is a feature article from Watershed Protection Techniques (Article 127) that provides an approach to crafting an effective watershed education program. The article provides the results of research on outreach techniques that appear most effective in influencing watershed behavior.

**North Carolina Wetlands Restoration Program
Upper Rocky River/Clarke Creek Local Watershed Plan
Table 6-2 - Watershed Education Efforts in North Carolina Municipalities**

Options to Educate the Public	MUNICIPALITY						
	Charlotte	Durham	Fayetteville	Greensboro	Washington	Wilmington	Winston-Salem
Bill Inserts	√	√	√	√		√	
Press Releases		√		√			
Brochures		√	√	√		√	
Public Hearings/Civic Events		√	√	√		√	
neighborhood Meetings		√		√		√	
Public Schools		√	√	√			
Advisory Groups	√	√		√		√	
Radio/TV Public Service Announcements	√	√	√	√		√	
Speakers Bureau		√		√			
Telephone Hot Line	√	√	√	√			
Internet	√	√	√	√		√	√
Community Outreach		√			√		
Newspaper Ads			√				
Mascot			√				
County Fairs			√				
Stream Watch Program							√
Educational Videos	√						

Note: Survey completed by CDM in 2002.

- The United States Environmental Protection Agency (U.S. EPA) website has an extensive collection of stormwater-related links, information, publications, and education materials. <http://www.epa.gov/owow/nps/>
- The Stormwater Manager's Resource Center (SMRC) is designed specifically for stormwater practitioners, local government officials, and others that need technical assistance on stormwater management issues. The Center is created and maintained by the Center for Watershed Protection, <http://www.stormwatercenter.net/>
- The Water Environment Federation (WEF) website offers several educational materials and resources. <http://wef.org/publicinfo/factsheets/>

MS-2 Provide Water-Based Recreation and Cultural Resources

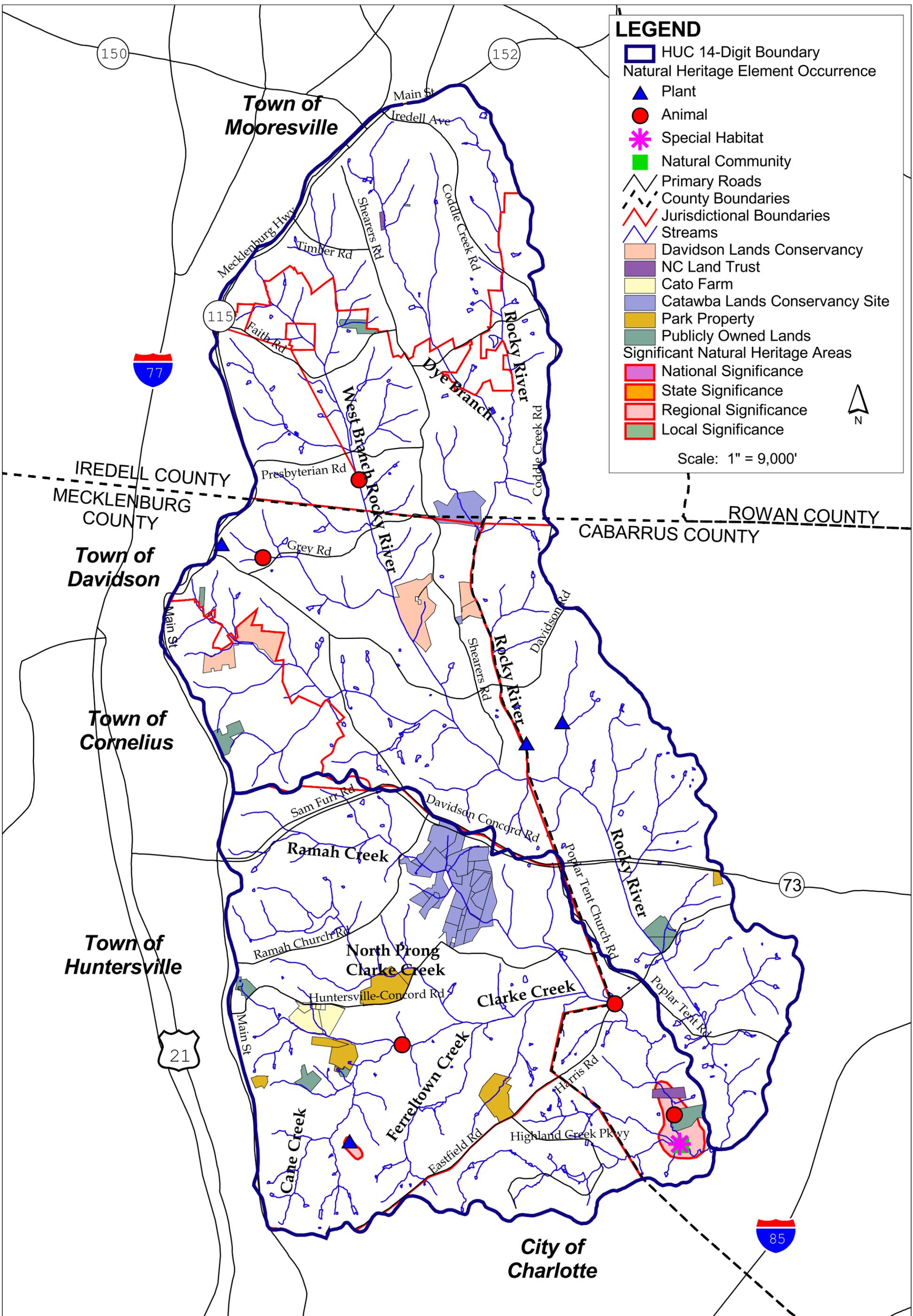
The recommended strategies for this goal reflect the strong need to keep the public "connected" to the region's water-based natural, cultural, and recreational resources. This requires direct and easily accessible links to community resources situated around the streams and lakes of the watershed. Community access to water-based resources provides public education and outreach opportunities as discussed in MS-1 in addition to the desired recreational opportunities.

In order to maintain this connection, it is important that the watershed management strategies discussed below be considered and implemented throughout the watershed. **Figure 6-2** presents the locations of public parks, areas of significant natural habitat identified by the NHP, lands preserved by local land trust for their ecological diversity, ongoing stream restoration projects, and wetlands identified by the NWI.

Stream Corridors, Greenways, and Linkages

These strategies seek to provide adequate access points to streams, lakes, and other water resources where recreation is encouraged throughout the study area, while preserving the water quality and flood control benefits of an intact riparian buffer corridor. Creation of these stream corridors and greenways also serves the secondary benefit of connecting individual residential neighborhoods into contiguous elements that can provide safe and pollution-free recreation and transportation corridors.

The primary goal for the stream corridors and greenways strategy is to preserve the natural function of the riparian buffers to the extent practicable throughout the watershed while providing the community with an amenity that can enhance adjacent development. These corridors will be developed through a combination of preservation of high-quality ecological areas and stream, wetland, and riparian buffer restoration (in cases where historical agricultural land uses and/or encroaching development have degraded the existing resource). Projects can be accomplished through development set-asides or through various purchase options and grant programs. Access can be accomplished through public expenditures or through grants, such as that received by the Town of Davidson for the construction of



Data Source: NCCGIA 2000 BasinPro and Mecklenburg, Iredell, and Cabarrus County GIS Departments

Figure 6-2
Upper Rocky River/Clarke Creek Local Watershed Plan
Land Preservation Areas and Key Natural Resources



approximately 20.2 miles (106,600 feet) of greenways and bike trails. Contact the Town of Davidson Planning Department for further discussion on the proposed greenway and bike trails <http://www.ci.davidson.nc.us/units/planning/Default.asp>.

Given the above, it is recommended that municipalities consider the following actions:

- 1) Revise, as needed, municipal ordinances to mandate or encourage paths and trails to be established and/or set-asides created during the development process consistent with conservation site design techniques.
- 2) Consider purchase options to acquire necessary rights-of way.
- 3) Provide demonstration projects for protected areas of habitat on municipally owned parcels to help illustrate the importance of habitat preservation to the community.
- 4) Develop a watershed-wide stream corridor and greenway plan to prioritize specific opportunities to provide the greatest degree of contiguous stream corridor as is practicable in the watershed. Note that this will obviously require multi-jurisdictional collaboration.
- 5) Pursue options to preserve and rehabilitate heritage corridors. Prepare historic preservation ordinances or components of existing ordinances that address water-based resources.

MS-3 Implement Land Preservation Techniques for Protecting Natural Resources

The purpose of this section is to discuss the benefits of land preservation and natural resource protection. Because land preservation typically involves protecting areas of significant natural habitat and species, the two typically overlap. The following sections provide recommended approaches for how to preserve lands rich in natural resources, what lands and resources to preserve, and how to manage and regulate impacts to those lands.

MS-3.1 Land Preservation

Land preservation provides a multitude of benefits towards protecting and preserving everyday functions of the watershed and its natural resources as well as preserving areas of significant habitat and/or species. By preserving land through non-profit land trusts or municipal land trusts it is assumed that the amount of development and associated impervious area is maintained at a very low level, thus ensuring the benefits typically associate with forested or open space lands. Those benefits include stormwater runoff infiltration into groundwater aquifers that provide water supplies and maintain stream baseflows, pollutant removal from stormwater runoff through infiltration and vegetative uptake, aquatic and terrestrial habitat preservation, and aesthetic benefits of water features and open land.

The value associated with land preservation can be increased when the lands being preserved consist of terrestrial or aquatic sites that have particular biodiversity significance including rare species, rare or high quality natural communities, or other important ecological features; or areas consisting of rare or endangered species, occurrences or exemplary or unique ecosystems, and special animal habitats, as identified by the NHP.

In general, land preservation can be considered a proactive approach to preserving both ground and surface water. It is important to prioritize lands based on their vulnerability and value for protecting and conserving natural resources. For this effort, this is reflected in the subwatershed ranking protocol and the identification of subwatersheds having significant natural resources. The Current Natural Resources/Habitat Value Tier one and two subwatersheds can be used to prioritize land preservation efforts (see Figure 6-1 and/or Figures 4-1 through 4-3 in Section 4). Pursuant to the prioritization ranking protocol, it is also recommended that priority be given to lands in headwater areas (i.e., first and second order stream drainage areas), riparian buffers, floodplains, wellhead protection areas, and other areas draining to streams supporting “sensitive resources.”

The following land preservation techniques and natural resource protection strategies were adapted from the Chester County Water Resources Authority, 2001 *Chester County, Pennsylvania Water Resources Compendium – Part I: Technical Report – Assessment of 21 Watersheds Originating in Chester County, Pennsylvania*. The key recommended land preservation techniques include private land stewardship, municipal and private land trusts, and the public purchase of select land resources.

Private Land Stewardship

Private land stewardship involves the donation of land or rights to the land to a qualified conservation organization and/or municipality. The types of donations include: (1) outright gifts of land, (2) gifts of land with retained life estate, (3) bargain sales of land, (4) gifts by codicil, and (5) conservation easements. The primary incentives for the use of these techniques are federal income, gift, and estate tax reductions.

Municipal and Private Land Trusts

Non-profit land trusts (such as the Catawba Lands Conservancy, Davidson Lands Conservancy, and North Carolina Land Trust – see Section 2.9.1 of this LWP for a discussion of both) are capable of developing preservation programs involving grant funding, landowner contacts, and easement acquisition. They are often comprised predominately of volunteers capable of utilizing the interests of the local citizenry to preserve the lands to which they are closely tied. Local municipalities should consider creating similar municipal land trusts or joining forces with an existing land trust and expand their efforts to the watersheds boundaries. Assisting existing land trusts may help to minimize the duplication of efforts, therefore maximizing time and money towards the ultimate goal of preserving land.

Public Purchase of Select Land Resources

While the acquisition of key parcels or rights to key parcels offers perhaps the ultimate protection for resources, it also must be used judiciously due to the limited amount of funds available for such purposes. Obviously, municipalities that use acquisition in combination with other preservation techniques get more for their money. For example, municipalities that have limited funds may find that they can achieve the greatest success by purchasing the development rights on several parcels, as opposed to purchasing a single tract. Another example would be to use easements to protect riparian buffer areas around fee-simple purchases.

MS-3.2 Natural Resource Protection Strategies

Land preservation can be an expensive technique for preventing the destruction of areas of significant habitat and/or species. Often, entire parcels must be purchased to ensure the protection of habitat areas along streams that could potentially be protected by local riparian stream buffer ordinances and/or other protection strategies. Adapting local ordinances towards ensuring the protection of natural resources can be an equally effective and much less expensive technique. For example, the conservation design techniques discussed in Section 6.3-MS-5 (Implement New Development Controls) outline specific techniques that can be used to achieve development objectives and protect natural resources.

This section further elaborates on techniques available to municipalities to minimize disturbance to natural resources. Among other things, techniques include the buffering of streams and the protection of prime aquifer recharge areas, among others. For example, one common technique for protecting public water supply wells is to establish a buffer zone of 100 to 200 feet around public water supply wells to protect against contaminating land uses or practices (NCDENR, 1998 – Section .0203). On residential properties in North Carolina, owners are required to maintain “isolation distances” of 100 to 200 feet between their well and septic tank. Farmers are encouraged to protect their sources of water by limiting disturbance near surface water bodies and wellhead areas in accordance with North Carolina Public Water Supply rules.

Prioritize areas of natural resource protection using the prioritization ranking protocol’s Current Natural Resources/Habitat Value Tier I and II subwatersheds (described in Section 4 and shown on Figures 4-1 through 4-3 and/or Figure 6-1). Lands to consider for preservation efforts include:

- *Significant Natural Heritage Areas* identified by the NHP. These areas consist of terrestrial or aquatic sites that have particular biodiversity significance including rare species, rare or high quality natural communities, or other important ecological features.
- *Significant Natural Heritage Element Occurrences* identified by the NHP. These areas consist of rare or endangered species, occurrences or exemplary or unique ecosystems, and special animal habitats.

- Existing riparian wetlands identified by the National Wetlands Inventory (NWI) of the U.S. Fish and Wildlife Service.
- Lands adjacent to existing publicly-owned or conservation lands

Also consider preserving lands with significant aquatic habitat in subwatersheds having exceptional current health and those at risk for future impairment. Land preservation in these areas will help maintain the existing aquatic habitat within the subwatershed by preventing stream degradation resulting from urban development. Efforts may be focused in Current Watershed Health and Future Risk Tier I and II subwatersheds (see Figure 6-1 and/or Figures 4-1 through 4-3).

Protecting Riparian Buffers and Corridors

Riparian stream buffers are critical for maintaining stream health and protecting aquatic and wildlife habitat. Such corridors can be regulated as part of new development or can be encouraged as part of land management practices. Land being considered for conservation easements should be assessed in terms of its ability to help protect water resources; easement terms should be structured accordingly.

- Revise municipal ordinances to require riparian stream buffers along all intermittent and perennial streams. They should meet the following criteria:
 - The North Carolina Wildlife Resources Commission (NCWRC) recommends 50-foot riparian buffers on both sides of intermittent streams and 100-foot riparian buffers on both sides of perennial streams. In areas of significant wildlife or aquatic habitat, 100-foot riparian buffers on both sides of intermittent streams and 200-foot riparian buffers on both sides of perennial streams are recommended.
 - Riparian buffers should extend, at a minimum, to the maximum area inundated by the 100-year, 24-hour storm event, assuming worst-case future land use (build-out) conditions. This should apply to all intermittent and perennial streams.
- Protect and enhance existing riparian buffers or, where they do not exist, create or restore forested riparian buffers to meet the minimum standards identified above.
- Where new development is occurring, utilize conservation development design techniques through ordinance provisions and/or incentives to delineate and integrate the protected riparian buffers within the subdivision design, while accommodating development objectives consistent with municipal zoning, such as:
 - Apply conservation design practices and natural resource protection measures to delineate the resources to be protected (including undisturbed riparian buffer) and separate the building envelope and disturbance areas from the protected resources.

- Setback all structures and constructed features from waterbodies to provide for the undisturbed riparian buffer, and reduce setback requirements from the street to reduce driveway lengths, limiting imperviousness.
- Include a preservation deed in plats as they are developed. Provide tax grants for these areas.
- Apply minimum developable area requirements or minimum disturbance/maintenance standards that allow the undisturbed riparian buffers to be included as part of the individual lot area(s), but excluded from the area of disturbance or construction. When the protected riparian buffer is included as part of an individual lot area(s), implement measures to ensure the long-term protection and management of the forested riparian buffer (see below).
- Consider reducing the required riparian buffer width to 75 feet from edge of water (on either side of the stream) if land area is insufficient to accommodate the recommended riparian buffer and/or to be consistent with a municipality's comprehensive planning objectives. This should be applied ONLY when each of the following has also been implemented:
 - Conservation design techniques that minimize the amount of stormwater generated and maximize the use of pervious areas for infiltration of rainfall and stormwater, and achieve other open space and environmental resources protection objectives appropriate for the site and zoning.
 - Other BMPs such as level spreaders, meadow grass filter strips, or similar techniques to disperse overland flow prior to entering the protected riparian buffer area where the width of the riparian buffer is less than 75 feet.
- Implement measures to ensure the long-term protection and management of the forested riparian buffer, including:
 - Establish permanent restrictions of use and maintenance of the riparian buffer area through deed restrictions and/or through conservation easements.
 - Designate an entity responsible for management and protection of the protected riparian buffer, such as a homeowners' association, municipality, easement holder, etc.
 - Where the protected riparian buffer is included on individual lot(s), require property owners to sign a document that they understand the restrictions and maintenance requirements. Install a visible linear feature (and/or signage) to demarcate the outer edge of the protected area (i.e., level spreader, tree line, etc.).
 - Provide a management and maintenance plan for the forested riparian buffer. Plans for the proper maintenance of riparian buffers including

mowing and other activities can be obtained from local Natural Resources and Conservation Service (NRCS) offices, NCSU Cooperative Extension office, or NCWRP riparian buffer specialists.

