Hunting Creek Watershed Plan

Burke County, NC

February 2011

Prepared for Carolina Land & Lakes Resource Conservation & Development Council
1175 South Brady Avenue, Suite 101-3
Newton, NC 28658

Prepared by Equinox Environmental Consultation & Design, Inc.
37 Haywood Street, Suite 100
Asheville, NC 28801

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Executive Summary

Hunting Creek is listed on North Carolina's 303(d) list of impaired streams due to compromised ecological and biological integrity (NCDWQ 2007). Fish community samples conducted by the North Carolina Division of Water Quality (NCDWQ) in Hunting Creek found an absence of pollution intolerant fish and a high percentage of diseased fish leading to a bioclassification of 'Fair' (NCDWQ, unpublished data). In addition, NCDWQ also noted the presence of easily erodable, vertical stream banks, a sandy substrate, and the absence of true rock riffles in Hunting Creek (NCDWQ 2003).

The primary goal of this plan is to improve water quality in the Hunting Creek Watershed so that its fish communities will improve and Hunting Creek can support its designated use of maintaining biological integrity once again. In doing so, it will be removed from the state's 303(d) list of impaired waters. Additional goals of the Hunting Creek Watershed include:

- Develop additional partnerships to facilitate better land stewardship among the state, county, city, and private citizens.
- Engage the community in water quality awareness and education.
- Complement the Mission 2030 Plan (City of Morganton 2010), a comprehensive land use plan developed by the City of Morganton in 2009.
- Stimulate economic opportunities in the community and create jobs as management measures are implemented

The Hunting Creek Watershed is a 25.5 square mile urban watershed located in central Burke County and drains eastern Morganton. It is part of the Upper Catawba River Basin that originates in the South Mountains and flows north into the Catawba River upstream of Lake Rhodhiss. Interstate 40 and US Highway 70 traverse the watershed in an east-west direction. Thirty-seven percent of the Hunting Creek Watershed is developed with including residential, commercial, institutional, and industrial land uses. Forested land covers 49% of the watershed and primarily occurs in the southeastern portion of the watershed, but also occurs sporadically in the northern areas of the watershed.

Although no watershed plan exists specifically for the Hunting Creek Watershed, there are several plans and programs that have been adopted in the City of Morganton, Burke County, and the Upper Catawba River Basin. These plans and programs are important tools in directing growth, managing impervious land cover, and protecting natural resources. Further integration of advances in best management practices and low impact development would take these programs to a higher level of preventing further degradation of water quality.

To address the impairment of Hunting Creek and develop a plan of action to improve stream conditions in within the watershed, a group of stakeholders representing local governments, state agencies, institutions, and interested citizens was assembled. This group, called the Hunting Creek Partners, met on eight separate occasions to provide input to the watershed assessment and restoration plan.

A watershed assessment was conducted by Equinox Environmental Consultation & Design, Inc. (Equinox) in 2009 to begin to understand the causes of Hunting Creek's impairment. The results of that assessment are as follows:

- *Fish Community* - Overall, the species richness and composition were below normal at all sites in the Hunting Creek Watershed and are likely associated with degraded habitat.
- *Benthic Macro Invertebrate Community* - The benthic macro invertebrate communities found in Hunting Creek indicate that poor habitat is certainly a concern in the watershed as are nutrients and possibly toxic substances.
- *Water Chemistry* - Nitrogen concentrations are consistently high at all sample sites and appear to be higher in areas that drain agricultural land and low density development rather than areas with denser development.
- *Fecal Coliform Bacteria* - All sites sampled contain fecal coliform bacteria levels well over the level considered safe by the State standard.
- *Windshield Survey* - All stream channels appear to exhibit some degree of stream bank erosion and in-stream sedimentation. Sand or silt substrate dominated the majority of sites, which filled and covered aquatic habitat including riffles, pools, and other features.
- *Habitat Assessment* - Aquatic habitat assessments reflect habitat conditions that are not conducive to supporting a robust fish community.
- *Erosion Sites* - Eroding stream banks are a significant source of sediment input to streams resulting in sedimentation of riffles, pools, and other aquatic habitat features.
- *Impacted Riparian Areas* - Riparian areas were often found to be degraded due to lack of woody vegetation and soil disturbances.
- *Utility Crossings* - Over 80 miles of sewer lines exist in the Hunting Creek Watershed with a large portion of them paralleling Hunting Creek.

Data collected indicate that aquatic habitat is degraded throughout the watershed and that it is likely a combination of factors leading to stream impairment. Land cover alteration from forest to development over time has led to an increase in impervious surfaces. An increase in impervious surfaces such as roads, parking lots, and roof tops contributes to an increase in stormwater runoff. Stormwater runoff flowing off impervious surfaces carries pollutants as well as builds volume and velocity as it enters adjacent streams. The increased volume and velocity leads to stream bank erosion as the stream attempts to handle the increase in water levels. Sediment originating from eroding stream banks is causing increased sedimentation in streams. Pools and riffles have become dominated by fine sediments and lack interstitial spaces, large woody debris, and organic matter where aquatic organisms live and feed. As a result, the aquatic organism habitat has become degraded and the fish community impaired.

In addition to these impacts, agricultural and residential land management practices in the watershed are compounding matters. Agricultural practices in the watershed often include pasture or cropland directly adjacent to the stream bank resulting in a lack of woody riparian vegetation. Furthermore residential and institutional landscaping practices include mowing stream banks, which also reduce the effectiveness of riparian vegetation to filter pollutants and hold stream bank soil in place.

Implementing on-the-ground management measures and practices targeted towards remediating these impacts are necessary if conditions in Hunting Creek are to improve. The Hunting Creek Watershed Plan recommends four main management measures:

- *Stormwater Best Management Practices (BMPs)* – Stormwater BMPs offset the impacts of impervious cover and filter pollutants from stormwater runoff. The on-site detention and infiltration of runoff protects adjacent streams from increased water volumes and velocities leading to stream bank erosion by slowly releasing stormwater to match pre-development hydrology.
- *Stream Channel Restoration and Riparian Area Enhancement* - Stream restoration techniques that reestablish the proper dimension, pattern, and profile to the stream channel will result in reduced stream bank erosion, improved sediment transport, and better in-stream habitat conditions. Revegetation of the riparian area adjacent to the restored stream channel with native shrubs, trees, and herbaceous plants will reestablish a riparian area's ability to filter sediment and other pollutants originating from upland areas.
- *Protect Intact Forests* - To address future impacts to areas in the watershed with functioning stream channels and intact riparian areas, protecting undeveloped, private, forested lands will ensure the long-term health of the watershed.
- *Local Government Programs and Practices* – Programs and practices such as catch basin clean out, storm drain stenciling, low impact development, and land stewardship go above and beyond physical improvements. These practices often involve improving programs already underway and set a positive example of good stewardship that the public can learn from and follow.

Each management measure contains an outreach and education component as well as an implementation strategy consisting of specific actions, an implementation schedule that includes a timeline over which the actions are expected to be achieved, and a success indicator that tracks progress and monitors the effectiveness of the management measures.

In addition to management measures, the plan includes a watershed monitoring component and discusses the need for additional watershed assessments. Additional assessments are needed to address data gaps that still exist, particularly for water quality related issues. Routine monitoring of water quality parameters will determine whether or not implementation of management measures is resulting in reduced pollutant levels. General fish community monitoring will provide an overall indication of whether or not the ecological health of Hunting Creek is improving.

Completion of management measures over time will contribute to improving watershed conditions. It should be noted that lag times between implementation and response at a watershed level often occur and that fish communities may or may not improve greatly once restoration efforts are implemented. Based on the results of restoration efforts, it may be necessary to modify management actions during the planning period. At the end of the 10-year life span of this document, the plan will need to be re-evaluated and updated.

The Hunting Creek Watershed Plan is organized into five Sections. Section 1 introduces Hunting Creek's impairment and discusses why citizens living in the watershed should be concerned. It also introduces the Hunting Creek Partners and the process that took place in developing the Hunting Creek Watershed Plan. Section 2 characterizes the Hunting Creek Watershed with a description of its geographic location, population, and land use. It goes on to highlight existing plans in the City of Morganton, Burke County, and the Upper Catawba River Basin. Existing watershed conditions are described in Section 3. These conditions are based upon findings from the watershed assessment and include a synopsis of causes and sources of stressors. Section 4 states the watershed plan goals and describes in detail recommended management measures. This section also discusses the types of additional watershed assessments that should be undertaken to gather more information about stressors as well as a monitoring component that is intended to track improvements over time. The strategy for implementing management measures is discussed in Section 5. A plan for completing these actions is offered in a series of tables. Partners can utilize these tables to track progress over time.

The process of restoring Hunting Creek will take many years and will require broad, collaborative partnerships across multiple agencies, organizations, and jurisdictions. The Hunting Creek Watershed Plan is intended to guide planning and restoration efforts in the Hunting Creek Watershed for the next 10 years. It serves as a road map to restoring the ecological health and function of streams in the watershed so that fish communities will improve and Hunting Creek can support its designated use of maintaining biological integrity once again.

Acknowledgements

The Hunting Creek Watershed Plan was a collaborative effort of many contributing agencies, organizations, and individuals. Funding for the plan was provided under an EPA Section 319 Grant with North Carolina Clean Water Management Trust Fund monies funding watershed assessment activities.

Benthic macro invertebrate sampling, fecal coliform bacteria sampling, and additional stream walk activities were conducted by the North Carolina Division of Water Quality and the North Carolina Ecosystem Enhancement Program as in-kind contributions. Data from the Lake Rhodhiss Study was provided by Carolina Land and Lake Resource Conservation and Development Council and Dr. Jon Knight.

Finally, the Hunting Creek Partners cumulatively contributed over 170 hours of in-kind services through eight stakeholder meetings over the course of two years. Their participation was critical to providing knowledge about the watershed as well as developing outreach, education, and implementation strategies to engage the public in water quality issues.

The preparers of this plan are greatly appreciative of everyone who helped develop the Hunting Creek Watershed Plan.

Where to Find the Nine Elements in this Plan

a. An identification of the causes (stressors) and sources or groups of similar sources that need to be controlled.	Section 3 Watershed Conditions Section 3.4 Synopsis of Causes and Sources of Stressors
b. A description of the Nonpoint Source pollution (NPS) management measures that will need to be implemented to achieve load reductions and meet the goals of the watershed plan.	Section 4 Management Measures
c. A schedule for implementing the NPS management measures that is reasonably expeditious.	Section 5 Implementation Strategy
d. An estimate of the pollutant load reductions expected for the management measures.	Not Applicable due to biological impairment, however, pollutant load reductions for stormwater BMPs are provided in Section 4.2.5
e. A description of interim, measurable milestones for determining whether NPS management measures or other control actions are being implemented.	Section 5 Implementation Strategy Table 5.2 Implementation Schedule
f. A set of criteria that can be used to determine whether loading reductions are being achieved over time.	Section 5 Implementation Strategy Table 5.1 Hunting Creek Action Plan
g. A monitoring component to evaluate the effectiveness of the implementation efforts over time measured against the criteria.	Section 4.7 Watershed Monitoring
h. An information/education component to enhance public understanding of the project and encourage participation in management measures.	Section 4.2.6 Stormwater BMPs, Outreach and Education Section 4.3.5 Stream Channel Restoration and Riparian Area Enhancement, Outreach and Education
i. An estimate of the amount of technical and financial assistance needed, including associated costs and or sources to implement the plan.	Section 5 Implementation Strategy Table 5.1 Hunting Creek Action Plan

Key to Abbreviations

BMP	Best Management Practice
CCAP	Community Conservation Assistance Program
CLLRCD	Carolina Land and Lakes Conservation and Development
CMP	Corrugated Metal Pipe
CWMTF	Clean Water Management Trust Fund
CWP	Center for Watershed Protection
HUC	Hydrologic Unit Code
LEED	Leadership in Energy and Environmental Design
LID	Low Impact Development
NCDOT	North Carolina Department of Transportation
NCDWQ	North Carolina Division of Water Quality
NCEEP	North Carolina Ecosystem Enhancement Program
NCIBI	North Carolina Index of Biological Integrity
NCSU	North Carolina State University
NPDES	National Pollutant Discharge Elimination System
NPS	Nonpoint Source pollution
NRCS	National Resource Conservation Service
SWCD	Soil and Water Conservation District
TMDL	Total Maximum Daily Load
WPCOG	Western Piedmont Council of Governments
WPCC	Western Piedmont Community College

Section 1 Introduction

1.1 Hunting Creek is Impaired

Hunting Creek is impaired due to degraded aquatic habitat. In 2006, it was officially listed on North Carolina's 303(d) list of impaired streams due to compromised ecological and biological integrity (Table 1.1; NCDWQ 2007). Fish community samples conducted by the North Carolina Division of Water Quality (NCDWQ) in Hunting Creek in 2002 and 2003 found an absence of pollution intolerant fish and a high percentage of diseased fish leading to a bioclassification of 'Fair' (NCDWQ, unpublished data). NCDWQ also noted the presence of easily erodable, vertical banks, a sandy substrate, and the absence of true rock riffles in Hunting Creek (NCDWQ 2003).

Table 1.1 Hunting Creek Listed on NCDWQ's 303(d) list of Impaired Waters[1]

Catawba River Basin **Catawba River Headwaters** **8-Digit Subbasin 03050101**

Assessment Unit Number / Description / Classification	Old DWQ Subbasin	Name / Miles/Acres	Use Support Category	Use Support Rating	Reason for Rating	Parameter of Interest	Collection Year	IR Category
11-36-(0.7)		**Hunting Creek**	Aquatic Life	Impaired	Fair Bioclassification	Ecological/Biological Integrity FishCom	2003	5
From a point 1.0 mile upstream of Burke County SR 1940 to a point 0.4 mile downstream of Pee Dee Branch								
WS-IV	03-08-31	7.4 FW Miles						

[1]NCDWQ 2010 -North Carolina Integrated Report Category 4 and 5 Impaired Waters List Page 20 of 139

Hunting Creek originates in the South Mountains and flows north into the Catawba River above Lake Rhodhiss, a water supply reservoir for Morganton, Granite Falls, Lenoir, and Valdese. Lake Rhodhiss is also impaired due to high pH levels caused by excessive algal blooms and high dissolved oxygen levels. It has been reported that drinking water from Lake Rhodhiss has taste and odor problems, likely due to a type of algae growing in the lake (Knight 2009). Information is currently being gathered by NCDWQ to determine the source of the Lake Rhodhiss impairment as part of another project.

How did Hunting Creek become impaired and what can be done about it? Little data exists on water quality conditions in Hunting Creek or its tributaries other than the fish community samples collected by NCDWQ in 2002 and 2003. To begin to understand the problem, Carolina Land & Lakes Resource Conservation & Development Council (CLLRCD) contracted Equinox Environmental Consultation & Design, Inc. (Equinox) to conduct a watershed assessment in 2009. During the assessment, data was collected to establish baseline conditions on water chemistry, stream bank erosion, channel modification and other factors that may contribute to the degradation of fish communities in Hunting Creek. Based on these data and other observations, this watershed plan seeks to identify why fish communities in Hunting Creek are impaired and what steps can be taken to improve stream conditions so that Hunting Creek can support a healthy aquatic ecosystem.

Unfortunately, there are a lot of unknowns. Although the data collected provides several clues, it is difficult to come to any resolute conclusions about the causes of impairment with only two years of data. Furthermore, it is also uncertain whether or not fish communities will improve greatly once restoration efforts are implemented. What is certain, however, is that there are many opportunities to improve stream conditions in Hunting Creek through stormwater management, stream restoration and enhancement, protecting existing intact forests, and increasing public awareness of water quality issues. It is also certain that the process will take many years and will require broad, collaborative partnerships across multiple agencies, organizations, and jurisdictions. Through continuous and coordinated efforts over time, improving stream conditions will enhance the ecological and biological integrity of aquatic organisms, which may lead to the removal Hunting Creek from the impaired waters list.

1.2 Why care?

Why should citizens living and working in the Hunting Creek Watershed concern themselves with the condition of Hunting Creek? There are a number of environmental, economic, and social factors that relate stream health to community health.

Environmental Factors
Streams are valuable resources that provide a variety of ecosystem services. Ecosystem services are natural processes that benefit the environment and in-turn benefit people. A hydrologically functioning stream provides flood control that reduces property loss and damage during flood events. A healthy stream provides habitat for a variety of plants, fish, amphibians, and insects that prey on pests such as mosquitoes, black flies, and midges. A functioning aquatic ecosystem also provides surface water filtration, purification, and pollutant processing.

How the land we live on is utilized directly influences the health of streams. As it stands, much land adjacent to Hunting Creek has been cleared of woody vegetation leading to eroding stream banks that threaten to damage adjacent property. There is a reduction in the diversity of plants and animals living in Hunting Creek because the habitat is so degraded. The ability of Hunting Creek to provide ecosystem services has been greatly diminished.

Economic Factors
Financial resources are continuously required to mitigate the effects of poor water quality. Polluted water requires more money to treat so that it may be used for drinking. Additional costs are associated with repairing property, bridges, utilities, and other infrastructure due to flood damage and stream bank erosion. In most instances, it requires less of a financial investment to protect natural resources and prevent damage to streams than it costs to restore impacted streams.

During the height of algal blooms in Lake Rhodhiss, the Town of Valdese estimated an extra $800 per week to treat the drinking water at its treatment facility.
-Lake Rhodhiss Study, 2009

Enhanced stream corridors can be an attractive asset within a community. Greenways and parks along stream banks provide recreational opportunities and attract visitors who spend time and money in the area. Furthermore, implementing best management practices to improve watershed health employs local businesses such as engineers, land graders, landscapers, and nurseries, to name a few.

Bethel Park is a 30 acre city park located in the center of the Hunting Creek Watershed. The park is situated between East Prong Hunting Creek and Fiddlers Run, which converge just north of the park boundary. During rain events greater than 3 inches, water exits the stream channel and floods areas of the park and causes extensive stream bank erosion and property damage. The City of Morganton Parks and Recreation Department estimates an annual cost of $13,000 for materials to armor eroding stream banks, repair the walking track, replace amenities such as trash receptacles, restore electric lines to the light poles, as well as costs associated with in-house labor (Stines 2010).

Social Factors

Healthy streams provide recreational opportunities such as fishing, boating, swimming, or just splashing around and getting your feet wet. Attractive stream corridors consist of clean flowing water and lush vegetation that contribute to the livability and aesthetic benefits of a community. Walking paths and greenways along streams provide hiking, biking, and nature watching opportunities. When a stream is impaired, however, it cannot fulfill these uses because the water is unsafe for contact and there is a danger of collapsing stream banks. A healthy environment results in a healthy, thriving community and investing in the environment is an investment in community.

1.3 Hunting Creek Partners and the Planning Process

The Hunting Creek Watershed planning process was initiated in September 2008 to address the impairment of Hunting Creek and develop a plan of action to improve stream conditions in Hunting Creek. A group of stakeholders representing local governments, state agencies, institutions, and interested citizens was assembled (Table 1.2). This group, called the Hunting Creek Partners, met on eight separate occasions to provide input to the watershed assessment and restoration plan.

During the initial phases of the planning process, existing information about the watershed was gathered. Partners identified local needs and developed goals for the project. In addition to improving stream conditions in Hunting Creek so that it may be removed from the 303(d) impaired waters list, the Hunting Creek Partners envision integrating economic, recreational, and educational opportunities into the plan to achieve community involvement in water quality improvements.

The Hunting Creek Partners were integral in providing information about the watershed such as its history, existing land use practices, and future development activities. This information was useful in guiding watershed assessment activities. Possible restoration projects, potential landowners, and funding opportunities were presented by members of the partnership in an effort to start getting projects on the ground. The Hunting Creek Partners were also active in developing outreach, education, and implementation strategies to engage the public in water quality issues. The group discussed what water quality programs are in place, how they could be improved, what audience needs to be reached, and what message needs to be relayed and how. Each individual contributed their knowledge and expertise that collectively went towards developing the plan. An implementation strategy and schedule have been included in this plan to provide a framework for prioritizing management measures as technical and financial resources become available.

This plan is intended to guide planning and restoration efforts in the Hunting Creek Watershed for the next 10 years. Watershed problems are addressed with a focus on solutions that provide information on how much time and money is needed to address problems. Technical information such as assessment methods and data analysis is provided as an attachment in the Appendix for further investigation by the reader. Following the 10 year life span of this document, watershed conditions will likely change and the plan will need to be updated.

Table 1.2 Hunting Creek Partners

Name	Organization
Lee Anderson	City of Morganton Development and Design
Russ Cochran	City of Morganton Development and Design
Mark Young	City of Morganton Development and Design
Daniel Stines	City of Morganton Parks and Recreation
Mark Collins	Burke County Planning and Development
Susan Berley	Burke County Planning and Development
Jennifer Forney	Burke County Planning and Development
Kevin Clark	Burke County Soil & Water Conservation District
Pamela Bowman	Burke County Soil & Water Conservation District
Damon Pollard	Burke County NRCS
Russell Lyday	NRCS-Morganton Field Office
Spring Williams-Byrd	NC Cooperative Extension Service
Tony R. Gallegos	Western Piedmont Council of Governments
Johnny Wear	Western Piedmont Council of Governments
Eric Mueke	NC Division of Forest Resources
Dan McClure	Carolina Land & Lakes RCD
Donna Lichtenwalner	Carolina Land & Lakes RCD
Jack Huss	Carolina Land & Lakes RCD Board Member
Mary O'Neil	CLLRCD Council Member
Jonathon Berry	Broughton Hospital
Lee Kiser	Western Piedmont Community College
Penny Peeler	Western Piedmont Community College
Neil Wisenbaker	Western Piedmont Community College
Rick Gaskins	Upper Catawba Riverkeeper
Carrie Mahoney	Upper Catawba Riverkeeper
Connie Adams	Citizen, Foothills Soil Consulting
Fred Falls	Citizen
Pete Wallace	Citizen

Section 2 Watershed Characterization

2.1 Geographic Location

The Hunting Creek Watershed is a 25.5 square mile urban watershed located in central Burke County. It is part of the Upper Catawba River Basin that originates in the South Mountains and flows north through eastern Morganton into the Catawba River upstream of Lake Rhodhiss. Interstate 40 and US Highway 70 traverse the watershed in an east-west direction (Figure 2.1). The watershed is cataloged with the 14 digit hydrologic unit code (HUC) 03050101060050, which is a numbering system that serves as a watershed address.

Burke County is located in the Western Piedmont and Blue Ridge physiographic province of North Carolina (Griffeth et al. 2002). The landscape varies from steep mountainous terrain to rolling hills and broad valleys. Elevations within the Hunting Creek Watershed range from 2,200 feet at the southern most boundary where the South Mountains lie to 1,000 feet in the north where Hunting Creek converges with the Catawba River.

The average annual rainfall in the Hunting Creek Watershed is 49.6 inches. In the winter, the average air temperature is 40° F while in the summer the average air temperature is 75° F (NRCS 2006). The underlying bedrock in the watershed is primarily comprised of igneous intrusive and metamorphic rock such as granitic and biotite gneiss. The geology and climate greatly influence the development of soils, which are predominantly coarse-textured sandy clay loam with slowly permeable upland soils.

2.2 Population and Land Use Characteristics

Like many cities in North Carolina, Burke County had its beginnings in agriculture. From the mid 1800s to the early 1900s, crops, livestock and industry such as grist mills and tanneries were the primary economy (NRCS 2006). Industrialization in the early 1900s converted the agricultural economy to the manufacturing sector (NRCS 2006). Today, the service industry is the largest sector in Burke County with jobs related to health care (City of Morganton 2010). The unemployment rate for the county hovers around 10% (U.S. Census Bureau 2002). In 2009, Burke County has an estimated population of 89,148, while the county seat of Morganton has an estimated population of 17,029 (U.S. Census Bureau 2002).

As part of the Hunting Creek Watershed assessment, land use data were developed to spatially view land use patterns within the watershed and assist in the identification of stream impacts (Figure 2.2). Based on this analysis, 37% of the Hunting Creek Watershed is developed with 27% residential and open space, 8% commercial, institutional, and industrial, and 2% in mixed urban and transportation land uses.

Forested land covers 49% of the watershed and primarily occurs in the southeastern portion of the watershed, but also occurs sporadically in the northern areas of the watershed. The majority of forested land is within private ownership with only a small portion of forested land in public ownership. Thirteen percent of the Hunting Creek Watershed is in agricultural uses, which primarily includes pasture or hay lands. Nursery and cropland only comprise 1% of the watershed area.

Table 2.1 lists the acreage and percentage of each land use within the Hunting Creek Watershed. For a detailed discussion of methods on how land use data was developed, refer to Appendix A.

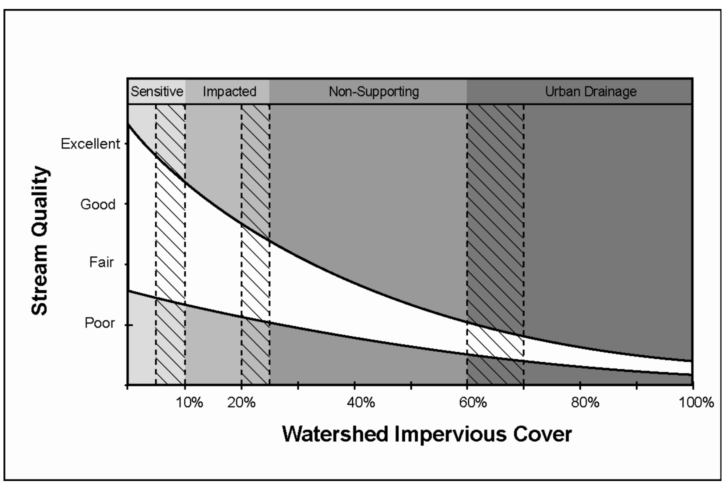
Approximately one tenth of the watershed is comprised of state-owned parcels including Broughton Hospital, the North Carolina School for the Deaf, the J. Iverson Riddle Developmental Center, and the North Carolina State Correctional Facility. In addition to these state-owned parcels, several large institutions such as Western Piedmont Community College, Grace Hospital, and the Western Carolina Center also exist in the watershed. Figure 2.3 illustrates the distribution of state, county, and city owned land within the watershed.

Using land cover data, the total amount of impervious surfaces including roof tops, driveways, sidewalks, roads, and parking lots was calculated. The estimated area of impervious surfaces in the Hunting Creek Watershed is 2,071 acres or 13% of the watershed, which is equivalent to the amount of agricultural

Table 2.1 Land Use within the Hunting Creek Watershed

Land Use	Total	
	Acres	% of Watershed
Developed	**6,071**	**37%**
Low Density Residential	3,101	19%
Medium Density Residential	903	6%
High Density Residential	62	0.4%
Commercial	565	3%
Industrial	263	2%
Institutional	609	3%
Transportation	178	1%
Mixed Urban	197	1%
Open Space	388	2%
Agriculture	**2,102**	**13%**
Cropland	76	1%
Pasture/Hay	1,878	12%
Nursery	34	0%
Livestock Operation	16	0%
Forest	**7,924**	**49%**
Forest	6,483	40%
Plantation	230	2%
Shrub/Scrub	1,114	7%
Other	**241**	**1%**
Water	39	0%
Barren Land	202	1%
TOTAL	16,337	100%

Figure 2.4 The Impervious Cover Model



The white area expresses the impervious cover to stream quality relationship. The hatched area represents the transition between stream quality conditions.

land in the watershed. Studies conducted by the Center for Watershed Protection relate watershed impervious cover to the hydrologic, physical, water quality, and biological conditions of a stream. The Impervious Cover Model predicts a decline in stream quality as the impervious cover of a subwatershed increases (Figure 2.4; Schueler 2004). In the Hunting Creek Watershed, a 13% watershed impervious cover places stream quality in the impacted classification, which is consistent with biological indicators found by NCDWQ. Stream quality of impacted streams could continue to decline if impervious cover increases within the watershed whereas stream quality could improve if management measures are implemented to mitigate the effects of impervious cover.