- Delineate the protected forested riparian buffer on final subdivision plans consistent with municipal plan submission requirements.
- On agricultural lands where protected riparian buffer widths are less than 100 feet, implement additional agricultural conservation management plans and nonpoint source water quality BMPs approved by the county conservation district to provide equivalent reduction of runoff and nonpoint source pollutants.
- Promote a 5- to 15-foot no-mow zone along streams and open flow channels on existing small residential lots (1 acre or less). However, allow paths and access areas to the streams to maintain the linkage between community and water resources.
- For all riparian buffers, the following should apply:
 - “Forested riparian buffer” includes 10 - 12 species of trees and/or a combination of trees and shrubs, with preference given to native plant species suitable for riparian conditions and managed to minimize invasive species. Refer to NCWRP’s “Guidelines for Riparian Buffer Restoration” for further discussion on species diversity and composition.
 - Implement forested riparian buffers throughout the study watersheds, but with particular priority given to first and second order (headwater) streams, and streams supporting sensitive resources (including sources of groundwater recharge, Natural Heritage Program (NHP) sites, etc.), particularly in Current Watershed Health Tier I and II subwatersheds.
 - The priority is to establish a network of forested riparian buffer protected from disturbance. Existing vegetation within the riparian buffer width should not be disturbed by construction activities. Mowing within the riparian buffer should also be prevented to maintain mature vegetation, reduced velocities, and sheet flow. Where needed, forested and unforested vegetation should be established through natural succession. Selective planting should be encouraged on sites devoid of vegetation to stimulate native species and discourage invasive species. Plant selection and planting should be done consistent with USDA riparian forested buffer guidance. It is encouraged that local volunteer groups be involved in the riparian buffer planting.
 - Forested riparian buffers can be included as unmaintained (unmowed) yard areas, passive recreation areas or natural areas, but should not include any use that is considered a source of pollutants.
 - Forested riparian buffers should be undisturbed except for designated forest management practices, with the exceptions of regulated activities permitted by

the state (i.e., stream or wetland crossing), unpaved trail access, or soil or stream conservation project.

- Extend and inter-connect riparian buffers to the maximum extent practicable.
- Link riparian corridors with other habitats, wildlife corridors, and established greenways.
- Municipalities should select their final implementation strategies and ordinance provisions for forested riparian buffers based on an overall evaluation of the properties within their municipality that would be affected by the riparian buffer requirements to ensure overall consistency with the municipality's other planning and zoning objectives.
- Emphasize efforts to educate residential and other riparian land owners regarding benefits, restricted uses, and management requirements of forested riparian buffers by developers, municipalities, watershed and conservation organizations and government agencies.

Environmental Protection Ordinance

Creation of a free-standing "environmental resources protection" ordinance could enhance the direct protection of natural resource lands by consolidating and strengthening land disturbance and development-related resource protection standards, including site disturbance regulations, set-asides of lands containing or protecting natural resources, resources protection ratios (partial to full), conservation plan requirements, woodland/vegetation conservation standards, wetland conservation standards, floodplain conservation district, steep slope conservation district, riparian buffer standards, groundwater and/or well-head protection standards, and landscaping, buffering, and screening standards, among others. One significant advantage of adopting a free-standing ordinance is that "earth disturbances" outside the scope of traditional zoning, subdivision, and land development ordinances can be regulated (based on level of impact, square footage of disturbance, etc.). See Section 2.7 for a description of the stormwater and development-related ordinances for each of the jurisdictions comprising the watershed.

MS-4 Restore Aquatic and Wildlife Habitat

Aquatic habitat in the Upper Rocky River/Clarke Creek Watershed has been damaged due to man's activities, including highway and stream crossing construction, flood control, channel modifications, industrial and residential development, agriculture, irrigation, livestock grazing, and accidental habitat loss. These changes in natural aquatic habitat cannot always be restored to their natural state, but efforts to mitigate for their negative effects can be accomplished through watershed plans such as this and a collaboration of efforts by communities, municipalities, and the NCWRP. Restoration projects identified in this study include riparian wetlands restoration, stream restoration, and riparian buffer restoration. See

Section 7 for a description of the recommended watershed protection and improvement project sites.

MS-4.1 Riparian Wetlands Restoration

Riparian wetlands are areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support (and that under normal circumstances do support) a prevalence of vegetation typically adapted for life in saturated soil conditions. This is the definition of riparian wetlands as it appears in the regulations jointly issued by the Army Corps of Engineers (COE) and the U.S. EPA (33 CFT Part 328.3(b), 40 CFR Part 232.2(r), and 40 CFR Part 230.3(t)). Riparian wetlands provide food, protection from predators, and other vital habitat factors for many of the nation's fish and wildlife species, including endangered and threatened species. They also intercept stormwater runoff and release floodwaters gradually to downstream systems. When riparian wetlands are converted to systems without water retention capacity, downstream flooding problems increase. In addition, wetland ecotypes have economic value associated with recreational, commercial, and subsistence use of fish and wildlife resources and they remove pollutants from overland flows before they reach our lakes and rivers.

Wetland restoration (or re-establishment), as defined by the River Corridor and Wetlands Restoration Department of the US EPA, is "the manipulation of the physical, chemical, or biological characteristics of a site with the goal of returning natural/historic functions to a former wetland. Re-establishment results in rebuilding a former wetland and results in a gain in wetland acres" (US EPA, September 23, 2003). Based on GIS calculations performed for this study using the historical presence of hydric soils and the NWI, it is estimated that approximately 75 percent, or 3,900 acres, of the riparian wetlands in the Upper Rocky River/Clarke Creek Watershed have been destroyed. Several wetland restoration opportunities were identified in this study, and with the help of the municipalities, may be implemented by the NCWRP.

Riparian wetlands restoration projects were identified for this study and included in the recommended watershed protection and improvement project sites (see Section 6.4). The recommended implementation strategy for wetland restoration is to concentrate efforts in Current Natural Resources/Habitat Value and Current Watershed Health Tier 1 and 2 subwatersheds (see Figure 6-1 and/or Figures 4-1 through 4-3). Subwatersheds with high Current Watershed Health scores are currently experiencing water quality and stream degradation and will benefit from wetland restoration projects. Potential wetland restoration projects should also be prioritized based on recommended downstream projects such as stream restoration and riparian buffer preservation that would benefit from the flood attenuation capability of riparian wetlands. Implementing wetland restoration projects in tandem with stream restoration projects and proposed wet ponds will provide the greatest benefit for both.

MS-4.2 Stream Restoration

The Upper Rocky River/Clarke Creek Watershed consists of approximately 182 miles of first through fourth order streams that provide aquatic habitat to a multitude of wildlife species. Streams provide spawning and breeding habitat for fish and other wildlife including turtles, frogs, toads, and salamanders. The degradation observed in the streams of the study watershed can be directly associated with the effects of agricultural and urban development. Increased stormwater runoff from urban areas, high sediment loads, and channelization from agricultural and urban development has led to increased streambank erosion, channel widening and incision, and loss of habitat. As a result, portions of the Upper Rocky River, Clarke Creek, and Dye Branch are impaired and are included in the State's 303(d) list as not supporting their intended uses (see Figure 5-1).

Stream restoration, much like wetland restoration, has the goal of returning the natural/historic functions of the stream corridor to its former state. A stream corridor typically consists of the stream channel, floodplain, and transitional upland fringe. Based on field observations and GIS analyses performed for this study (see Section 4), at least 15 percent (28 miles) of the first through fourth order streams in the watershed could benefit from some form of restoration, including riparian buffer restoration, stream restoration, or streambank stabilization (see Section 7 for a description of how potential stream restoration sites were determined). Many stream segments have been channelized and degraded from past agricultural land use practices.

Stream restoration projects require careful planning and design to be sited correctly and to perform as designed. Stream restoration projects can be difficult to maintain during the early stages of project completion. Storm events often can cause streambank erosion and destruction of habitat structures if vegetation has not yet taken hold. If new development occurs upstream of a stream restoration site and doesn't require onsite hydrologic controls, or there aren't any existing controls between the development and the restoration site, increased storm flows and velocities can destroy even matured stream restoration sites. Therefore, upstream hydrologic controls (e.g. wet and dry detention ponds) were considered a necessity when prioritizing stream restoration opportunities, regardless of the condition of the stream.

Stream restoration opportunities identified for this study are included in the recommended watershed protection and improvement project sites. See Table 7-1 in Section 7.2.4.2 for a list of the project sites and Figure 7-3 for their locations. The recommended implementation strategy for stream restoration is to concentrate efforts in Current Natural Resources/Habitat Value and Current Watershed Health Tier 1 and 2 subwatersheds (see Figure 6-1 and/or Figures 4-1 through 4-3). Stream restoration projects protect downstream natural resources by creating meandering of the stream channel, which reduces instream velocities and resulting streambank erosion and provides habitat through a sequencing of pools and riffles.

Stream restoration efforts should not be limited to those identified for this study. If an opportunity to restore a degraded stream is brought to the NCWRP's or a municipality's attention by a local land owner, that opportunity should be considered a high priority if sufficient upstream hydrologic controls are or will be in place.

MS-4.3 Riparian Buffer Restoration

If a 100-foot riparian buffer is assumed on both sides of the 182 miles of first through fourth order streams, approximately 10 percent (or 7 square miles) of the watershed is directly contiguous to an intermittent or perennial stream. Many wildlife species including amphibians, reptiles, birds, and mammals depend on the aquatic habitat provided by riparian buffers.

The NCWRP's "Guidelines for Riparian Buffer Restoration" identifies riparian buffer restoration projects that have the greatest value for reducing pollutants in our surface waters as well as providing important aquatic and wildlife habitat (NCDENR-DWQ-WRP, January, 2001). Riparian buffers provide many additional benefits including conveying floodwaters, protecting streambanks from erosion, mitigating stream warming, reducing drainage problems from adjacent areas, and providing recreational opportunities and aesthetic benefits. Based on GIS calculations performed for this study, it is estimated that approximately 55 percent, or 100 miles, of contiguous forested riparian buffer has been destroyed in the Upper Rocky River/Clarke Creek Watershed. Riparian buffer restoration opportunities were identified for this study and included in the recommended watershed protection and improvement project sites (see Section 7). Efforts to restore additional riparian buffers should be concentrated in Current Natural Resources/Habitat Value and Current Watershed Health Tier 1 and 2 subwatersheds.

Riparian buffer restoration efforts should not be limited to those identified by this study. If an opportunity to restore a degraded riparian buffer is presented to the NCWRP's or a local municipality's attention by a landowner, that opportunity should be considered a high priority.

MS-5 Implement New Development Controls

MS-5.1 Comprehensive Land Use Plan

Comprehensive land use plans offer several options for municipalities to protect water resources by including recommendations for:

- stream buffers;
- protection of stream headwaters and groundwater;
- transfer of development rights from agricultural and other areas;
- recognition of the importance of stream headwaters as particularly sensitive;
- avoidance of inter-basin transfers;
- reduction in allowable number of new housing units;

- reduction of development density;
- open space requirements for all new development;
 - Consider an aggressive open space regulation, similar to that of the Towns of Huntersville and Davidson. See Section 2.7.1 for a description of open space requirements for both communities.
 - Areas dedicated as open space should be prioritized based on significant natural habitat or propensity for erosion if disturbed. For example, riparian buffers, rock outcrops, riparian wetlands, etc. should be dedicated as open space in the plat.
- clustering with a minimum percent of open space required in sensitive areas; and
- concentration of industrial/commercial uses along transportation corridors.
 - For example, the Charlotte-Mecklenburg North Corridor Light Rail, which will run along NC 115 from the City of Charlotte to the Town of Mooresville, is expected to be completed by 2008. Concentrating office, residential, and commercial development along the rail corridor will help to decrease development sprawl in other parts of the watershed and increase preservation efforts.

Effective erosion and sediment controls must be enforced during the implementation of comprehensive land use plans and LID. Jurisdictions should consider improving erosion and sediment control requirements and assisting the state in the enforcement of those requirements.

MS-5.2 Innovative Land Use Planning

LID design is a term that encompasses a number of land development design practices that have some or all of the following goals in common (Prince George's County, Maryland, 1997). They:

- Provide an improved technology for environmental protection of receiving waters.
- Provide economic incentives that encourage environmentally sensitive development.
- Develop the full potential of environmentally sensitive site planning and design.
- Encourage public education and participation in environmental protection.
- Help build communities based on environmental stewardship.
- Reduce construction and maintenance costs of the stormwater infrastructure.
- Introduce new concepts, technologies, and objectives for stormwater management such as micromanagement and multi-functional landscape features (bioretention areas, swales, and conservation areas); mimic or replicate hydrologic functions; and maintain the ecological/biological integrity of receiving streams.

- Encourage flexibility in regulations that allows innovative engineering and site planning to promote “smart growth” principles.
- Encourage debate on the economic, environmental, and technical viability and applicability of current stormwater practices and alternative approaches.

These goals strive to achieve a holistic approach to development design that maximizes the preservation of key land resources, protects site hydrology, preserves natural resources, and satisfies community interest in complimentary and aesthetically pleasing development. The watershed’s large number of streams and headwater areas, agricultural land (consisting of prime agricultural soils), and unique aquatic and terrestrial habitat argue for design approaches responsive to conservation principles.

Many jurisdictions have strict land development design criteria that prevent the use of creative design techniques, such as LID. These approaches, if continued, will “fail to comprehensively maintain predevelopment ecological functions at sites and fail to prevent development impacts to the overall watershed ecological health (Prince George’s County, Maryland’s Department of Environmental Resources, 1997)”. The following techniques are presented to assist municipalities to understand how to improve the development design process and the benefits of changing municipal codes to allow or require conservation design practices.

- Eliminating unnecessary impervious cover requirements by reducing requirements for roadway widths and double sidewalks; requiring porous pavement parking areas, grassed swales in place of curbs, and alternative cul-de-sac designs to allow sufficient room for emergency vehicle turn-around while reducing the total paved area; and reducing building setbacks for shorter driveways.
- Promoting designs that disperse runoff to porous areas and incorporate alternative site drainage techniques into site landscaping to minimize stormwater runoff and maximize infiltration (including the use of grading elements that maximize flow over pervious (vegetated) surfaces to reduce the concentration of runoff and therefore the need for structural stormwater management practices).
- Promoting negotiations as part of the development review process at the sketch plan level (as opposed to discussions that typically occur after developers have spent large sums of money on design and engineering).
- Netting out of certain site constraints for resource protection - for example, critical natural features of a site (or a percentage thereof) are protected from disturbance and netted out of the acreage otherwise used for development, thereby removing areas containing certain natural resources or site constraints from the acreage to be developed.

- Local ordinances should require that a wetlands identification assessment be performed on all new developed to help identify wetlands not specifically identified by the NWI.
- Promoting the use of cluster housing options and reducing policy and planning impediments to these designs.
- Advocating the elimination of curb and gutter for street drainage in favor of roll-over curbing and grassed swales to promote stormwater diffusion, infiltration and treatment.
- Advocating the use of rain barrels to retain a predetermined volume of rooftop runoff, which can be used for reuse in lawn and garden watering.
- Considering the use of alternative roadway design to reduce total impervious area.
- Considering the use of minimum disturbance/minimum maintenance standards (i.e., land disturbance ordinance provisions) to reduce or eliminate the affects of land disturbance, clearing, and grading.
- Removing directly-connected impervious areas from the watershed.

While several of these techniques lend themselves to regulations, conservation design is less a function of regimented codes and procedures than it is about communication among land planning and environmental professionals, knowledgeable developers, community representatives, and regulatory authorities who combine their understanding and perspectives to create economically and environmentally viable plans. For additional LID design strategies refer to Prince George's County, Maryland's *Low-Impact Development Design Strategies* report, June, 1999 or the LID Center at <http://www.lowimpactdevelopment.org/>.

MS-5.3 Design Considerations for Improving Water Quality

Water quality BMPs should be implemented in new developments that generate increased stormwater runoff and pollutant loads to the extent that stream and habitat degradation occurs. The percentage of impervious area at which stream degradation (i.e. streambank erosion, destruction of aquatic habitat, etc.) occurs is dependent upon site specific characteristics such as soil type, vegetation cover, species of macroinvertebrate, etc. In general, research indicates that a watershed imperviousness of 10 percent is the approximate threshold at which streams become unstable and begin to erode resulting in habitat degradation (ASCE-WEF, 1998 and CWP, March, 2003). Jurisdictions should consider revising their ordinances to require water quality BMPs for new development whose imperviousness is 10-15 percent or greater of the total area, or at a minimum should consider adopting the NC regulations for class IV water supply watersheds. For a description of the rules, refer to NCDENR's Water Supply Watershed Protection Program website at <http://h2o.enr.state.nc.us/wswp/index.html>. The most logical specific locations and

sizes for these proposed BMPs can be determined by hydrologic, hydraulic, and water quality modeling.

Jurisdictions should consider implementing *BMP treatment trains* to maximize the use of available site conditions from the point of runoff generation to the receiving water discharge in order to maximize benefits. An example BMP treatment train would be the transition of stormwater runoff from a commercial parking area to grassed swales capable of infiltrating runoff and removing pollutants through sedimentation and vegetative uptake; then to onsite wet detention ponds also capable of remove pollutants through sedimentation and vegetative uptake, and detaining small storm events which in turn reduce peak flows; then to regional detention sites (e.g. large wet ponds or wetlands) that provide flood control benefits. **Figure 6-3** shows a recommended BMP treatment train approach (Fulton County, 2001).

There are numerous types of structural and non-structural best management practices (BMPs) that can be implemented to mitigate stormwater and nonpoint source pollution within a watershed. *Structural BMPs* are measures that require the design and construction of a facility to help reduce or eliminate a nonpoint source of pollution and control stormwater. *Non-structural BMPs* are passive, site design/regulatory approaches that positively impact water quality and reducing stormwater runoff without requiring the construction of specific stormwater management control structures. Below is a collection of potential BMPs that can be implemented by all those who influence water quality and stormwater runoff, including land owners/operators, residents, developers, municipalities, and counties.

Non-Structural BMPs

- Land Use Planning/Management
- Good Housekeeping Practices
- Illegal Dumping Control
- Illicit Connection Prevention, Detection, and Removal
- Street Cleaning
- Vehicle Use Reduction
- Hazardous Waste Collection
- Public Outreach and Watershed Education

Structural BMPs

- Wet Detention Basin
- Dry Extended Detention Basin
- Modified Dry Extended Detention Basin
- Constructed Wetlands
- Bioretention Areas
- Alum Injection
- Sand Filter/Media Filtration
- Infiltration Basin
- Infiltration Trench
- Porous Pavement
- Biofilter
- Water Quality Inlets and Oil/Water Separators
- Grass Swales
- Filter Strip

A general description of each BMP and its expected pollutant removal benefit is provided in Appendix H. It is not the intent of this management plan to dictate the actual selection of BMPs to be implemented by municipalities and counties, but rather

BMP Treatment Train

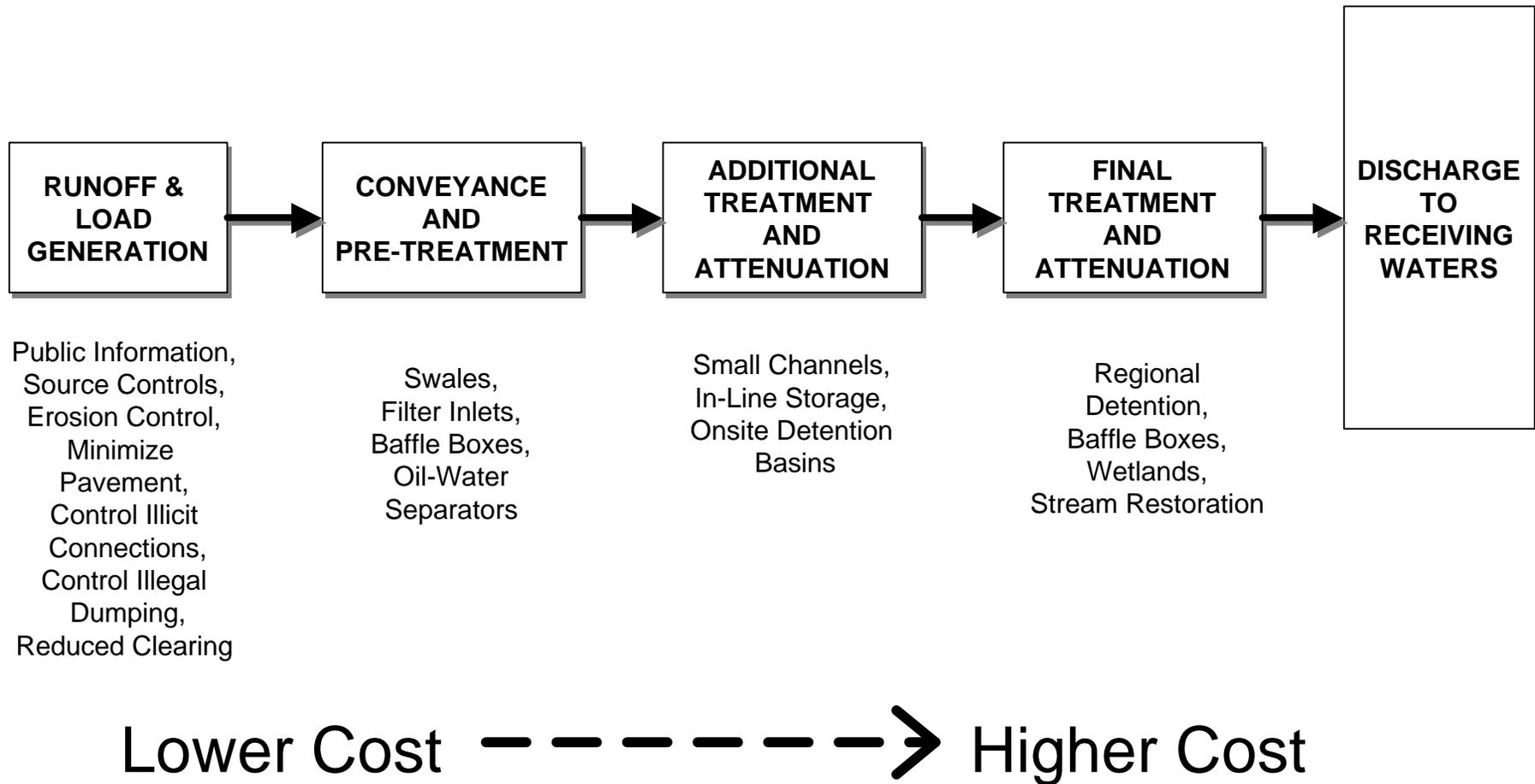


Figure 6-3

to provide a collection of BMPs from which to choose. A framework for BMP implementation for stormwater and water quality control should be developed for the watershed based on these recommendations and local political and regulatory will. Existing manuals such as NCDWQ's *Stormwater Best Management Practices Manual*, the Charlotte Stormwater Design Manual, and the Huntersville Water Quality Design Manual are currently in place and might serve as a basis for surrounding jurisdictions as appropriate in an effort to provide consistent and effective stormwater and water quality control.

The Town of Huntersville Water Quality Design Manual was adopted on February 17, 2003 and incorporated into their zoning ordinance to establish stormwater management requirements and controls. The design manual was developed and is currently maintained by the Mecklenburg LUESA for the Town of Huntersville. The Town of Davidson is currently considering adopting the water quality ordinance and the associated design manual. A copy of the design manual can be obtained for review from the following link: <http://www.charmeck.org/Departments/LUESA/Water+and+Land+Resources/Programs/Water+Quality/Huntersville+Ordinance/Home.htm>. Some general recommended BMP design criteria are provided below:

- Control runoff from the one-inch storm event. This will capture approximately 80 to 90 percent of all storm events (ASCE, 1998).
- Implement wet detention ponds before considering wet retention and dry detention basins. Maintain a minimum two-week retention time for removing approximately 85 percent of the total suspended solids (Hartigan, 1989). Clean-out intervals should be determined based on cost/benefit ratios relating sediment removal cost to pollutant removal benefit.
- Reduce post-development peak runoff rates of the 1-year to 10-year events to the corresponding pre-development peak runoff rates.
- Maintain the existing time of concentration in the watershed to the extent practicable. Time of concentration is the travel time of a parcel of water to move down a specified area (ASCE-WEF, 1992).
- Where site conditions (i.e. soil types) allow, infiltrate the net increase in runoff from the one-inch storm to protect groundwater recharge and allow removal of pollutants through the soils and vegetative uptake (see Appendix H for a list of recommended infiltration BMPs). Where site conditions allow, infiltrate the net increase of the two-year storm event.
- Where not infiltrated, implement onsite stormwater BMPs specifically designed to reduce sediment, nutrients, and other pollutant loads from runoff for events up to a one-inch storm.
- Where stormwater basins are necessary, implement wet detention, constructed wetlands, or dry detention basins to improve pollutant removal and allow infiltration of stormwater.

- Install and maintain oil/water separators and water quality inlets in storm drains of automobile service, maintenance, parking, and salvage areas.
- Require stormwater outfalls to discharge to level spreaders outside of stream buffers.

MS-6 Reduce Stormwater and Flooding Impacts

Municipalities have the primary responsibility for managing stormwater within their boundaries through their ability to create a stormwater ordinance. Stormwater ordinances should be considered in each municipality to address the ten principles of stormwater management presented below. Each municipality should strive to implement watershed-based standards that are consistent with other municipalities within their watershed. Municipalities are encouraged to coordinate with adjacent municipalities and other municipalities within their watershed to establish consistent stormwater management criteria, while being careful to address localized conditions. The guidelines provided here recommend a consistent set of principles and strategies to assist municipalities in establishing more effective, consistent, and watershed-based controls.

Chester County, Pennsylvania's Chester County, Pennsylvania Water Resources Compendium – Part I: Technical Report – Assessment of 21 Watersheds Originating in Chester County, Pennsylvania, which was developed by the Chester County Water Resources Authority with technical assistance from Gaadt Perspectives, Inc. and CDM, was required to address the same multi-jurisdictional hurdles that face the Upper Rocky River/Clarke Creek Local Watershed Planning Group and form a watershed-wide approach for combating stormwater and flooding impacts in all jurisdictions. Their approach is based around ten paramount principles for municipal stormwater management and is provided below for consideration by this Local Watershed Planning Group.

Ten Principles for Municipal Comprehensive Stormwater Management

The overall need and purpose for effective stormwater management is to create post-development conditions that are consistent with the natural characteristics of the watershed's resources and which mimic, to the extent feasible, the pre-development hydrology of local watersheds. This can be accomplished by conducting land uses in a manner that maintains stream baseflow, stable stream channel (geomorphologic) conditions, flood carrying capacity of the streams and their floodplains, and surface water quality.

The greatest opportunity to reduce future impacts of land use is during the design and construction of new land development. Thus, it is recommended that municipalities develop performance standards within their stormwater ordinances to encourage effective stormwater management. Performance standards should address the following ten principles of stormwater management.

The ten principles should be implemented collectively and through an integrated development design process. They are not intended to be implemented in a piecemeal manner, and doing so can exacerbate stormwater management problems. The ten principles of comprehensive stormwater management are presented in **Table 6-3** and discussed below.

Table 6-3. Ten Principles of Stormwater Management

Ten Principles of Comprehensive Stormwater Management	
1.	Define “Pre-Development Condition”
2.	Establish forested riparian buffer networks
3.	Protect riparian wetlands and floodplains that reduce runoff and flooding
4.	Protect instream channels and geomorphologic conditions
5.	Minimize the volume of stormwater runoff generated
6.	Protect infiltration and groundwater recharge
7.	Protect water quality by removing nonpoint source pollutants
8.	Protect adjacent lands from direct stormwater discharge
9.	Ensure long-term operation and maintenance of stormwater facilities
10.	Develop a hydrologic and hydraulic stormwater model for the entire watershed

1. Define “Pre-Development Condition.”

The fundamental strategy needed to maintain post-development hydrologic conditions that are similar with natural conditions and carrying capacity of the receiving streams, floodplains, and groundwater is to accept the pre-development condition for the design of the site development and its stormwater management system. This will establish a basis of stormwater management that is more consistent with the carrying capacity of the receiving streams and floodplains. Pre-development conditions can be interpreted in many different ways and should therefore have some type of baseline associated with it. Some examples of pre-development conditions can be meadow conditions, forest, or historic land use (e.g. land use identified by soil survey maps or historic aerial photography).

There could, however, be exceptions to this. For sites where existing conditions are less developed than the assigned pre-development condition, then the lesser of the two should take precedence. Recharge and runoff requirements should be made flexible to accommodate the special considerations of areas of redevelopment. Redevelopment can be defined as any construction, alteration, or improvement exceeding five thousand square feet of land disturbance on sites where existing land use is commercial, industrial, institutional, or multi-family residential. In these areas, requirements should allow for flexibility in applying stormwater sizing criteria, depending on the amount of increase or decrease in impervious area created by the redevelopment. As previously stated, urban site design should implement water quantity controls (i.e., infiltration, detention, etc.) to the maximum extent possible for

the site. However, stormwater quality BMPs should also be implemented to protect water quality of streams and groundwater.

2. *Establish forested riparian buffer networks.*

Because of the water quality, infiltration, and streambank stabilization functions provided by riparian buffers, they should be included as a standard element of municipal comprehensive stormwater management. The specific recommendations and strategies for riparian buffers are presented in Section 6.3 MS-3.2.

3. *Protect riparian wetlands and floodplains that reduce runoff and flooding.*

Riparian wetlands located in riparian buffers and floodplains serve an often unrecognized and under-valued function – storage and attenuation of flood waters. Riparian wetlands tend to form in areas of low slopes. When these are located along riparian buffers and in floodplains, they become inundated during flooding events. Due to their vegetation and low slopes, water that finds its way into the wetland area tends to slow down and be temporarily stored. It eventually flows out of the wetland, and infiltrates or evaporates, depending on site conditions. This storage or attenuation of flood waters can contribute to reducing peak flood flows further downstream.

Similarly, floodplains provide room for flood flows to expand across the stream valley, which contributes to lowering flood levels and reduced velocities. Protecting floodplains from fill and construction are strongly recommended to preserve the maximum flood carrying capacity of the natural floodplain, and therefore avoid increasing peak flow rates or flood levels. The following are recommended key strategies for improving floodplain function.

- Enforce municipal floodplain management ordinances.
- Establish forested riparian buffer networks along all intermittent and perennial streams to protect floodplains and provide floodwater attenuation and storage.
- Improve conveyance and attenuation of flood flows within the floodplain using level spreaders at outfalls to prevent channelization within the flood zone and maintain sheet flow.
- Pursue opportunities to remove existing structures from floodplains and to reclaim and restore floodplain lands to natural conditions.
- Prevent development in the future land use 100-year 24-hour floodplain or for the recommended riparian buffer width, whichever is greater.
- Re-connect the floodplain to the channel through the implementation of recommended stream restoration opportunities as discussed in Section 6.4.

In addition to protecting wetlands and floodplains consider purchasing small lakes and farm ponds at the headwaters of first order streams. Retrofits to outlet structures can help to control downstream hydrology and improve pollutant removal

capabilities. Concentrate efforts on retrofitting ponds in Tier I and II subwatersheds for all scoring categories (see Figure 6-1 and/or Figures 4-1 through 4-3).

4. Protect instream channels and geomorphologic conditions

The most destructive impacts of ineffective stormwater management are excessive and rapid downcutting and erosion of the channels of the receiving streams. This results in very deeply incised channels (often up to tens of feet), the erosion and transport of sediments to downstream reaches, siltation of instream habitats, movement of pollutants, and damage to private properties. Many continuous years of constant degradation results in stream channels that require costly investment to restore them to their natural geomorphologic conditions. This restoration frequently costs several hundred to over a thousand dollars per linear foot of stream. By maintaining post-development hydrologic conditions that are consistent with the carrying capacity of the stream channel and its floodplain, these impacts can be reduced or eliminated.

Degradation of stream channels occurs primarily through erosion caused by storms with a return frequency of one to two years. Municipal stormwater ordinances should be designed to avoid such erosion by requiring retention and controlled release of stormwater to avoid excessive peak flow rates of these small events. Retention volume performance standards are the easiest approach, since stormwater recharge and flood control objectives also require similar measures. By providing a clear standard, the municipality can allow the site design to be compared with the standard without prescribing exactly how the standard should be met. This provides greater flexibility to the site development process.

To protect stream channels from degradation, it is recommended that municipalities require that the post development peak discharge rate should be controlled by requiring attenuation or retention/detention of stormwater from a one-year, 24 hour design storm for a period of 24- to 48-hours, or as determined from site-specific modeling, prior to release. This should be achieved by first utilizing onsite overland attenuation techniques, and then, if necessary, retention/detention basins.

By also requiring that stormwater system designs address the infiltration and water quality requirements and implementing conservation design practices, the total volume needed to be addressed in the design of the retention, detention, or attenuation BMPs is reduced. Municipalities should also encourage the elimination of concentrated overland flow of stormwater through developments by dispersing the flow through BMPs to pervious areas and by allowing runoff from outfalls to diffuse through the buffer system using level spreaders prior to discharging to the stream. Instream culverts should be designed to ensure fish and water passage at low flow, avoid channel scour, and maintain or enhance the natural channel geometry and habitat of the stream.

Observations made during the Rosgen Level I Rapid Stream Assessment (see Section 2.5) indicate that second and third order streams are currently degrading due to channel incision and head-cut migration. The sediment transport associated with channel incision and streambank erosion can account for a majority of the sediment load in streams (DEP, MWCOG, 1987). The following efforts to stop sedimentation of the streams through channel incision, head-cut migration, and streambank erosion should be prioritized in Current Natural Resources/Habitat Value Tier I and II subwatersheds (see Section 4 and Figures 4-1 through 4-3).

- Identify streams that would benefit from streambank stabilization and re-vegetation efforts.
- Install grade control structures in actively degrading streams to stop the head-cut currently being observed in second and third order streams.

5. *Minimize the volume of stormwater runoff generated.*

Site designs for new developments or for redevelopment of existing properties should strive to minimize the generation of stormwater and maximize pervious areas for infiltration of rainfall and stormwater. This will have benefits in reducing the volume of stormwater runoff, as well as reducing the amount of pollutants reaching the streams in stormwater runoff, reducing flood flows, reducing the storage volumes required in onsite retention/detention facilities, and protecting groundwater recharge.

To achieve a reduction in the volume of stormwater being generated, it is strongly recommended that municipalities review and, where appropriate, revise their current ordinances to consider the following:

- **Reduce the requirements for unnecessary impervious cover (pavement).**
The more area that is covered in impervious surface, the larger the volumes of stormwater and flood waters that are generated from the site. This directly translates into requirements for larger stormwater management facilities and larger and more frequent flood events.
- **Establish ordinances and incentives to encourage and promote “conservation development design practices” within the municipality.**
Conservation development design pays attention to many of the details that can significantly reduce the volume of stormwater generated and increase the volume of rainfall infiltrated into the ground (among other benefits). Section 6.3-MS-5 provides a more detailed discussion of the techniques and benefits of conservation design practices.
- **Disperse rainfall runoff to pervious areas.**
Designing developments to disperse rainfall runoff into pervious (i.e., vegetated areas or lawns) areas can significantly reduce the volume of stormwater that must be collected and handled through the stormwater management system.

- Apply flexibility for urbanized areas.
Municipalities should not only consider implementing these strategies for new development, but also when developing or redeveloping urban areas. These areas generate large volumes of stormwater runoff and often have older and sometimes insufficient stormwater management systems.

6. *Protect infiltration and groundwater recharge.*

The key component of maintaining the natural hydrologic conditions of the streams and groundwater of a watershed is protecting the natural infiltration and groundwater recharge characteristics of each site. Thus, the primary approach to reducing the volume of stormwater runoff is to protect and promote onsite infiltration and recharge of stormwater. This not only reduces runoff impacts, but increases the amount of water recharging the aquifer system, making it available for water supply use and helping to maintain stream baseflow conditions during dry weather. Municipal stormwater ordinances can play a key role in this by incorporating the following concepts.