Figure 2.1 Location of the Hunting Creek Watershed

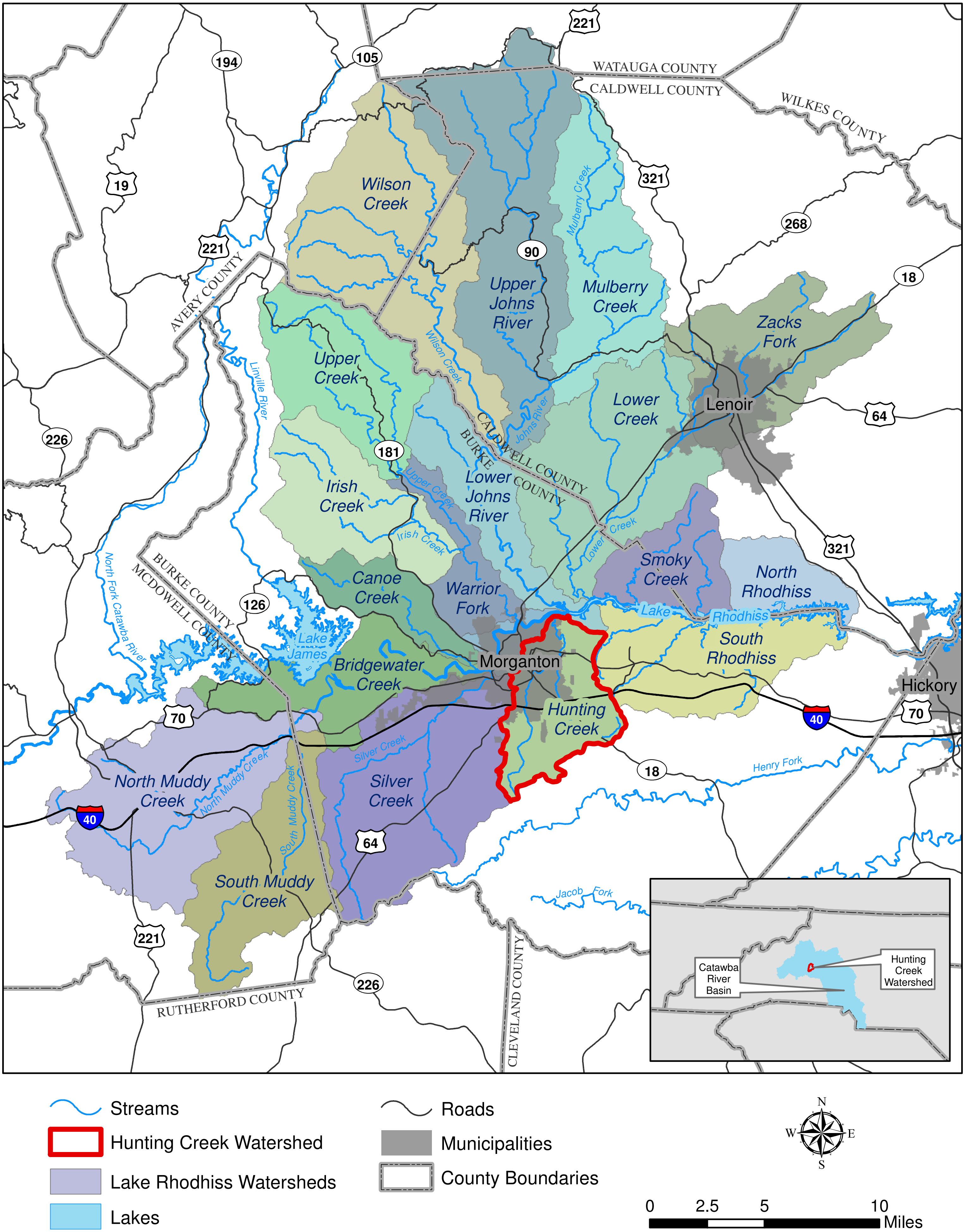


Figure 2.2 Land Use in the Hunting Creek Watershed

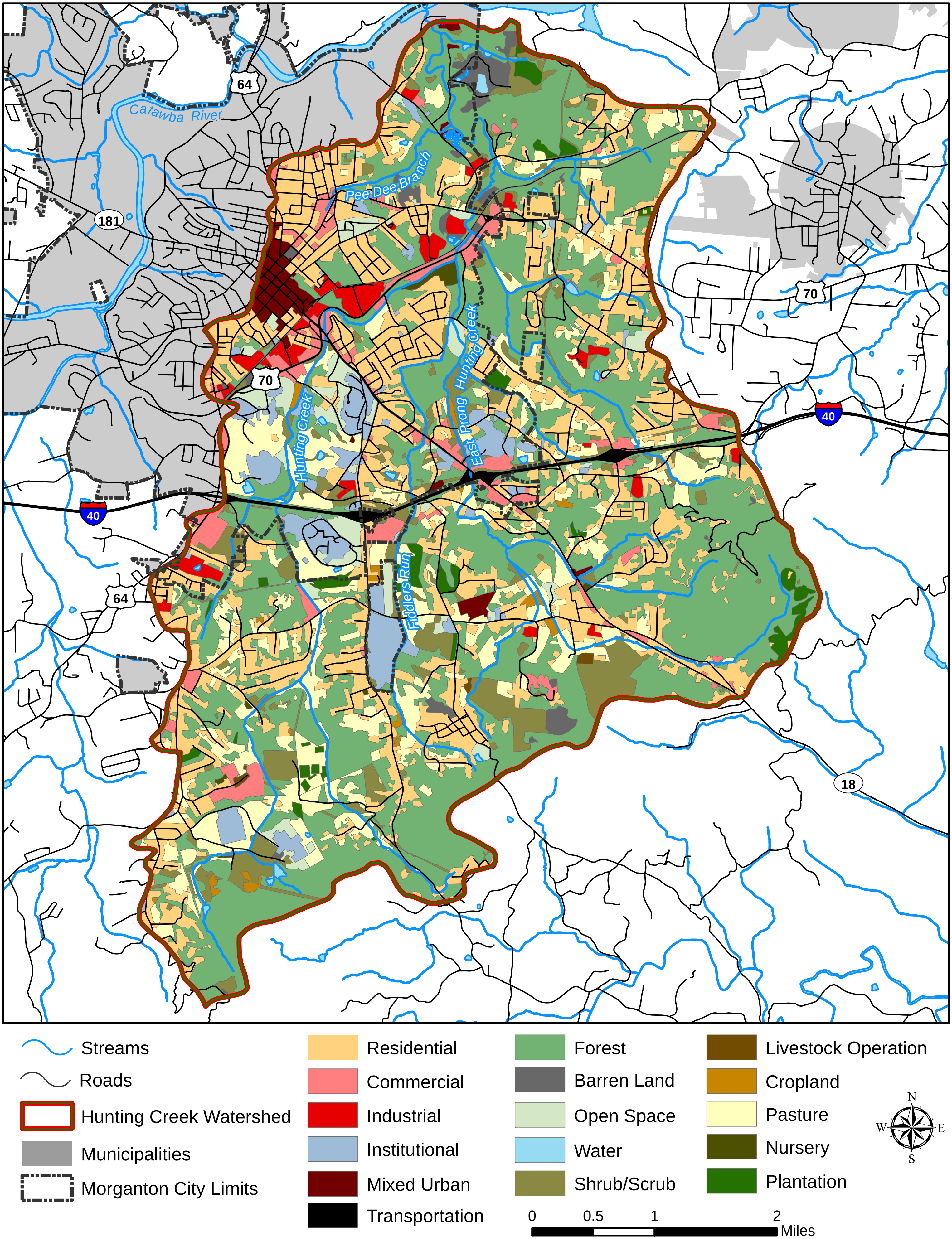
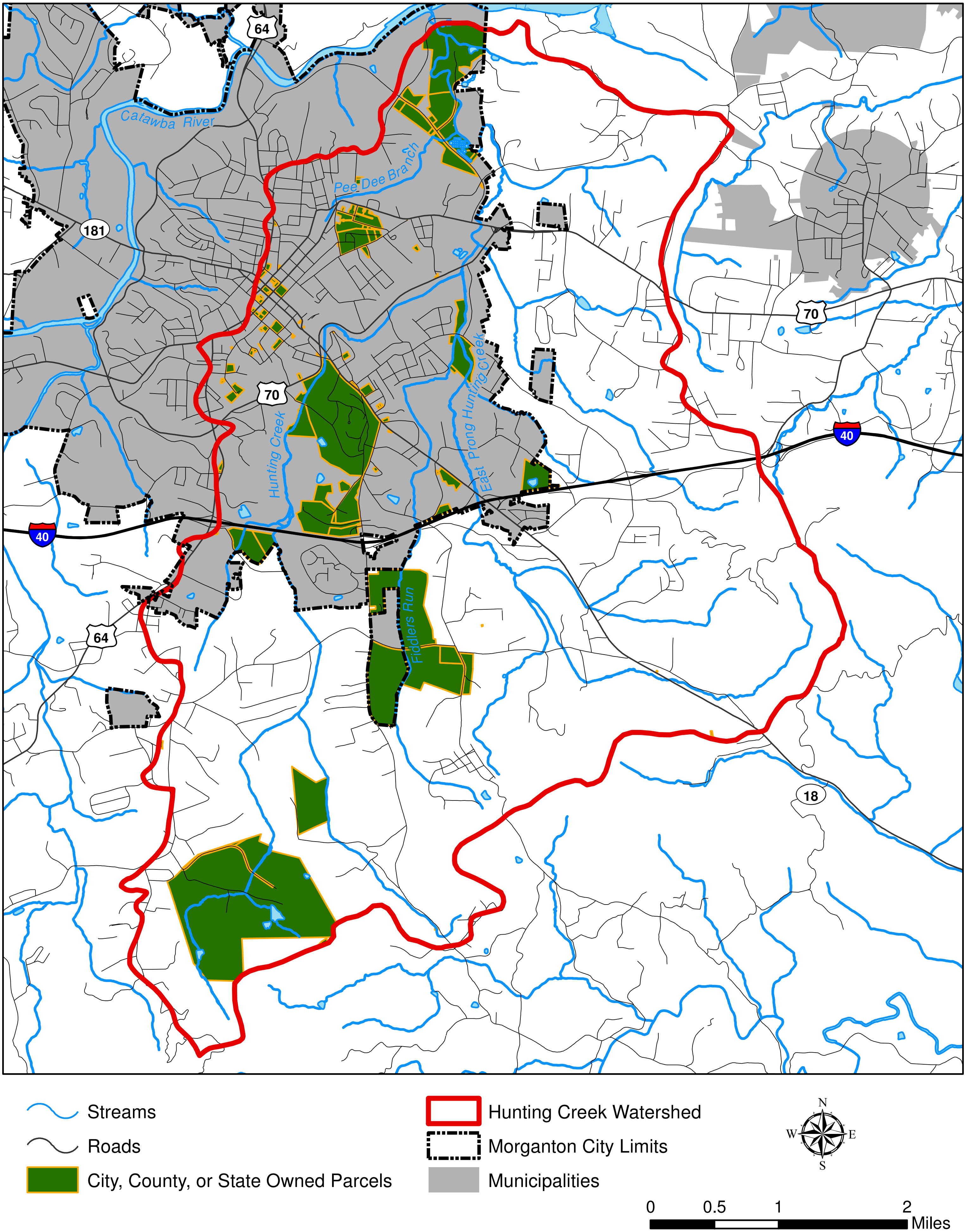


Figure 2.3 City, County, and State Owned Land in the Hunting Creek Watershed



2.3 Existing Plans and Programs

Although no watershed plan exists specifically for the Hunting Creek Watershed, there are several plans and programs that have been adopted by the City of Morganton, Burke County, and organizations in the Upper Catawba River Basin. The primary intent of these programs is to influence land use by encouraging development that protects natural resources and water quality. A brief summary of these programs are presented below, but it should be noted that the jurisdiction of these programs may or may not fall within the Hunting Creek Watershed, and therefore, may not be entirely applicable.

These plans and programs are important tools in directing growth, managing impervious cover, and protecting natural resources. Further integration of advances in best management practices and low impact development would take these programs to a higher level of preventing further degradation of water quality.

2.3.1 City of Morganton

City of Morganton Mission 2030 Plan. Completed in 2010, the Mission 2030 Plan (City of Morganton 2010) is a long-range, comprehensive plan that will guide development, land use, and decision-making over the next 10 to 20 years in the City of Morganton. Through the process of task teams and community engagement, the plan makes recommendations for sustainable land development by integrating economic development with services to the community while protecting natural and cultural resources. The City of Morganton only comprises approximately one third of the Hunting Creek Watershed, but several recommendations made in the Mission 2030 Plan do fall within the watershed. Recommendations and management measures presented in this plan for the Hunting Creek Watershed should be coordinated so that restoration efforts can be implemented in concert with development activities as opportunities arise.

Zoning and Overlay Districts (Sections 9-4005 and 9-4006). The City of Morganton has adopted zoning regulations that manage growth, prevent the improper use of land, and promote health and the general welfare of its citizens. In addition to designated zoning districts, overlay districts such as a Flood Damage Prevention District, Watershed Protection District, and Phase II Stormwater District have also been established to protect sensitive natural resources. Flood hazard areas along streams in the Hunting Creek Watershed have been delineated and include a no-build area where certain types of development are prohibited.

Watershed Protection Ordinance (Section 9-7001). The City of Morganton occurs within a public water supply watershed and has adopted regulations to protect water resources within this watershed. The Watershed Protection Ordinance regulates built-upon limits for high, medium, and low density development, specifies uses that are allowed and not allowed, and requires a vegetative buffer along all perennial waters within particular areas of the water supply watershed. It should be noted that grass qualifies as a vegetative buffer under this ordinance. The Watershed Protection Ordinance applies to the entire portion of Morganton that is within the Hunting Creek Watershed.

City of Morganton Phase II Stormwater Ordinance. The City of Morganton qualifies as a Phase II Community under the National Pollutant Discharge Elimination System (NPDES) established under authority of the Clean Water Act. As a Phase II Community, Morganton must create and maintain a stormwater program that includes strategies to sustain and improve the public storm drain system, enforce stormwater and erosion standards related to construction activities, prevent illegal dumping in the storm drain system, and educate the public about stormwater issues. In response to this requirement, Morganton has developed a Phase II Stormwater Ordinance (Sections 9-8001 to 9-8031) for varying density developments.

Street Sweeping Practices. The City of Morganton currently owns and operates two street sweeping vehicles. Over time, dirt, debris, and salt from deicing accumulate along the curbing of streets. Street sweeping removes this material before stormwater washes it into the storm drains that flow directly to streams.

The City of Asheville collected more than 2.9 million pounds of dirt and debris from city streets in 2006.
- City of Asheville Stormwater Services Report to Citizens, April 2007

2.3.2 Burke County

Zoning Ordinances. Developed in concert with the goals and objectives stated in the Comprehensive Land Use Plan of Burke County, zoning ordinances were developed to guide land development within the county. Land use and development density is regulated within specific zoning districts (Article VI Section 601). A designated Conservation District (Article IX Section 911) protects environmental areas, wildlife habitat, scenic views, and viable working farms by requiring a minimum of open space. There are no areas in the Hunting Creek Watershed that are within the Conservation District.

Catawba River, Lake James, Lake Rhodhiss, and Lake Hickory Overlay District. In order to "protect water quality, aesthetics, fish and wildlife habitat, and recreational use…by minimizing erosion, preventing siltation and turbidity, stabilizing soils, preventing excess nutrients and chemical pollution, maintaining healthy tree canopy and understory, preserving fish, birds, and wildlife habitat, and respecting the overall condition of the shoreline," Burke County incorporated an overlay district on all land within 250 feet of the Catawba River, Lake James, Lake Rhodhiss, and Lake Hickory shorelines (Article XII Sections 1201 to 1218). A natural woodland buffer must be maintained free of development within 50 feet of the shoreline. In addition, stormwater management and erosion control rules are also incorporated within this overlay district. Although this ordinance does not apply to any areas within the Hunting Creek Watershed, it does contribute to the protection of Hunting Creek's receiving waters.

Scenic Overlay District. The Scenic Overlay District (Article XXI Sections 2101 to 2117) was "enacted to encourage reasonable and appropriate development that is sensitive to aesthetic, environmental, and economic concerns…compatible with the area's natural resources, cultural history, wildlife habitat, and scenic landscapes while promoting tourism and recreational activities…" The Scenic Overlay District does not occur within the Hunting Creek Watershed, but developments within this district must preserve or enhance the ecological character and function of natural features and mitigate impacts of development. In addition, where developments within the Scenic Overlay District occur within 50 feet of a water body, a natural vegetative buffer must be maintained.

2.3.3 Organizations in the Upper Catawba River Basin

2010 Catawba River Basinwide Water Quality Plan. The Basinwide Planning Unit of NCDWQ prepares water quality plans for the 17 major river basins in North Carolina and updates them every five years. The plans aim to identify water quality problems and restore full use to impaired waters on a basinwide scale. The 2010 Catawba River Basinwide Water Quality Plan (NCDWQ 2010) was approved in September 2010 and broadly focuses assessment and management recommendations at an 8-Digit Hydrologic Unit Code (HUC) level, which amounts to over 3,000 square miles. As part of the Catawba River Basin, the Hunting Creek Watershed Plan addresses management issues at a smaller, more manageable, 14-Digit HUC scale.

Lake Rhodhiss Nonpoint Source Study. To address water quality issues contributing to the impairment of Lake Rhodhiss, CLLRCD developed a watershed restoration plan for the 745 mi^2 watershed. The study established 10 water quality sampling stations to monitor and compare nutrient loading in 12 streams flowing into Lake Rhodhiss, including Hunting Creek. The study recommends nutrient management and best management practices specifically for landscape nursery operations (CLLRCD 2009). This study is discussed further in Section 3.2.

Lake Rhodhiss TMDL. NCDWQ is currently monitoring wastewater treatment plants within the Lake Rhodhiss watershed. Monitoring will be completed in 2012 to determine if the development of a total maximum daily load (TMDL) is necessary (Adugna Kebeda, NCDWQ, personal communication, July 23, 2010). If NCDWQ determines that a TMDL is necessary for Lake Rhodhiss, all contributing watersheds including Hunting Creek will be regulated to ensure that pollutant loads do not exceed an acceptable value.

These plans and ordinances are a good foundation for protecting water quality by controlling the location and density of development in the Upper Catawba River Basin. Building upon and improving these programs will ensure better land use practices that prevent further degradation of land and water resources. Specific measures that should be incorporated into these existing programs are included in Section 4.5.

Section 3 Watershed Conditions

3.1 Water Quality Standards and Designated Uses

Over 50 miles of perennial streams flow within the 25.5 square mile Hunting Creek Watershed. These streams are classified by NCDWQ as having designated uses for drinking, culinary, or food processing purposes (Water Supply IV), wading, boating, fishing, wildlife, fish consumption, agriculture, and the survival and maintenance of biological integrity (Class C).

*A waterbody is **impaired** if it does not attain the water quality criteria associated with its designated use.*

Unfortunately, Hunting Creek is unable to fulfill these designated uses because it cannot support the survival and maintenance of ecological and biological integrity. This finding was based upon fish community samples conducted by NCDWQ in Hunting Creek in 2002 and 2003 (NCDWQ 2007). What they found was an absence of pollution intolerant fish, meaning the fish they did find can live with pollution present. They also found a high percentage of diseased fish. This resulted in a bioclassification of 'Fair' and the listing of 7.4 miles of Hunting Creek on North Carolina's list of impaired waters. Figure 3.1 illustrates the NCDWQ stream designations and the impaired segment of Hunting Creek.

To address this impairment, a need was identified to develop a watershed plan that delineates corrective actions that will reduce impacts and restore Hunting Creek back to health so that it can support its designated uses once again. Little data exists on water quality conditions in the Hunting Creek Watershed other than the fish community samples collected by NCDWQ and a 2008 study of Lake Rhodhiss tributaries, one of which is Hunting Creek. Because little information was available about water quality in Hunting Creek, a watershed assessment was conducted to identify the factors causing impairment so that on-the-ground management measures could be developed to target those sources. The following sub-sections discuss the types of assessments that were conducted to identify the causes and sources of impairment. The results and implications of assessment findings are briefly discussed. For detailed methods and data, refer to Appendix B-H.

3.2 Lake Rhodhiss Study

As part of a 2008 study to evaluate phosphorus and nitrogen loading into Lake Rhodhiss, a water quality sampling station was established on Hunting Creek just above its confluence with the Catawba River (Knight 2009). The station was one of twelve stations in the Lake Rhodhiss Watershed where grab samples were collected at 4 to 6 week intervals between April 2007 and May 2008. The water samples were analyzed for turbidity, conductivity, nitrogen, ammonia, phosphorus, and total suspended solids. Stream level and flow measurements were also taken at this station in order to calculate water discharge rates.

Results from samples collected in Hunting Creek during the Lake Rhodhiss Study (CLLRCD 2009) revealed the following:

- Nitrogen concentrations during baseflow are high compared to other streams in the study.
- Phosphorus concentrations are elevated, but are not unusually high relative to other streams in the basin.
- Nitrogen, phosphorus, and total suspended solid concentrations increased rapidly as water levels rose during storm events, while conductivity decreased slightly.
- Hunting Creek exhibited the greatest extreme water level peak during storm flows compared to base flows relative to other streams examined in the Lake Rhodhiss study.

Based on concentration and discharge data collected in the Lake Rhodhiss Study (Knight 2009), annual pollutant loads were estimated for the Hunting Creek Watershed using median nutrient concentrations as well as flow-weighted concentrations. These estimates are compared to estimates developed by the Western Piedmont Council of Government (WPCOG) using existing land use, weather, and nutrient data and plugging it into the Generalized Watershed Loading Functions computer-based model. These methods are detailed in their report entitled *Comprehensive-Based Modeling Approach for Predicting Sediment and Nutrient Loads in the Lake Rhodhiss Watershed* (WPOG 2003). Table 3.1 compares the annual pollutant loads for both estimates.

Table 3.1 Estimated Annual Pollutant Loads for the Hunting Creek Watershed, April 2007 - May 2008

Pollutant	Using Median Concentrations[1] (metric tons/year)	Using Flow-Weighted Concentrations[1] (metric tons/year)	Average of the two methods (metric tons/year)	WPCOG 2003[2] Estimates (metric tons/year)
Total Nitrogen	21.03	20.28	20.66	35.96
Total Phosphorus	0.61	1.20	0.91	2.74
Total Suspended Solids	80	140	110	--

[1]from Knight (2009)
[2]from WPCOG (2003)

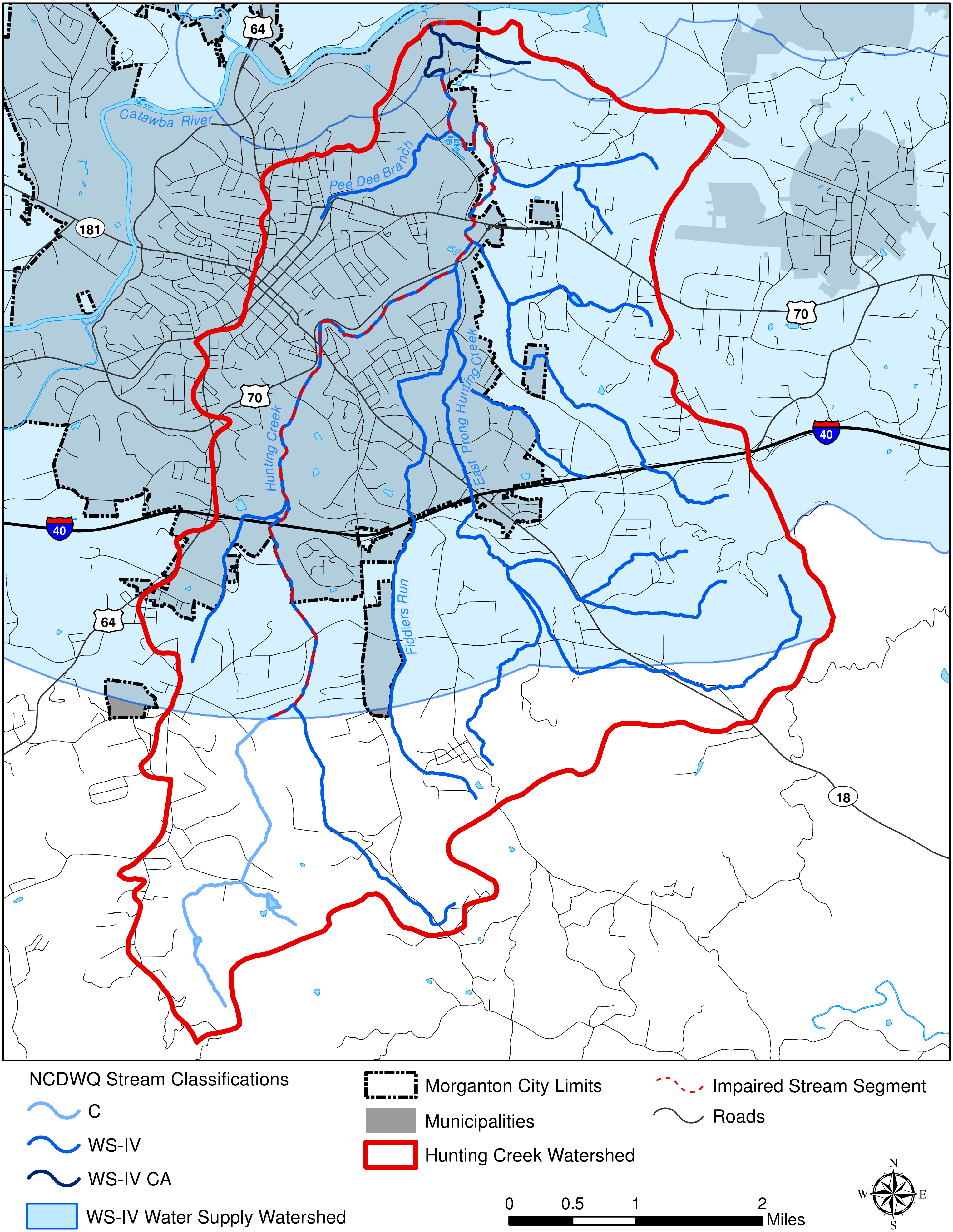
It should be noted that drought conditions existed for the duration of the Lake Rhodhiss Study. Because of this, baseflow conditions reported in the study likely represent less than typical baseflows in non-drought years. Furthermore, nutrient concentration data was collected during one small rain event, which probably does not represent a typical storm event. The implication of these conditions is likely an underestimate of pollutant loading in Hunting Creek. For additional information on the Lake Rhodhiss Study including methods and data, refer to *Phosphorus and Nitrogen Loading and Export from Rhodhiss Lake* (Knight 2009).

Explanation of Water Quality Parameters

Nitrogen	*A nutrient essential for plant growth that can cause algal growth if it occurs in excess.*
Ammonia	*A nutrient derived from decaying organic matter. Levels greater than 2.0 mg/L can be toxic to fish.*
Phosphorus	*A nutrient essential for plant growth commonly found in fertilizer. Excess phosphorus can lead to excessive algae blooms that lead to the depletion of dissolved oxygen in streams.*
Conductivity	*Measures the ability of water to conduct an electrical current due to dissolved salts and solids in the water. It is a useful indicator of water quality conditions although the dissolved substances may or may not represent pollution. Conductivity generally increases with increasing concentrations of nitrogen.*
Total Suspended Solids	*Quantifies the presence of suspended solids in water by weight (mg/L).*
Turbidity	*A measure of the visual clarity of water and indicates the presence of fine particulate matter suspended in the water column.*

Environmental Quality Institute,2004

Figure 3.1 Water Supply Watersheds & NCDWQ Stream Classifications in the Hunting Creek Watershed



3.3 Hunting Creek Watershed Assessment

Although results from the Lake Rhodhiss Study provide information about nutrients at one downstream site on Hunting Creek from which to compare nutrients in other streams in the Lake Rhodhiss Basin, the study did not reveal the reason for elevated pollutant levels in the Hunting Creek Watershed or their source. A more extensive watershed and subwatershed level assessment was necessary to evaluate potential stressors and determine what areas of the watershed contribute the most pollution.

A watershed assessment was conducted in 2009 to collect additional fish community data, water chemistry data, information about stream bank erosion, channel modification, and other factors that may contribute to the degradation of fish communities in Hunting Creek. Based on these data and other observations, a better understanding of why fish communities in Hunting Creek are impaired and what steps can be taken to improve stream conditions is gained.

3.3.1 Fish Community Sampling

To supplement the NCDWQ fish community data and to document current biological conditions within the Hunting Creek Watershed, fish community assessments were conducted at three sites in May 2009 and three sites in June 2010 (Figure 3.2). In 2009, one sample was taken at the same location as the NCDWQ site, one was taken upstream on Hunting Creek, and the other on East Prong Hunting Creek. In an attempt to sample streams with the best possible fish habitat, samples were collected on smaller streams in the upper, less developed portions of the watershed in 2010.

Equinox Environmental biologists collect fish from Hunting Creek.