Depending on soil type, infiltration standards can be achieved through infiltration trenches and basins. Conservation design practices that work toward disconnecting impervious surfaces and routing stormwater to pervious areas (athletic fields, open space, vegetated swales, etc.) can also be used to achieve infiltration standards and to significantly improve recharge of stormwater in developed and developing areas. Such practices should also be considered when redeveloping urban areas, to the extent that site conditions allow.

7. *Protect water quality by controlling nonpoint source pollutants.*

Stormwater is a resource when used to recharge groundwater aquifers. However, it can also have negative impacts on both groundwater and surface water quality if not properly handled. For this reason, municipalities should craft stormwater ordinances to minimize stormwater impacts on water quality. In general, this requires the use of BMPs that provide some degree of removal of both urban and agricultural pollutants prior to release to the streams or recharge to the groundwater (recommended stormwater BMPs to achieve this are provided in MS-5.3 and Appendix G).

Water quality management should be provided through the use of structural and/or non-structural BMPs. Use of the recommended structural BMPs for new development is designed to help municipalities achieve the overall objective of reducing pollutant loading. The BMPs must be sized to achieve this level of treatment for a particular size storm. It is recommended that municipalities require new development to include stormwater BMPs sized to handle at a minimum at least the net runoff from a one-inch storm. In this way, treatment through BMPs will occur on over 80 percent of the volume of rainfall that occurs in most years, and capturing runoff from over 95 percent of rainfall events that occur in an average year. Every BMP should have an acceptable form of water quality pretreatment. This generally means some form of sediment trapping at the front (receiving) end of the BMP.

Non-structural approaches that contribute to water quality protection include conservation design practices that minimize the amount of stormwater runoff generated; reduce and disconnect impervious land cover; infiltrate or re-use stormwater onsite; minimize site disturbance and concentrate development; and protect floodplains, riparian buffers, riparian wetlands, woodlands, steep slopes, and other natural areas through ordinance provisions.

Stormwater ordinances should pay particular attention to runoff from land uses prone to having contaminated runoff. These areas should have some sort of pre-treatment prior to infiltration or discharge to streams. These areas include:

- Vehicle salvage yards and recycling facilities
- Vehicle service and maintenance facilities
- Vehicle and equipment cleaning facilities
- Fleet storage areas for buses, trucks etc.
- Facilities that generate or store hazardous materials
- Industrial sites
- Outdoor liquid container storage
- Outdoor loading and unloading facilities
- Public works storage areas
- Commercial container nurseries.

Pre-treatment BMPs may include oil/water separators and water quality inlets, sand or organic filters, multi-chamber treatment trains, wet detention or stormwater ponds, and riparian wetlands. In addition to BMPs, jurisdictions should consider protecting and vegetating steep slopes and road embankments and stabilize gravel and dirt roads to reduce runoff and erosion.

8. Protect adjacent lands from direct stormwater discharge.

It is recommended that municipalities craft stormwater ordinances to avoid the situation where stormwater is simply discharged to a neighboring property to avoid the use of BMPs or construction of additional conveyance systems (open swales, culverts, etc.). It is recommended that such practices be prohibited unless an easement for conveyance or discharge of stormwater onto adjacent properties is obtained. This can become a problem when a developing property is located away from a waterway and cannot discharge collected stormwater directly into a stream. Strategies to protect adjacent lands from erosion and flooding include obtaining an easement through which the discharge is conveyed, and design and construction of a conveyance swale, channel, or structure that protects the property from erosion and flooding.

9. *Ensure long-term operation and maintenance of stormwater facilities.*

It is recommended that municipal ordinances require that all BMPs have an enforceable O&M plan and agreement or other provision to ensure that the system functions as designed through its design life. The entity to be responsible for maintaining the facility should be designated (i.e., land owner, developer, municipality, stormwater utility, or homeowner association, etc.) and an adequate source of maintenance funds be established. A maintenance plan should be prepared by the developer and provided to the entity responsible for maintaining the facility. It should also be required that the municipality be given the right, without the responsibility, to enter an unmaintained facility to perform needed maintenance, and to then be reimbursed by the responsible entity.

10. *Develop a hydrologic and hydraulic stormwater model for the entire watershed.*

Prepare hydrologic and hydraulic models of the watershed to accurately define occurrences of structural and road flooding under existing and proposed future land uses in the 2-, 10-, 25-, 50- and 100-year, 24-hour storms. The development of complete models of the watershed (including all areas draining more than 100 acres) allows floodplain managers and planners to determine the likely impacts of proposed projects and developments on downstream areas. By requiring developers to submit models of the development that can be integrated into the watershed-wide model, planners can more accurately determine the most critical nodes of the drainage system and begin to prioritize capital improvements to address current and future concerns. A number of model platforms are available, the most prevalent in North Carolina being the US Army Corps of Engineers' HEC-HMS hydrologic model and HEC-RAS hydraulic model. Each is a public domain model available for download at www.hec.usace.army.mil.

MS-7 Implement Non-Stormwater Discharges Management

As evidenced by the presence of the Upper Rocky River on the state's 303(d) list of non-supporting streams, the management of fecal coliform (*Escherichia coli* [E coli] and other enterococci bacteria) in the Upper Rocky River/Clarke Creek watershed is a concern that could potentially affect the entire watershed, as the types of land uses and habitat found along this reach can be found across the watershed. In general, presence of these bacteria in streams is an indication of contamination by fecal matter from animals or humans. The fecal matter enters the stream network through a number of potential sources. Fecal matter can be deposited directly in the stream from direct contact with livestock that are bathing and drinking in the streams and connected farm ponds, from wild animals including waterfowl and mammals, or from domesticated animals. Human sources emanating from failing or unmaintained septic systems, illicit direct connections between the sanitary sewer system and the stormwater system and stream network, debilitated sanitary sewer systems having cracked or collapsed pipes and leaking joints, and chronic sanitary sewer overflows due to inadequate capacity or maintenance are also potential sources of the contamination.

The application of the appropriate management strategy to address the fecal coliform contamination is dependent on the accurate determination of the most likely sources of the contamination. As discussed above, there are a variety of potential sources for fecal coliform in the typical urbanizing watershed. It is imperative that the most likely sources of contamination be identified through fecal coliform source tracing studies before Total Maximum Daily Limits (TMDLs) are applied to the potential (but unsubstantiated) sources of fecal coliform. The fecal tracing study, which can cost-effectively be performed to develop a catalog of fecal coliform sources in the study area, can be used to accurately and cost-effectively apply the most appropriate management strategies to address the likely sources of contamination. In general, implementation of the following strategies (as appropriate based on the source tracing study and knowledge of the local wastewater collection and treatment system) will lead to some reduction in fecal coliform levels as part of a systemic program:

- Provide for routine maintenance of the sanitary sewer collection system to reduce the potential for clogging and overflows due to solids accumulation, intruding roots, and other deleterious materials.
- Perform system-wide evaluations and modeling to assess the capacity of the sanitary system and to prioritize repairs and upgrades.
- Develop an illicit connection and elimination program to remove direct connections between the wastewater collection system and the stream network.
- Raise public awareness to the need for routine on-site septic and community disposal systems through public education and outreach conducted in association with county health departments in the watershed.
- Initiate septic tank monitoring program to prevent/reduce the number of failing septic tanks.
- Coordinate planning among municipalities, counties, and utilities to ensure consistency of wastewater system development and infrastructure expansion with local land use plans, ordinances, and adopted resource management plans.
- Each municipality or group of municipalities should delineate and adopt planned growth areas where municipal wastewaters systems can be used, thus reducing the number of onsite wastewater package plants and septic tanks.
- Review and revise municipal ordinances to restrict densities of residential development in rural and natural areas where municipal wastewater will not be provided.
- Develop alternative livestock watering schemes that keep cattle out of the stream network and directly-connected lakes.
- Develop stringent pet-waste ordinances and increase awareness of the importance of properly disposing of pet waste, particularly on greenways and parks adjacent to the stream network.

Generally speaking, the US EPA suggests that on-site wastewater collection and disposal systems (septic systems) can provide cost-effective alternatives to centralized wastewater collection and treatment systems, provided they are maintained on a regular basis to ensure efficient operation. As development continues in the watershed, however, on-site systems will likely give way to the centralized systems as residential densities increase. As this occurs, care should be taken to ensure that the new systems are designed with adequate capacity to accommodate the planned growth.

MS-8 Continue Water Quality Monitoring and Modeling

Water quality monitoring data collected by state and municipal agencies is used to conduct the evaluations needed to make pollution control decisions. Without that data, water quality problems in the watershed could not be identified and the resulting recommendations to prevent/reduce future problems could not be developed with reasonable chances for success. The more extensive the catalog of water quality monitoring data, the more specific the identification of problems and solutions can be. In addition to identifying problems and solutions in the watershed, the NRCS has identified ten reasons for conducting water quality monitoring (USDA-NRCS, Dec. 1996):

- Analyze trends
- Define water quality problem
- Determine source, transport, and fate of pollutants
- Define critical areas
- Model validation and calibration
- Conduct research
- Assess compliance
- Measure effectiveness of conservation practices
- Evaluate program effectiveness
- Make waste load allocations.

MS-8.1 Water Quality Monitoring Parameters

It is important to identify the water quality parameters that should be sampled versus those that can be sampled. Water quality sampling can be a very expensive process and should therefore be optimized to obtain the most valuable information for the least cost. Using historical water quality monitoring data can help identify the specific parameters that should continue to be monitored versus those that have not shown to exceed state standards in the past. Parameters that have been shown to exceed state standards should be continually monitored, especially once controls have been put in place, to determine if the proposed solutions are indeed reducing pollutant concentrations. Parameters such as mercury, cadmium, iron, etc. may have

shown no dangerous levels based on historic data, as shown in Appendix D. Those parameters should not be permanently ignored, but the interval between sampling may be reduced. A water quality analysis of historic water quality monitoring data was conducted for this study and can be found in Section 3.

Because water quality monitoring is often conducted for the purpose of identifying potential sources of pollutants, a blend of wet and dry-weather sampling is important. Pollutants are generally associated with surface water runoff and are therefore reflected in wet-weather sampling, but groundwater contamination can often be the source of pollution in streams. Effective dry-weather flow sampling will help indicate whether unusually high levels of pollutants are the result of surface water or groundwater contamination. Wet-weather sampling will also allow storm events to be modeled using water quality models such as SWMM and HSPF.

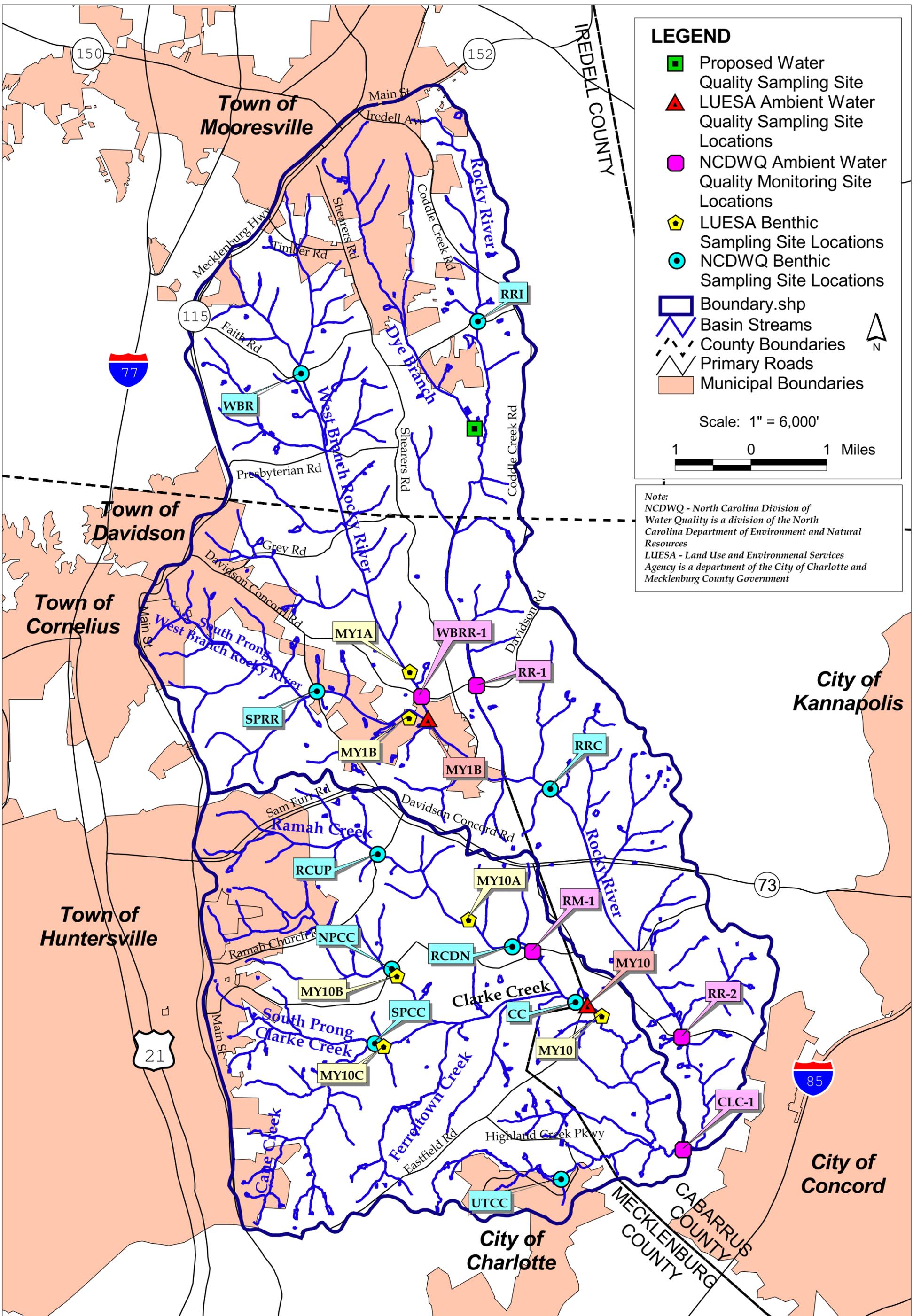
MS-8.2 Water Quality Monitoring Locations

The appropriate locations of monitoring sites should be based on observed problems in the watershed, areas of the watershed that have not been monitored in the past, and areas of significant aquatic habitat. The NRCS's *National Handbook of Water Quality Monitoring, 1996* offers recommendations on developing monitoring strategies. When implemented, these various stations will provide a catalog of data throughout the watershed that will enable more specific problem areas to be identified. As previously mentioned, water quality monitoring can be a very expensive task. Limited funds may reduce the number of sites, therefore identifying the appropriate location can be a very important task.

Water quality sampling should be performed immediately upstream of areas of significant aquatic habitat. Protecting and monitoring these areas will ensure continued ecological diversity and a source of reference for other streams in the watershed of what local habitat can endure. Sample locations should be located upstream and downstream of areas of high nonpoint and point source discharges. Development of a widespread network of monitoring stations downstream of diverse land uses will enable improved assessment of how much degradation to the stream network is likely attributable to specific watershed stressors.

MS-8.3 Additional Monitoring

All water quality models should be calibrated or verified using site-specific field data. Models such as the WMM require runoff quantity and water quality data for calibration. An extensive catalog of water quality monitoring data from a suite of sampling sites is necessary to estimate accurate pollutant loads, regardless of the level of detail the model is capable of providing. The NCWRP and NCDWQ are currently working together to collect water quality data over a one-year period at the five locations in the watershed, as shown on **Figure 6-4**. The sampling includes bi-monthly baseflow sampling with random storm flow sampling included. The LWPG should consider partnering with NCDWQ to continue sampling at these locations at the end of the current contract and increase the interval. The Mecklenburg County



Data Source: NCCGIA 2000 BasinPro and Mecklenburg, Iredell, and Cabarrus County GIS Departments

Figure 6-4
 Upper Rocky River/Clarke Creek Local Watershed Plan
 Water Quality Sampling Site Locations (Chemistry and Benthics)



Land Use and Environmental Service Agency (LUESA) currently collects water quality data at two locations in the watershed, also shown in Figure 6-4. Telephone conversations with LUESA indicate that sampling is expected to continue at these locations.

Streamflow and precipitation monitoring gages should be included at all water quality sampling sites. Water quality models, such as WMM, use storm flow and baseflow estimates in conjunction with event mean concentrations (EMCs) to calculate pollutant loads. The water quality models cannot be calibrated to match loadings predicted by the models without streamflow monitoring data. Precipitation data is also vital for accurately modeling specific storm events in large watersheds, such as this one. Rainfall intensity, duration, and quantity can all vastly affect the pollutant concentrations observed throughout the watershed.

Additional long-term sampling and data collection will be needed to continue developing a catalog of water quality data that can be used to refine the watershed management efforts undertaken by the LWPG in the years to come. Specific recommendations for additional water quality monitoring and data collection to support decision-making tools are listed below.

- Continue to sample baseflows monthly and storm flows quarterly (or as frequently as practicable) at the identified NCDWQ monitoring stations for the long term to develop a catalog of data and identify watershed trends.
- Consider adding an additional monitoring station at the confluence of Dye Branch and the Rocky River south of Mooresville to provide better resolution of land uses in the upper reaches of the watershed.
- Conduct benthic macroinvertebrate surveys annually at the ten established survey stations in the watershed to develop a catalog of data and to monitor the effects of land use changes and the implementation of watershed management strategies
- Sample Charlotte-Mecklenburg LUESA's monitoring stations MY-1B and MY-10 during the same baseflow and storm flow events as the NCDWQ stations using the same methods and, if possible, the same personnel.
- Install streamflow gages and rain gages at each NCDWQ monitoring station to provide streamflow data and spatial rainfall data.
- Implement a Weather-Tracker program in the watershed to have interested residents record weather information that can be used for the refinement and calibration of hydrologic and water quality models.
- Consider sampling for pesticides at least biannually after performing cursory research into the types actively used in the watershed.
- Conduct a Bacterial Source Tracking (BST) effort using antibiotic resistance methods to identify potential fecal coliform contamination sources to support the implementation of effective and appropriate management strategies.