Sampling methodology was based on the NCDWQ fish community assessment protocols (NCDWQ 2006b) and results were derived using the North Carolina Index of Biological Integrity (NCIBI). The NCIBI incorporates information about species richness and composition, fish abundance, age, and fish condition to summarize the effects of all classes of factors influencing aquatic communities.

NCIBI Bioclassifications

Excellent Good Good-Fair	*Fully supports aquatic life use support*
Fair Poor	*Does not support its life use support and water quality standards are not being met*

Overall, the species richness and composition were below normal at all sites in the Hunting Creek Watershed and are likely associated with degraded habitat. Based on the fish community assessment, both sites located on Hunting Creek resulted in Fair ratings, which corroborate the NCDWQ findings of 2002 and 2003 (Table 3.2; NCDWQ 2007). The East Prong Hunting Creek site rated Good-Fair, as did the upper watershed sites; however, stream conditions indicate that fish habitat is still degraded. All fish species collected during the assessment were tolerant of pollution; no intolerant or sensitive species were found, which would be an indicator of better stream conditions. It is possible, however, that even without the presence of intolerant species, a Good-Fair rating at the NCDWQ site is feasible with watershed improvements. Species documented at the upstream sites could migrate downstream and improve species richness and composition at the downstream site. These improvements would in turn improve the NCIBI bioclassification of Hunting Creek and ultimately result in Hunting Creek being removed from the list of impaired waters.

Table 3.2 Fish Community Bioclassification Ratings

Site ID	Site	Location	Date	NCIBI Score	NCIBI Rating
1	Hunting Creek Downstream	Amherst Road	2009	40	Fair
1	Hunting Creek Downstream	Amherst Road	2003	40	Fair[1]
1	Hunting Creek Downstream	Amherst Road	2002	38	Fair[1]
2	Hunting Creek Middle	Coal Chute Road	2009	38	Fair
3	Hunting Creek Upstream	Poteat Road	2010	46	Good-Fair
4	East Prong Hunting Ck	Bethel Road	2009	42	Good-Fair
5	Fiddlers Run	Upstream from NC 18	2010	46	Good-Fair
6	East Prong Hunting Creek	Upstream Williams Road	2010	44	Good-Fair

[1]NCDWQ 2006b

3.3.2 Benthic Macro Invertebrate Sampling

Benthic macro invertebrate community sampling was conducted by NCDWQ and NC Ecosystem Enhancement Program (NCEEP) staff at six sites in June and August 2010 using the NCDWQ Biological Assessment Unit's Qual 4 Method (NCDWQ 2006a). The six sites were located on Hunting Creek, Fiddlers Run, and East Prong Hunting Creek and captured a variety of watershed conditions (Figure 3.2).

NCDWQ and NCEEP biologists collect and tally benthic macro invertebrates.

These invertebrates, which include aquatic insects, crustaceans, mollusks, and worms, are an important part of the aquatic ecosystem food chain, especially for fish. They are also an indicator of water quality since some macro invertebrates cannot live in polluted water while others thrive in such conditions.

The benthic macro invertebrate communities found in Hunting Creek indicate that poor habitat is certainly a concern in the Hunting Creek Watershed as are nutrients and possible toxicity (Tyndall 2010). The uppermost Hunting Creek site primarily drains cropland and pasture upstream of dense development and supports the most intolerant benthic macro invertebrate community resulting in an Excellent bioclassification rating (Table 3.3).

The sites on Fiddlers Run, East Prong Hunting Creek, Pee Dee Branch, and the furthest downstream site on Hunting Creek all received Good-Fair ratings. The site with the most tolerant benthic macro invertebrate community indicating severe water quality issues was located at the middle Hunting Creek site at Bethel Road and received a Fair bio-clsssification rating. The benthic communities found at this site support that nutrients and severe water quality degradation from urban runoff are a concern as Hunting Creek flows through Morganton.

Table 3.3 Benthic Macro Invertebrate Community Bioclassification Ratings[1]

Site ID	Site	Location	Date	NCIBI Score	NCIBI Rating
1	Hunting Creek Upstream	Poteat Road	2010	4.3	Excellent
2	Fiddlers Run	Bethel Road	2010	5.27	Good-Fair
3	East Prong Hunting Ck	Bethel Road	2010	4.85	Good-Fair
4	Hunting Creek Middle	Bethel Road	2010	6.26	Fair
5	Pee Dee Branch	Kirksey Drive	2010	5.5	Good-Fair
6	Hunting Creek Downstream	Causby Quarry Road	2010	5.29	Good-Fair

[1]Tyndall 2010

3.3.3 Water Chemistry Sampling

Water chemistry was monitored at six fixed locations within the Hunting Creek Watershed. Sampling occurred four times: June and December 2009 and June and December 2010 (Figure 3.2). Baseflow grab samples were collected and analyzed at a state certified laboratory for ammonia, nitrogen, phosphorus, and total suspended solids. Conductivity, dissolved oxygen, and temperature were also measured during these field sampling events.

Results of the water chemistry data reveal that nitrogen concentrations are consistently high at all sites (Table 3.4). Nitrogen concentrations appear to be higher in areas that drain agricultural land and low density development rather than areas with denser development. The furthest upstream site on Hunting Creek has a relatively higher concentration of nitrogen than the site furthest downstream. Pee Dee Branch, which drains downtown Morganton, has the lowest nitrogen levels of all sample sites, while Fiddlers Run has the highest.

Conductivity is elevated at downstream sites on Hunting Creek that drain the majority of the urban core. Conductivity is also relatively high at the Fiddlers Run site, which may contribute to the high levels at the Hunting Creek site downstream of the confluence with East Prong Hunting Creek. The elevated conductivity levels at these sites indicate that there is an increased amount of dissolved substances in the water, but it does not indicate the type of pollution.

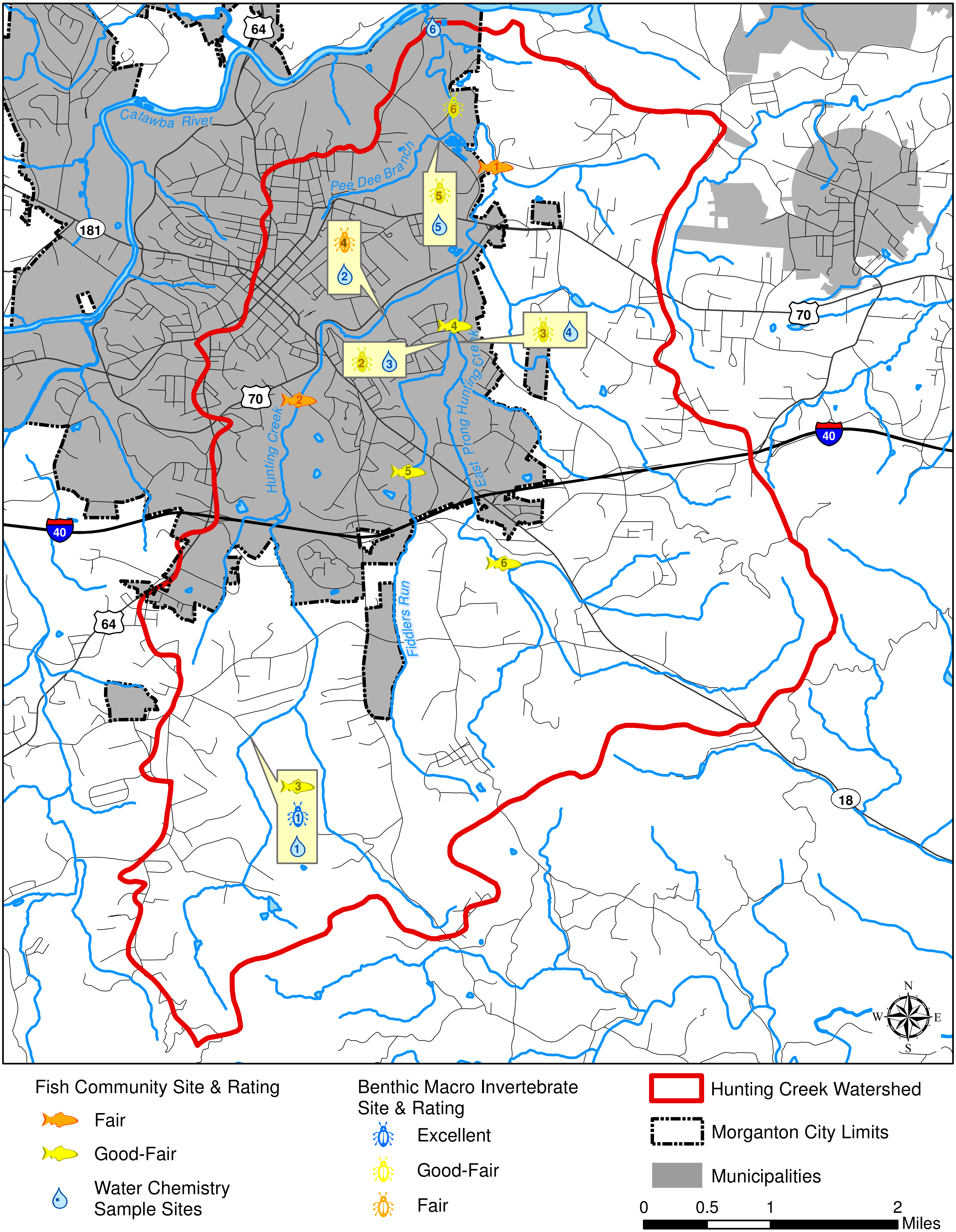
Unlike nitrogen, total phosphorus does not appear to be elevated anywhere. Total suspended solids were also low, however, because samples were collected during baseflow it is uncertain whether or not this would be the case during a rain event. Finally, no evidence of low dissolved oxygen levels was evident based on samples collected in the summer of 2009 and the winters of 2009 and 2010.

Table 3.4 Summary of Water Chemistry Data in the Hunting Creek Watershed, June 2009 – December 2010

Site ID	Site	Date	Ammonia NH_3 (mg/L)	Nitrate NO_3 (mg/L)	Total Phosphorus (mg/L)	TSS[1] (mg/L)	Temp-erature (°C)	Conductivity (µS/cm)	DO[1] (mg/L)
	Acceptable Maximum Values[2]		0.50	0.3	0.05	100.0	variable	70.0	variable
1	Hunting Cr - Poteat Rd	6/23/2009	0.12	1.00	0.04	6.0	20.5	73.9	7.15
1	Hunting Cr - Poteat Rd	12/17/2009	0.10	1.20	<0.05	<5.0	6.9	65.6	8.50
1	Hunting Cr - Poteat Rd	6/29/2010	<0.10	1.10	<0.05	6.2	21.6	74.2	---
1	Hunting Cr - Poteat Rd	12/9/2010	<0.10	0.80	<0.05	<5.0	3.4	72.7	11.48
1	Hunting Cr - Poteat Rd	**mean**	**0.11**	**1.03**	**0.05**	**5.6**	**13.10**	**71.6**	**9.04**
2	Hunting Cr - Bethel Rd	6/23/2009	0.11	1.00	0.05	4.0	21.7	97.2	7.82
2	Hunting Cr - Bethel Rd	12/17/2009	<0.10	1.10	<0.05	5.4	5.8	85.1	9.12
2	Hunting Cr - Bethel Rd	6/29/2010	<0.10	1.00	0.051	5.6	23.3	94.9	---
2	Hunting Cr - Bethel Rd	12/1/2010	<0.10	0.72	0.05	5.0	2.9	91.0	13.53
2	Hunting Cr - Bethel Rd	**mean**	**0.10**	**0.96**	**0.05**	**5.0**	**13.43**	**92.05**	**10.16**
3	Fiddlers Run	6/23/2009	0.11	1.30	0.04	8.8	20.6	101.5	7.90
3	Fiddlers Run	12/17/2009	<0.10	1.50	<0.05	6.4	5.4	88.3	10.71
3	Fiddlers Run	6/29/2010	<0.10	1.50	<0.05	10.0	22.9	84.7	---
3	Fiddlers Run	12/1/2010	<0.10	1.00	<0.05	<5.0	2.5	89.6	13.88
3	Fiddlers Run	**mean**	**0.10**	**1.33**	**0.05**	**7.55**	**12.85**	**91.03**	**10.83**
4	East Prong Hunting Cr	6/23/2009	0.13	0.60	0.03	7.2	21.1	83.6	7.56
4	East Prong Hunting Cr	12/17/2009	<0.10	0.86	<0.05	<5.0	5.3	74.8	11.3
4	East Prong Hunting Cr	6/29/2010	<0.10	0.83	<0.05	8.8	23.4	86.0	---
4	East Prong Hunting Cr	12/1/2010	<0.10	0.60	<0.05	<5.0	2.2	89.2	14.24
4	East Prong Hunting Cr	**mean**	**0.11**	**0.72**	**0.04**	**7.0**	**13.0**	**83.4**	**11.03**
5	Pee Dee Branch	6/23/2009	0.07	0.70	0.04	1.6	20.2	79.0	7.75
5	Pee Dee Branch	12/17/2009	<0.10	0.10	<0.05	<5.0	5.3	75.7	11.65
5	Pee Dee Branch	6/29/2010	<0.10	0.58	<0.05	<5.0	22.3	69.3	---
5	Pee Dee Branch	12/1/2010	<0.10	0.80	<0.05	<5.0	2.9	79.6	12.78
5	Pee Dee Branch	**mean**	**0.09**	**0.55**	**0.05**	**4.15**	**12.68**	**75.9**	**10.73**
6	Hunting Cr Vine Arden Rd	6/23/2009	0.18	0.80	0.05	9.2	21.6	94.9	10.68
6	Hunting Cr Vine Arden Rd	12/17/2009	0.36	0.97	<0.05	9.2	5.3	79.2	11.60
6	Hunting Cr Vine Arden Rd	6/29/2010	<0.10	0.90	<0.05	11.0	23.6	88.6	---
6	Hunting Cr Vine Arden Rd	12/1/2010	<0.10	0.69	<0.05	11.0	2.9	114.4	11.81
6	Hunting Cr Vine Arden Rd	**mean**	**0.19**	**0.89**	**0.05**	**10.10**	**13.35**	**94.28**	**11.36**

[1]TSS – Total Suspended Solids, DO – Dissolved Oxygen
[2]According to the University of Asheville North Carolina Environmental Quality Institute
Note: Samples below detection limits are indicated by < detection limit value.

Figure 3.2 Sampling Sites in the Hunting Creek Watershed



3.3.4 Fecal Coliform Bacteria Sampling

As part of an in-kind contribution to the project, NCDWQ collected fecal coliform bacteria at five of the fixed water chemistry monitoring sites and one additional location on Hunting Creek at Causby Quarry Road. Samples were collected 5 times within 30 days and analyzed by NCDWQ laboratories.

Fecal coliform bacteria originate from warm blooded animals and while not a human health threat, they are an indicator of pollution. Although it is uncertain what the source of fecal coliform bacteria in the Hunting Creek Watershed is, the presence of fecal coliform bacteria in streams is often attributed to faulty sewer line or septic systems, agricultural runoff from pasture or livestock access to streams or runoff from dog refuse in residential areas. The reporting limit in North Carolina for safe levels of fecal coliform bacteria in surface water is 200 colony forming units per 100 mL (cfu/100 mL). Table 3.5 shows the geometric mean of the 5 samples collected within 30 days at each site. All sites had fecal coliform bacteria levels well over the level considered safe. It should be noted that municipal sewer lines run parallel to all streams where fecal coliform bacteria were sampled.

Table 3.5 Fecal Coliform Bacteria in the Hunting Creek Watershed[1]

Site ID	Waterbody	Location	Geometric Mean (cfu/100 mL)
1	Hunting Creek	Poteat Road (SR 1950)	928
2	Hunting Creek	Bethel Road (SR 1704)	2,024
3	Fiddlers Run	Bethel Road (SR 1704)	591
4	E Prong Hunting Ck	Bethel Road (SR 1704)	1,018
5	Pee Dee Branch	Kirksey Drive (SR 1443)	700
	Hunting Creek	Causby Quarry Road (SR 1571)	1,054

[1]Tyndall 2009

3.3.5 Windshield Survey

A windshield survey was conducted in February 2009 to obtain a general impression of stream and watershed conditions (Equinox 2009a). One day was spent driving around the watershed observing streams at 30 different bridge crossings. Water quality parameters such as temperature, dissolved oxygen, and conductivity were collected as well as information regarding riparian zone activity, bank stability, channel conditions, in-stream habitat, channel modification, and possible locations for agricultural and stormwater best management practices (BMP).

In general, conductivity was elevated across the watershed. Conductivity ranged from 29-104 µS/cm with lower conductivity levels occurring in smaller, headwater streams and increasing further downstream. This is consistent with the conductivity data collected during the water chemistry sampling. Although dissolved oxygen levels were normal, water temperature was higher than was expected for a field day in February. Temperatures ranged from 7.9 to 14.1°C with a median temperature of 11.1°C.

Physical stream features observed during the windshield survey reveal that all stream channels exhibit moderate incision. A channel is incised when water cannot escape the stream banks

Typical incised stream with riparian impacts from adjacent residence.

during high flow rain events. Because water cannot escape, it often scours the stream banks causing erosion and in-stream sedimentation. Channel modifications such as straightening or ditching, and increases in water volume from stormwater runoff are typical causes of incision.

Impacts to riparian areas were evident at most sites observed during the windshield survey. Roads, residential yards, pasture or hay fields, land in cultivation, and commercial, institutional, and industrial land uses commonly occur in the riparian area.

Sedimentation in Hunting Creek was observed to be heavy and widespread. Sand or silt substrate dominated with only a few areas in the watershed containing abundant coarse material typical of good fish habitat. Floodplain soil textures in the watershed are coarse and are more prone to stream bank collapse than finer textured soil (Connie Adams, Foothills Soil Consulting, Inc., personal communication). These coarse-textured floodplain soils are one factor that would lead to increased stream bank erosion. Therefore, in-stream sediment is likely originating from eroding stream banks that were also commonly observed during the windshield survey. Because of the excessive in-stream sedimentation, aquatic habitat including riffles, pools, and other features were extensively degraded.

Sandy substrate commonly observed in streams throughout the watershed.

Livestock access to streams appears to be minimal based on observations from bridge crossings. Most pastures observed have livestock fenced out of the stream, although the riparian zones were narrow, usually less than 30 feet.

3.3.6 Stream Walk

To thoroughly investigate the larger stream channels in the Hunting Creek Watershed and to identify in-stream problems and impacts, 8.60 miles of Hunting Creek were walked by Equinox, while 7.10 miles of East Prong Hunting Creek and 4.25 miles of Fiddlers Run were walked by NCDWQ as an in-kind contribution. Locations of stormwater outfalls and drainage ditches, erosion sites, utility crossings, dump sites, channel modifications, structural crossings, impacted buffers, and other potential stream impacts in were documented. For details on the stream walk, refer to *Hunting Creek Watershed Assessment and Best Management Practices Evaluation* (Equinox 2009a).

Habitat Assessment

To document in-stream aquatic habitats and adjacent terrestrial conditions, a habitat assessment was conducted for stream segments utilizing the NCDWQ Biological Assessment Unit Protocol for Habitat Assessment of Mountain to Piedmont Streams (NCDWQ 2006b). Assessment scoring categories (metrics) include channel modification, in-stream habitat, bottom substrate, pool variety, riffles, bank stability, shading, and riparian width. Figure 3.3 illustrates the habitat scores for all stream segments assessed.

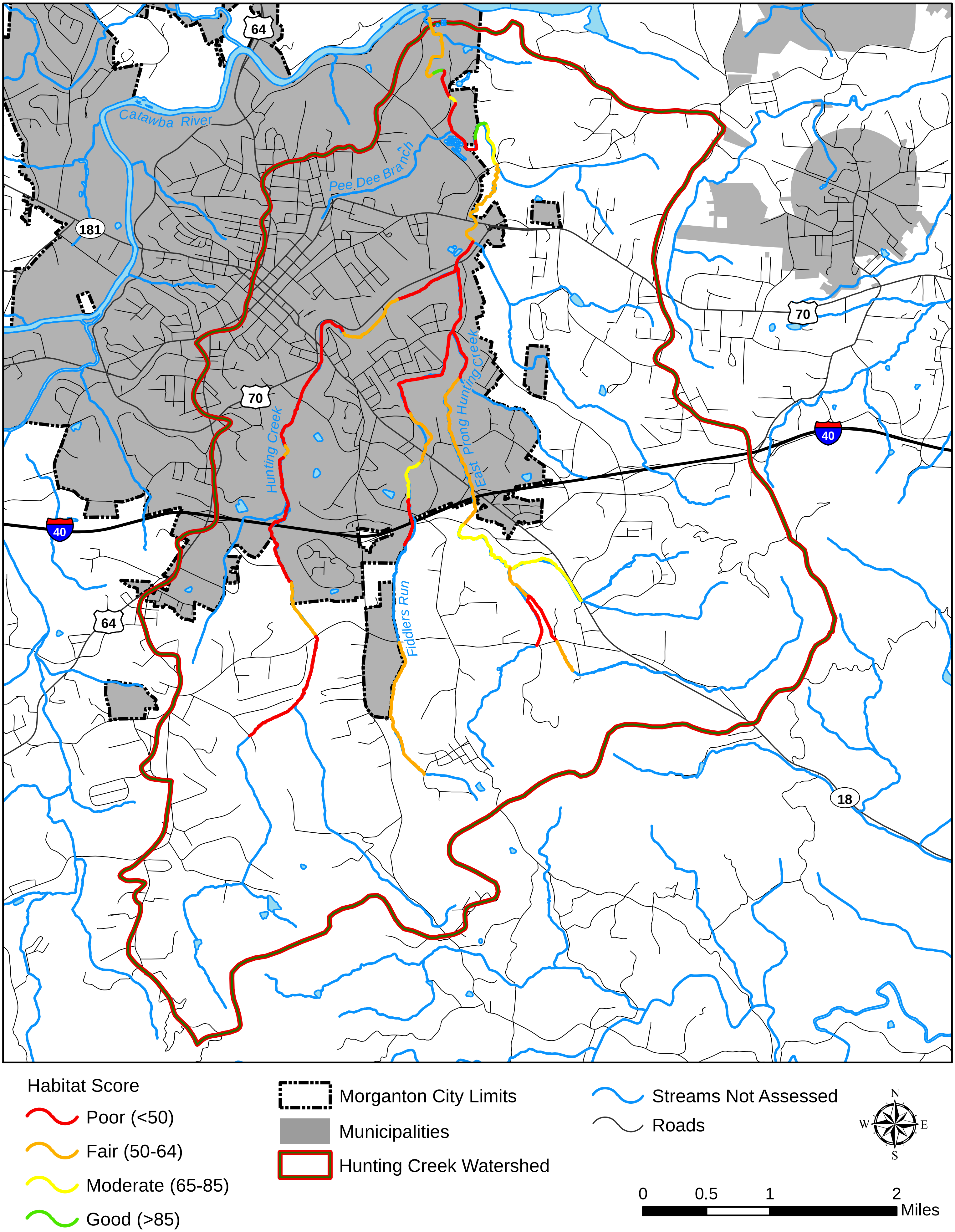
Based on the habitat assessment, aquatic habitat conditions are degraded in Hunting Creek, East Prong Hunting Creek, and Fiddlers Run. With a maximum possible score of 100, the average habitat score for all 20 miles of stream that were evaluated was 53. In the few places where stream habitat was rated as Moderate or Good, the streams had adequate woody riparian vegetation widths and were flowing through well-wooded areas.

Of all the metric categories, substrate, riffle habitat, and riparian width received the lowest scores (average scores of 5 out of 15, 5 out of 16, and 5 out of 10, respectively). These scores are indicative of channels with infrequent riffles and highly embedded or very homogeneous bottom substrates. In-stream habitat, bank stability, and pool variety metrics received moderately low scores (average scores of 12 out of 20, 9 out of 14, and 6 out of 10, respectively). In combination, the aquatic habitat scores reflect habitat conditions that are not conducive to supporting a robust fish community.

Stream Habitat Features

Channel Modification	*Alteration to a stream channel that includes straightening, widening, deepening, or dredging that affects hydrology, water temperature and flow thus diminishing the quality and diversity of aquatic species and riparian vegetation*
In-stream Habitat	*Features that are favorable for benthic macro invertebrate colonization or fish cover including rocks, aquatic plants, sticks, leaf packs, logs, snags, undercut banks, and root mats*
Bottom Substrate	*Material occurring on the bottom of the stream channel such as boulders, cobbles, gravels, sand, or silt where macro invertebrates and fish live, feed, and spawn*
Pool Variety	*Areas deeper than a stream's average depth with little or no surface turbulence where fish live and spawn*
Riffle Habitats	*Areas of aeration where water flows over rocks, debris jams, or through narrow channel areas and allows for oxygen to dissolve in the water*
Bank Stability	*The degree to which erosion or bank failure is occurring due to soil binding and stream bank vegetation*
Shading	*Canopy cover over a stream bank which affects water temperature as well as photosynthesis of aquatic vegetation*
Riparian Width	*Woody vegetation occurring from the stream bank perpendicular to the stream channel which serves as a buffer for pollution entering the stream*

Figure 3.3 Habitat Scores



Conductivity of Hunting Creek and Contributing Outfalls

In addition to taking conductivity readings within stream walk segments in the main stem of Hunting Creek, where a pipe outfall or tributary was encountered, conductivity, dissolved oxygen, and temperature readings were also collected to determine what portion of the watershed may be contributing higher inputs of pollutants. An attempt to determine whether the origin was wastewater or stormwater was made, although in some circumstances this was difficult due to the intricate network of underground conveyances.

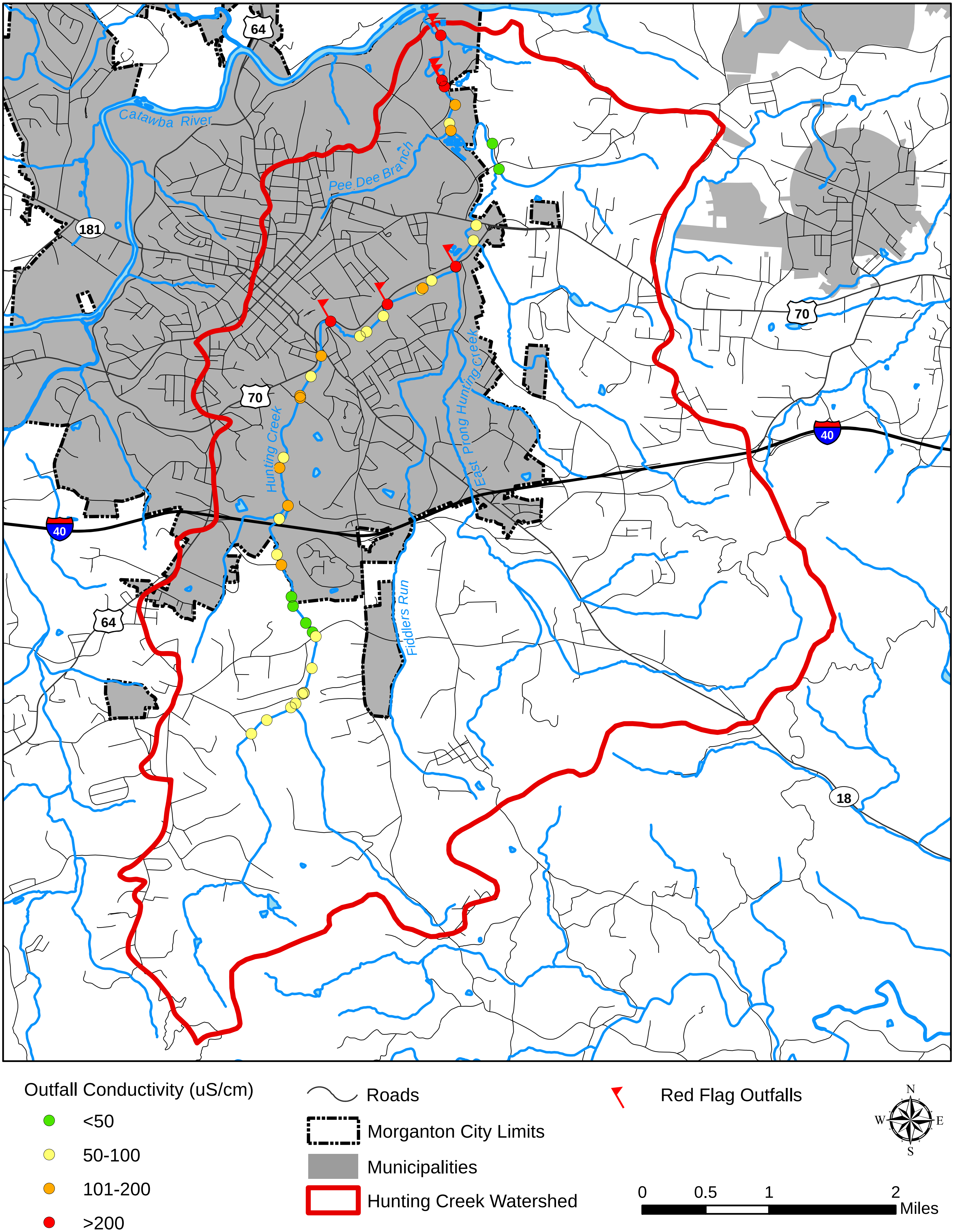
Pipe outfall entering Hunting Creek.

Outfall conductivity ranged from 17-995 µS/cm with 86 µS/cm being the median value. The land area draining to outfalls with conductivity readings greater than 200 µS/cm were flagged to determine what may be contributing to the elevated conductivity readings upstream of the outfall. Table 3.6 shows the values and potential sources of red flagged conductivity readings. Figure 3.4 illustrates conductivity levels of all outfalls to Hunting Creek including the red flagged outfalls.

Table 3.6 Red Flagged Outfalls

ID	Receiving Stream	Stream Bank	Type	Material	Temperature (°C)	Conductivity (µS/cm)	Potential Sources
1	Hunting Creek	right	channel	earthen	11.6	291.6	stream drains Vulcan Quarry Lands, City Firing Range, and a portion of WWTP
2	Hunting Creek	left	channel	earthen	12.9	773.0	stream drains Vulcan Lands
3	Hunting Creek	left	24" pipe	metal	11.6	464.4	stream drains old landfill
4	Hunting Creek	left	24" pipe	metal	11.7	995.0	pipe drains old landfill
5	Hunting Creek	left	20" pipe	metal	12.7	772.0	pipe drains industrial facility, vehicle service businesses, and US-70
6	Hunting Creek	left	channel	earthen	16.3	227.1	stream drains B&E Mulch and Stone
7	Hunting Creek	left	60" pipe	concrete	17.0	226.3	stream drains downtown and abandoned industrial complex

Figure 3.4 Outfall Conductivity along Hunting Creek



Erosion Sites

Although much of Hunting Creek's stream banks exhibit some erosion, only sites with severe and active erosion were documented during the stream walk. Eroding stream banks varied from 6-13 feet in height and 25-100 feet in length. The width of woody riparian vegetation was less than 10 feet on one or both banks at all erosion sites. Coarse-textured loamy soils present throughout floodplains in the Hunting Creek Watershed are more susceptible to bank collapse, especially without riparian vegetation holding it in place. Eroding stream banks are a significant source of sediment input to streams.

Erosion site along Hunting Creek.

Erosion site along Hunting Creek.

Channel Modification

Recent modifications made to the stream channel from channel straightening or bank armoring from rip-rap, concrete, or other materials were recorded when encountered. Although the majority of streams in the Hunting Creek Watershed were likely straightened during the agricultural era of the early 1900's, only modifications within the last 10 years were noted during the stream walk. Channel modification was only observed at three locations, which were all associated with stream bank armoring. Boulders, concrete slabs, and other hardscape materials were placed on the stream banks to prevent property loss from erosion. While this practice prevents localized erosion, it is often a temporary fix that displaces and exacerbates erosion to a downstream location.

Bank armoring with rip rap along Hunting Creek.

Bank armoring with large concrete slabs along Hunting Creek.

Impacted Riparian Areas
Riparian areas were often found to be degraded due to lack of woody vegetation and soil disturbances. Utility right-of-ways such as sewer pipes and electrical power lines often occur within the riparian area and require vegetation to be maintained to a minimum. Where woody vegetation in the riparian zone is disturbed, sediment and other pollutants are able to enter the stream. The average length of the 16 significantly disturbed riparian areas observed along Hunting Creek was 150 feet long and extended an average of 60 feet beyond the stream bank.

Lack of woody vegetation in the riparian area.

Large tree removal along the power line right-of-way parallel to stream impacting the buffer.

Utility Crossings
Where utilities occur along the floodplain, stream bank, or stream bottom of Hunting Creek, their location was recorded during the stream walk. The types of utilities included electric power lines, sewer lines, gas lines, and unknown pipes. The condition of the observed utility was noted as well as potential concerns, if applicable. Several utilities were observed to be contributing to some degree of erosion where it crossed the stream corridor. Exposed pipes crossing the stream were also noted as being susceptible to damage during high flow events.

Pipe utility parallel to Hunting Creek along stream bottom.

Power lines crossing Hunting Creek overhead.

Over 80 miles of sewer lines exist in the Hunting Creek Watershed, including a line parallel to the entire length of Hunting Creek from its headwaters to the Catawba River. These lines service all but the southern and eastern most portions of the watershed. Sewer line construction dates range from 1945 to 1985 (Don Danford, City of Morganton, personal communication), and according to him, several wastewater spills have occurred within the past 10 years (Table 3.5). These leaks were repaired as soon as knowledge was gained about the leakage.

Table 3.7 Historic Sewer Leaks in the Hunting Creek Watershed, 2000-2009

Date	Receiving Stream	Location	Number of Spills	Leakage Quantity (gal)
2000	Fiddlers Run	Woodlawn Dr.	1	1,500
2002	unknown	unknown	3	2,200
2005	unknown	unknown	15	unknown
2007	Fiddlers Run	Sloan Ave.	1	3,000
2007	Hunting Creek	unknown	1	2,800
2008	Hunting Creek	Herron St.	1	400
2009	Hunting Creek	Knollwood Dr.	1	400

Structural Crossings

Bridges, culverts, dams, and other structures were recorded when they were observed to cross Hunting Creek. Four crossings are not aligned with the stream flow and were observed to be causing stream bank erosion near and around the structures' footings. Two crossings, including a relic dam and a hanging culvert, pose barriers to fish movement. Another concern identified at several structural crossings was bank scour and erosion on the upstream and downstream side of the crossing.

Bridge crossing not aligned with flow of stream (As indicated by arrow) causing stream bank erosion.

Relic dam creating a barrier to fish migration.

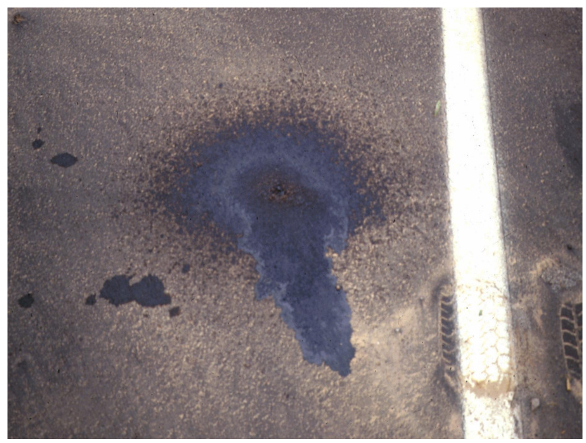
Although not technically a structural crossing, it should be noted that the slow moving waters at the mouth of Hunting Creek may serve as a fish barrier. The slow moving backwaters of Lake Rhodhiss likely inhibit riverine fish species from moving into the Hunting Creek Watershed from other tributaries of the Catawba River.

3.3.7 Stormwater BMP Retrofit Inventory

A final activity conducted as part of the Hunting Creek Watershed assessment (Equinox 2009a) was a stormwater best management practice (BMP) retrofit inventory to observe existing stormwater management and identify opportunities to improve stormwater management through retrofitting. Results of the inventory are presented in Section 4.1 along with recommended stormwater BMP types.

Stormwater management in the Hunting Creek Watershed, like most stormwater systems in the region, is designed to remove water from a site as quickly as possible through a network of underground pipes. Stormwater runoff is received through storm drain grates located in roads and parking lots and is then routed through an underground series of pipes to an outfall. Outfalls release stormwater directly into streams. This type of system does not treat or remove pollutants that reside on impervious surfaces. Furthermore, concentrating the flow of runoff increases the volume and velocity of stormwater into the stream, which often leads to stream bank erosion and increased sedimentation in waterways.

Stormwater running off parking lots is directed to the stream channel through a series of storm drains, underground pipes, and outfalls.



Stormwater runoff carries pollutants residing on impervious surfaces into adjacent water ways.

3.4 Synopsis of Causes and Sources of Stressors

The Hunting Creek Watershed assessment (Equinox 2009a) helped identify the assortment of causes leading to biologically impaired fish communities. Although the data clearly indicate that aquatic habitat is degraded throughout the watershed, it is likely an amalgamation of factors leading to stream impairment. The combination of natural conditions existing in the watershed combined with poor land use practices over time has led to a variety of circumstances affecting the physical characteristics of the stream channel as well as water chemistry.

Over time, urban development has transformed 37% of the Hunting Creek Watershed from forest land to residential, commercial, industrial, and institutional land. With this type of development, a significant increase in impervious surfaces such as roads, parking lots, and roof tops are created, which prevents precipitation from percolating into the ground. Water falls on these impervious surfaces, accumulates, and runs off into streams resulting in increased stream flow volume and velocity. This increase in volume and velocity causes stream bank scour and erosion by overwhelming the stream channel and disturbing the naturally occurring coarse textured floodplain soils, which are more susceptible to erosion and collapse.

Sediment originating from eroding stream banks is leading to increased sedimentation in streams throughout the Hunting Creek Watershed, but particularly in developed areas. Boulders, cobbles, and coarse stream bed material, where aquatic organisms seek refuge, are buried by sand and silt. Sediment has also filled in pools and riffles to the extent that there are few places for fish and other aquatic organisms to live and breed. As a result, habitat for aquatic organisms has become degraded and the fish community impaired.

Other anthropogenic activities combined with coarse textured floodplain soils causes additional chain reactions. Common agricultural practices include straightening stream channels and clearing riparian vegetation to maximize the amount of productive space for pasture or cropland. In low density residential areas, streams may be moved to accommodate homes and other structures and lawns are mowed up to the stream bank. Not only do such channel modifications lead to incised channels and stream bank erosion, but combined with riparian vegetation alteration, these activities reduce organic matter inputs to streams. Organic material such as sticks, leaf packs, logs, and root mats provide essential habitat for aquatic organisms to live, feed, and reproduce.

Land use activities in upland areas are also impacting stream conditions in the Hunting Creek Watershed. Pasture land, fertilizer on croplands and lawns, and pesticide inputs from turf management all contribute towards increased conductivity levels, nitrogen concentrations, and fecal coliform bacteria levels. The impacts of these practices are exacerbated by the presence of slowly permeable, clay subsoils occurring in upland areas of the watershed. Precipitation does not permeate these soil types deeply; instead it runs off the land into the stream carrying pollutants with it.

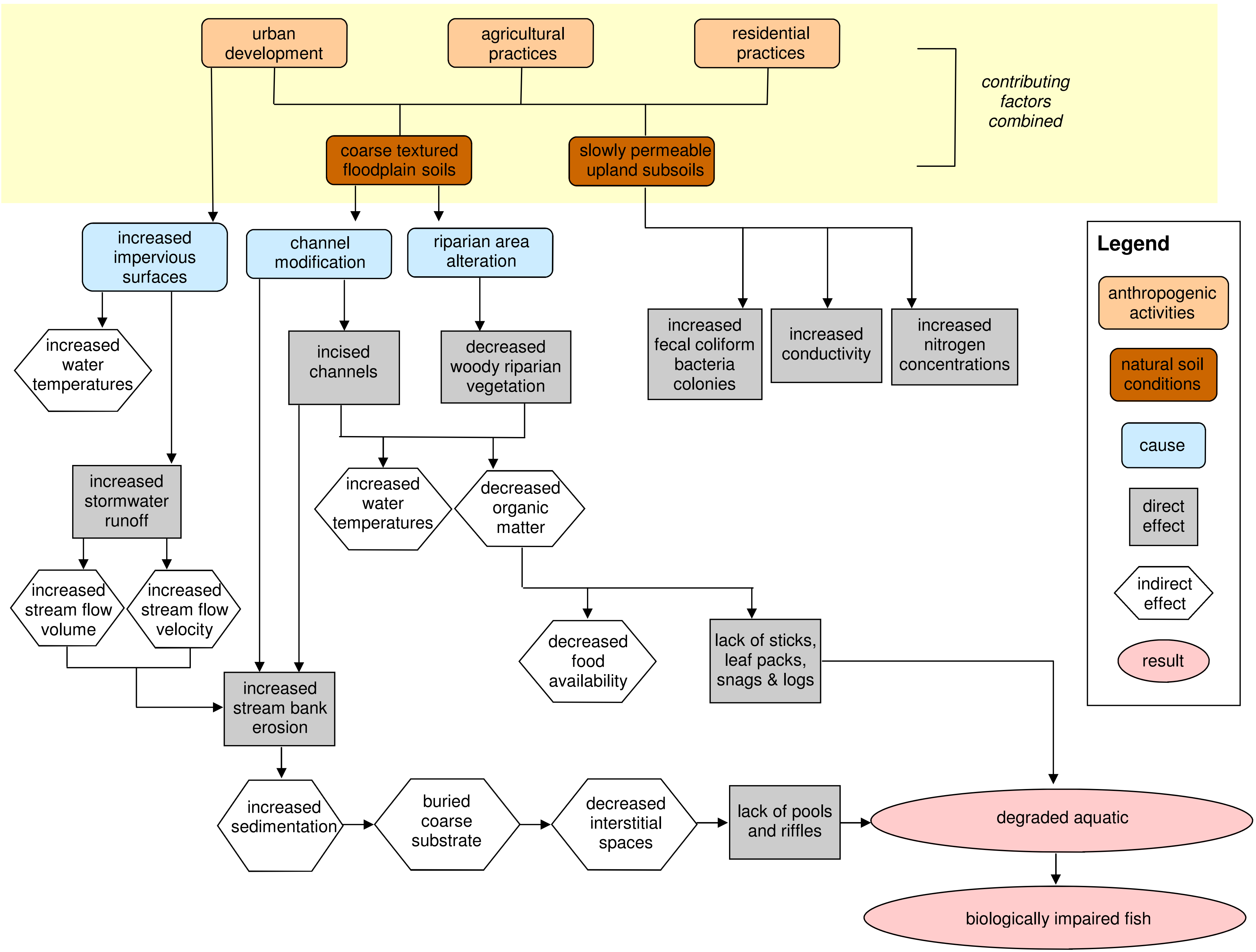
Figure 3.5 illustrates the chain of reactions resulting from impacts observed in the Hunting Creek Watershed. Implementing on-the-ground management measures targeted towards remediating these impacts will begin to restore Hunting Creek back to health so that it may once again support the survival and maintenance of diverse biological communities.

In addition to these stressors, consistencies among other data collected during the watershed assessment reveal other stressors whose seriousness and sources remain unknown. In addition, their impact on the fish community is also unknown. The most obvious signs that these stressors exist were revealed by the following watershed assessment data:

- Elevated nitrogen concentrations occur in areas that drain agricultural land and low density residential areas.
- Fecal coliform bacteria levels are elevated throughout the watershed.
- Higher conductivity levels occur within the City of Morganton.

To identify and isolate the specific pollutants causing these conditions will require additional data collection. While specific management measures to address these potential stressors cannot be recommended at this time, such data collection is necessary in order to develop appropriate measures. Remediation efforts to reduce the impacts of the additional stressors will contribute to additional improvement of aquatic habitat and the overall health of the fish community in Hunting Creek.

Figure 3.5 Stressor Schematic



Section 4 Management Measures

4.1 Watershed Management Goals

The ultimate goal of this watershed restoration plan is to improve water quality in the Hunting Creek Watershed so that its fish communities will improve and Hunting Creek can support its designated use of maintaining biological integrity once again. In doing so, it will be removed from the state's 303(d) list of impaired waters.

In the process of improving water quality in Hunting Creek, the Hunting Creek Partners identified additional goals. As implementation efforts are coordinated, the Hunting Creek Partners aim to:

- Develop additional partnerships to facilitate better land stewardship among the state, county, city, and private citizens.
- Engage the community in water quality awareness and education.
- Complement the Mission 2030 Plan (City of Morganton 2010), a comprehensive land use plan developed by the City of Morganton in 2009. Community needs such as infrastructure improvements, greenways, bridges, and others should be incorporated into the Hunting Creek Watershed Plan.
- Stimulate economic opportunities in the community and create jobs as management measures are implemented.

The following section describes in detail the steps or management measures that support these goals and begin the process of restoring Hunting Creek. A brief discussion of why these steps are important is included. How these measures are to be implemented are discussed in Section 5.

4.2 Stormwater Best Management Practices

In the Hunting Creek Watershed, impervious surfaces cover 13% of the watershed. During a rain event, stormwater flows across these impervious surfaces, builds volume and velocity, and carries pollutants with it into streams. Stormwater best management practices (BMP) offset the impacts of impervious cover and remove pollutants by capturing runoff, storing water on-site, and allowing pollutants to settle out of the water. The on-site detention and infiltration of stormwater runoff protects adjacent streams from increased water volumes and velocities leading to stream bank erosion by slowly releasing stormwater to match pre-development hydrology. In the process, many pollutants such as nitrogen, heavy metals, and phosphates are removed from the water. In addition, stormwater BMPs decrease the potential for stream bank erosion by reducing stormwater volume and velocity, improve wildlife habitat by enhancing open space, reduce urban heat island effects by reducing heat-absorbing pavement, and beautify the landscape with the addition of water features and vegetation. Stormwater BMPs are typically categorized into three types: simple, structural, and non-structural or natural.

4.2.1 Simple Stormwater BMPs

Simple stormwater BMPs include small, low cost measures that cumulatively add up to make a big impact. Homeowners and small businesses can easily implement simple stormwater BMPs on their properties. Simple steps include disconnecting downspouts so that runoff from rooftops does not flow directly into the storm drain adding to runoff volume and velocity to streams. Downspouts may be connected to rain barrels or cisterns that collect rain water to be used for landscape irrigation.

An above ground cistern located at the City of Morganton Parks and Recreation maintenance building catches runoff from the roof. The high pressure water is used to clean equipment.

A rain barrel is attached to a downspout and collects rain water.

4.2.2 Non-Structural Stormwater BMPs

Non-structural, or natural stormwater BMPs, incorporate plant material, soil mixes, and diversions that filter pollutants by natural processes. As shown in Figure 4.1, stormwater flows into a non-structural BMP and pollutants are absorbed into the soil. Nutrients are taken up by plants while microbes break down organic substances. They typically occur as vegetated depressions that capture runoff and allow plants to take up excess nutrients and water while filtering runoff through a soil medium. Examples of non-structural stormwater BMPs include bio-retention areas, constructed wetlands, and bio-swales.

Gene Turner Park Rain Garden

Gene Turner Park is a 2.3 acre city park located in central Morganton outside the Hunting Creek Watershed. It contains two ball fields, two batting cages, a field house, and approximately a half acre of impervious surfaces. In 2009, a rain garden was installed to capture and treat stormwater runoff from the parking lot and adjacent road. The highly visible rain garden also serves to educate the public about stormwater and demonstrates how best management practices function. The project was funded by a grant from the Environmental Protection Agency and was a collaborative effort between the City of Morganton, Burke County Soil and Water Conservation, and Carolina Land and Lake Resource Conservation and Development Council. The following photos exhibit the installation of the rain garden.

A depression is being dug for the installation of a bio-retention area at Gene Turner Park in Morganton outside the Hunting Creek Watershed.

The depression is filled with a soil medium that allows water to slowly infiltrate into the ground while removing pollutants through filtration.

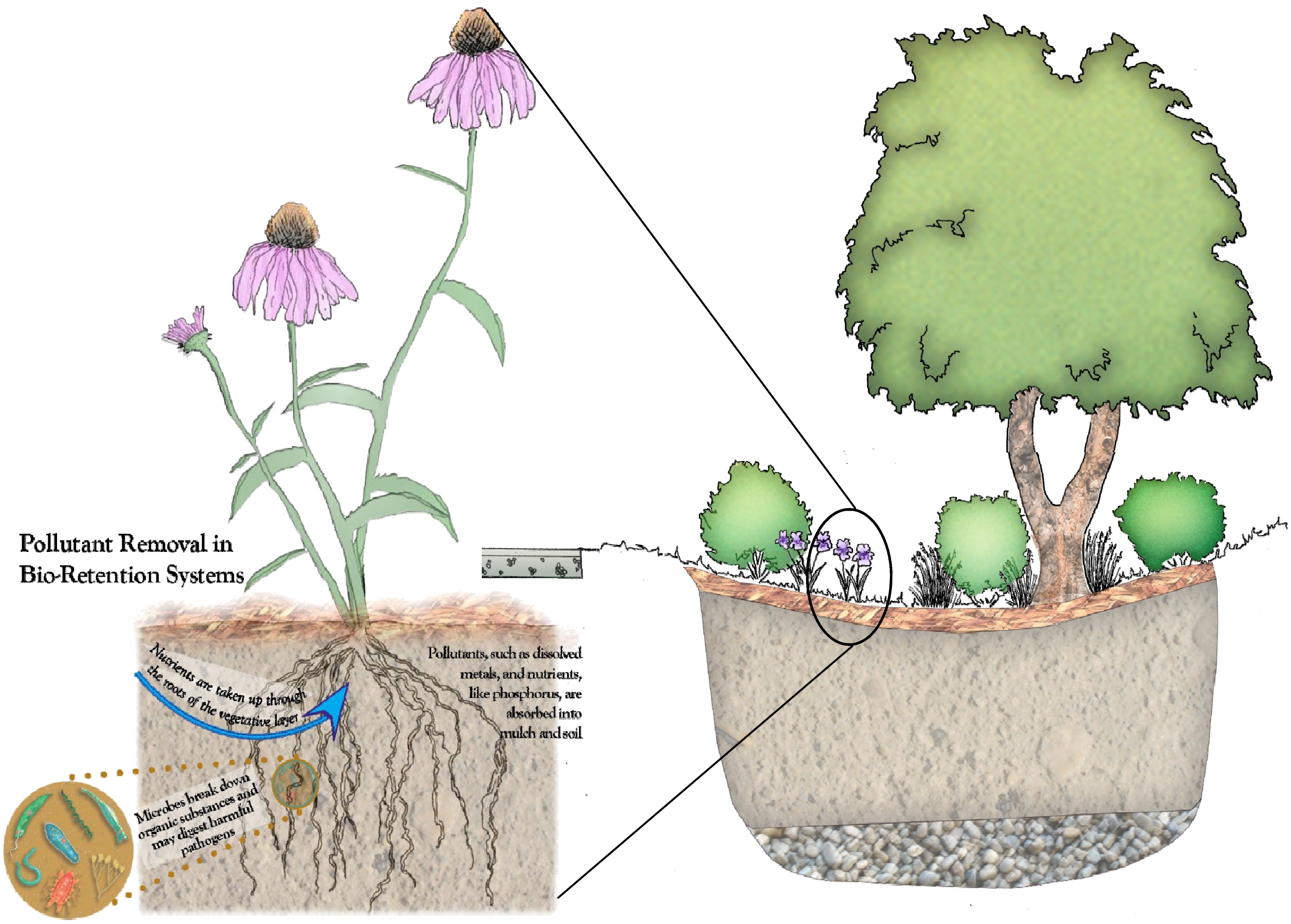
Water from the parking lot flows into a storm grate….

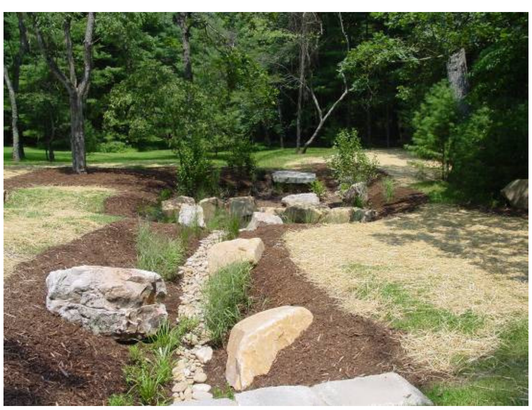
…and enters the bio-retention area through an underground pipe.

A stand pipe is placed within the bio-retention area to direct overflowing water back into the storm system in the event of large rainfall.

The bio-retention area is landscaped with vegetation that can withstand periodic fluctuations in water levels. It also adds to the aesthetics of the park.

Figure 4.1 Plant Uptake and Pollutant Removal Processes





A bio-swale is another type of non-structural BMP. Here the bio-swale is shown immediately after construction. The rocks, plants, and mulch slow stormwater runoff and filter pollution before water enters the stream.

Same bio-swale as the image to the left shown 3 years after installation. In addition to treating stormwater runoff, the landscaping adds to the aesthetics of the site.

A constructed wetland at a city park captures stormwater runoff from a residential development and a parking lot. It also serves as a water feature in the park and provides wildlife habitat.

A bio-retention area effectively captures runoff, preventing large volumes of polluted runoff from entering a stream.

A small curb cut allows stormwater from a parking lot to enter into a bio-retention area bordering the parking lot.

Following a rain event, stormwater enters the bio-retention area where it is absorbed by mulch and soil and is taken up by plants.

4.2.3 Structural Stormwater BMPs

Structural stormwater BMPs are typically engineered structures that are intended to treat larger areas of imperviousness. They vary greatly in size, complexity, and function. One example of a structural BMP is extended detention. Extended detention is designed to capture stormwater and temporarily store it for 12-24 hours allowing sediment and other pollutants to settle out before it slowly continues to follow its drainage pattern. Extended detention structures can be installed wherever water flows through a culvert. A structure, such as a riser or gabion wall is installed upstream of the culvert and causes the water to backup (Figures 4.2-4.3). Over the course of extension time, the water slowly releases through the existing culverts or corrugated metal pipes (CMP).

Figure 4.2 Extended Detention through a Riser Structure

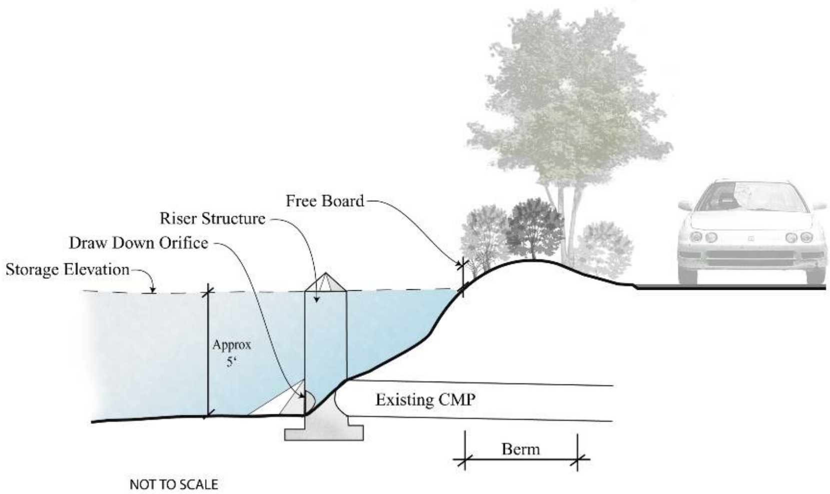
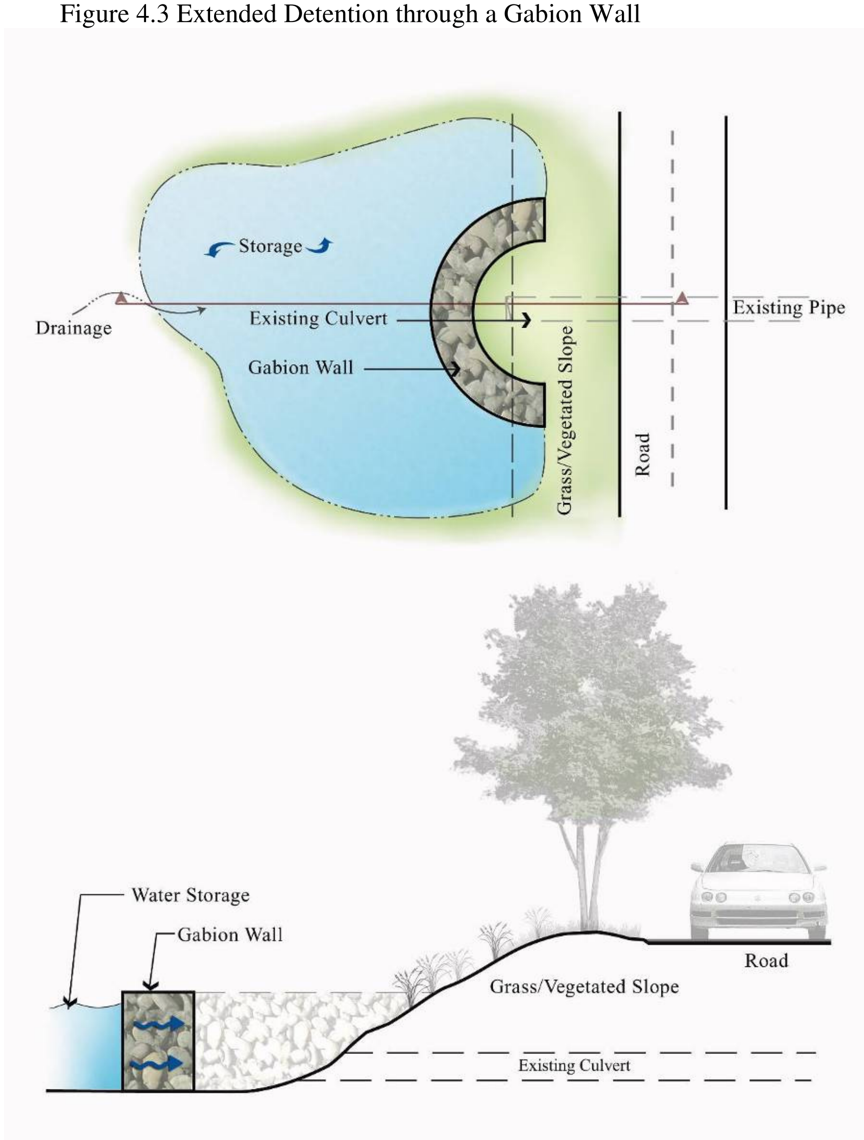


Figure 4.3 Extended Detention through a Gabion Wall



Filtration, another type of structural BMP, can be as simple as filters in storm grates or as complex as large chambers with multiple filters that serve to remove pollutants. Another common structural stormwater BMP is pervious pavement, which allows stormwater to infiltrate into the ground rather than runoff into the stormwater conveyance system.