In addition to water chemistry monitoring, monitoring of benthic macroinvertebrates, particularly aquatic insects, is an extremely important tool for assessing the health of streams, rivers, and lakes. Biological surveys are good indicators of both short- and long-term conditions, as various intolerant benthic invertebrates are eliminated and replaced by more tolerant forms as waters become polluted. Certain species of macroinvertebrates can also be good indicators of a wide range of pollutants, thus possibly reducing the amount of water chemistry parameters that should be sampled. See Section 3 of this LWP for additional information related to benthic sampling performed in the watershed.

MS-8.4 Additional Modeling

As discussed in Section 3, the public domain Watershed Management Model (WMM) was used to support the development of the watershed management plan and establish an overall framework for assessing pollution control strategies within the watershed. A more detailed description of the modeling effort is provided in Appendix E of this LWP.

WMM should be updated periodically based on new information on pollutant loads determined by water quality monitoring and to reflect new development. Additional modeling efforts should be concentrated in subwatersheds predicted to exceed state standards and/or produce high sediment loads under existing or future land uses. A summary of the predicted pollutant loads developed by the WMM can be found in Appendix E.

MS-9 Watershed-Based Cooperative Planning

The NCWRP initiated this watershed plan in an effort to not only identify candidate restoration, enhancement, and preservation opportunities, but to develop a comprehensive management plan that sustains or improves the aquatic habitat and water quality in the watershed to the maximum extent possible. There are eight jurisdictions comprising the watershed including Mecklenburg, Cabarrus, and Iredell Counties; the Towns of Cornelius, Davidson, Huntersville, and Mooresville; and the City of Charlotte. It should be noted that Mecklenburg County will not have any jurisdictional rights in the watershed once the Town's of Cornelius, Davidson, and Huntersville incorporate their sphere's of influence in their ETJs (see Section 2.6.1 for additional information related to jurisdictional boundaries and sphere's of influence).

One overarching goal of this watershed plan is for each municipality and county to adopt this watershed-based (non-jurisdictional) MP&IS with inter-governmental cooperation and project participation. Eight individual jurisdictions makes this a challenging task, but one that would accommodate planned growth in a manner that maintains (or re-establishes) the natural hydrologic characteristics of the watershed – specifically stream baseflow, stable stream channel (geomorphologic) conditions, flood-carrying capacity of the streams and their floodplains, and surface water quality – to the maximum extent practicable within the constraints of available resources, technical feasibility, landowner willingness, and local political support.

The jurisdictions comprising the watershed should consider establishing a permanent (or long term) Watershed Management Team (or committee) for the entire Upper Rocky River sub-basin (six HUCs), who meet regularly to consider integrated efforts to fund and implement watershed restoration and preservation strategies.

Jurisdictions should consider developing special multi-jurisdictional task forces comprised of representatives from each jurisdiction to be responsible for the management strategies identified in this study. For instance, a lands preservation task force would be responsible for identifying lands containing areas of significant aquatic or wildlife resources; working in conjunction with landowners to preserve lands, purchase easements, or purchase entire parcels; and maintaining the current conditions of the land. Additional task forces may include the following:

- habitat restoration;
- habitat preservation;
- public education and outreach;
- land use planning;
- greenways and nature corridors;
- water quality;
- stormwater/floodplain management; and
- any other aspect that may influence watershed management.

These task forces would also be responsible for the development of additional watershed management plans and models for their respective tasks. For example, a stormwater/floodplain management task force may be responsible for the development of a watershed-wide hydrologic and hydraulic model and stormwater management plan. These models and plans would help determine potential locations of existing and projected future stormwater problems related to flooding, erosion, and water quality. The task forces could report periodically to the overall Upper Rocky River Watershed Steering Committee.

The MP&IS should be updated at least every five years to account for the changes in land use and associated hydrology and water quality in the watershed. The results of the work conducted by the special task forces can also be used to update the MP&IS.

MS-10 Identify Funding Opportunities

One of the most difficult aspects of watershed and stormwater planning (and project implementation) is funding. Watershed planning and project implementation cost money, and funds either come from the municipal budget, or costs are passed on to developers. Normally, however, once the developer has sold the properties, there is no source of funding for maintaining or improving stormwater facilities. The following is a compilation of watershed-related funding opportunities shown to be effective in other areas of the country and may be applied for this watershed. A list

of additional specific funding opportunities and the relevant contacts are provided in **Table 6-4**.

- Pursue **Federal** grants provided to municipalities

- National Pollutant Discharge Elimination System-Related State Program Grants

Water Quality Cooperative Agreements are available to assist states, interstate agencies, and other public or nonprofit organizations in developing, implementing, and demonstrating innovative approaches relating to the NPDES program. Examples are watershed approaches for combined sewer overflow and storm water discharge problems, pretreatment and sludge (biosolids) program activities, and alternative ways to measure the effectiveness of point source programs.

- Resource Conservation and Development Grants

These grants encourage and improve the capability of state and local units of government and local nonprofit organizations in rural areas to plan, develop, and carry out programs for resource conservation and development.

- Environmental Quality Incentives Program

This program provides technical, educational, and financial assistance to eligible farmers and ranchers to address soil, water, and related natural resource concerns on their lands in an environmentally beneficial and cost-effective manner. The program provides assistance to farmers and ranchers in complying with federal, state, and tribal environmental laws, and encourages environmental enhancement. The purpose of this program is achieved through the implementation of structural, vegetative, and land management practices on eligible land. This program is funded through the Commodity Credit Corporation (CCC). The National Resource Conservation Service (NRCS) provides overall program management and implementation leadership for conservation planning and implementation. The Farm Service Agency provides leadership for administrative processes and procedures for the program.

- Rivers, Trails, and Conservation Assistance

Federal funds provide staff assistance to support partnerships between government and citizens to increase the number of streams and landscapes protected and trails established nationwide. Examples of funded projects include develop new trails and greenways; protect and restore river resources, access and views; convert abandoned railways to multi-purpose trails; promote and develop systems of trails and greenways; conserve open space; and establish new conservation organizations and alliances.

- Pursue **state** funding and grants

**North Carolina Wetlands Restoration Program
Upper Rocky River/Clarke Creek Local Watershed Plan
Table 6-4 - Potential Funding Opportunities**

Funding Opportunity	Funding Source	Contact	Website Address
BMPs			
	Conservation Reserve Program (only applies to cropland), US Department of Agriculture, Farm Services Agency	Local	Iredell – Jeanie Murdock 704-873-6761 Ext. 3 Cabarrus – Dawn Brown 704-920-3300 Mecklenburg – Anganette Byrd 704-336-2455
	Environmental Quality Incentives Program (EQUIP, only applies to agricultural or pasture lands)	Local	Iredell – Jeanie Murdock 704-873-6761 Ext. 3 Cabarrus – Dawn Brown 704-920-3300 Mecklenburg – Anganette Byrd 704-336-2455
	Section 319 NPS Grant Program, administered by the NC Department of Environmental and Natural Resources, Division of Water Quality, Water Quality Section	State	Kim Nimmer, NC Division of Water Quality based out of Raleigh, 919-733-5083, ext. 582
	NC Clean Water Management Trust Fund	Western Piedmont	Bern Schumak, Dobson 336-366-3801
	Agriculture Cost Share Program (only applies to agricultural lands)	State	David Williams, Department of Environment and Natural Resources, based out of Raleigh 919-715-6103
STREAM RESTORATION OPPORTUNITIES			
	NC Wetlands Restoration Program	State	Hal Bryson, NC Wetlands Restoration Program, based out of Raleigh 919-733-5208
	Clean Water Management Trust Fund	Western Piedmont	Bern Schumak, Dobson 336-366-3801
WETLANDS RESTORATION OPPORTUNITIES			
	NC Wetlands Restoration Program	State	Ron Ferrell, Program Manager for the NC Wetlands Restoration Program, based out of Raleigh 919-733-5208
	Wetlands Reserve Program, US Department of Agriculture, NC Natural Resources Conservation Service	Local	Iredell – Jeanie Murdock 704-873-6761 Ext. 3 Cabarrus – Dawn Brown 704-920-3300 Mecklenburg – Anganette Byrd 704-336-2455
	Forestry Incentives Program, US Department of Agriculture, NC Natural Resources Conservation Service	Local	Iredell – Jeanie Murdock 704-873-6761 Ext. 3 Cabarrus – Dawn Brown 704-920-3300 Mecklenburg – Anganette Byrd 704-336-2455
PRESERVATION OPPORTUNITIES			
	Clean Water Management Trust Fund	Western Piedmont	Bern Schumak, Dobson 336-366-3801
	The Nature Conservancy	Local	Sandra Cavalaire, based out of Durham, 919-403-8558, ext 1017
	Conservation Tax Credit Program, NC Department of Environment and Natural Resources	State	Bill Flournoy, based out of Raleigh, 919-715-4191

**North Carolina Wetlands Restoration Program
Upper Rocky River/Clarke Creek Local Watershed Plan
Table 6-4 (continued) - Potential Funding Opportunities**

Funding Opportunity	Funding Source	Contact	Website Address
ADDITIONAL HABITAT PROTECTION / RESTORATION PROGRAMS			
	Partners for Fish and Wildlife, US Fish & Wildlife Service	State John Ann Shearer 919-856-4520, ext. 17	http://partners.fws.gov/
	Wildlife Habitat Incentives Program (WHIP, US Department of Agriculture, Natural Resources Conservation Service)	Local Iredell – Jeanie Murdock 704-873-6761 Ext. 3 Cabarrus – Dawn Brown 704-920-3300 Mecklenburg – Anganette Byrd 704-336-2455	http://www.nrcu.usda.gov/programs/whip/
	Forest Development Program, NC Department of Environment and Natural Resources, Division of Forest Resources (provides financial resources for reforestation)	Local Mount Holly, 704-827-7576 d12opsrm@ncmail.net	
	Stewardship Incentive Program, US Department of Agriculture, NC Natural Resources Conservation Service	Local Iredell – Jeanie Murdock 704-873-6761 Ext. 3 Cabarrus – Dawn Brown 704-920-3300 Mecklenburg – Anganette Byrd 704-336-2455	http://www.nrcs.usda.gov/programs/sip
	Forest Nursery Program (produces and sells at cost to NC landowners a wide variety of forest tree and shrub seedlings for forest regeneration, wildlife habitat improvements, wetlands mitigation and research)	Local Mount Holly, 704-827-7576 d12opsrm@ncmail.net	
	NC Natural Heritage Trust, NC Department of Environment and Natural Resources, Division of Parks and Recreation	State Jennifer Dennis, based out of Raleigh, 919-715-8703	http://ils.unc.edu/partkproject/heritage/nhtf.html

- North Carolina Wetlands Restoration Program (NCWRP)

The NCWRP is an innovative, nonregulatory program established by the NC General Assembly in 1996 to restore riparian wetlands, streams, and streamside (riparian) areas throughout the state. The NCWRP seeks sites that are suitable and feasible for restoration projects. The goal of stream and wetland restoration is to improve water quality, enhance wildlife habitat, reduce flooding, and provide recreation opportunities. Unlike other programs, the NCWRP does not disperse grants. The NCWRP's restoration process starts with an on-site evaluation of the potential project site. If the site is suitable, the NCWRP will acquire the property, design a project based on a reference ecosystem, and then construct and monitor the project (NCWRP).

- Pursue **local** funding and grants

- Tax Revenues (General Fund)

Property tax revenue is usually put into a local government's General Fund along with other unrestricted revenues and used to finance general government operations. The use of property tax revenue to finance stormwater system administration and operation is fairly common in cities in North Carolina. Local governments often issue general obligation bonds to finance large capital projects which are paid off over an extended period with tax revenues. Also, annual stormwater operation and maintenance funds usually come from the general fund. General funds are commonly used to fund stormwater programs because no special administrative mechanisms are required for their use (Eaker, 1994).

- Stormwater Utility

Under the public stormwater utility concept, local governments view the provision of stormwater facilities and their maintenance as a service that is being provided to their residents. Under this option, homeowners and commercial entities pay their fair share for the use of their services, with user fees based on the development's impact on the stormwater system. User fees are typically assessed by the amount of impervious area and/or land use of the tract. Using such a fee structure ensures that those who contribute the most to the stormwater problem, or those who use the system the most, will pay their share of the cost. A stormwater utility offers local governments a stable and equitable source of revenue to support comprehensive stormwater planning, capital projects, operation and maintenance activities, water quality programs, and other elements of a stormwater program. Another advantage of such a utility is that adjustments or credits can be allowed to act as an incentive for property owners to install stormwater controls to minimize stormwater runoff from their property (Eaker, 1994). Currently Charlotte, Cornelius, Davidson, Huntersville, and Mecklenburg County collect stormwater user fees to pay for related programs.

- Special Assessments

Another funding option available in North Carolina is the use of special assessments. Special assessments can be levied against properties in proportion to the benefit each receives from the particular project. Under GS 153A-185, local governments are permitted to levy special assessments for watershed improvement projects, drainage projects, and water resource development projects. This financing option is best used to finance the construction costs of specific stormwater management projects, such as construction of off-site detention/retention basins. This mechanism has the advantage of requiring those who contribute to runoff or receive a service to pay their share of the cost. Cost assessments are made based on frontage on a watercourse protected or benefited by the project. One drawback of this option is that a special assessment is a one-time source of capital project funds and is not used to cover annual operation and maintenance. Also, the work must be completed before assessments are made, requiring another source of funds to cover initial construction costs (Eaker, 1994).

- Non-Profit Land Trusts

Establish a municipal non-profit land trust capable of developing a preservation program involving grant funding, landowner contacts, and easement acquisition of riparian wetlands, such as the Davidson Lands Conservancy. A discussion of and local contact information on the Davidson Lands Conservancy and Catawba Lands Conservancy is provided in Section 2.9.1.

6.4 Management Strategies and the NPDES Phase II Stormwater Rules

A number of jurisdictions in the Upper Rocky River / Clarke Creek watershed are communities that are specifically identified by NC DWQ as being subject to the NPDES Phase II Stormwater Rules, promulgated on December 8, 1999 and required by March 10, 2003. The Towns of Cornelius, Davidson, and Huntersville, and Mecklenburg and Cabarrus Counties are included in the list of municipal separate storm sewer systems (MS4s) located in defined urbanized areas that are therefore subject to the Phase II rules. There is ongoing legal debate in North Carolina regarding the applicability of the rules to counties that has not been resolved as of the date of this report.

The Phase II rules are intended to reduce adverse impacts to water quality and habitat that are caused by unregulated sources of stormwater discharges. The Phase II rules include six minimum measures that are to be implemented “to the maximum extent practicable” to meet these objectives. They include:

- Public Education and Outreach,

- Public Participation/Involvement,
- Illicit Discharge Detection and Elimination,
- Construction Site Runoff Control,
- Post-Construction Runoff Control, and
- Pollution Prevention/Good Housekeeping.

To some extent, communities are self-regulated under the Phase II program in that they are responsible for developing a program to comply with the intent of the Phase II rules. The US EPA provides guidance documents that provide BMP recommendations and measurable goals that can be used to assess compliance. In general, the Management Strategies provided in Section 6 represent programs that would likely be in general agreement with the types of practices that can be implemented to comply with the Phase II rules.

Section 7

Recommended Watershed Protection and Improvement Project Sites

7.1 Introduction

As a key end product of this LWP, 31 recommended watershed protection and improvement project sites were identified in an effort to arrest/prevent watershed degradation and also assist the NCWRP in meeting future compensatory mitigation needs for stream, riparian buffer, and wetland impacts.

The sites were selected from a suite of candidate BMPs that were identified and screened using GIS data, windshield surveys, and input from members of the LWPG. These sites, if implemented, will provide numerous benefits including pollutant removal, flood control, streambank stabilization, aquatic and wildlife habitat, aesthetic value, and recreational opportunities for the community. The purpose of this section is to describe the selection process, initial site screening, and selection of the priority sites to be included among the recommended watershed protection and improvement project sites.

7.2 Restoration, Creation, Preservation, and Enhancement Opportunities

7.2.1 Best Management Practices Selected for Implementation

The purpose of the recommended watershed protection and improvement project sites is to restore, create, preserve, and/or enhance the natural resources in the Upper Rocky River/Clarke Creek watershed. There are numerous types of BMPs capable of performing one or more of the goals mentioned above. The purpose of this section is to identify the candidate BMPs that were considered to provide the most significant positive impact to the watershed. The following is a brief description of the BMPs selected for implementation.

Restoration

The goal of restoration is to return the natural and historic functions of a site by removing the causes of physical, chemical, and/or biological impacts. Based on GIS data, field reconnaissance, and input from members of the LWPG, CDM identified a number of streams, wetlands, and riparian buffers that have incurred considerable impacts through agricultural and urban development. Their restoration would help to improve watershed hydrology and habitat, and decrease erosion, sedimentation, and flooding. The types of restoration projects include:

- **Stream Restoration:** Stream restoration can be a cost-effective method for restoring aquatic and wildlife habitat and reducing streambank erosion and instream channel velocities. Restoration generally involves restoring the natural meandering of the stream, reconnecting the floodplain, protecting stream banks, and providing

aquatic and wildlife habitat. For additional information on stream restoration visit the NC Stream Restoration Institute at <http://www5.bae.ncsu.edu/programs/extension/wqg/sri/>.

- **Wetland Restoration:** Wetland restoration can be a costly, but highly effective method for restoring aquatic and wildlife habitat, flood control, and water quality benefits. Restoration generally involves inundating the site throughout the year and planting or re-establishing specific types of native vegetation that not only survive, but flourish under wetland conditions. For additional information on wetland restoration contact the NCWRP or visit their website at <http://h2o.enr.state.nc.us/wrp/index.htm>.
- **Riparian Buffer Restoration:** Riparian buffer restoration can be an inexpensive method for restoring wildlife habitat and providing pollutant removal benefit. Restoration generally involves planting or re-establishing a diverse species of native vegetation and trees within a 50- to 200-foot buffer on both sides of the stream and creating/ensuring sheet flow within the buffer. For additional information review the NCWRP's *Guidelines for Riparian Buffer Restoration*, which can be downloaded at <http://h2o.enr.state.nc.us/wrp/resources/resources.htm>.
- **Existing Wet Pond Retrofits:** Retrofitting existing wet ponds can be a cost-effective method for creating aquatic and wildlife habitat and improving pollutant removal benefit. Retrofitting typically involves planting wetland vegetation, removing accumulated sediment, and altering the outlet structure to capture the stormwater runoff from the one-inch storm event and possibly raise the normal pool to increase surface area, flood control benefits, and basin volume for sediment removal. For additional information, review BMP design manuals such as the NCDENR *Stormwater Management Guidance Manual* (NCDENR, 1993) and the Charlotte-Mecklenburg *Stormwater Design Manual* (City of Charlotte, 1993).