Filtration chambers are installed during construction of the Bojangles parking lot in Morganton (outside the Hunting Creek Watershed). The chambers will capture stormwater and filter it through a sand and stone medium before releasing it to a nearby stream.

Permeable pavers are installed in the parking lot of Willow Ridge Apartments in Morganton. Stormwater carrying pollutants will infiltrate through the pavers rather than washing off into nearby waterways.

As part of the Hunting Creek Watershed assessment, a stormwater BMP retrofit inventory was conducted to identify opportunities to improve stormwater management at developed sites. The inventory identified 72 individual BMP retrofit opportunities at 32 different sites throughout the watershed (Figure 4.4). Cumulatively, these stormwater BMPs have the potential to reduce runoff volume and velocity from 111 acres of existing impervious surfaces while making a slight reduction in the removal of pollutants. Although stormwater management could be improved in virtually all existing developments within the Hunting Creek Watershed, retrofitting all sites is not practical or financially feasible. Therefore, sites were prioritized according to the following criteria:

*A **stormwater retrofit** is a best management practice installed after construction where little or no stormwater controls exist.*

1. Sites located in subwatersheds with more impervious area received a higher priority in an effort to minimize the cumulative impact of stormwater runoff in those subwatersheds.
2. Individual BMPs that treat a greater percentage of imperviousness have a greater effect on stormwater impacts and therefore received a higher priority.
3. Because nitrogen concentrations were found to be elevated in streams throughout the watershed (Section 3), a higher priority was given to sites that have the potential to remove more nitrogen.

4. Sites that are highly visible such as streetscapes or are easily accessible to provide educational opportunities for groups were assigned a higher priority.
5. Sites that occur on public land were given a higher priority since projects on public property often have a greater likelihood of implementation.
6. Sites that drain pollution hotspots, or areas that may produce higher levels of pollution, were given a higher priority since they are likely to be direct contributors of pollutants.

Considering these prioritization criterion, stormwater BMP retrofit opportunities identified were assigned high, medium, and low priorities and are listed in Table 4.1. Eight BMPs were prioritized as high priorities, 37 BMPs were identified as medium priorities, and 27 BMPs were given low priority. Recommended BMP types primarily include non-structural stormwater BMPs such as bio-retention, constructed wetlands, and bio-swales, but also include a few structural stormwater BMPs such as extended detention and filtration chambers. The type of stormwater BMPs selected were based upon the type of desired treatment and the available space on-site. Site constraints such as buildings, utilities, and slope also largely determined the type of BMP recommended.

Site descriptions, rationales for prioritization, proposed management options, and supporting graphics are provided for two of the high priority sites in Section 4.2.4 to provide examples of different treatment opportunities. Although descriptions provided are site specific, similar stormwater BMP concepts may be applied at other sites throughout the watershed. Refer to Appendix H for more details on stormwater BMP prioritization methods.

Figure 4.4 Stormwater BMP Retrofit Sites in the Hunting Creek Watershed

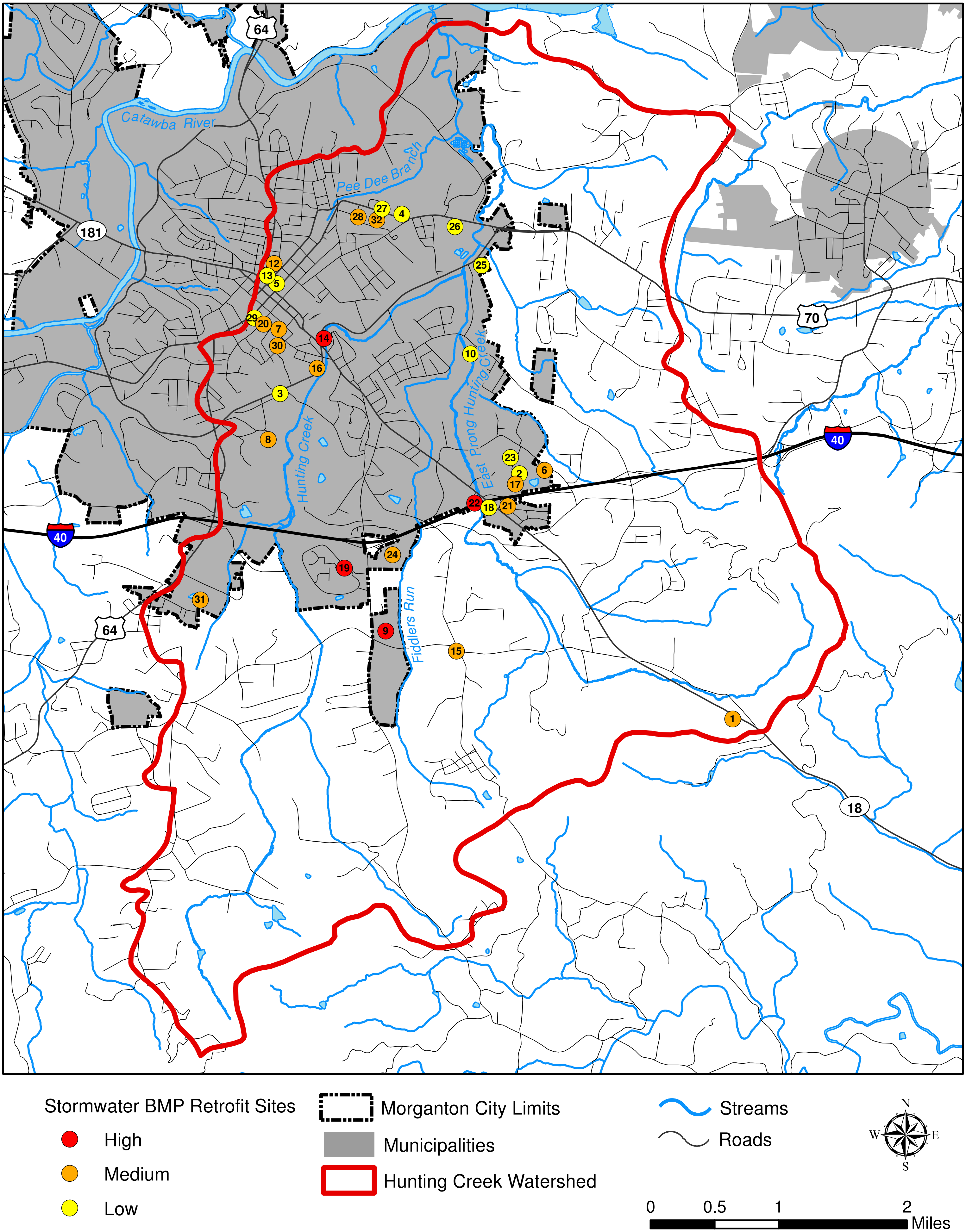


Table 4.1 Prioritized Stormwater BMP Retrofits

Site	BMP ID	Property Name	Type of BMP	Sub watershed	% Drainage Area Impervious	Nitrogen Removal (lb/year)	Accessible?	Public Land	Hot Spot	Priority
14		Roses, Shoe Show, Aaron's, Wachovia	bio-retention	4	55%	1.1	yes	no	yes	High
9	B	Liberty Middle School	constructed wetland	5	49%	2.3	yes	yes	no	High
9	D	Liberty Middle School	bio-retention	5	43%	1.0	yes	yes	no	High
9	F	Liberty Middle School	extended detention	5	42%	1.4	yes	yes	no	High
19	A	J. Iverson Riddle Development Center	extended detention	7	29%	16.9	yes	yes	no	High
19	B	J. Iverson Riddle Development Center	bio-retention	7	50%	3.7	yes	yes	no	High
19	C	J. Iverson Riddle Development Center	extended detention	7	50%	3.6	yes	yes	no	High
22		I-40 West Entrance Ramp at NC-18	constructed wetland	7	74%	3.4	no	yes	no	High
1		Burke County Recycling and Waste Center	bio-retention	9	53%	0.3	no	yes	yes	Medium
6	A	Burke County Human Resources Center	bio-retention	7	50%	0.4	yes	yes	no	Medium
6	B	Burke County Human Resources Center	bio-retention	7	50%	0.3	yes	yes	no	Medium
7	A	Morganton Municipal Auditorium	bio-retention	5	47%	0.1	yes	yes	no	Medium
7	B	Morganton Municipal Auditorium	bio-retention	5	47%	0.1	yes	yes	no	Medium
7	C	Morganton Municipal Auditorium	bio-retention	5	47%	0.4	yes	yes	no	Medium
7	D	Morganton Municipal Auditorium	bio-retention	5	47%	0.3	yes	yes	no	Medium
7	E	Morganton Municipal Auditorium	bio-retention	5	47%	0.2	yes	yes	no	Medium
8	A	North Carolina School for the Deaf	bio-retention	5	50%	0.5	yes	yes	no	Medium
8	B	North Carolina School for the Deaf	constructed wetland	5	21%	4.1	yes	yes	no	Medium
9	A	Liberty Middle School	bio-retention	5	50%	0.8	yes	yes	no	Medium
9	C	Liberty Middle School	bio-retention	5	48%	0.6	yes	yes	no	Medium
9	E	Liberty Middle School	extended detention	5	18%	1.4	yes	yes	no	Medium
15	A	Mull School	bio-retention	4	50%	0.3	yes	yes	no	Medium
15	B	Mull School	extended detention	4	50%	0.3	yes	yes	no	Medium
15	C	Mull School	constructed wetland	4	35%	1.3	yes	yes	no	Medium
24	A	Fiddlers Run Shopping Center	bio-retention	8	55%	1.0	no	no	yes	Medium
24	B	Fiddlers Run Shopping Center	bio-retention	8	55%	1.4	no	no	yes	Medium
24	C	Fiddlers Run Shopping Center	bio-retention	8	55%	1.7	no	no	yes	Medium
24	D	Fiddlers Run Shopping Center	bio-retention	8	55%	1.3	no	no	yes	Medium
28	A	Hillcrest Elementary School	bio-retention	4	50%	0.3	yes	yes	no	Medium
28	B	Hillcrest Elementary School	bio-retention	4	50%	0.3	yes	yes	no	Medium

Site	BMP ID	Property Name	Type of BMP	Sub watershed	% Drainage Area Impervious	Nitrogen Removal (lb/year)	Accessible?	Public Land	Hot Spot	Priority
30		Burke County Junior High School	bio-retention	5	47%	0.4	yes	yes	no	Medium
12		Right of Way	extended detention	5	41%	22.5	no	no	no	Medium
16		NAPA Auto Parts and Auto Zone	bio-retention	4	56%	1.3	no	no	no	Medium
17	B	Rooster Bush Chevrolet Car Dealership	bio-retention	7	55%	1.2	no	no	no	Medium
20		JORDANS INC	bio-retention	5	47%	1.7	yes	no	no	Medium
21	A	Sage Brush Steakhouse	bio-retention	7	54%	0.4	yes	no	no	Medium
21	C	Sage Brush Steakhouse	bio-retention	7	55%	0.1	yes	no	no	Medium
23	D	Grace Hospital, Blue Ridge Health Care	bio-swale	7	50%	1.4	yes	no	no	Medium
23	G	Grace Hospital, Blue Ridge Health Care	constructed wetland	7	49%	5.9	yes	no	no	Medium
25	A	The Outreach Center	bio-retention	3	55%	1.1	no	no	no	Medium
25	D	The Outreach Center	bio-retention	3	55%	1.2	no	no	no	Medium
26	C	Viscotec	bio-retention	1	54%	4.5	no	no	yes	Medium
31		Environmental Ink	constructed wetland	5	63%	1.0	no	no	no	Medium
24	E	Fiddlers Run Shopping Center	bio-retention	8	55%	0.9	no	no	yes	Medium
32	B	Burke County Board of Education	extended detention	5	34%	3.8	no	yes	no	Medium
2	A	Foothills Medical Park	bio-retention	7	50%	0.2	yes	no	no	Low
2	B	Foothills Medical Park	bio-retention	7	50%	0.3	yes	no	no	Low
5	A	Bank of Granite, Restaurant	bio-retention	4	47%	0.1	yes	no	no	Low
5	B	Bank of Granite, Restaurant	bio-retention	4	47%	0.3	yes	no	no	Low
5	C	Bank of Granite, Restaurant	bio-retention	4	47%	0.5	yes	no	no	Low
10		Bethel Park	bio-retention	8	7%	0.2	yes	yes	no	Low
13		Mull , Inc	bio-retention	4	47%	2.0	no	no	no	Low
17	A	Rooster Bush Chevrolet Car Dealership	structural bmp	7	55%	0.5	no	no	no	Low
18		El Paso Mexican Restaurant	bio-retention	7	55%	0.6	no	no	no	Low
21	B	Sage Brush Steakhouse	bio-retention	7	49%	0.3	yes	no	no	Low
23	A	Grace Hospital, Blue Ridge Health Care	extended detention	7	10%	1.1	yes	no	no	Low
23	C	Grace Hospital, Blue Ridge Health Care	extended detention	7	32%	1.0	yes	no	no	Low
23	E	Grace Hospital, Blue Ridge Health Care	bio-retention	7	50%	0.4	yes	no	no	Low
23	F	Grace Hospital, Blue Ridge Health Care	bio-retention	7	50%	0.7	yes	no	no	Low
25	B	The Outreach Center	bio-retention	3	55%	0.3	no	no	no	Low
25	C	The Outreach Center	bio-retention	3	55%	0.3	no	no	no	Low
27		MHA - Cognitive Con	bio-retention	4	55%	0.4	no	no	no	Low

Site	BMP ID	Property Name	Type of BMP	Sub watershed	% Drainage Area Impervious	Nitrogen Removal (lb/year)	Accessible?	Public Land	Hot Spot	Priority
32	A	Whisnant, C. Scott Et Al	extended detention	5	13%	2.1	yes	no	no	Low
3		State Farm Insurance	bio-retention	2	55%	0.2	no	no	no	Low
4	A	New Day Christian Church	extended detention	4	12%	1.3	no	no	no	Low
23	B	Grace Hospital, Blue Ridge Health Care	extended detention	7	30%	0.8	yes	no	no	Low
26	A	Viscotec	extended detention	1	15%	4.0	no	no	yes	Low
26	B	Viscotec	constructed wetland	1	29%	4.1	no	no	yes	Low
29	A	Psalms Urgent Care, Pharmacy, Insurance Agency	bio-retention	5	47%	0.1	no	no	no	Low
29	B	Psalms Urgent Care, Pharmacy, Insurance Agency	bio-retention	5	47%	0.2	no	no	no	Low
29	C	Psalms Urgent Care, Pharmacy, Insurance Agency	bio-retention	5	47%	0.5	no	no	no	Low
4	B	New Day Christian Church	bio-retention	4	5%	0.3	no	no	no	Low

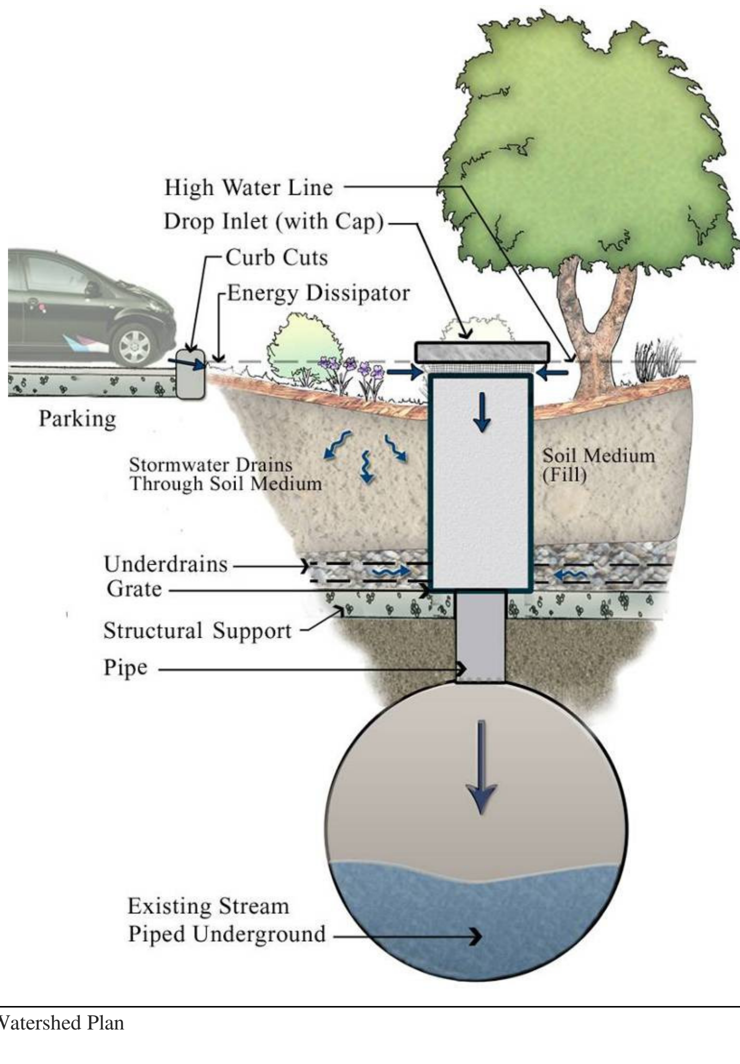
4.2.4 Site Exhibits

Site 14: Roses, Shoe Show, Aaron's, Wachovia

This site is a large commercial strip-mall with an extensive parking lot that has been built directly over the main stem of Hunting Creek. In total, the site drains approximately 2 acres of impervious surfaces including the retail buildings, the parking lot, and a portion of US-70. No treatment of stormwater occurs prior to it entering Hunting Creek.

Stormwater treatment in this location can be accommodated by refining the parking lot configuration to incorporate several bio-retention islands. Treatment areas could be placed so there is no or minimal loss of parking spaces, however, further study for parking reconfiguration and circulation would be required. The bio-retention islands would be strategically located to intercept surface runoff and filter stormwater through a soil medium. Once filtered, the water would be piped to an outfall to Hunting Creek. Figure 4.5 illustrates a cross-section of a bio-retention island in a parking lot and how it functions to capture and treat stormwater runoff. In addition to treating stormwater runoff, this site offers high visibility by the public. Furthermore, the expansive parking lot would benefit from aesthetic enhancements through trees and landscaping that also provides shade.

Figure 4.5 Cross-Section of a Bio-retention Island in a Parking Lot



Site 9: Liberty Middle School

Liberty Middle School is located south of downtown Morganton adjacent to Fiddlers Run. Multiple opportunities to incorporate stormwater BMPs on available open space around the school would provide stormwater treatment for rooftops and parking areas (Figure 4.6). Available open space also provides an opportunity to daylight an existing pipe system that is routed directly to the Fiddlers Run immediately adjacent to the athletic fields (Figure 4.7). In addition to treating stormwater runoff and enhancing the stormwater conveyance system, stormwater BMPs provide educational opportunities on school grounds.

Figure 4.6 Plan View of Liberty Middle School

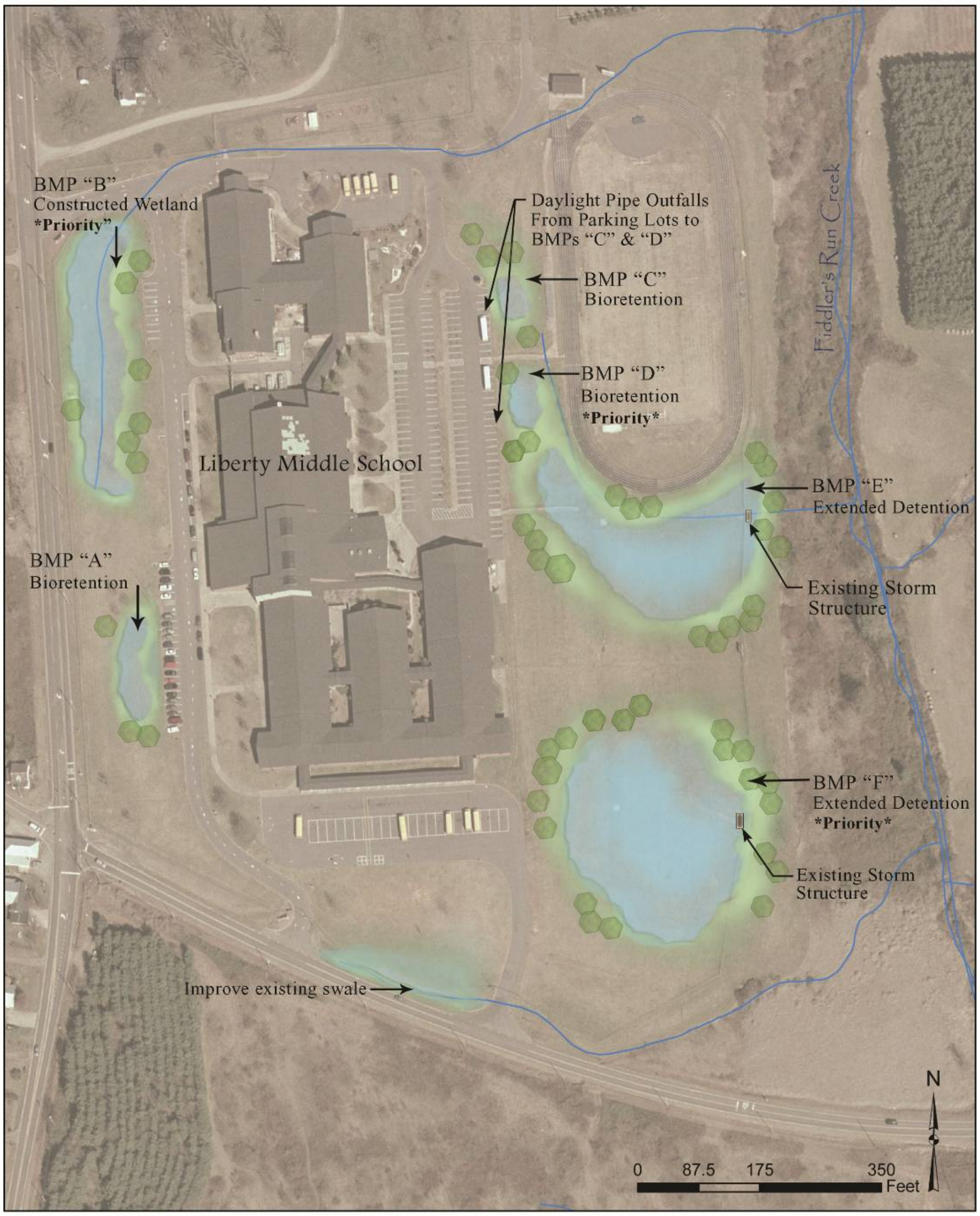


Figure 4.7 Illustration of BMP C

4.2.5 Pollutant Reduction Potential

Each BMP type has a varying efficiency for removing different pollutants. Table 4.2 lists BMP types and the pollutant removal efficiencies of each.

Table 4.2 Pollutant Removal Efficiencies of Stormwater BMP Types

BMP Type	Ability to Reduce Volume?	Total Suspended Solids	Nitrogen	Phosphorous	Fecal coliform Removal Ability
Bio-retention	possible	85%	35%	45%	high
Constructed Wetlands	yes	85%	40%	40%	high
Bio-swale	no	35%	20%	20%	low
Extended Detention	yes	50%	10%	10%	medium
Filtration	possible	85%	30%	35%	high
Permeable Pavement	possible	0%	0%	0%	low
Riparian Buffers	no	60%	30%	35%	high

(NCDWQ 2007)

An estimate of pollution reduction potential was calculated based on pollutant removal efficiencies, Burke County annual precipitation, the percent of impervious surfaces draining to each stormwater BMP, the pollutant concentration in runoff based on land use, and the area of land draining to the stormwater BMP using the SIMPLE method (Schueler 1987). It should be noted that the calculations in this model are only rough approximations of actual pollutant reductions. A more in depth study of each site would be required to accurately estimate pollutant reductions.

Table 4.3 shows the cumulative annual reductions in nitrogen, phosphorus, total suspended solids, and zinc if all identified stormwater BMPs were to be installed in the Hunting Creek Watershed. Refer to Appendix I for a complete table of pollutant reduction calculations for individual stormwater BMPs.

Table 4.3 Potential Pollutant Reductions from Stormwater BMP Retrofis in the Hunting Creek Watershed

	Total Nitrogen (lb/year)	**Total Phosphorus (lb/year)**	**Total Suspended Solids (lb/year)**	**Zinc (lb/year)**
All proposed stormwater BMPs	121	116	4,309	2,881

Comparing the potential pollutant reductions from stormwater BMP retrofits to the estimated annual pollutant loads in the Hunting Creek Watershed (Table 3.1), one can see that the resulting reductions are slight; however, the cumulative benefits of reducing impervious surface area, reducing stormwater volume and velocity contributing to stream bank erosion, improving wildlife habitat, beautifying the landscape, and educating the public about stormwater runoff far outweigh the ability of stormwater BMPs to remove nutrients.

Furthermore, stormwater BMPs can achieve additional goals stated in this plan. Mutual cooperation and collaboration between landowners, local governments, and non-profit groups is necessary to achieve stormwater BMP implementation. As private landowners learn about best management practices from demonstration projects on public land, they will want to install BMPs on their property. Finally, stormwater BMP installation requires professional services for design, construction, and maintenance thus employing contractors and stimulating the local economy.

Stormwater BMPs are just one of several management measures to improve water quality in the Hunting Creek Watershed. The following subsections detail additional steps that support the process of restoring fish communities in Hunting Creek.

4.2.6 Outreach and Education Strategies for Stormwater Best Management Practices

To engage the public in stormwater management, the Hunting Creek Partners developed an outreach and education strategy that identifies target audiences, the message to be relayed to target audiences, and the best methods for message delivery. Targeted audiences vary from the general public to educators, developers, large landowners, and elected officials. The common message is that everyone can do their part. Because audiences vary, the message and method of delivery is adapted to effectively capture the attention of a particular group. The following strategies were developed for each target audience.

General Public

Members of the general public include everyone who lives and works in the Hunting Creek Watershed. This includes home owners, businesses, churches, parents, children, and voters. The general public has the ability to influence elected officials with voting power. Increasing awareness about stormwater management within this group is important since each individual action can collectively make a difference in watershed conditions. Educating the general public on proper lawn care that minimizes the excessive use of fertilizers, encouraging downspout disconnection to allow rooftop runoff to infiltrate into the ground, preventing fluid leakage from cars and other measures can make a difference in water quality conditions if they are adopted on a large scale by the general public. Relaying the message of how stormwater affects each person and their quality of life is central to affecting a change in behavior.