Creation

The purpose of constructing new BMPs like wet detention ponds is to control hydrology, remove pollutants through sedimentation and vegetative uptake, reduce downstream flooding, create aquatic and wildlife habitat, and provide aesthetic and recreational benefit to the community.

- **Wet Pond Creation:** Constructing wet detention ponds can be a costly, but highly effective method for providing all the benefits mentioned above. Construction involves creating a permanent and flood control pool that can be used to remove sediment and control runoff from storm events, respectively. For additional information review BMP design manuals such as the NCDENR *Stormwater Management Guidance Manual* (NCDENR, 1993) and the Charlotte-Mecklenburg *Stormwater Design Manual* (City of Charlotte, 1993).

Preservation

The goal of preservation is to ensure the continued hydrologic, ecological, and water quality benefits associated with key natural resources in the watershed. The most

effective preservation method is to remove the threat to, or prevent the decline of wetlands, streams, and riparian buffers through land and easement purchases. Several conservation programs have been created in this watershed to purchase lands having significant natural resources, such as the Catawba Lands Conservancy and Davidson Lands Conservancy, see Section 2.9.1 for a description of both of the non-profit land trusts.

- **Wetland Preservation:** Wetland preservation can be an effective method for ensuring continued benefits associated with wetlands including aquatic and wildlife habitat, flood control, pollutant removal, and aesthetic/recreational value. Preservation generally involves purchasing the wetland through non-profit land trusts or preventing development and the associate destruction of the wetland through easements. Section 2.9.1 provides a description and web links for various land trusts in NC. Section 6.3, MS-3 provides additional information on various land preservation techniques.
- **Riparian Buffer Preservation:** Riparian buffer preservation can be an effective method for ensuring the continued benefit associated with riparian buffers including aquatic and wildlife habitat and pollutant removal. All intermittent and perennial streams should have stream buffers required by local ordinances (see Section 2.7.4 to see if your jurisdiction requires riparian buffers), but increasing the required width at locations of significant natural resources can further increase the potential or preserving those resources. Preservation generally involves acquiring easements that prevent development within a riparian buffer of 200 to 300 feet on both sides of ecologically important stream reaches. Section 2.9.1 provides additional information and contact information for local land trusts.

Enhancement

Enhancement typically involves modifying an existing site to increase one or more of its functions. For the purpose of this study, enhancement projects were not specifically identified. Rather, they were assumed to be incorporated as part of preservation or restoration projects. For instance, when preserving a wetland or riparian buffer additional plantings, sediment removal, level spreaders, etc. may be incorporated to increase the pollutant removal, flood control, and aesthetic value of the site.

7.2.2 Initial Site Identification

The purpose of the initial site identification phase was to identify any potential restoration, creation, preservation, and/or enhancement projects without consideration for various siting criteria (e.g. minimum project length/area, subwatershed ranking prioritization score, upstream hydrologic controls, etc.). The reasoning for this approach was to identify as many potential opportunities without site restrictions outlined by the specific goals of this LWP. For example, a stream restoration opportunity may not meet the minimum length requirements outlined in this study, but may be located in a Tier 1 or 2 subwatershed, on a second-order

stream, and on a single parcel (see Figures 4-1 through 4-3). The site may not be a priority due to length restrictions, but may be easily implemented due to intangibles not capable of being identified by this analysis (e.g. land owner cooperation). The initial site identification was performed using GIS data, windshield surveys and field reconnaissance conducted for the Rosgen Level I assessment, and input from members of the LWPG.

7.2.2.1 Site Selection Criteria and Process

GIS Data Site Identification

GIS data such as aerial photography, stream coverages, parcel coverages, planimetrics, and roads were used during the identification process. GIS data should not be used as a final design tool, but for the purposes of this watershed-wide analysis it provided sufficient detail for the screening of potential watershed project sites (see Section 2). The following is a list of the characteristics considered during the site identification process for each of the restoration, creation, preservation, and enhancement project types.

Stream Restoration

- Channelization: Does the stream appear to have been channelized in the past; based on a lack of sinuosity?
- Stream order: First through third order streams only.

Riparian Buffer Restoration

- No development: No habitable structures in the buffer.
- 1,000 feet: Minimum length of contiguous degraded buffer.
- 85 percent: Minimum percentage of degraded buffer.
- 100 feet: Minimum buffer width on either side of the stream.

Existing Wet Pond Retrofits

- Drainage area: Minimum 20 ac contributing drainage area.

Wetland Restoration

- No development: No habitable structures in the area.
- No NWI: No existing wetlands identified by the NWI.
- Hydric soils: There must be existing hydric soils based on the GIS soils coverages.

Riparian Buffer Preservation/Enhancement

- 85 percent: Minimum percentage of forested buffer.
- 2,000 feet: Minimum length of contiguous forested buffer.
- 2 parcels: Maximum number of parcels per 2,000 feet.
- 300 feet: Minimum buffer width on either side of the stream.

Wet Pond Creation

- Drainage area: Minimum 20 ac contributing drainage area.

Potential wetland preservation/enhancement was not evaluated using GIS data due to the significant number of wetlands identified by the NWI and inability to identify site-specific characteristics and differentiate between the effectiveness of each wetland.

Field Site Identification

Candidate restoration, creation, preservation, and enhancement sites were identified during windshield surveys and the Rosgen Level I assessment. Particular consideration was given to sites having signs of degraded habitat and structural condition of streams, wetlands, and riparian buffers. Many factors were considered in identifying potential projects including accelerated rates of bed degradation and channel bank erosion; lack of forest cover and/or mature vegetation in the riparian buffer; anticipated impacts to the riparian buffer during the restoration process; lack of channel sinuosity, particularly in non-wooded cattle pastures; presence of riparian wetlands for preservation and enhancement; and channel instability/degradation.

Input from LWPG

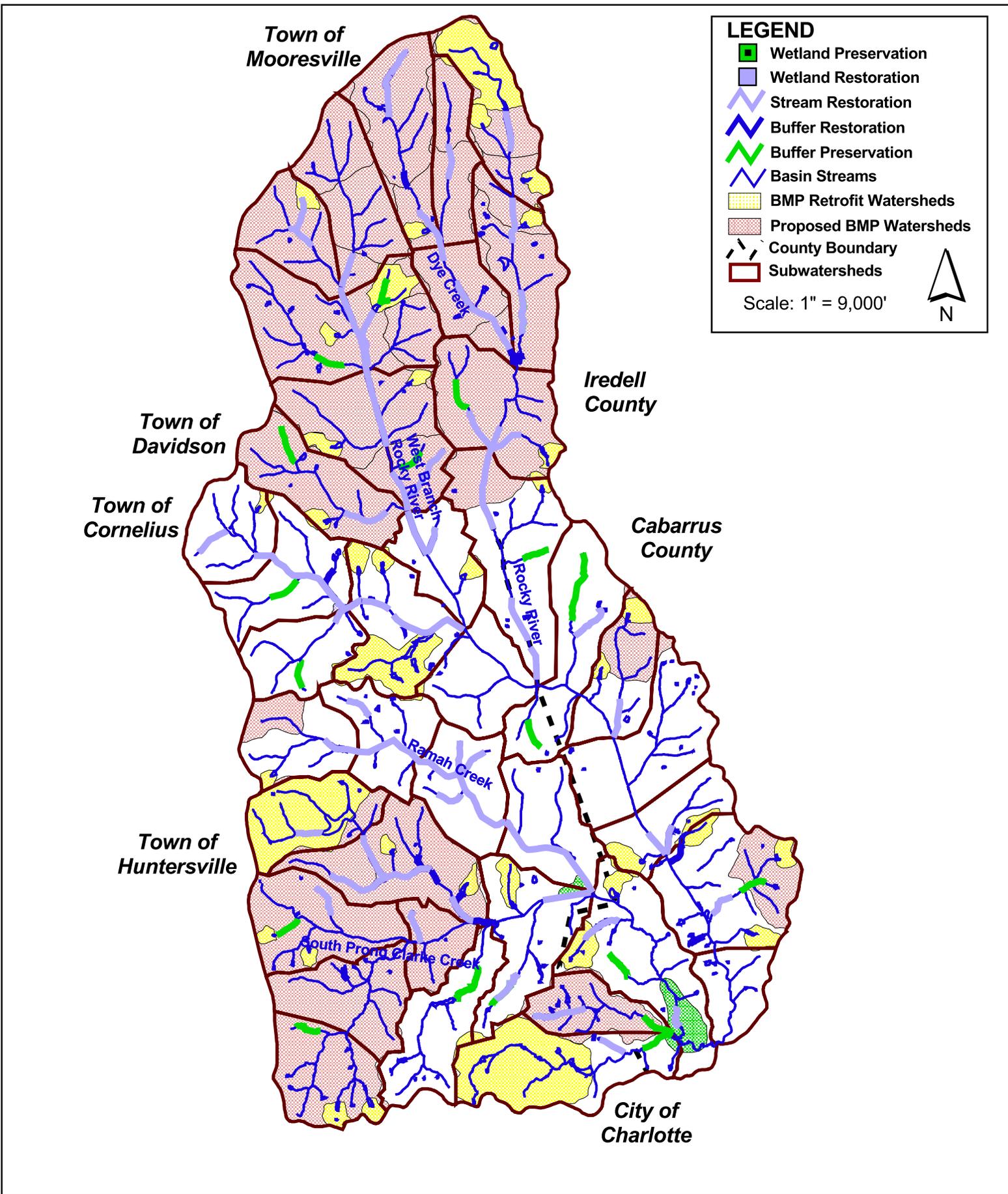
Members of the LWPG provided input on locations of potential restoration and preservation opportunities based on their extensive knowledge of and experience in the watershed. Input was provided during meetings, email correspondence, and telephone conversations with the LWPG.

7.2.2.2 Results of the Initial Site Identification

The GIS data, windshield surveys, and input from members of the LWPG resulted in the identification of:

- 37 miles of potential stream restoration;
- 17 acres of potential wetland restoration;
- 8.5 miles of potential riparian buffer restoration;
- 5,080 acres of watershed area contributing to wet pond retrofits;
- 11,340 acres of watershed area contributing to proposed wet ponds;
- 315 acres of potential wetland preservation and enhancement; and
- 9.2 miles of potential riparian buffer preservation and enhancement.

Figure 7-1 shows each of the candidate sites and reaches identified during the initial site selection process. Approximately 22 percent of the first through third order streams were identified as candidate restoration sites. 17 percent of the existing wet ponds were identified as candidate retrofit sites. It was assumed that all of the stream and wetland restoration projects identified during the initial site identification process are viable candidate sites based on habitat and structural degradation, but it is not reasonable to assume that they can all be implemented based on cost and land owner constraints.



Data Source: NCCGIA 2000 BasinPro

Figure 7-1
Upper Rocky River/Clarke Creek Local Watershed Plan
Preliminary Watershed Protection and
Improvement Project Sites



7.2.3 Initial Site Screening

The candidate restoration, creation, preservation, and enhancement projects identified during the initial site identification were included in a preliminary analysis and then screened for the purpose of identifying the most cost-effective and beneficial sites in terms of pollutant removal, habitat creation, channel stabilization, etc. as well as the sites with the greatest potential for being implemented by the NCWRP and/or local stakeholders. Site-specific information was obtained for each of the candidate sites for the purpose of screening the sites based on criteria identified by the NCWRP and CDM through past experience with restoration and preservation work. The sites remaining after the initial screening process were considered potential improvement projects for implementation. The following is a description of the preliminary analysis and screening criteria identified for each of the potential project types.

7.2.3.1 Stream Restoration

Table F-1 in Appendix F lists each of the candidate sites and provides site-specific information related to each site. The following is a description of the criteria used in the initial site screening analysis of potential stream restoration projects.

- **Minimum stream length of 2,000 feet.** Projects less than this in length are typically cost-prohibitive when compared to longer candidate sites.
- **First through third order streams only.** Fourth order streams and above are typically cost prohibitive due to size and flow considerations. Also, based on the Rosgen Level I analysis it was determined that fourth order streams and above have likely already stabilized and the head-cut observed in the watershed has progressed to first through third order streams. Therefore, restoring a stable fourth or fifth order stream would provide less benefit than restoring a currently degrading second or third order stream.
- **Parcel impacts.** A maximum number of parcel impacts was not identified, but projects requiring approval from multiple land owners are less likely to be implemented. Therefore, candidate sites were eliminated if there were a large number of parcel impacts unless there was considerable need for restoration, land owner willingness, or other outstanding issues that may allow for a restoration project to be completed.
- **Percentage of intact riparian buffer.** It was assumed that the benefit gained from restoring a stream with a mature and fully intact riparian buffer (100 feet on both sides of the stream) may be negated due to the impacts associated with construction activities in the riparian buffer.

The initial site selection process identified 55 potential stream restoration projects totaling 37 miles. The screening criteria mentioned above resulted in the elimination of 26 candidate projects. The remaining 29 sites represent 21 miles of potential first through third order stream restoration opportunities.

7.2.3.2 Wetland Restoration

Table F-2 in Appendix F lists each of the candidate sites and provides site-specific information related to each site. A description of each of the columns is also provided in the Appendix. The following is a description of the criteria used in the initial site screening analysis of potential wetland restoration projects.

- **Development Impacts.** The required surface area for each of the existing wet pond retrofit sites was calculated and incorporated into GIS (see Appendix F for a description of the required surface area calculations and assumptions). The site was eliminated if there were any development impacts (e.g. roads, homes, etc.) within the required surface area.

There were not many screening criteria required due to the more selective site selection process, described in Section 7.2.2.1. The initial site selection process identified 2 potential wetland restoration projects covering a total of 17 acres. The screening criteria mentioned above resulted in the elimination of none of the candidate projects.

Water control structures were also considered as potential watershed BMPs capable of re-connecting the floodplain of incised streams and inundating overbank areas, thus returning the natural flood attenuating capability of the disconnected floodplain. The proposed water control structures include a weir that can be raised automatically in response to increased streamflow to temporarily store the “first flush” of runoff in the floodplain. It is possible that allowing the periodic inundation of these overbank areas in storm events that historically flooded these areas, particularly those areas that include hydric soils, could provide partial mitigation credit for NCWRP. Four candidate sites were evaluated for this study and one was eliminated due to development impacts. The three remaining sites could potentially inundate 322 acres of riparian wetlands. The results of the evaluation can be found in Table F-5 in Appendix F.

7.2.3.3 Riparian Buffer Restoration

Table F-3 in Appendix F lists each of the candidate sites and provides site-specific information related to each site. The following is a description of the criteria used in the initial site screening analysis of potential riparian buffer restoration projects.

- **Minimum project length of 2,000 feet.** 1,000 feet was initially identified as a minimum project length, but due to the considerable number potential projects, that number was increased to 2,000 feet in order to identify the largest contiguous projects.
- **Surrounding development.** There must be some urban or agricultural development directly contributing stormwater runoff to the riparian buffer. The riparian buffer would then provide pollutant removal benefit to the surrounding development. Restoring a riparian buffer that is surrounded by forest provides very little stormwater attenuation or pollutant removal benefit.

- **Land use.** Restoration projects located on land use types such as graveyards were eliminated.

The initial site selection process identified 29 potential riparian buffer restoration projects totaling 8.5 miles. The screening criteria mentioned above resulted in the elimination of 18 candidate projects. The remaining 11 sites represent 3.4 miles of potential riparian buffer restoration opportunities. It should be noted that some of the riparian buffer restoration projects were not removed from consideration if less than 2,000 feet in length but part of a candidate stream restoration project.

7.2.3.4 Existing Wet Pond Retrofit

Table F-4 in Appendix F lists each of the candidate sites and provides site-specific information related to each site. The following is a description of the criteria used in the initial site screening analysis of potential existing wet pond retrofit projects.

- **Development Impacts.** The required surface area for each of the existing wet pond retrofit sites was calculated and incorporated into GIS. The site was eliminated if there were any development impacts (e.g. roads, homes, etc.) within the required surface area.

The initial site selection process identified 36 potential existing wet pond retrofit projects, which receive stormwater runoff from 7.94 square miles (5,080 acres). The screening criteria mentioned above resulted in the elimination of 22 candidate projects. The remaining 14 sites receive stormwater runoff from 6.25 square miles (4,000 acres).

7.2.3.5 Wet Pond Creation

Table F-5 in Appendix F lists each of the candidate sites and provides site-specific information related to each site. A description of each of the columns is also provided in the Appendix. The following is a description of the criteria used in the initial site screening analysis of the proposed wet ponds.

- **Development Impacts.** The required surface area for each of the proposed wet ponds was calculated and incorporated into GIS. The site was eliminated if there were any development impacts (e.g. roads, homes, etc.) within the required surface area.

The initial site selection process identified 12 proposed wet ponds, which receive stormwater runoff from 17.7 square miles (11,340 acres). The screening criteria mentioned above resulted in the elimination of 6 candidate projects. The remaining 6 sites receive stormwater runoff from 6.7 square miles (4,310 acres).

7.2.3.6 Wetland Preservation and Enhancement

Wetland preservation/enhancement opportunities were identified through windshield surveys and input from members of the LWPG. The candidate sites,

shown in Table F-2 in Appendix F, were therefore considered viable and not screened. The potential 2 sites represent 315 acres of potential wetland preservation and enhancement opportunities.

7.2.3.7 Riparian Buffer Preservation and Enhancement

Table F-6 in Appendix F lists each of the candidate sites and provides site-specific information related to each site. The following is a description of the criteria used in the initial site screening analysis of the riparian buffer preservation opportunities.