Public service announcements on public access television using iconic characters and catchy phrases can capture the attention of viewers and educate them about what they can do to reduce stormwater runoff. Students at Western Piedmont Community College and Freedom High School can help develop YouTube videos to post on Partner websites. The website may also contain a distribution map of installed stormwater BMP sites that the public can interact with. In order to affect change and motivate citizens into action, it is critical to explain to the general public that better stormwater management protects the environment, reduces costs for treating polluted water, and improves the community's quality of life through landscape enhancements.

Educators

The educator audience includes elementary, middle school, high school, and college teachers who relay information to students and parents. The role of teachers is to raise awareness about water quality to future generations. The Western Piedmont Council of Governments and the cooperative extension have developed stormwater curriculum that teachers can integrate into lessons about watersheds and the water cycle. Teachers may also take their classes on field trips to tour stormwater BMP demonstration projects. Finally, teachers can also utilize media developed for the general public such as YouTube videos and the interactive map.

Developers

Because developers are primarily the parties involved in creating impervious surfaces, they are an important audience to reach. Phase II requirements mandate stormwater controls on new developments, but can be difficult to navigate through the variety of ordinances and specifications. A simple, straightforward, comprehensive manual with all the rules and regulations explained in plain terms would help developers interpret how they are to implement regulations. Through workshops and tours of demonstration projects, developers would be encouraged to rethink development in terms of low impact development, green construction, and the cost of new stormwater BMPs versus the cost of retrofitting.

Large Landowners

Although a relative term, large landowners are primarily state institutions with large campuses that contain buildings, parking lots, and turf grass. Examples of large landowners in the Hunting Creek Watershed include Broughton Hospital, NC School for Deaf, J. Iverson Riddle Development Center, Western Piedmont Community College, NC State Correctional Facility, and NC Department of Transportation land (Figure 2.3). These institutions should be leaders in good housekeeping and best management practices that the general public can learn from. Stormwater BMP projects on these properties can serve as demonstration projects that can be included in a tour. Furthermore, grounds keepers and landscapers of these facilities should be educated on best practices for turf grass management as well as stormwater BMP maintenance.

Elected Officials
Elected official including the mayor, city council, county commissioners, and economic development officials should be kept well apprised of watershed restoration activities. Elected officials not only influence the passage of local ordinances and regulations, they also vote to approve capital budgets that may lead to project implementation. Informing these leaders about the issues Hunting Creek faces while providing them with management solutions that address the issues is important and can be done through a series of presentations and one-on-one meetings. Because local governments are often strapped for cash, it is important to make them aware of the economic, social, and environmental benefits of stormwater BMPs (Section 1.2). They should be made well aware that protecting natural resources requires less of a financial investment than restoring impacted streams. Polluted water requires more money to treat so that it can be used for drinking. Furthermore, repairing property, bridges, utilities, and other infrastructure due to flood damage and stream bank erosion is more costly than preventing it with best management practices.

4.3 Stream Channel Restoration and Riparian Area Enhancement

The Hunting Creek Watershed assessment revealed the extent of stream channel degradation throughout the watershed (Section 3). Stream channels in the Hunting Creek Watershed are highly incised and lack woody riparian vegetation, leading to stream bank erosion, property loss, sedimentation, and degraded aquatic habitat. Incised streams in particular are detached from their adjacent floodplains, which reduces or eliminates the ability of the floodplain to mitigate storm flow velocities and are subject to being constantly eroded.

4.3.1 Stream Channel Restoration

To rectify these problems, it will be necessary to apply stream restoration techniques that reestablish the proper dimension, pattern, and profile to the stream channel. Restoration of degraded reaches will lead to reduced erosion, improved sediment transport, and better in-stream habitat conditions. Revegetation of the riparian area adjacent to the restored stream channel with native shrubs, trees, and herbaceous plants should be conducted in concert with stream restoration to reestablish a riparian area's ability to filter sediment and other pollutants originating from upland areas.

Eroding stream bank along Hunting Creek lacking woody riparian vegetation.

Bob's Creek, an eroding stream in the Muddy Creek Watershed that underwent stream restoration.

Bob's Creek with reestablished channel dimension and pattern and planted riparian area.

Bob's Creek with established riparian vegetation.

As part of a 2009 study conducted for the NC Ecosystem Enhancement Program (Equinox 2009b), Equinox identified potential stream restoration and enhancement projects. Using GIS analysis of 2005 aerial photos and professional judgment, potential projects were identified using the following criteria:

- *Streams that contain minimal or no forested riparian buffer*. Stream impacts from adjacent land uses are greater in areas where little to no woody vegetation occurs in the riparian area.
- *Drainage area at the most downstream point is less than 10 mi^2*. Stream restoration is often more successful on smaller reaches with smaller drainage areas where future changes in land use are less likely to effect the restored channel.
- *Project length is a minimum of 2,000 contiguous feet*. Longer projects are logistically more cost effective to implement.
- *Project involves 3 or fewer landowners*. The feasibility of implementing a successful project declines as the number of landowners increases.

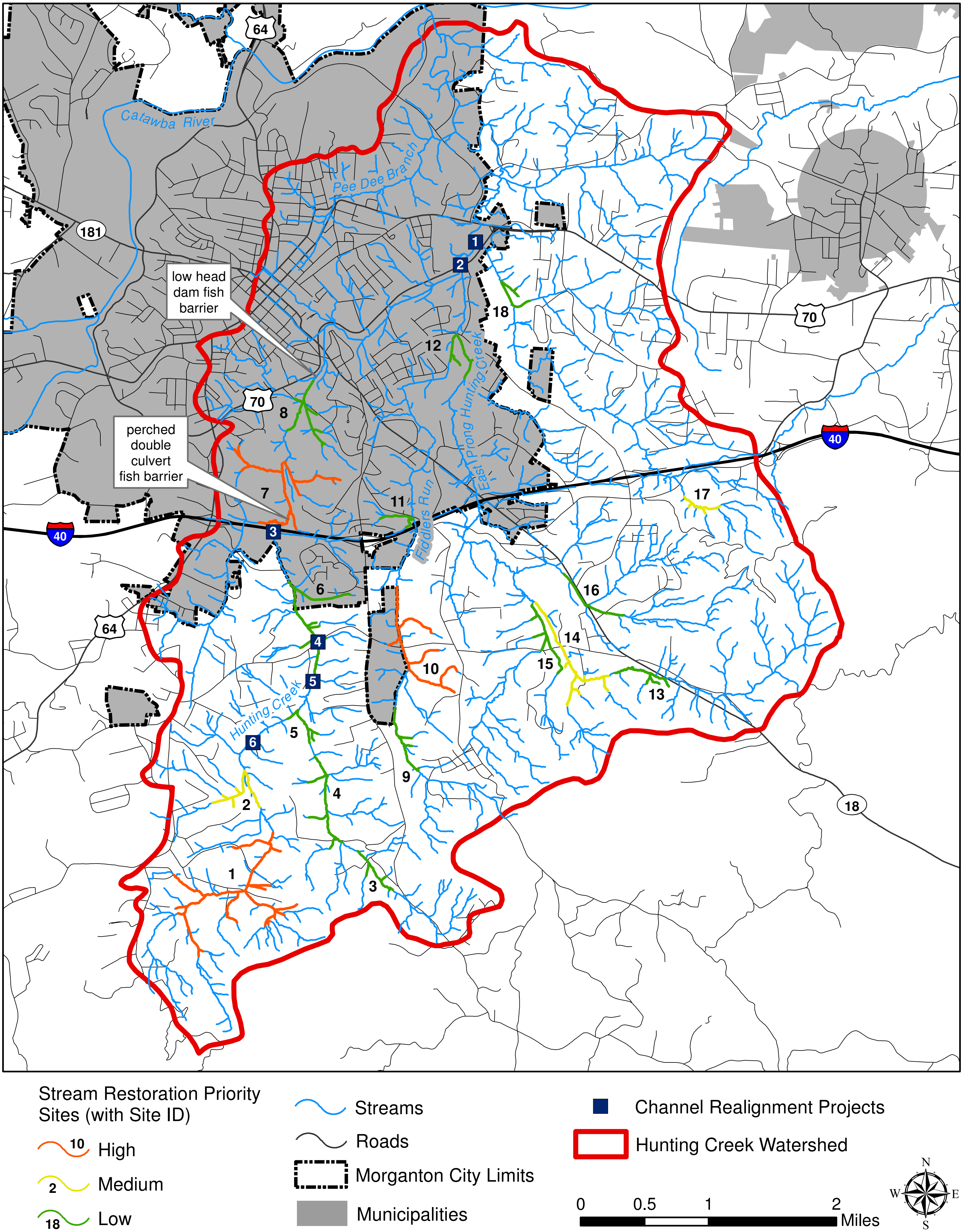
Following these criteria, the study identified eighteen potential stream restoration and enhancement projects in the Hunting Creek Watershed totaling 21 miles of stream (Figure 4.8). The projects were prioritized to distinguish between projects of varying feasibility and restoration effectiveness. Streams with longer lengths and smaller drainage areas received higher priority. In addition, streams with adjacent wetland restoration opportunities were given high priority since wetlands provide additional water quality benefits.

According to the prioritization, 3 high priority restoration projects were identified, 3 medium priority projects, and 12 low priority projects (Table 4.4). All stream restoration projects are located on a mix of state, county, city and privately owned land. Prior to implementation, projects must be assessed in greater detail to determine whether or not they are feasible based upon physical constraints and landowner agreement. Table 4.4 lists potential stream restoration projects that are shown in Figure 4.8.

Table 4.4 Potential Stream Restoration and Enhancement Projects

Site ID	Length (ft)	Downstream Drainage Area (mi²)	Number of Landowners	Landowner Type	Wetland Opportunities?	Priority
10	11,075	1.3	3	state and county	no	high
1	20,131	1.6	2	state and private	yes	high
7	12,349	7.3	1	state	yes	high
2	4,969	2.3	3	private	no	medium
14	8,129	1.9	10	private	yes	medium
17	2,334	0.3	1	private	yes	medium
5	3,005	2.9	4	private	yes	low
6	9,499	5.5	12	private	yes	low
4	6,306	1.5	5	state and private	yes	low
8	6,051	8.2	2	state and county	no	low
13	3,743	1.4	3	private	yes	low
12	3,974	6.5	2	city and private	yes	low
16	3,276	1.2	2	private	yes	low
18	2,954	2.7	2	private	yes	low
3	3,166	0.8	3	private	yes	low
9	3,975	0.6	6	state, county and private	no	low
15	4,862	1.0	5	private	yes	low
11	2,129	0.1	1	private	no	low

Figure 4.8 Potential Stream Restoration & Enhancement Projects in the Hunting Creek Watershed



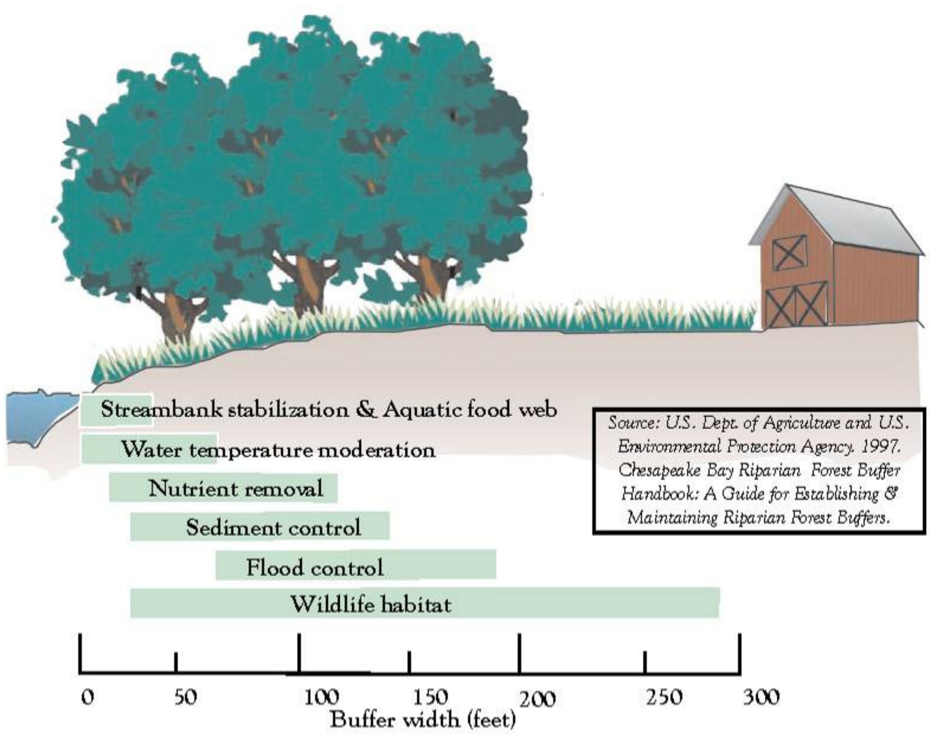
4.3.2 Riparian Area Enhancement

Upon further investigation of stream restoration projects, it may be determined that some streams contain physical constraints or that the stream banks are currently stable, but the riparian vegetation is sparse or nonexistent. These conditions exist primarily in developed areas where utilities must be maintained, but also include agricultural lands and low density developments. Riparian areas in such condition are not effective at capturing sediment or other pollutants originating from upland areas. In those cases, enhancement of woody riparian vegetation and expansion of the riparian area width is all that is needed or possible.

Forested buffers along streams act as filters to reduce sediment inputs associated with adjacent land use practices. Additionally, riparian vegetation can reduce stream bank scour during storm events by holding the soil in place (Figure 4.9). For these purposes, riparian areas in the Hunting Creek Watershed should be enhanced by reestablishing native trees, shrubs, and herbaceous plants. Control of invasive exotic plant species should also be carried out in conjunction with all riparian vegetation enhancement projects. In addition to creating monocultures, the most common invasive exotic plants do not have the root structure necessary to hold stream banks in place or to filter pollution.

Riparian area enhancement should be carried out on all streams segments listed in Table 4.4, especially on segments that were determined to be non-feasible for full stream restoration because of too many constraints.

Figure 4.9 Functions of Woody Riparian Vegetation



Recommended Native Plant Species for Use in Stream Restoration and Riparian Enhancement

Trees	*River Birch, Bitternut Hickory, Shagbark Hickory, Sugarberry, Persimmon, Green Ash, Blackgum, Sycamore, Black Cherry, Swamp Chestnut Oak, Water Oak, Shumard Oak, Black Willow, White Basswood*
Small Trees & Shrubs	*Southern Sugar Maple, Painted Buckeye, Tag Alder, Service Berry, Red Chokeberry, Common Paw Paw, Sweet Shrub, Ironwood, Buttonbush, Alternate Leaf Dogwood, Silky Dogwood, Hazelnut, Deciduous Holly, Winterberry, Virginia Willow*
Herbs	*Jack-in-the-Pulpit, Swamp Milkweed, Fringed Saxifrage, Bladder Sedge, Hop Sedge, Lurid Sedge, Broom Sedge, Tussock Sedge, Fox Sedge, Turtlehead, Umbrella Sedge, Bottlebrush Grass, Joe Pye Weed, Boneset, Jewel Weed, Soft Rush, Rice Cutgrass*

Developed by the North Carolina Stream Restoration Institute, NCSU
Note: this list is not exhaustive and is intended as a guide. Plants listed in the table may not be appropriate and revegetation plans should be developed for site specific conditions

4.3.3 Channel Realignment

In addition to channel reconfiguration and riparian enhancement, locations where the stream channel is not aligned correctly with road crossings are an additional concern. These areas are characterized by bank scour, accumulations of large woody debris, and impacts to utilities. Realignment of the stream channels would reduce the risk of structural damage to the road crossing and impacted utility crossings. Specific locations that need to be addressed are included in Table 4.5 and shown in Figure 4.8.

Bridge crossing not aligned with flow of stream causing stream bank erosion.

Pipe utility crossing Hunting Creek under US-70 bridge. Note dislodged footer causing sag in pipe at joint.

Table 4.5 Channel Realignment Projects

ID	Stream	Type	Concern	Alignment	Notes
1	Hunting Creek	railroad crossing - bridge	improper alignment causing bank erosion	flow not aligned	footers causing erosion and debris blockage
2	Hunting Creek	utility pipe above stream	dislodge footer	N/A	dislodged footer causing sagging pipe
3	Hunting Creek	road crossing - bridge	debris blockage	flow not aligned	sediment clogging 2 of 3 box culverts
4	Hunting Creek	road crossing - bridge	none	flow not aligned	
5	Hunting Creek	utility pipe above stream	joint failure in pipe	N/A	dislodged footer causing sag in pipe at joint
6	Hunting Creek	road crossing - bridge	improper alignment causing bank erosion	flow not aligned	

4.3.4 Fish Barrier Removal

Finally, there are two structures, one culvert and one low head dam that are not only associated with stream restoration projects, but were also deemed to be barriers to aquatic organism passage (Figure 4.8). Removal or remediation of these structures is necessary to allow movement of aquatic organisms throughout the watershed. This is particularly important for fish species with limited swimming or jumping abilities. Furthermore, these structures are likely preventing some fish species from recolonizing the upstream portions of the watershed. Retrofitting the culvert and removing the dam will allow the channel pattern, cross-section dimensions, and longitudinal profile to be adjusted, thus improving channel ecological function. Removal of these barriers would allow the free movement of fish species within the Hunting Creek Watershed and allow new species, whether introduced or migrants from nearby watersheds, to become reestablished. Should the fish community fail to respond to removal of the barriers and improvements in aquatic habitat by the end of the implementation period, fish species reintroductions may be necessary. Those considerations are beyond the scope of the present planning document.

Structural crossing with double culverts creating a barrier to fish migration.

Low head dam in Hunting Creek creating a barrier to fish migration.

4.3.5 Outreach and Education for Stream Restoration and Riparian Area Enhancement

Public engagement in stream channel restoration and riparian area enhancement is critical to altering behaviors, especially when it comes to minimizing development activities and maintaining woody vegetation in the riparian area. Outreach and education strategies developed by the Hunting Creek Partners target private landowners, local governments, and state institutions. Although the target audience varies slightly, the message is similar for all groups and must be consistent.

By explaining the importance of maintaining a forested riparian area, a broader understanding of specific practices that impact water quality can be gained. Video productions could illustrate how woody vegetation along stream banks versus mowing directly to the stream channel edge prevents soil erosion and filters pollutants. Furthermore, this best management practice will minimize loss of property due to erosion and can lower maintenance costs of brush clearing and stream bank repair. The compilation of a manual listing ideal riparian area widths, plant species, planting successions, and other practices can serve as a guide for planting and maintaining an effective riparian area.

Landowners should be educated to understand that maintaining a forested buffer does not result in giving up land, rather it should be considered an investment in land quality. Not only does an intact riparian buffer reduce stream bank erosion leading to property loss, trees add to the aesthetics of a property. Forested riparian areas can also be a recreational amenity in parks and along greenway corridors. Strategically placed educational kiosks can make recreational users aware of the benefits of maintaining woody vegetation along stream banks on their properties. Public safety concerns such as vegetation blocking sight or crime prevention can be addressed through proper environmental design.

Local governments and state institutions should be leaders in land stewardship. Public works departments and grounds keepers should utilize best management practices when landscaping. Furthermore, local representatives at state facilities should be encouraged to bring a message to Raleigh so that state officials can incorporate stream restoration and riparian enhancement projects into budgets and facility plans.

Finally, good land stewards should be recognized for championing best management practices on their property. Through media publicity such as newspapers, TV, and social media, landowner champions can be interviewed to relay their experience to other landowners in the watershed.

4.4 Protecting Intact Forests

While the previous management measures are targeted at restoring stream channel integrity and aquatic habitat conditions, they do not address future impacts to areas having functioning stream channels and intact riparian areas. In the case of the Hunting Creek Watershed, this involves protecting undeveloped, private, forested lands. Implementing management measures to protect conditions at these sites is important to the long-term health of the watershed. Management strategies to be used in protecting these areas include the following:

- *Fee simple purchase of lands*. The property is purchased with the intention of perpetual conservation by a land trust, local government, or other land steward.
- *Acquisition of conservation easements for entire properties or riparian areas only*. A property owner voluntarily agrees to give up certain development rights on their property or on portions of their property. These areas are placed within a conservation easement, which is recorded on the deed, and is therefore legally binding.
- *Transfer of development rights (TDR)*. In order to protect intact forests from development, the right to develop on a forested property can be relocated to an area more suitable for dense development. The cost of purchasing TDRs is offset by density bonuses given to developers within high density development areas.
- *Incentive contracts for agricultural lands*. To encourage farmers to maintain forested riparian buffers, contracts may be drawn between land owners and local agencies.
- *Informal landowner agreements*. Although the least desirable strategy for preserving intact forests, landowners may develop written agreements with local governments or non-profit organizations to preserve forest lands on their property.

Preserving intact forests and riparian areas will serve to protect water quality, minimize erosion and sedimentation, and protect functioning aquatic and upland wildlife habitats. Forested riparian areas provide shade and organic material such as leaves, twigs, and large woody debris that are important components in maintaining aquatic communities for both fish and macroinvertebrates.

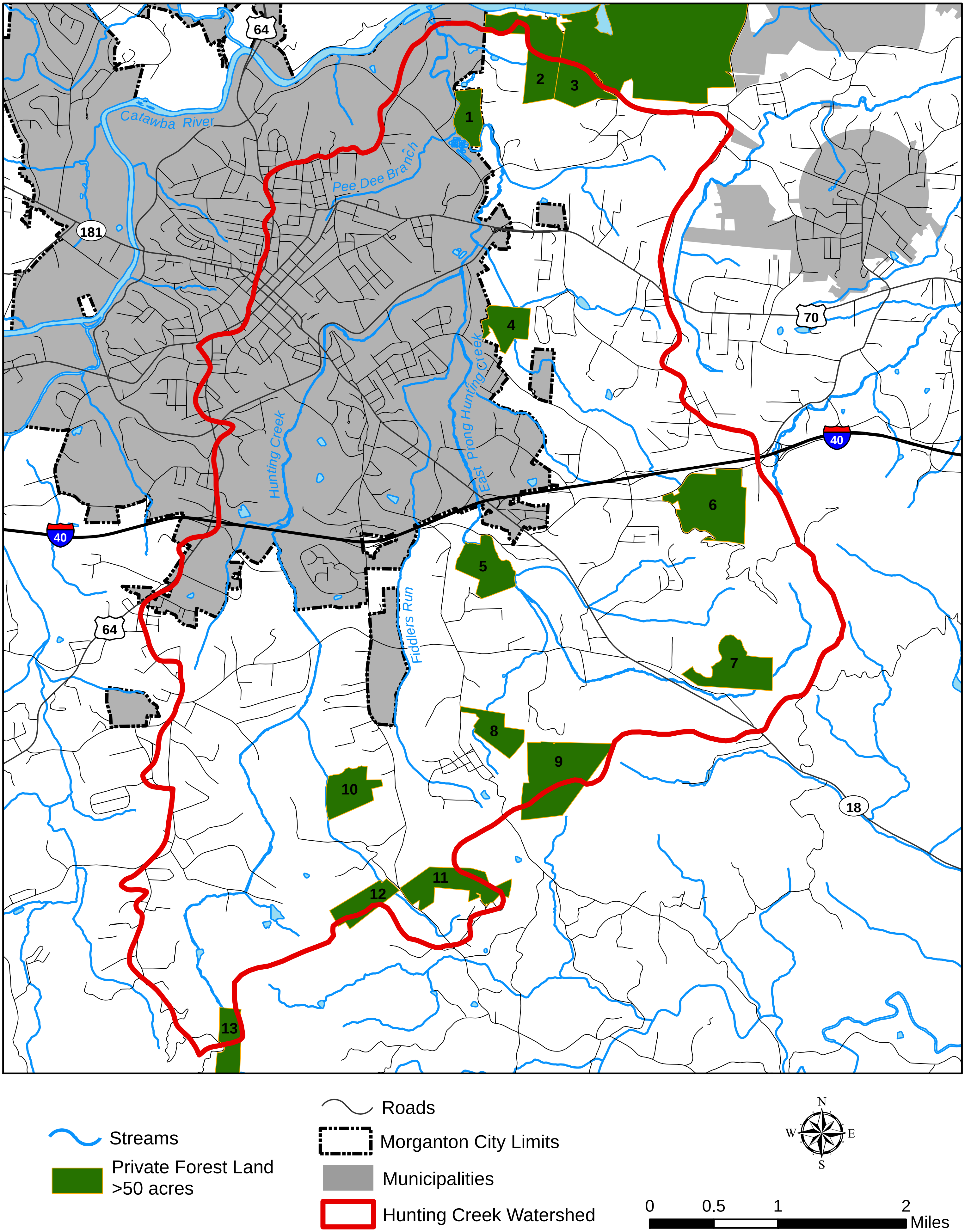
Using land cover (Figure 2.2) and Burke County parcel data, forested parcels ≥50 acres were identified with GIS. A total of 13 forested tracts totaling 2,056 acres within the Hunting Creek Watershed were identified for preservation. Cumulatively, these tracts would effectively protect forested riparian areas along 12 miles of streams. Potential preservation tracts are listed in Table 4.6 and shown in Figure 4.10.

Table 4.6 Potential Forest Preservation Tracts

Site ID	PIN	Total Parcel Acreage	Length of Streams (ft)
1	271413130769	50	4,065
2	271400461836	137	2,223
3	271402769618	916	2,585
4	271300256506	59	3,371
5	271209158681	85	6,404
6	272205182460	166	13,570
7	272217222442	103	6,609
8	271105284920	58	6,475
9	271110571131	184	6,275
10	270111663535	73	6,083
11	271113122749	98	3,174
12	270100617868	58	2,340
13	270000152768	69	1,926

Outreach and education strategies for protecting intact forests should target landowners with large, forested tracts. Land trusts, local governments, the Soil and Water Conservation District, and the NC Division of Forest Resources (NCDFR) should educate these landowners on the benefits of preserving their land and the financial incentives available if they were to put their land into conservation. NCDFR can serve as a resource to landowners who wish to create a forest management plan on their property. Finally, the City of Morganton and Burke County officials should become well acquainted with TDRs as a land development tool that supports the Mission 2030 Plan and protects intact forests.

Figure 4.10 Potential Forest Preservation in the Hunting Creek Watershed



4.5 Local Government Practices and Programs

Local governments including city, county, and state jurisdictions have a large role to play in watershed restoration. Day-to-day operations often affect water quality within a community. Management measures that local governments can fulfill go beyond physical improvements and often involve improving programs already underway (Section 2.3). Furthermore, local agencies can set a positive example of good stewardship that watershed residents can learn from and follow. The following subsection highlights programs and practices that complement existing operations in the Hunting Creek Watershed.

4.5.1 Streets, Storm Drains, and Utilities

Proper maintenance of infrastructure is not only important for the upkeep of municipal services, it is also important for pollution prevention. There are several small measures that, if adopted, can have a large cumulative effect.

Catch Basin Cleanout

When stormwater runs off the street during a rain event, it enters a storm drain with a catch basin before it enters a pipe that channels water to the nearest stream. Catch basins are designed to capture trash, debris, sediment, and other material before it flows to the stream. Over time, this debris accumulates and if it is not routinely cleaned out, it can be transported to the stream or clog the infrastructure. Regular catch basin cleanouts remove trash, sediment, and debris from the system, thereby reducing pollution to streams.

Stenciling on a storm drain lets the public know where stormwater goes.

Pipe utility crossing Hunting Creek above stream with debris pile behind pipe. Also note erosion along stream bank

Storm Drain Stenciling

In an effort to raise awareness, storm drain stenciling reminds citizens that everything going into the storm drain eventually ends up in the stream or river. Custom stencils or weatherproof tags are inexpensive and can be applied by volunteers.

Utilities

A sewer line runs parallel to Hunting Creek for approximately 80 miles from its headwaters to the Catawba River. In order to avoid possible leaks, overflows, or breaks, it is important to regularly inspect sewer infrastructure and repair or replace faulty sewer lines. In addition to sewer line inspections, it is important to check on other pipelines and utilities in the stream corridor as well. During the stream walk assessments, several pipes originally installed underground were observed to be exposed due to stream bank erosion and channel down-cutting. These pipes are now threatened by further erosion, log jams, and flood events. Exposed utilities may also contribute to stream bank instability and erosion.

Stormwater Administrator
Section 9-8010 of the Morganton Stormwater Ordinance designates a stormwater administrator to carryout and enforce the city's stormwater ordinance and review applications for development to ensure they follow stormwater management standards. At the time this plan was developed, this position remained vacant due to budgetary constraints. This position should be filled as soon as possible.