- **Surrounding development.** There must be some urban or agricultural development directly contributing stormwater runoff to the riparian buffer. The riparian buffer would then provide pollutant removal benefit to the surrounding development. Restoring a riparian buffer that is surrounded by forest provides very little benefit.

The initial site selection process identified 19 potential riparian buffer preservation projects along 9.2 miles of stream. The screening criteria mentioned above resulted in the elimination of 10 candidate projects. The remaining 9 sites represent 5.0 miles of potential riparian buffer preservation opportunities.

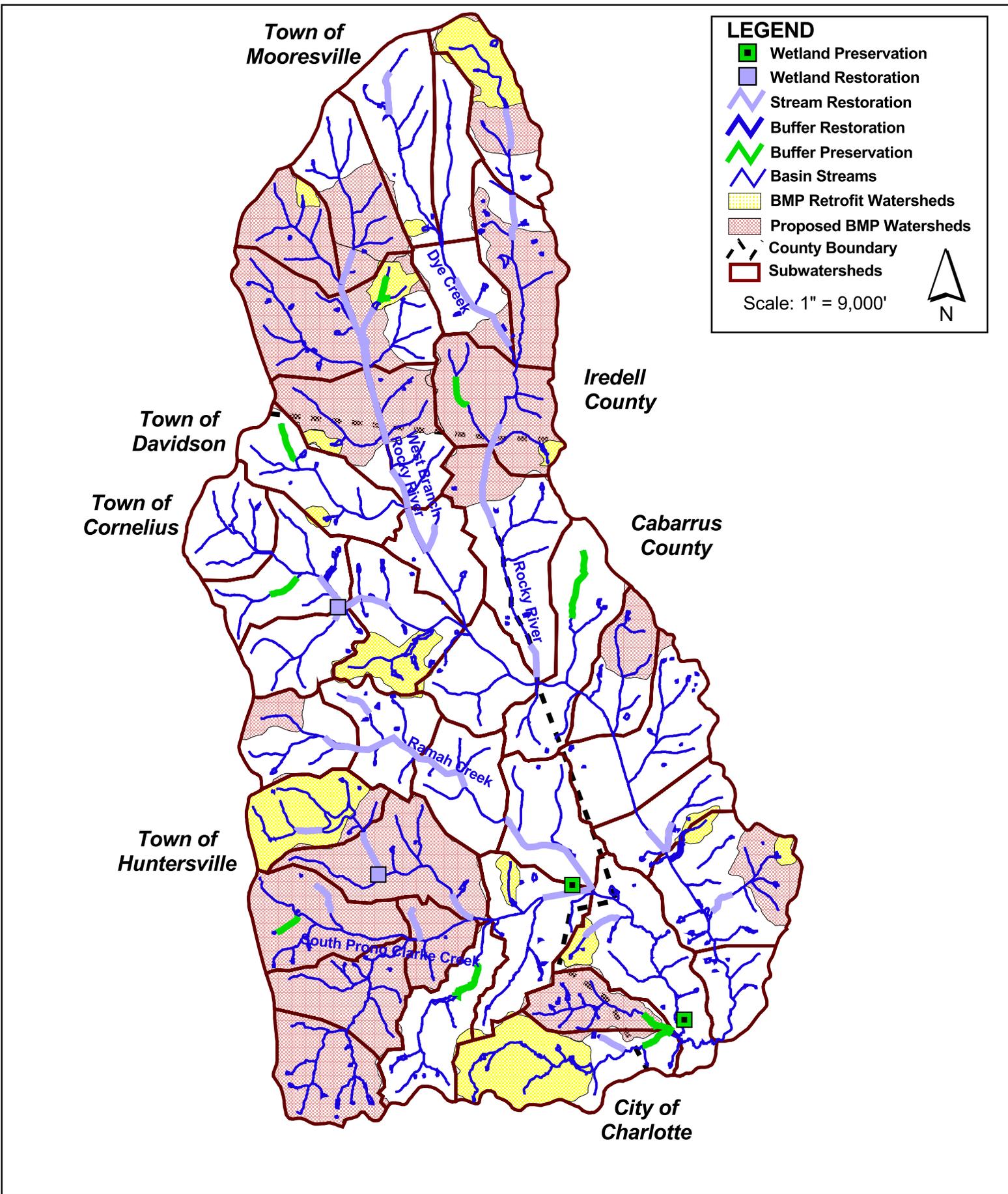
7.2.3.8 Results of the Initial Site Screening

The initial screening process eliminated several of the potential restoration, creation, preservation, and enhancement projects from consideration due to development, parcel, size, land use, etc. impacts determined from the GIS analysis. Figure 7-2 shows the remaining potential project sites that may be implemented by the NCWRP and/or local stakeholders. These sites, if implemented, will provide numerous benefits including pollutant removal, flood control, streambank stabilization, aquatic and wildlife habitat, aesthetic value, and recreation for the community.

7.2.4 Final Recommended Watershed Protection and Improvement Project Site Identification

The restoration, creation, preservation, and enhancement projects not eliminated during the initial screening phase (described in Section 7.2.3 above) were included in a more detailed evaluation which included a cost analysis, pollutant generation and removal estimate, and cost/benefit analysis to determine the projects that would provide the greatest benefit to addressing observed watershed stresses. The projects identified as recommended watershed protection and improvement sites were then ranked within their respective project categories (i.e. wet pond retrofits, stream restoration, riparian buffer preservation, etc.) based on the results of the cost/benefit analysis.

The information gathered for each of the sites during the initial screening process, shown in Tables F-1 through F-6 in Appendix F, was used to group the projects into the categories. The following is a description of the criteria considered when selecting the recommended watershed protection and improvement sites.



Data Source: NCCGIA 2000 BasinPro

Figure 7-2
Upper Rocky River/Clarke Creek Local Watershed Plan
Screened Watershed Protection and
Improvement Project Sites



7.2.4.1 Final Prioritization Criteria

Stream Restoration

There were 29 candidate stream restoration projects totaling 21 miles remaining from the initial site screening. The sites were prioritized based on the information in Table F-1 in Appendix F as well as other potential project impacts identified through additional analyses. Projects were prioritized if they were located on public lands, had few parcels (one to two), included destroyed riparian buffers, had poor Rosgen Level I scores, and most importantly, if the site is located in a Current Watershed Health and Current Natural Resources/Habitat Value Tier 1 or 2 subwatershed (see Figures 4-1 through 4-3). Other intangibles considered include the presence or absence of upstream hydrologic controls and the willingness of the jurisdiction to require hydrologic controls. Sites meeting these requirements were included as the highest-priority recommended watershed protection and improvement project sites as shown on Figure 7-3; those not meeting all of these criteria but that were still capable of improving overall water quality were considered “alternative” improvement project sites to be implemented where practicable.

Wetland Restoration

There were two candidate wetland restoration projects totaling 17 acres remaining from the initial site screening. The sites were prioritized based on the information in Table F-2 in Appendix F as well as other potential project impacts identified through additional analyses. Based on the information in the table, projects were prioritized if they were located on public lands, had low parcel impacts (two to three), and most importantly, if the site is located in a Current Watershed Health and Current Natural Resources/Habitat Value Tier 1 or 2 subwatershed (see Figures 4-1 through 4-3). Other intangibles considered include upstream water quality BMPs (i.e. wet detention pond, dry detention pond, etc.). A restored wetland is a sensitive and highly valuable resource that can be easily destroyed through heavy sedimentation from upstream development. If there is or will be a significant sediment source upstream of the proposed site, a water quality BMP must be constructed upstream of the wetland to remove the larger sediment particles from clogging up the vegetation in the wetland and significantly reducing vegetative uptake, which is a primary source of nitrogen removal in wetlands. Also, wetland restoration projects were prioritized if they were located immediately upstream of a stream restoration project that was included among the recommended project sites. The flood attenuation capabilities of the wetland would help reduce flows and velocities through the stream restoration project reach during storm events. Sites meeting these requirements were included as the highest-priority recommended watershed protection and improvement project sites as shown on Figure 7-3; those not meeting all of these criteria but that were still capable of improving overall water quality were considered “alternative” improvement project sites to be implemented where practicable.

Riparian Buffer Restoration

There were 11 candidate riparian buffer restoration projects totaling 3.4 miles remaining from the initial site screening. The sites were prioritized based on the

information in Table F-3 in Appendix F as well as other potential project impacts identified through additional analyses. Projects were prioritized if they were located on public lands, had low parcel impacts (one to two), had surrounding land use that will directly contribute stormwater runoff to the buffer, and most importantly, if the site is located in a Current Watershed Health and Current Natural Resources/Habitat Value Tier 1 or 2 subwatershed (see Figures 4-1 through 4-3). The surrounding land use criterion was an important consideration due to the benefit that would be observed immediately upon implementation of the buffer. If a riparian buffer restoration zone was directly connected to forest land, then there would not be a heavy sediment and/or pollutant load. The benefits associated with the riparian buffer (i.e. pollutant removal, reduction in stormwater runoff velocity, etc.) could not be realized by the project. Also, if the stream was among the restoration projects included in the recommended improvement projects, then restoration of the riparian buffer was included. Sites meeting these requirements were included as the highest-priority recommended watershed protection and improvement project sites as shown on Figure 7-3; those not meeting all of these criteria but that were still capable of improving overall water quality were considered “alternative” improvement project sites to be implemented where practicable.

Existing Wet Pond Retrofit

There were 14 candidate existing wet pond retrofit projects draining 4,000 acres remaining from the initial site screening. The sites were prioritized based on the information in Table F-4 in Appendix F as well as other potential project impacts identified through additional analyses. Projects were prioritized if they were located on public lands, had low parcel impacts (one to two), had mature upstream urban development, and most importantly, if the site is located in a Current Watershed Health and Current Natural Resources/Habitat Value Tier 1 or 2 subwatershed (see Figures 4-1 through 4-3). The existence of upstream urban development was prioritized due to the pollutant removal and flood control benefits observed immediately upon retrofitting the wet pond. Existing wet pond retrofits were also prioritized if a stream restoration or wetland restoration project was located immediately downstream of the wet pond and was included among the recommended project sites. As previously mentioned, the pollutant removal and flood control capabilities of the wet pond would help ensure the protection of the downstream projects. Sites meeting these requirements were included as the highest-priority recommended watershed protection and improvement project sites as shown on Figure 7-3; those not meeting all of these criteria but that were still capable of improving overall water quality were considered “alternative” improvement project sites to be implemented where practicable.

Wet Pond Creation

There were six proposed wet pond projects draining 4,310 acres remaining from the initial site screening. The sites were prioritized based on the information in Table F-5 in Appendix F as well as other potential project impacts identified through additional analyses. The prioritization criteria used were the same as that of the existing wet

pond retrofits Sites meeting these requirements were included as the highest-priority recommended watershed protection and improvement project sites as shown on Figure 7-3; those not meeting all of these criteria but that were still capable of improving overall water quality were considered “alternative” improvement project sites to be implemented where practicable.

Wetland Preservation and Enhancement

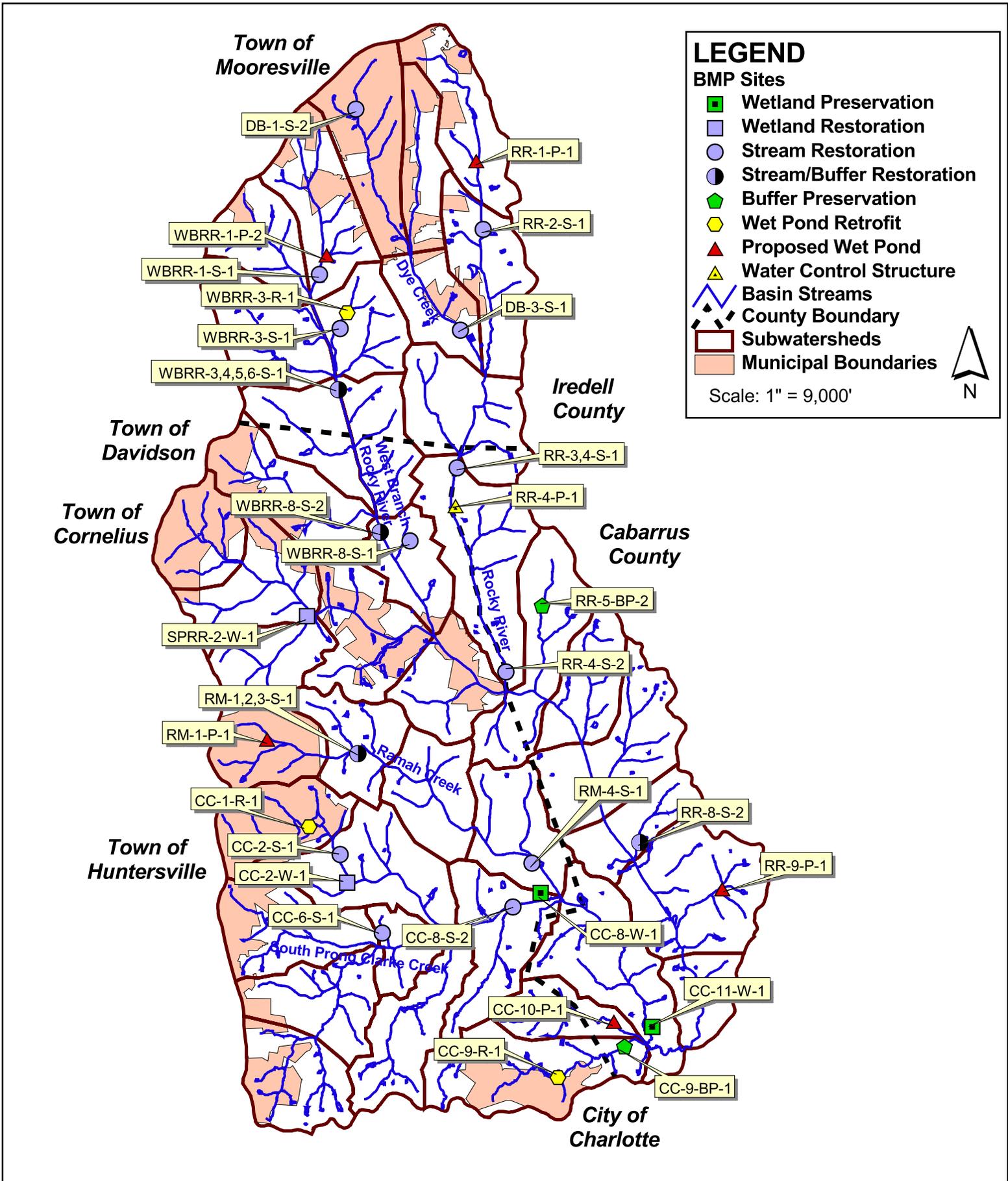
There were two candidate wetland preservation and enhancement projects totaling 315 acres remaining from the initial site screening. The sites were prioritized based on the information in Table F-2 in Appendix F as well as other potential project impacts identified through additional analyses. The prioritization criteria used were the same as that of the wetland restoration projects. Sites meeting these requirements were included as the highest-priority recommended watershed protection and improvement project sites as shown on Figure 7-3; those not meeting all of these criteria but that were still capable of improving overall water quality were considered “alternative” improvement project sites to be implemented where practicable.

Riparian Buffer Preservation and Enhancement

There were 9 candidate riparian buffer preservation and enhancement projects totaling 5.0 miles remaining from the initial site screening. The sites were prioritized based on the information in Table F-6 in Appendix F as well as other potential project impacts identified through additional analyses. Projects were prioritized if they were located on public lands, had low parcel impacts (one to two), and most importantly, if the site is located in a Current Natural Resources/Habitat Value and Future Risk Tier 1 or 2 subwatershed (see Figures 4-1 through 4-3). Other intangibles considered include the potential for development in the near future. The Tier 1 or 2 classification for the Future Risk category indicates that there are significant development pressures in the subwatershed and the site could be eliminated in two to three years due to development impacts. Also, if the stream was among the restoration projects included in the recommended improvement projects, then restoration of the riparian buffer was included. Sites meeting these requirements were included as the highest-priority recommended watershed protection and improvement project sites as shown on Figure 7-3; those not meeting all of these criteria but that were still capable of improving overall water quality were considered “alternative” improvement project sites to be implemented where practicable.

7.2.4.2 Results of the Prioritization Criteria

Figure 7-3 shows the 31 recommended watershed protection and improvement projects identified using the prioritization criteria mentioned above. The priority sites were ranked within their respective categories (i.e. wet pond retrofits, stream restoration, riparian buffer preservation, etc.) using conceptual cost estimates, results of a pollutant generation and removal analysis using WMM, and associated cost/benefit analysis.



Data Source: NCCGIA 2000 BasinPro

Figure 7-3
Upper Rocky River/Clarke Creek Local Watershed Plan
Recommended Watershed Protection and
Improvement Project Sites

Conceptual level cost estimates for the 31 candidate projects were developed in 2003 dollars using typical planning-level cost curves and costs from previous restoration work completed by the NCWRP. Riparian wetland and wet pond costs were developed for each site using cost equations based on the estimated volume of water impounded for the normal pool plus runoff from the one inch storm event (Harnell, 1986). Stream and buffer restoration costs were developed from past NCWRP project experience (Haupt, NCWRP). Land costs were accounted for restoration and preservation projects using the GIS 2002 tax parcel coverages for Cabarrus, Iredell, and Mecklenburg Counties. Surface area estimates for the proposed wet ponds and riparian wetlands were determined using a calculus based method for estimating pond volume based on topography. All conceptual project costs included an allowance for a 20-year operations and maintenance program.

The list of recommended watershed protection and improvement projects sites and associated ranking is provided in **Table 7-1**. Summary sheets were developed for each of the 31 recommended projects and are also included in Appendix F. The sheets provide site-specific information including site characteristics, subwatershed ranking, water quality analysis results, cost/benefit analysis results, which habitat stressors were addressed, and any additional relevant information. **Figure 7-4** is an example summary sheet for a stream restoration site in subwatershed CC-8 in the Town of Huntersville.