4.5.2 Best Practices for Development
As the City of Morganton and Burke County grow, there are a variety of practices that can be implemented for private and public sector development projects in an effort to protect water resources in the watershed.

Smart Growth and Low Impact Development
Smart Growth concentrates development in the city center while Low Impact Development is development or re-development that minimizes imperviousness and maintains pre-development hydrology through stormwater management and open space preservation. Consistent with Morganton's Mission 2030 Plan (City of Morganton 2010), redevelopment and development of industrial, commercial, and institutional districts should occur as infill development and should not be expanded to include additional undeveloped land area. Furthermore, the 2030 plan states "Residential subdivisions should be encouraged to be cluster developments to preserve tree cover and open space…" To encourage this type of development, programs such transfer of development rights, density bonuses, and other subsidies should be available as incentives.


Traditional development patterns perpetuate sprawl.


Cluster development patterns protect open space and character while protecting water resources.

Stormwater Fee
In addition to the environmental costs of stormwater, managing stormwater costs money – money towards the maintenance and improvement of the storm drain system. Furthermore, programs required by the City of Morganton to implement Phase II regulations also have an associated cost. Implementing a stormwater fee based on the amount of impervious surfaces on a property, including rooftops, driveways, and parking lots will encourage Low Impact Development and can provide a revenue stream for Phase II requirements, capital improvement

projects, stormwater BMP demonstration projects, and additional watershed analysis. To encourage and reward landowners who implement stormwater best management practices on their property, discounts or scaling fees can be given as an incentive.

The City of Asheville collected approximately $2.3 million in fees in 2006 from stormwater fees.
-City of Asheville Stormwater Services Report to Citizens, April 2007

4.5.3 Land Stewardship Programs

In the Hunting Creek Watershed, approximately 10% of land is publicly owned by the State of North Carolina, Burke County, and the City of Morganton. It is crucial that these publicly owned lands serve as examples of good land stewardship. There are a variety of opportunities to implement improved land use practices that will lead to reduced pollution and restored water quality.

Park and Landscape Maintenance

Much of the open space at parks and institutions in the Hunting Creek Watershed are comprised of turf grasses. Turf management practices such as fertilization, pesticide application, mowing and other maintenance practices contribute nutrients, toxins, sediments, and other pollutants to the stream. Woody vegetation in the riparian area is often controlled or removed from the riparian area in order to maintain grass up to the stream channel. This essentially eliminates the pollutant filtering function and soil holding capacity of the riparian area. Training landscapers and groundskeepers in turf best management practices and maintaining woody riparian vegetation will reduce pollution runoff and serve as an example for the public.

Watershed Reforestation

One alternative to turf grass is reforestation. The Center for Urban Forest Research estimates the cost:benefit of urban forests as 1:2 (2003). By re-vegetating a land area with native trees, stormwater infiltration is increased, thus reducing runoff. Additional benefits include improved air quality, carbon sequestration, wildlife habitat creation, as well as beautification. Furthermore, maintenance costs associated with turf management will be reduced or eliminated. Opportunities for reforestation and tree plantings exist at public schools and institutions, vacant lots, streetscapes and medians, and other large grassed areas.

Recognition Programs

A final incentive that encourages good land stewardship is recognition programs. Recognition programs can be as simple as a newspaper article recognizing a good land steward or as sophisticated as one that includes a certification program for landowners that adopt a minimum number of defined best management practices on their property. These types of programs attempt to award positive behavior rather than punish negative behavior through fines.

4.6 Additional Watershed Assessments

Although sufficient data is available to address sources of major stressors within the Hunting Creek Watershed, data gaps still exist, particularly for water quality related issues. Additional assessments are needed to determine outfall sources and contents, hotspot characteristics, and fecal coliform bacteria sources. These data are necessary to determine site specific impacts, to establish more accurate pollutant reduction targets, and to determine remediation needs. Efforts to reduce the impacts of these stressors will lead to improved water quality conditions and, subsequently, to improvements in the aquatic communities of Hunting Creek.

4.6.1 Water Chemistry Sampling

Two years of water chemistry data was collected at 6 sites throughout the Hunting Creek Watershed. According to this data, nitrogen concentrations and conductivity were observed to be elevated (Section 3.3.3). Because it is difficult to develop any conclusions about water chemistry stressors based on four sampling events, additional water chemistry sampling should be conducted in order to observe trends in water quality. Additional samples will also help identify potential anomalies that may have occurred during 2009 and 2010 sample events. Collecting water chemistry samples at additional locations other than the 6 established sites will also assist in isolating the source of pollutant inputs.

4.6.2 Outfall Assessment

During stream walks, outfall pipes were documented, but the exact source and contents of their discharges were not determined (Section 3.3.6). Some of the discharges exhibited high conductivity levels, indicating the presence of unknown dissolved substances. Until the contents of these discharges are known, their impacts on the biological communities of Hunting Creek will remain unknown. In order to determine if remediation is necessary, it will be essential to identify the source and contents of the discharge.

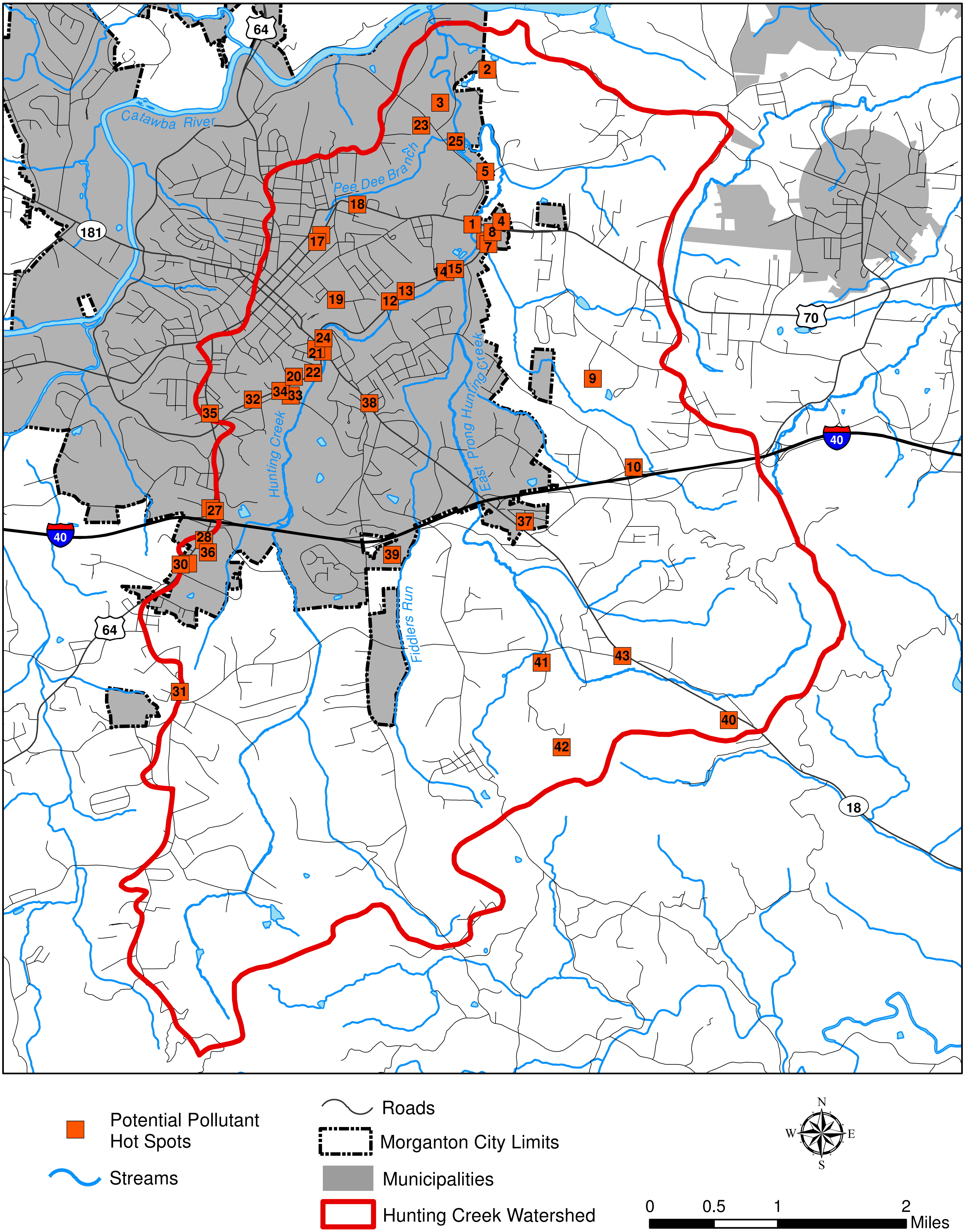
4.6.3 Hotspot Assessment

A general inventory of hot spot locations in the Hunting Creek Watershed that may produce higher levels of pollution was conducted during windshield surveys (Figure 4.11). While the type of facility was identified (gas station, car wash, etc.) the hot spots were not assessed as to the amount and type of pollutants that may be emanating from those facilities. In order to determine remediation needs, an in-depth inventory and assessment of these hotspots is needed. Remediation needs may range from simple, low cost procedural changes to construction of engineered treatment structures.

4.6.4 Sediment Source Assessment

Sediment within the Hunting Creek Watershed is seen as being a significant stressor on aquatic habitat conditions. While sediment originating from eroding stream banks, disturbed riparian areas in urban and developed portions of the watershed, and to a lesser extent, agricultural areas was identified during the habitat assessments, other sources of sediment were not examined. Therefore, a more detailed sediment source survey will be necessary to identify the remaining significant sediment sources and to quantify the volume of sediment originating from each site. These data will be needed to determine appropriate remediation techniques and to prioritize these sites for repair.

Figure 4.11 Potential Pollutant Hot Spots in the Hunting Creek Watershed



4.6.5 Fecal Coliform Bacteria Assessment

Fecal coliform bacteria are elevated throughout the Hunting Creek Watershed (Section 3.3.4). All 6 sites assessed in 2009 have geometric means that exceed the state standard of 200 cfu/100 ml. Because the sample sites were widely distributed throughout the watershed, no specific conclusions regarding the source of these bacteria can be made. A more detailed watershed analysis that associates potential fecal coliform bacteria sources with the 2009 data is necessary. Based on that analysis, additional fecal coliform bacteria measurements can be made to confirm the need for remediation activities.

4.7 Watershed Monitoring

To determine the effectiveness of management measures, the ecological and physical conditions of the watershed should be monitored over time. As specific actions are completed, biological and aquatic habitat conditions are expected to improve. Such improvements should lead to improvements in the fish community. Fish community monitoring will be the primary indicator of whether or not the ecological health of Hunting Creek is improving. Secondary indicators include improvements in benthic macro invertebrate communities, fecal coliform bacteria levels, and aquatic habitat conditions. Water chemistry parameters should also be monitored to determining pollutant loading reductions. In general, these factors should be evaluated on a watershed basis, but some site specific monitoring may be required.

4.7.1 Biological Monitoring

Fish Community

Fish community sampling should be conducted at previously sampled sites located throughout the Hunting Creek Watershed (Figure 3.2) using NCDWQ's (2006) sampling methodology. Fish IBI data from NCDWQ's 2002 and 2003 sampling will be used as the benchmark by which to document changes to the fish community over time. Sampling should occur at 5 year intervals or more frequently if aquatic habitat conditions show significant improvements (Table 4.7). Fish community sampling may be integrated into specific stream restoration projects to provide before and after evaluation data.

Benthic Macro Invertebrate Community

Benthic macro invertebrate communities should be sampled every 5 years at previously established locations (Figure 3.2, Tyndall 2010) to determine trends in ecological health of the Hunting Creek Watershed. Samples will be collected using NCDWQ's Biological Assessment Unit's Qual 4 Method. Benthic macro invertebrate data collected in 2010 will serve to represent baseline conditions. Benthic macro invertebrate community ratings of Good-Fair or better at all sites will be the target level to be achieved (Table 4.7).

Fecal Coliform Bacteria

Although not known to be a factor directly affecting fish communities, fecal coliform bacteria levels do indicate fecal coliform bacteria levels are elevated. Fecal coliform bacteria sampling should be conducted every 5 years at previously established sample locations (Table 4.7). The arithmetic mean of bacteria levels at the six sampling sites (Section 3.3.4) taken in September

2009 will serve to represent baseline conditions. Target levels of achievement will be to reduce fecal coliform bacteria levels to <200 cfu/ml, the North Carolina standard for surface waters. More frequent sampling may occur if additional efforts are undertaken to identify and eliminate the sources of fecal coliform bacteria in the Hunting Creek Watershed.

4.7.2 Water Chemistry Monitoring

Water Chemistry

Although pollutant loading reduction goals have not been established for this watershed plan, monitoring select water chemistry parameters would provide insight into how the watershed is responding to the implementation of management measures. Therefore, water samples should be collected every other year from the six previously established sites in the Hunting Creek Watershed (Table 4.7; Equinox 2009). Parameters to be monitored include nitrogen, phosphorus, total suspended solids, and conductivity. Other pollutants may be included if they are identified during additional watershed assessments. The data for each parameter at each site will be examined for trends over time. Water chemistry data collected during 2009 and 2010 will serve as the benchmark levels for comparison.

Pollutant identification and monitoring in association with individual outfalls and hotspots also may be necessary to determine the effectiveness of remediation efforts. Monitoring of individual sites will be based on the conditions present and the pollutant of concern. The need for monitoring of these sites will be dependent upon the results of in-depth outfall and hotspot assessments to be completed as part of this plan.

4.7.3 Aquatic Habitat Assessments

To document improvements in aquatic habitat conditions, habitat assessments should be conducted during years 6 and 10 (Table 4.7) at select reaches from the 36 sample reaches assessed by Equinox and NCDWQ as part of the Hunting Creek Watershed assessment (Equinox 2009). The habitat assessments will follow NCDWQ metric scoring protocols (NCDWQ 2006). A mean total metric score of 51 will serve as the benchmark for aquatic habitat conditions. A mean total metric score of ≥65 will be the target level to be achieved. The aquatic habitat assessment data will be compared with fish and benthic macro invertebrate community data taken in the same years. Correlations among these data will be used as indicators of improving habitat and biological community conditions.

4.7.4 Watershed Stewardship

__Watershed stewardship__ ensures investments in watershed conservation practices are protected and managed for purposes of maintaining water quality, wildlife habitat, and community awareness.

Stewardship is an important component of the Hunting Creek Watershed Plan. Watershed improvements, be they physical improvements, stormwater BMPs, riparian re-vegetation, or land protection measures, all require stewardship to ensure they are maintained and protected for the long term. This is necessary not only to maintain their effectiveness, but to protect the community's investment in improving the Hunting Creek Watershed. As management measures are implemented throughout the watershed, it is necessary to monitor them on a regular basis. Monitoring in this sense will be to ensure structures are functioning properly, lands are being managed appropriately, and that encroachments into areas under legal protection (e.g. conservation easements) are not occurring. It will be the responsibility of the watershed coordinator (Section 4.8) to oversee stewardship activities.

For each monitoring activity, frequencies, benchmark levels, target levels, and load reduction targets have been developed (Table 4.7). Fish community, benthic macro invertebrate community, and aquatic habitat benchmarks are based on metric scoring methods, whereas fecal coliform bacteria target levels are based on direct measures. If aquatic habitat conditions are improving, the total fish IBI score should show an upward trend.

Table 4.7 Hunting Creek Effectiveness Monitoring Plan

Parameter	Monitoring Years	Benchmark Levels	Target Levels	Load Reduction Target
Biological				
Fish Community	5, 10	Fair fish IBI rating at indicator site Fair/Good-Fair fish IBI rating at other sites (Fish IBI scores 38-40)	Good-Fair or better fish IBI rating at all sites (Fish IBI scores >40)	Not applicable
Benthic Macro invertebrates	3,6, 10	Fair to Excellent (IBI scores 6.26-4.30)	Good-Fair or better at all sites (IBI scores >7.48)	Not applicable
Fecal Coliform Bacteria	3, 6, 10	5 in 30 day sample average = 1,052 cfu/ml		5 in 30 day sample average ≤200 cfu/ml (North Carolina standard)
Water Chemistry				
Total Nitrogen	2, 4, 6, 8, 10		Declining trend	
Total Phosphorus	2, 4, 6, 8, 10		Declining trend	
Total Suspended Solids (TSS)	2, 4, 6, 8, 10		No increase or declining trend	
Conductivity	2, 4, 6, 8, 10		Declining trends and decreasing variability (elimination of high conductivity outfalls)	
Aquatic Habitat	6, 10	Average habitat score – 51 (36 sites)	Average habitat score ≥65 (36 sites)	Not applicable

4.8 Watershed Coordinator

Continuous coordination and administration is a necessary component in carrying out any management plan. It is necessary to maintain momentum and ensure progress is made in implementing management measures and achieving project goals. In the case of the Hunting Creek Watershed Plan, this will best be accomplished by designating a lead individual coordinator, whether hired independently or from an existing agency or organization. The position should be assigned day-to-day responsibilities for coordinating watershed activities as well as assisting in securing project funding, maintaining project records, ensuring project reporting requirements are met, and documenting project accomplishments. It is also incumbent upon the watershed coordinator to facilitate communication among the Hunting Creek Partners and to determine when revisions to the management plan are necessary and to take appropriate actions in getting the plan revised.

Section 5 Implementation Strategy

5.1 Overview

The Hunting Creek Watershed Plan is intended to guide planning and restoration efforts in the Hunting Creek Watershed for the next 10 years. It serves as a road map to restoring the ecological health and function of streams in the watershed so that fish communities will improve and Hunting Creek can support its designated use of maintaining biological integrity once again. In doing so, it will be removed from North Carolina’s 303(d) list of impaired waters (NCDWQ 2010)

Implementation strategies have been developed in a collaborative effort among the Hunting Creek Partners. It is important for the Hunting Creek Partners to work together to implement the Hunting Creek Watershed Plan, but it must be understood that recommended strategies are not mandatory. The State of North Carolina is ultimately responsible for addressing impaired waters and will take regulatory action if water quality improvements are not being achieved. Therefore, it is in the Partners’ best interest to take the lead in implementing management measures so that regulatory actions are not imposed and so that efforts can benefit the local community.

The implementation strategy is composed of three parts: an action plan, an implementation schedule, and a watershed monitoring plan. The action plan identifies specific management measures and activities to be carried out. The implementation schedule reveals the timeline over which the planned actions are expected to be achieved. It also includes a mechanism to track how well the management actions are being implemented.

5.2 Action Plan

This implementation strategy identifies specific actions necessary to restore ecological health to the Hunting Creek Watershed over a 10-year period. The plan address four main management measures: stormwater BMPs, stream restoration and riparian area enhancement, forest protection, and local government programs and practices, as well as the inclusion of additional watershed assessments and a watershed monitoring component. Each management measure consists of a series of recommended actions that, upon completion, will contribute to improving watershed conditions. It should be noted that lag times between implementation and response at a watershed level often occur and that fish communities may or may not improve greatly once restoration efforts are implemented. Based on the results of restoration efforts, it may be necessary to modify management actions during the planning period. At the end of the 10-year life span of this document, the plan will need to be re-evaluated and updated.

An action plan for each management measure has been developed that includes the following components (Table 5.1-5.5):

- *Management Action* - what is to be done
- *Targets* - how much of each action is planned
- *Responsible Party* - who will take the lead in getting a specific action completed

- *Schedule for Implementation* - when will the work be completed: short-term 1-3 years, mid-term 4-6 years, long-term 7-10 years
- *Financial Resources* - estimated costs needed to implement an action
- *Potential Funding Sources* - specific grant agencies or existing programs
- *Technical Resources Needed* - information or professional services needed to implement an action
- *Qualitative Success Indicators* - criteria to measure water quality improvements

Table 5.1 Hunting Creek Action Plan for Stormwater BMPs

Management Actions (what)	**Targets (how much)**	**Responsible Party (who)**	**Schedule for Implementation (when)**	**Financial Resources (how much)**	**Potential Funding Sources**	**Technical Resources Needed**	**Qualitative Success Indicators**
Disconnect building downspouts	100 buildings	Hospital, Burke County, City of Morganton, State Institutions	Mid to long-term	Minimal	Local and State agencies	Need more assessment of numbers	Reduced runoff volume to streams
Install bio-retention areas at high priority sites	3 sites, 5 acres treated	City of Morganton, Burke County, State Institutions	Long-term	$25,400 per impervious acre treated[1] (decreased unit cost will increase area treated)	CCAP, NCDWQ 319, CWMTF, local govt, landowner match	Engineering, Landscape Architect Design, Material Supplier	Reduced pollutant loads HIGH PRIORITY ACTIVITY
Install constructed wetlands at high priority sites	2 wetlands	City of Morganton, Burke County, State Institutions	Long-term	$2,900 per impervious acre treated[1]	CCAP, NCDWQ 319, CWMTF, local govt, landowner match	Engineering, Landscape Architect Design, Material Supplier	Reduced runoff volume to streams and reduced pollutant load
Install extended detention structures	3 detention structures	City of Morganton, Burke County, State Institutions	Long-term	$3,800 per impervious acre treated[1]	CCAP, NCDWQ 319, CWMTF, local govt, landowner match	Engineering, Landscape Architect Design, Material Supplier	Reduced stream bank erosion and reduced pollutant load
Install stormwater BMPs at medium and low priority sites	20 stormwater BMPs	City of Morganton, Burke County, State Institutions	Long-term	Varies greatly - will depend on sites chosen	CCAP, NCDWQ 319, CWMTF, local govt, landowner match	Engineering, Landscape Architect Design, Material Supplier	Reduced runoff volume to streams and reduced pollutant load

Table 5.1 Hunting Creek Action Plan for Stormwater BMPs (continued)

Management Actions (what)	Targets (how much)	Responsible Party (who)	Schedule for Implementation (when)	Financial Resources (how much)	Potential Funding Sources	Technical Resources Needed	Qualitative Success Indicators
Develop educational curriculum for school teachers	Number of elementary, middle, and high school teachers reach depends on school population	Burke County, WPCOG, Coop. Extension Service	Ongoing	Based on population size; $6,000/yr city regional contract for all public outreach	local/state gov't., private foundations DU, TU, Duke Energy	Information on what curriculum already exists, Educators	Increased environmental awareness of watershed conditions
Hold workshops to showcase demonstration projects	10 workshops	NCSU, WPCC, Burke County SWCD, WPCOG, engineering firms	Ongoing	$3,000 per workshop	CCAP, DWQ 319, Burke County SWCD	Staff to lead and coordinate	Increased environmental awareness of watershed improvements HIGH PRIORITY ACTIVITY
Broadcast video public service announcements	15 public service announce-ments	City of Morganton, private installers	Ongoing	$0-50 per radio announcement[1]	Local and State gov't.	Video production	Increased environmental awareness of watershed activities HIGH PRIORITY ACTIVITY
Compile comprehensive manual of stormwater regulations and best management practices	1 manual	City of Morganton, Burke County, WPCOG,	Mid-term	Minimal	NCDWQ 319, 305 (j), Local and State govt	Staff to lead and coordinate	Increased knowledge, application, and compliance by developers
Post YouTube videos of stormwater BMP functions	Utilize existing videos	WPCOG, City of Morganton public access channel	Mid-term	Free		Video production	Increased awareness of stormwater issues and BMPs

Table 5.2 Hunting Creek Action Plan for Stream Restoration and Riparian Area Enhancement

Management Actions (what)	Targets (how much)	Responsible Party (who)	Schedule for Implementation (when)	Financial Resources (how much)	Potential Funding Sources	Technical Resources Needed	Qualitative Success Indicators
Restore stream channels	2,000 ft/year 20,000 ft total	Watershed Coordinator	Long-term	$250-300 per stream foot for design, construction & monitoring	EEP, EQIP, CWMTF, DWQ 319, CCAP, DWQ, NCACSP	Engineering, Landscape Architect Design, Material Supplier	Improved stream channel and aquatic habitat
Restore riparian vegetation	30,000 feet	Watershed Coordinator	Long-term	$14,000 per acre	EEP, EQIP, CWMTF, DWQ 319; CCAP, DWQ, NCACSP	Landscape Architect Design, Material Supplier	Improved stream channel and aquatic habitat HIGH PRIORITY ACTIVITY
Realign stream channel at bridge crossings	4 bridges	NCDOT or bridge owner	As bridges are upgraded or replaced	Varies	EEP, EQIP, CWMTF, DWQ 319; CCAP, DWQ, NCACSP	Engineering Assistance	Improved stream channel and aquatic habitat
Remove fish barriers	2 barriers	Landowner, State Institutions	Long-term	Varies	EEP, EQIP, CWMTF, DWQ 319; CCAP, DWQ, NCACSP	Engineering Assistance, Fisheries Biologist	Improved stream channel and aquatic habitat
Feature good land stewards in media	2 landowners per year	Watershed Coordinator	Short-term	$300	EEP, EQIP, CWMTF, DWQ 319; CCAP, DWQ, NCACSP	Info on land stewards, Staff to lead and coordinate	Increased public awareness of watershed conditions
Develop policy for protecting riparian areas with overlay buffer requirement in zoning regulations	N/A	Burke County, Morganton	Mid-term	$30,000	Burke County; Morganton	Examples of buffer rules in other jurisdictions	Buffer rules passed
Install educational kiosks about the function of riparian vegetation	3 kiosks	Morganton, Watershed Coordinator	Mid-term	$6,000	EEP, EQIP, CWMTF, DWQ 319; CCAP, DWQ, NCACSP	Graphic Artist	Increased public awareness of watershed conditions HIGH PRIORITY ACTIVITY

Table 5.2 Hunting Creek Action Plan for Stream Restoration and Riparian Area Enhancement (continued)

Management Actions (what)	Targets (how much)	Responsible Party (who)	Schedule for Implementation (when)	Financial Resources (how much)	Potential Funding Sources	Technical Resources Needed	Qualitative Success Indicators
Create a video library of restoration projects and post to web	5 videos	Watershed Coordinator, Morganton	Long-term	N/A	EEP, EQIP, CWMTF, DWQ 319; CCAP, DWQ, NCACSP	IT Department	Use of library by public
Hire Watershed Coordinator	1 part-time position	CLLRCD	Short-term	$20,000 per year	EEP, EQIP, CWMTF, DWQ 319; CCAP, DWQ, NCACSP	Environmental Planner	HIGH PRIORITY ACTIVITY

Table 5.3 Hunting Creek Action Plan for Intact Forest Protection

Management Actions (what)	Targets (how much)	Responsible Party (who)	Schedule for Implementation (when)	Financial Resources (how much)	Potential Funding Sources	Technical Resources Needed	Qualitative Success Indicators
Protect intact forested lands >50 acres	13 tracts, 2,067 acres	Watershed Coordinator, NCDFR, land trusts	Mid-term	Varies	NCDFR, conservation groups, fundraisers	Owner contact info, Land Trust coordination	Terrestrial and aquatic habitat protected, acres/tracts under management plan
Reestablish woody vegetation on areas managed for turf grass	100 acres	Watershed Coordinator, NCDFR, private land owners	Mid-term	$1,000 - $5,000 per acre	NCDFR, USFS, conservation groups, fundraisers	Volunteer groups, Landowner Cooperation, Material Supplier	Acres planted, Number of trees established, Planting projects accomplished, Number of volunteers engaged

Table 5.4 Hunting Creek Action Plan for Local Government Practices and Programs

Management Actions (what)	Targets (how much)	Responsible Party (who)	Schedule for Implementation (when)	Financial Resources (how much)	Potential Funding Sources	Technical Resources Needed	Qualitative Success Indicators
Develop maintenance procedures	Street sweeping, catch basin cleanout	City of Morganton (various deptartments NCDOT	Ongoing	$30 per mile, $250 per catch basin	City Operating Budget	Staff to lead and coordinate	Lower pollutant loads originating from streets
Inspect and repair sewer lines	as needed	City of Morganton	Ongoing	Varies	City Operating Budget, CDBG – County Rural Center	Staff to lead and coordinate	Lower pollutant loads
Hire a Stormwater Administrator	1 full-time position	City of Morganton, WPCOG	Mid to Long-term	$40,000 per year	Stormwater fee	Qualified staff	Full Compliance of Phase II Requirements
Develop LID incentives program	1 program	City of Morganton	Mid-term	$15,000	City Operating Budget	Model ordinances from State or Federal resources	Decrease pollutant levels and volume of water
Implement a stormwater fee	N/A	City of Morganton, Burke County	Mid to Long-term	$15,000	City Operating Budget	Accurate mapping of impervious surfaces, GIS Analyst	Improved stormwater infrastructure, revenue
Conduct landscape maintenance workshops	4 workshops	City of Morganton, Burke County, SWCD	Short-term	$3,000 per workshop	Participant fee, NCDWQ 319, CWMTF, local govt,	Staff to lead and coordinate	Increased environmental awareness of best management practices
Develop land steward recognition programs	1 program	Watershed Coordinator, City of Morganton, Burke County, SWCD	Short-term	$15,000	City of Morganton, Burke County, SWCD	Model programs from State or Federal resources	Education of landowners, Possible tax breaks/incentives based on easements, Protection of streams and watersheds
Storm drain stenciling	1,000 storm drains	Watershed Coordinator, City of Morganton, volunteers	Short-term	Minimal	N/A	Stencil Design, Volunteers, Staff to lead and coordinate	Achieve public awareness

Table 5.5 Hunting Creek Action Plan for Additional Watershed Assessments

Management Actions (what)	Targets (how much)	Responsible Party (who)	Schedule for Implementation (when)	Financial Resources (how much)	Potential Funding Sources	Technical Resources Needed	Qualitative Success Indicators
Inventory source and contents of suspect outfalls	unknown	CLLRCD	Short-term	$3,000	NCDWQ 319, CWMTF	Professional Services	Additional information about stressors and sources leading to stream impairment
Identify significant hotspot locations	unknown	CLLRCD	Short-term	$3,000	NCDWQ 319, CWMTF	Professional Services	Additional information about stressors and sources leading to stream impairment
Identify significant sediment sources	unknown	CLLRCD	Short-term	$3,000	NCDWQ 319, CWMTF	Professional Services	Additional information about stressors and sources leading to stream impairment
Identify fecal coliform bacteria sources	unknown	CLLRCD	Short-term	$3,000	NCDWQ 319, CWMTF	Professional Services	Additional information about stressors and sources leading to stream impairment

5.3 Implementation Schedule

The implementation schedule for the Hunting Creek Watershed Management Plan presents the timeline over which each management action will be achieved during the plan's 10-year life (Table 5.6). Target numbers for each management action are taken from Table 5.1-5.5 and distributed across years based on Partner input. The table is also designed to compare actual versus planned accomplishments for each management action. The planned accomplishment numbers will serve as interim milestones against which progress in implementing the management measures will be evaluated. Significant deviations from the planned accomplishments, particularly those affecting aquatic habitat and water chemistry, will provide a first indication that the management plan may need revision.