7.3 Implementation Strategy and Schedule

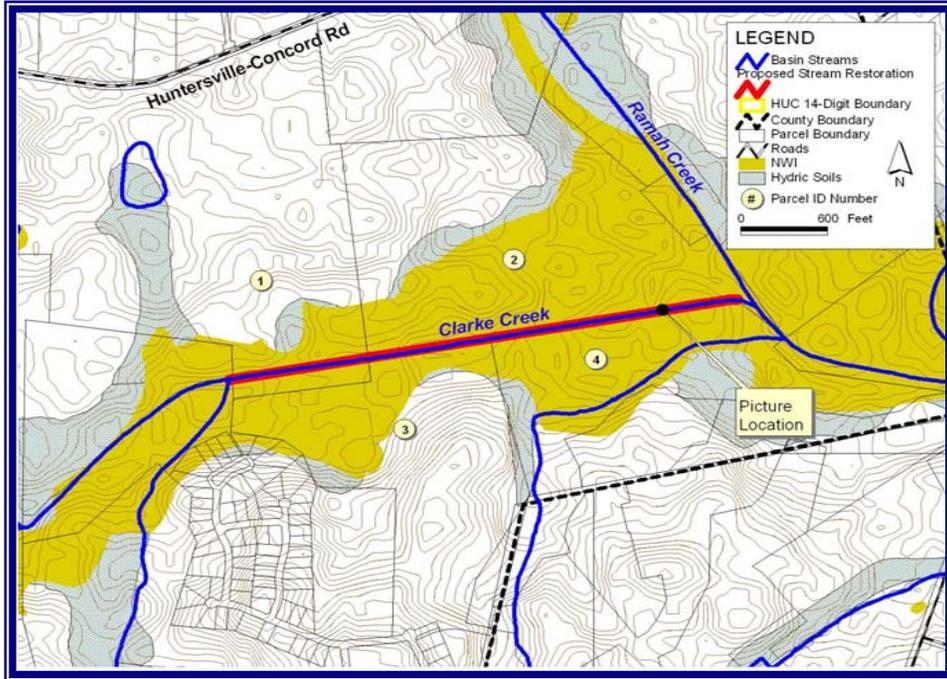
The recommended watershed protection and improvement project sites should be considered for implementation based on their cost/benefit and subwatershed priority within each category, as shown on Table 7-1. The projects were not ranked comparatively outside of their respective classifications due to the inability to quantitatively compare the benefits of different project types to one another (such as existing wet pond retrofits to riparian buffer preservation). Opportunity (i.e. land owner willingness to sell or donate conservation easements) typically becomes the primary factor for implementing BMPs on privately owned lands.

Recommended watershed management and improvement projects should be implemented by utilizing the prioritization protocol outlined in **Table 7-2**. This table assigns a priority (highest, intermediate, or lowest) to each type of project (e.g., stream restoration, wet pond retrofit, etc.) based on the location of the candidate project in the watershed. Using this protocol, projects located within tiered subwatersheds would be identified as priority projects, and groups seeking to implement projects could select between projects of the same type located in the tiered subwatersheds based on the most favorable cost/benefit ratio as shown in Table 7-1. The table may also be utilized to determine which types of projects may be most applicable to a given subwatershed based on its classification as a Tier 1 or Tier 2 subwatershed for Current Health, Current Natural Resources and Habitat Value, and Future Risk.

North Carolina Wetlands Restoration Program
Upper Rocky River/Clarke Creek Local Watershed Plan
Table 7-1 - Recommended Watershed Protection and Improvement Project Sites

Project ID	Project Type	Subwatershed	Subwatershed Ranking Protocol Results (Score)			Project Dimensions		Parcels #	Total Project Cost ²	Cost/Benefit Analysis ³		Related Project(s) ⁴
			CH ¹	NR ¹	FR ¹	acres	feet			Cost/Benefit	Basis	
Habitat Preservation Opportunities												
RR-5-BP-2	Buffer Preservation	RR-5	18	10	36	-	5,260	4	\$ 340,000	\$65.21/LF	LF Stream	
CC-9-BP-1	Buffer Preservation	CC-9	30	4	34	-	2,480	3	\$ 270,000	\$109/LF	LF Stream	Wetland Preservation (CC-11-W-1)
CC-11-W-1	Wetland Preservation	CC-11	25	13	34	265	-	9	\$ 2,940,000	\$0.82/LB	TSS	Buffer Preservation (CC-9-BP-1) and Wet Pond (CC-10-P-1)
CC-8-W-1	Wetland Preservation	CC-8	28	10	36	50	-	3	\$ 200,000	\$16.92/LB	TSS	Stream Restoration (RM-4-S-1 and CC-8-S-2)
Stream and Buffer Restoration Opportunities												
WBRR-8-S-2	Stream and Buffer Restoration	WBRR-8	17	8	33	-	3,460	2	\$ 460,000	\$133/LF	LF Stream	Stream Restoration (WBRR-8-S-1)
RR-8-S-2	Stream and Buffer Restoration	RR-8	28	10	36	-	2,180	1	\$ 290,000	\$133/LF	LF Stream	
RM-1,2,3-S-1	Stream and Buffer Restoration	RM-1,2,3	25	9	40	-	12,330	24	\$ 2,000,000	\$162/LF	LF Stream	Wet Pond (RM-1-P-1)
WBRR-3,4,5,6-S-1	Stream and Buffer Restoration	WBRR-3,4,5,6	25	9	39	-	12,100	16	\$ 2,160,000	\$179/LF	LF Stream	Stream Restoration (WBRR-1-S-1 and WBRR-3-S-1)
Stream Restoration Opportunities												
RR-4-S-2	Stream Restoration	RR-4	28	10	35	-	2,475	4	\$ 270,000	\$109/LF	LF Stream	
RR-2-S-1	Stream Restoration	RR-2	27	6	36	-	3,430	2	\$ 400,000	\$117/LF	LF Stream	Wet Pond (RR-1-P-1)
RR-3,4-S-1	Stream Restoration	RR-3,4	28	10	37	-	7,815	12	\$ 920,000	\$118/LF	LF Stream	Water Control Structure (RR-4-P-1)
RM-4-S-1	Stream Restoration	RM-4	24	12	34	-	8,950	13	\$ 1,150,000	\$129/LF	LF Stream	Stream Restoration (CC-8-S-2) and Wetland Preservation (CC-8-W-1)
CC-8-S-2	Stream Restoration	CC-8	28	10	36	-	3,540	4	\$ 470,000	\$133/LF	LF Stream	Stream Restoration (RM-4-S-1) and Wetland Preservation (CC-8-W-1)
CC-2-S-1	Stream Restoration	CC-2	26	5	34	-	3,540	4	\$ 470,000	\$133/LF	LF Stream	Wetland Restoration (CC-2-W-1)
CC-6-S-1	Stream Restoration	CC-6	28	7	33	-	2,550	4	\$ 340,000	\$133/LF	LF Stream	
DB-3-S-1	Stream Restoration	DB-3	26	2	36	-	6,515	7	\$ 1,020,000	\$157/LF	LF Stream	
WBRR-8-S-1	Stream Restoration	WBRR-8	17	8	33	-	2,050	1	\$ 330,000	\$161/LF	LF Stream	Stream/Buffer Restoration (WBRR-8-S-2)
WBRR-1-S-1	Stream Restoration	WBRR-1	28	3	39	-	2,610	2	\$ 420,000	\$161/LF	LF Stream	Stream/Buffer Restoration (WBRR-3,4,5,6-S-1) and Wet Pond (WBRR-1-P-2)
WBRR-3-S-1	Stream Restoration	WBRR-3	24	3	37	-	4,260	3	\$ 690,000	\$162/LF	LF Stream	Stream/Buffer Restoration (WBRR-3,4,5,6-S-1) and Wet Pond Retrofit (WBRR-3-P-1)
DB-1-S-2	Stream Restoration	DB-1	44	3	24	-	3,270	20	\$ 640,000	\$196/LF	LF Stream	
Stormwater and Water Quality Facilities												
CC-9-R-1	Wet Pond Retrofit	CC-9	30	4	34	13	-	3	\$ 60,000	\$0.24/LB	TSS	
CC-1-R-1	Wet Pond Retrofit	CC-1	29	1	26	32	-	2	\$ 60,000	\$0.34/LB	TSS	Stream Restoration (CC-2-S-1)
RR-4-P-1	Water Control Structure	RR-4	28	10	35	30	-	11	\$ 2,120,000	\$1.39/LB	TSS	Stream Restoration (RR-3,4-S-1)
WBRR-1-P-2	Wet Pond	WBRR-1	28	3	39	29	-	6	\$ 3,960,000	\$11.36/LB	TSS	Stream Restoration (WBRR-1-S-1)
CC-10-P-1	Wet Pond	CC-10	27	4	32	12	-	1	\$ 2,930,000	\$14.99/LB	TSS	Wetland Preservation (CC-11-W-1)
RR-1-P-1	Wet Pond	RR-1	32	3	37	21	-	4	\$ 3,270,000	\$17.49/LB	TSS	
RR-9-P-1	Wet Pond	RR-9	32	6	38	12	-	2	\$ 2,410,000	\$17.72/LB	TSS	
RM-1-P-1	Wet Pond	RM-1	20	2	40	5	-	2	\$ 1,580,000	\$26.73/LB	TSS	
WBRR-3-R-1	Wet Pond Retrofit	WBRR-3	24	3	37	4	-	1	\$ 1,070,000	\$31.06/LB	TSS	Stream Restoration (WBRR-3-S-1)
SPRR-2-W-1	Wetland Restoration	SPRR-2	22	5	31	10	-	4	\$ 470,000	\$129.22/LB	TSS	
CC-2-W-1	Wetland Restoration	CC-2	26	5	34	7	-	2	\$ 370,000	\$177.45/LB	TSS	Stream Restoration (CC-2-S-1)

- Notes:
- Subwatershed Ranking Protocol Abbreviations: CH - Current Health; NR - Natural Resources and Habitat Value; FR - Future Risk
 = Tier 1 Subwatershed = Tier 2 Subwatershed
 - Total Project Costs include estimated land cost, capital costs, and 20-year operations and maintenance costs in 2003 dollars. See Section 7 for a discussion of cost development.
 - Projects are ranked on the basis of Cost/Benefit relative to the identified basis for comparison.
 - Related Project(s) are water quality, restoration, and preservation projects that can be implemented in concert with the identified project for additional benefit to the identified and downstream subwatersheds. Refer to figure titled *Recommended Watershed Protection and Improvement Project Sites* for project locations.



Note: Heavy sediment in stream with large sand bar. Looking downstream.

Upper Rocky River/Clarke Creek Local Watershed Plan

Best Management Practice Site Identification

Site Characteristics

Site ID	CC-8-S-2
Subwatershed ID	CC-8
BMP Type	Stream Restoration
Jurisdiction	Huntersville
Stream Length (ft)	3,540
Stream Order	4
Erosion Potential	Excessive
Rosgen Score	N/A
Parcel Impacts	4
% Buffer Intact	95%
Surrounding Land Use	Agricultural/Forest
Subwatershed Percent Imperviousness	
Existing Land Use	7%
Future Land Use	21%

Cost/Benefit

Land Cost	\$29,000
Capital Cost	\$389,000
O&M Cost	\$56,000
Total Project Cost	\$470,000

Subwatershed Ranking

Category	Score	Max Score
Current Watershed Health (1 - Least Impairment)	28	70
Future Risk to Watershed Functions (1 - Lowest Risk)	36	65
Current Natl Resources and Habitat Value (1 - Fewest Resources)	10	30

Tier 1	■
Tier 2	■

Habitat Stressors Addressed

Total Suspended Solids	○
Turbidity	○
Streambank Erosion	●
Fecal Coliform	○
Nutrients	○
Stream Buffer	●
Toxicity	○
Macro-invertebrate	●

High Impact ● Low Impact ○

Additional Information/Constraints

1. Medium number of parcel impacts.
2. High degree of channelization.
3. Existing trunk sewer on north bank of stream.
4. Exceptional wetland adjacent to site.
5. Adjacent to proposed stream restoration site (RM-4-S-1) and proposed wetland preservation site (CC-8-W-1).

**North Carolina Wetlands Restoration Program
Upper Rocky River/Clarke Creek Local Watershed Plan**

Table 7-2 - Subwatershed Prioritization Ranking Protocol Recommended Implementation Strategy

Project Type	Highest Priority			Intermediate Priority			Lowest Priority		
	C	N	F	C	N	F	C	N	F
Stream Restoration	√	√		√					√
Buffer Restoration	√	√		√					√
Buffer Preservation		√	√	√	√			√	
Pond Retrofits	√	√		√					√
Wet Ponds	√					√			
Water Control Structures	√					√			
Wetland Restoration	√	√			√				√
Wetland Preservation		√	√	√	√			√	

Notes

C = Current Watershed Health

N = Current Natural Resources and Habitat Value

F = Future Risk

√ = Tier 1 or 2 subwatershed

In implementing proposed watershed protection and improvement projects, consideration should be given to upstream development (existing and future) and resulting storm flows when selecting and/or identifying project opportunities. Stream restoration opportunities were not identified in this study without upstream hydrologic controls either already in place, included among the top 31 recommended project sites, or required for new development by municipal ordinances. This recommendation is intended to protect potential stream restoration sites from hydrologic changes and increased stresses attributable to upstream development that can occur without hydrologic controls that match pre- and post-development peak flows. For example, the implementation strategy for stream restoration site CC-2-S-1, as shown in Table 7-1, requires that the existing upstream wet pond CC-1-R-1 be retrofit before, or in tandem, with the stream restoration opportunity to control upstream hydrology. Maintaining pre-development peak flows will help to prevent CC-2-S-1 from being destroyed by small storm events.

It should be noted that the implementation of watershed protection and improvement project opportunities should not be limited to Tier 1 and 2 subwatersheds if cost-effective projects are identified at other locations in the watershed. In general terms, projects implemented in several subwatersheds simultaneously will provide incremental benefit to overall watershed health, and are preferable to isolated projects in scattered subwatersheds.

Projects would ideally be implemented by the LWPG as soon as practicable, particularly in the case where candidate sites may be lost to impending development or before the natural resources a project is intended to protect are irreparably damaged. In the event jurisdictions are forced to choose between a number of potential projects, consideration should be given to those located in subwatersheds identified in the subwatershed ranking protocol and relative to the stated goals of the jurisdiction and the LWPG.

7.4 Conclusions

The recommended watershed protection and improvement projects sites represent the highest priority BMPs (broadly defined to include all stormwater BMPs or watershed protection/improvement project types) of those identified in this study. If all 31 of the recommended projects were implemented, the following benefits could be realized for resources in the two local watersheds:

- 7 percent of the first through third order streams would be restored.
- 0.3 percent of the degraded or destroyed wetlands would be restored.
- 20 percent of the NWI defined wetlands would be preserved.
- 4.3 percent of the destroyed riparian buffers would be restored.
- 0.5 percent of the forested riparian buffers would be preserved.

- 0.3 percent of the watershed would contribute runoff to a retrofitted wet pond or proposed wet pond.

There are also non-qualitative benefits associated with the implementation of the recommended watershed protection and improvement project sites, including aesthetic value and community recreation. Benefits such as these cannot be readily measured, but in some instances may provide more benefit than the pollutants removed and habitat created themselves.

It can be concluded that the implementation of these and other BMPs alone may not result in a significant watershed-wide decrease in pollutant concentration in the streams and lakes or obtain the overall level of watershed health desired by the members of the LWPG. The BMPs must be coupled with additional watershed management practices such as land use planning, stormwater runoff controls, public education, etc. Section 6 of this LWP discusses the watershed-wide management strategies that should be used in conjunction with the implementation of the specific recommended watershed protection and improvement project sites and provides a number of potential funding sources.

Section 8

List of Abbreviations

- BMP – Best Management Practice
- BMP TYPES
 - BP – Buffer Preservation
 - P – Wet Pond or Water Control Structure
 - R – Wet Pond Retrofit
 - S – Stream Restoration and/or Buffer Restoration
 - W – Wetland Preservation
- CIP – Capital Improvement Plan
- CMU – Charlotte-Mecklenburg Utilities
- Constituents
 - BOD – Biological Oxygen Demand
 - Cd – Cadmium
 - COD – Chemical Oxygen Demand
 - Cu – Copper
 - DP – Dissolved Phosphorus
 - Pb – Lead
 - TDS – Total Dissolved Solids
 - TN – Total Nitrogen
 - TP – Total Phosphorus
 - TSS – Total Suspended Solids
 - Zn – Zinc
- CWP – Center for Watershed Protection
- EMC – Event Mean Concentration
- ETJ – Extraterritorial Jurisdiction
- FLUM – Flood Land Use Map
- GIS – Geographical Information Survey
- GR – General Residential District
- HUC – Hydrologic Unit Code
- LID – Low Impact Development
- LUESA – Land Use and Environmental Services Agency

- LWP – Local Watershed Plan
- LWPG – Local Watershed Planning Group
- MGD – Million Gallons Per Day
- NCCGIA – North Carolina Center for Geographic Information and Analysis
- NCDENR – North Carolina Department of Environment and Natural Resources
- NCDOT – North Carolina Department of Transportation
- NCDWQ – North Carolina Division of Water Quality
- NCGICC – North Carolina Geographic Information Coordinating Council
- NCWRP – North Carolina Wetlands Restoration Program
- NCWRC – North Carolina Wildlife Resources Commission
- NHP – Natural Heritage Program
- NPDES – National Pollutant Discharge Elimination System
- NRCS – Natural Resource and Conservation Service
- NURP – Nationwide Urban Runoff Program
- SCS – Soil Conservation Service
- SRP – Subwatershed Ranking Protocol
- STREAMS
 - CC – Clarke Creek
 - DB – Dye Branch
 - RR – Rocky River
 - SPRR – South Prong West Branch Rocky River
 - WBRR – West Branch Rocky River
- SWIM – Surface Water Improvement and Management
- TIP – Transportation Improvement Project
- UDO – Unified Development Ordinances
- USDA – United States Department of Agriculture
- USGS – United States Geological Survey
- WECO – Watershed Education for Communities and Local Officials
- WWTP – Wastewater Treatment Plant
- YPDRBA – Yadkin-Pee Dee River Basin Association

Section 9

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