Table 5.6 Hunting Creek Watershed Management Plan Implementation Schedule for Stormwater Best Management Practices

Management Action	Year	Short-Term			Mid-Term			Long-Term				Target
		1	2	3	4	5	6	7	8	9	10	
Disconnect building downspouts	Planned				10	15	15	15	15	15	15	100 buildings
	Actual											
Install bio-retention areas at high priority sites	Planned							1	1	1		3 sites/5 acres treated
	Actual											
Install constructed wetlands at high priority sites	Planned									1	1	2 sites
	Actual											
Install extended detention structures	Planned							1	1	1		3 structures
	Actual											
Install stormwater BMPs at medium and low priority sites	Planned				2	3	3	3	3	3	3	20 BMPs
	Actual											
Develop educational curriculum for school teachers	Planned	ongoing										
	Actual											
Hold workshops to showcase demonstration projects	Planned	1	1	1	1	1	1	1	1	1	1	10 workshops
	Actual											
Broadcast public service announcements	Planned	15	15	15	15	15	15	15	15	15	15	150 public service announcements
	Actual											
Compile comprehensive manual of stormwater regulations and best practices	Planned					1						1 manual
	Actual											
Develop YouTube videos of stormwater BMP functions	Planned					1+						≥1
	Actual											

Table 5.7 Hunting Creek Watershed Management Plan Implementation Schedule for Stream Restoration and Riparian Area Enhancement

Management Action	Year	Short-Term			Mid-Term			Long-Term				Target
		1	2	3	4	5	6	7	8	9	10	
Restore stream channels	Planned	2,000 ft	2,000 ft	2,000 ft	2,000 ft	2,000 ft	2,000 ft	2,000 ft	2,000 ft	2,000 ft	2,000 ft	20,000 feet
	Actual											
Restore riparian area vegetation	Planned							10,000 ft	10,000 ft	10,000 ft	10,000 ft	30,000 feet
	Actual											
Realign stream channels at bridge crossings	Planned	As bridges are upgraded or replaced										4 crossings
	Actual											
Remove fish barriers	Planned							1	1			2 barriers
	Actual											
Feature good land stewards in media	Planned	2	2	2	2	2	2	2	2	2	2	2 article per year
	Actual											
Develop policy for protecting riparian areas	Planned					1						Buffer rules passed
	Actual											

Table 5.7 Hunting Creek Watershed Management Plan Implementation Schedule for Stream Restoration and Riparian Area Enhancement (continued)

Management Action	Year	Short-Term			Mid-Term			Long-Term				Target
		1	2	3	4	5	6	7	8	9	10	
Install educational kiosks about the function of riparian vegetation	Planned				1	1	1					3 kiosks
	Actual											
Create a video library of restoration projects and post to web	Planned	As projects are completed										Create videos as projects completed
	Actual											
Watershed Coordinator position established	Planned		1									1 full-time position
	Actual											

Table 5.8 Hunting Creek Watershed Management Plan Implementation Schedule for Intact Forest Protection

Management Action	Year	Short-Term			Mid-Term			Long-Term				Target
		1	2	3	4	5	6	7	8	9	10	
Protect intact forested lands >50 acres	Planned			1	4	4	4					13 tracts; 2,067 acres
	Actual											
Reestablish woody vegetation on areas managed for turf grass	Planned	10	10	10	10	10	10	10	10	10	10	10,000 acres
	Actual											

Table 5.9 Hunting Creek Watershed Management Plan Implementation Schedule for Local Government Practices and Programs

Management Action	Year	Short-Term			Mid-Term			Long-Term				Target
		1	2	3	4	5	6	7	8	9	10	
Develop maintenance procedures	Planned	Ongoing										
	Actual											
Inspect and repair sewer lines	Planned	Ongoing										Repaired as needed
	Actual											
Hire a Stormwater Administrator	Planned								1			1 full-time position
	Actual											
Develop LID incentives program	Planned	Ongoing										
	Actual											
Implement a stormwater fee	Planned							1				Funding stormwater infrastructure
	Actual											
Conduct workshops on landscape maintenance practices	Planned	1	1	1	1							4 workshops
	Actual											
Develop land steward recognition programs	Planned			1								
	Actual											
Stormwater inlet stenciling	Planned	300	300	400								1,000 stenciled drains
	Actual											

Table 5.10 Hunting Creek Watershed Management Plan Implementation Schedule for Watershed Assessments

Management Action	Year	Short-Term			Mid-Term			Long-Term				Target
		1	2	3	4	5	6	7	8	9	10	
Inventory source and contents of suspect outfalls	Planned			X								Completed
	Actual											
Identify significant hotspot locations	Planned			X								Completed
	Actual											
Identify significant sediment sources	Planned			X								Completed
	Actual											
Identify fecal coliform bacteria sources	Planned			X								Completed
	Actual											

Table 5.11 Hunting Creek Watershed Management Plan Implementation Schedule for Monitoring

Management Action	Year	Short-Term			Mid-Term			Long-Term				Target
		1	2	3	4	5	6	7	8	9	10	
Fish community sampling	Planned					X					X	All fish sample sites rated Good-Fair or better
	Actual											
Benthic macro invertebrate community sampling	Planned					X					X	All benthic macro invertebrate sites rated Good-Fair or better
	Actual											
Fecal coliform bacteria sampling	Planned					X					X	Fecal coliform levels <200 cfu/ml
	Actual											
Water chemistry analysis	Planned	X	X	X	X	X	X	X	X	X	X	Declining pollutant levels
	Actual											
Aquatic habitat assessment	Planned					X					X	Aquatic habitat metric scores improving
	Actual											
Restored project reach sampling	As needed	X	X	X	X	X	X	X	X	X	X	Restored reaches physically stable and ecologically improving
Landowner performance assessment	As needed	X	X	X	X	X	X	X	X	X	X	Landowners adopting improved management practices
Stewardship monitoring	As needed	X	X	X	X	X	X	X	X	X	X	Resource investments and improvements protected

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Appendices

A	Land Use Analysis Methods
B	Fish Community Sampling Methods and Data
C	Benthic Macro-Invertebrate Community Sampling Methods and Data
D	Water Chemistry Sampling Methods and Data
E	Fecal Coliform Bacteria Sampling Methods and Data
F	Windshield Survey Methods and Data
G	Stream Walk Methods and Data
H	Stormwater BMP Retrofit Inventory Methods and Data
I	Pollutant Reduction Calculations for All Stormwater BMPs

Appendix A Land Use Analysis

Land use data was developed for the Hunting Creek Watershed to spatially observe land use patterns and assist in the identification of stream impacts. This data set provides a baseline from which land use pattern changes can be observed over time.

The land use data developed during the watershed assessment is based on 2005 color aerial photos. Color aerial photos for Burke County were downloaded from NC OneMap (NC OneMap). Aerials were viewed in ArcGIS 9.2 and land use was determined according to classifications developed by Equinox. These classifications integrate elements of the United States Geological Survey (USGS) Land Cover Institute Classifications (http://landcover.usgs.gov/pdf/anderson.pdf), the Tennessee Valley Authority (TVA) Integrated Pollutant Source Identification (ISPI) analysis, and the North Carolina Center for Geographic Information and Analysis (NCCGIA). While these agencies provide detailed land cover classifications, this level of detail was not required for the Hunting Creek watershed. More specific categories for developed areas were necessary to capture the essence of land use in this urban watershed. Land cover classifications and their definitions were as follows:

Developed

- **Low Density Residentia**l - < 2 dwellings per acre including lawns, driveways, small gardens, and wooded lots where residences occur.
- **Medium Density Residential** - 2-5 dwellings per acre including lawns, driveways, small gardens, and wooded lots where residences occur.
- **High Density Residential** - >6 dwellings per acre including lawns, driveways, small gardens, and wooded lots where residences occur.
- **Commercial** - Areas predominantly used for the sale of goods and services including structures and areas supporting this use. Includes shopping centers, office buildings, warehouses, gas stations, auto repair garages, banks, and storage units.
- **Industrial** - Facilities associated with the manufacturing of goods including assembly, finishing, processing, and packaging of products. Includes the facility, grounds, parking, shipping/transportation loading, stock piles, storage, and vehicles associated with the facility.
- **Institutional** - Buildings and grounds associated with schools, colleges, churches, hospitals, correctional facilities, county services, city services, and other public service organizations.
- **Transportation** - Includes major interstate highways, four-lane highways, and railroad tracks. Two lane roads and private roads are included within the adjacent land uses.
- **Mixed Urban** - Developed areas where no single use predominates and land use cannot be distinguished. May include a combination of high density residential, commercial, and institutional uses. Includes utilities such as electricity generating facilities and towers, waste water treatment plants, North Carolina Department of Transportation (NCDOT) maintenance facilities, waste management service facilities, and other uses that support urban infrastructure maintenance.
- **Open Space** - Undeveloped land within an urban area characterized by large grassy areas which may contain sparse trees and landscaping utilized for open space and recreation. Includes sports fields, parks, cemeteries, managed grounds, and other undeveloped areas with managed vegetation.

Agriculture

- **Cropland** - Land used for the cultivation of food and fiber including grains, vegetables, root crops, large garden areas, etc.
- **Pasture/Hay** - Areas used for grazing animals including hay fields.
- **Nursery** - Horticultural crops with rows of trees and shrubs. This category also includes orchards and vineyards.
- **Livestock Operations** - Large confined feeding operations for raising livestock and/or poultry.

Forest

- **Forest** - Mixed forest areas including deciduous and evergreen trees. This category does not capture the type of forest community or the structure, age, quality, or integrity of the forested stand.
- **Plantation** - Forested areas that are actively managed and harvested for timber production.
- **Shrub/Scrub** - Former pasture, cropland, or recently harvested forest that is in the process of early succession. Includes fallow lots with small trees and shrubs, power line corridors, and NCDOT right-of-ways.

Other

- **Water** - Surface waters including lakes, ponds, rivers, and streams that are large enough to be identified.
- **Barren Land** - Areas with little or no vegetation that have been altered through human activity such as excavating, dredging, or grading. Includes quarries, road cuts, cleared lots, and other areas of exposed soil.

Based on this analysis, 37% of the Hunting Creek Watershed is developed. Residential development alone comprises 25% of the watershed and is concentrated within Morganton city limits. Commercial, institutional, and industrial land uses also occur within Morganton city limits and comprise 8% of the watershed. Forested land covers 49% of the watershed primarily in the southeastern portion, but also sporadically in the northern area of the watershed. Thirteen percent of the watershed is within agricultural uses which primarily includes pasture or hay lands. Table A.1 lists the acreage and percentage of each identified land use occurring within the Hunting Creek Watershed.

Results of the land use data were presented to the Hunting Creek Partners at the second stakeholder meeting. Because the land use data was developed from 2005 aerial photos, land use changes have occurred within the past four years. Stakeholders identified these changes to the extent of their knowledge. These changes are indicated on the map and by parentheses in the table. Based solely on stakeholder feedback, developed land use increased by 195 acres, while agriculture land decreased by 97 acres and forest land decreased by 98 acres.

Table A.1 Land Use within the Hunting Creek Watershed

Land Use	Total	
	Acres	**% of Watershed**
Developed	**6,071**	**37%**
Low Density Residential	3,101	19%
Medium Density Residential	903	6%
High Density Residential	62	0.4%
Commercial	483 (565)	3%
Industrial	263	2%
Institutional	497 (609)	3%
Transportation	178	1%
Mixed Urban	197	1%
Open Space	388	2%
Agriculture	**2,102**	**13%**
Cropland	128 (76)	1%
Pasture/Hay	1,948 (1,878)	12%
Nursery	9 (34)	0%
Livestock Operation	16	0%
Forest	**7,924**	**49%**
Forest	6,483	40%
Plantation	256 (230)	2%
Shrub/Scrub	1,185 (1,114)	7%
Other	**241**	**1%**
Water	39	0%
Barren Land	202	1%
TOTAL	16,337	100%

Appendix B Fish Community Sampling Methods and Data

Fish community sampling methodology is based on the NCDWQ stream fish community assessment program protocols (NCDWQ, 2006). Results reported for the biological integrity of the Hunting Creek stream fish communities were derived from the North Carolina Index of Biological Integrity (NCIBI) methods (NCDWQ, 2006). The NCIBI incorporates information about species richness and composition, trophic composition, fish abundance, and fish condition to summarize the effects of all classes of factors influencing aquatic faunal communities. Based on this information the biological integrity of a streams fish community is rated as Poor, Fair, Good-Fair, Good, or Excellent. A fish community rated as Excellent, Good, or Good-Fair is considered to be fully supporting its aquatic life use support stream classification. Conversely, a fish community rating of Fair or Poor is considered as not supporting its life use support stream classification and water quality standards are not being met (NCDWQ, 2006).

Overall, the species richness and composition were below normal at all sites in the Hunting Creek Watershed and are likely associated with degraded habitat. Based on the fish community assessment, both sites located on Hunting Creek resulted in Fair ratings, which corroborate the NCDWQ findings of 2002 and 2003. The East Prong Hunting Creek site rated Good-Fair, as did the upper watershed sites; however, stream conditions indicate that fish habitat is still degraded. All fish species collected during the assessment were tolerant of pollution; no intolerant or sensitive species were found, which would be an indicator of decent stream conditions.

Site 1: Hunting Creek
Date: 5/20/09

Site ID: 1	Date: 5/20/2009
Stream: Hunting Creek	Time: 2:00 pm
Location: Amherst Road – SR 1512	No. of Shocking Units: 1
County: Burke	Duration (sec): 4960
River Basin: Catawba	Personnel: WT & SM
Sub-basin: 03-08-31	Reach Location: Start at bridge crossing and continued upstream approximately 600 feet
Drainage Area (sq.mi.): 23.4	Seine Used (Y/N): N0
Elevation: 1020	Avg Stream Width: 7.1 meters
Avg Stream Depth: 8 inches	Water Clarity (clear, turbid, etc): Clear
Substrate Type(s): Dominant sand. Few areas of gravel and cobble along shoreline.	
Habitat Description: Good pool habitat in outside bends of relatively sinuous reach. LWD relatively common. Riffles poor to non-existent. Upper portion of reach has fewer meanders with pools in bends. Decent root mats and undercut banks in areas providing additional habitat component. Good riparian zone providing adequate shading.	
Notes (Abnormalities, YOY presence, etc): No abnormalities detected. YOY – observed for bluehead chub, white sucker, bluegill, redbreast, stoneroller, and tessellated darter.	

Species	Total #	Length	Length	Length	Length	Length	Length	Length	Length	Length	Length
Bluehead Chub	44	114	135	128	100	105	105	112	78	105	98
		75	130	67	98	110	78	85	144	80	94
		120	87	147	175	65	110	92	130	80	65
		67	115	72	90	90	67	76	65	70	56
		83	52	70	50						

Rosyside Dace	17	79	90	80	102	65	74	49	48	52	55
		45	57	68	52	55	45	47			
Creek Chub	9	110	105	68	127	98	62	108	80	114	
White Sucker	29	160	152	167	102	172	132	128	130	109	138
		167	108	125	195	127	155	128	200	165	108
		158	204	170	222	172	168	185	111	145	
Bluegill	8	86	68	58	65	58	63	82	65		
Redbreast Sunfish	8	122	88	95	98	72	92	94	90		
Stoneroller	17	74	70	102	86	74	90	78	70	64	60
		65	90	65	65	60	78	68			
Spottail Shiner	19	105	94	93	90	95	90	85	90	83	70
		98	95	105	87	88	87	98	100	92	
Striped Jumprock	1	260									
Tessellated Darter	61	63	40	50	55	59	41	50	70	57	41
		47	65	60	54	54	47	54	55	55	53
		57	62	55	41	42	42	55	47	44	42
		50	47	50	47	52	44	57	57	40	42
		42	42	55	52	40	42	44	55	44	47
Flat Bullhead	1	170									
Fantail Darter	1	53									

Family	Common Name	Trophic Status	Tolerance	Multiple Age	Number
Catostomidae	White Sucker	Omnivore	Tolerant	Yes	29
Catostomidae	Striped Jumprock	Insectivore	Intermediate	No	1
Centrarchidae	Redbreast Sunfish	Insectivore	Tolerant	Yes	8
Centrarchidae	Bluegill	Insectivore	Intermediate	Yes	8
Cyprinidae	Stoneroller	Herbivore	Intermediate	Yes	17
Cyprinidae	Rosyside Dace	Insectivore	Intermediate	Yes	17
Cyprinidae	Bluehead Chub	Omnivore	Intermediate	Yes	44
Cyprinidae	Spottail Shiner	Omnivore	Intermediate	Yes	19
Cyprinidae	Creek Chub	Insectivore	Tolerant	Yes	9
Percidae	Fantail Darter	Insectivore	Intermediate	No	1
Percidae	Tessellated Darter	Insectivore	Intermediate	Yes	61
Ictaluridae	Flat Bullhead	Insectivore	Tolerant	No	1

Metric	Value	Score
No. of Species	12	3
No. of Fish	215	5
No. Darter Species	2	3
No. Sunfish, Bass, & Trout	2	3
No. Sucker Species	2	5
No. Intolerant Species	0	1
Percent Tolerant Fish	22	5
Percent Omnivore + Herbivore	51	1

Percent Insectivores	49	3
Percent Piscivores	0	1
Percent Diseased Fish	0	5
Percent Species Multiple Ages	75	5
	NCIBI Score	40
	NCIBI Rating	Fair

Site 2: Hunting Creek
Date: 4/24/09

Site ID: 2	Date: 4/24/2009
Stream: Hunting Creek	Time: 12:10 pm
Location: Coal Chute Road	No. of Shocking Units: 1
County: Burke	Duration (sec): 5253
River Basin: Catawba	Personnel: WT & SM
Sub-basin: 03-08-31	Reach Location: Start at bridge crossing – End at 1st powerline crossing upstream from bridge. Approximately 565 feet.
Drainage Area (sq.mi.): 5.69	Seine Used (Y/N): NO
Elevation: 1060	Avg Stream Width: 4.6 meters
Avg Stream Depth: 6 inches	Water Clarity (clear, turbid, etc): Clear
Substrate Type(s): Sand	
Habitat Description: Small shallow pools primarily resulting from scour behind downed woody debris. Habitat limited to woody debris, snags, and tires providing some habitat. Riffles poor to non-existent. Upper portion of reach has better meanders with pools in bends. Decent root mats in areas providing additional habitat component.	
Notes (Abnormalities, YOY presence, etc): Bluehead chub with dorsal fin erosion. Creek chub with caudal fin erosion. Redbreast sunfish with leach. YOY – present for rosyside dace, greenhead shiner, white sucker, stoneroller	

Species	Total #	Length	Length	Length	Length	Length	Length	Length	Length	Length	Length
Rosyside Dace	102	70	92	67	63	80	60	41	83	78	90
		85	48	77	63	85	67	62	70	48	60
		52	47	50	85	72	63	57	62	87	40
		55	48	47	50	47	44	48	50	57	47
		70	45	45	45	42	67	67	70	45	50
Greenhead Shiner	33	57	57	68	65	60	62	65	55	60	55
		55	58	64	60	55	45	48	55	52	55
		52	52	58	55	47	48	50	40	55	40
		55	57	48							
Fantail Darter	113	57	55	48	37	47	45	65	68	47	58
		60	62	50	52	38	47	45	52	52	50
		45	35	47	52	52	42	40	45	50	35
		35	35	38	40	50	70	68	55	63	68
		35	35	45	55	50	38	55	60	38	65
Bluehead Chub	125	112	145	167	110	130	82	92	115	84	115
		74	95	85	110	75	75	80	87	72	70
		70	58	60	70	57	118	98	68	90	87
		68	70	88	68	115	75	83	74	78	98
		114	95	85	65	70	75	68	62	65	58
White Sucker	2	100	118								

Creek Chub	10	95	110	115	92	88	90	55	60	45	50
Redbreast Sunfish	2	140	73								
Stoneroller	17	75	87	68	60	60	65	76	67	60	85
		80	85	60	60	65	70	63	57		

Family	Common Name	Trophic Status	Tolerance	Multiple Age	Number
Catostomidae	White Sucker	Omnivore	Tolerant	No	2
Centrarchidae	Redbreast Sunfish	Insectivore	Tolerant	No	2
Cyprinidae	Stoneroller	Herbivore	Intermediate	Yes	17
Cyprinidae	Rosyside Dace	Insectivore	Intermediate	Yes	102
Cyprinidae	Bluehead Chub	Omnivore	Intermediate	Yes	125
Cyprinidae	Greenhead Shiner	Insectivore	Intermediate	Yes	33
Cyprinidae	Creek Chub	Insectivore	Tolerant	Yes	10
Percidae	Fantail Darter	Insectivore	Intermediate	Yes	113

Metric	Value	Score
No. of Species	8	3
No. of Fish	404	5
No. Darter Species	1	3
No. Sunfish, Bass, & Trout	1	1
No. Sucker Species	1	3
No. Intolerant Species	0	1
Percent Tolerant Fish	3	5
Percent Omnivore + Herbivore	36	3
Percent Insectivores	64	5
Percent Piscivores	0	1
Percent Diseased Fish	0.99	3
Percent Species Multiple Ages	75	5
	NCIBI Score	38
	NCIBI Rating	Fair

Site 3: Hunting Creek
Date: 5/27/10

Site ID: 3	Date: 5/27/2010
Stream: Hunting Creek	Time: 8:00 am
Location: Poteat Road	No. of Shocking Units: 1
County: Burke	Duration (sec): 5068
River Basin: Catawba	Personnel: WT & KM
Sub-basin: 03-08-31	Reach Location: See GIS waypoints. Started at bridge crossing and extended 600 ft upstream.
Drainage Area (sq.mi.): 2.56	Seine Used (Y/N): NO
Elevation: 1112	Avg Stream Width: 2.9 meters
Avg Stream Depth: 6 inches	Water Clarity (clear, turbid, etc): Clear
Substrate Type(s): Primarily sand with some gravel in the riffles.	
Habitat Description: LWD present with some overhanging vegetation providing habitat. Pool habitat limited due to sedimentation. Riffles present but short.	
Notes (Abnormalities, YOY presence, etc): YOY – present for rosyside dace, greenhead shiner, bluehead chub	

Bluehead chub and Creek chub with fin rot.											
Species	Total #	Length	Length	Length	Length	Length	Length	Length	Length	Length	Length
Rosyside Dace	154	70	82	78	87	87	78	45	62	77	75
		74	42	78	75	67	50	68	55	70	62
		68	60	70	95	75	80	72	82	75	70
		72	82	75	47	55	75	42	60	75	75
		60	72	82	67	80	67	75	62	65	67
Greenhead Shiner	37	60	52	52	60	53	52	50	60	52	55
		55	50	52	55	47	50	65	52	50	55
		52	60	50	57	55	50	45	50	52	58
		47	50	52	47	47	55	57			
Redbreast Sunfish	3	87	38	85							
Bluehead Chub	75	178	140	142	120	147	80	68	73	87	95
		68	93	98	147	85	130	117	70	55	87
		75	127	112	112	82	72	97	87	124	105
		102	105	165	185	150	128	117	98	100	85
		84	120	92	122	120	87	135	72	97	117
Fantail Darter	36	68	55	63	68	37	65	42	47	57	58
		68	60	55	54	42	63	42	55	34	57
		45	52	42	62	50	45	42	42	37	45
		48	62	68	35	50	40				
Creek Chub	41	105	74	85	60	50	54	97	98	95	70
		100	85	80	53	110	97	80	75	74	97
		97	134	117	110	75	98	72	70	85	75
		78	75	78	70	57	77	82	87	95	132
		123	57								
White Sucker	6	155	130	210	160	100	182				

Family	Common Name	Trophic Status	Tolerance	Multiple Age	Number
Catostomidae	White Sucker	Omnivore	Tolerant	YES	6
Percidae	Fantail Darter	Insectivore	Intermediate	YES	36
Cyprinidae	Rosyside Dace	Insectivore	Intermediate	YES	154
Cyprinidae	Bluehead Chub	Omnivore	Intermediate	YES	75
Cyprinidae	Greenhead Shiner	Insectivore	Intermediate	YES	37
Cyprinidae	Creek Chub	Insectivore	Tolerant	YES	41
Centrarchidae	Redbreast Sunfish	Insectivore	Tolerant	YES	3

Metric	Value	Score
No. of Species	7	5
No. of Fish	352	5
No. Darter Species	1	5
No. Sunfish, Bass, & Trout	1	1
No. Sucker Species	1	3
No. Intolerant Species	0	1

Percent Tolerant Fish	13	5
Percent Omnivore + Herbivore	23	5
Percent Insectivores	77	5
Percent Piscivores	0	1
Percent Diseased Fish	0.6	5
Percent Species Multiple Ages	100	5
	NCIBI Score	46
	NCIBI Rating	Good-Fair

Site 4: East Prong Hunting Creek
Date: 5/20/09

Site ID: 4	Date: 5/20/2009
Stream: East Prong Hunting Creek	Time: 10:00 am
Location: Bethel Road – SR 1704	No. of Shocking Units: 1
County: Burke	Duration (sec): 4071
River Basin: Catawba	Personnel: WT & SM
Sub-basin: 03-08-31	Reach Location: Located downstream of Bethel Road. Reach extended from just downstream of sewer line crossing at cobble grade control and extended downstream approximately 600 feet
Drainage Area (sq.mi.): 8.98	Seine Used (Y/N): NO
Elevation: 1040	Avg Stream Width: 4.9 meters
Avg Stream Depth: 6 inches	Water Clarity (clear, turbid, etc): Clear for upstream pass. Became turbid during downstream pass due to unknown upstream disturbance.
Substrate Type(s): Dominant sand. Few areas of gravel.	
Habitat Description: Pool habitats primarily driven by scour below LWD. LWD relatively common. Riffles poor. Decent root mats and undercut banks in areas providing additional habitat component. Good riparian zone providing adequate shading.	
Notes (Abnormalities, YOY presence, etc): Abnormalities included 1 stoneroller with spinal deformity, 1 redbreast sunfish with leach, and 1 creek chub with lesion. YOY – observed for tessellated darter, white sucker, bluehead chub, stoneroller, and creek chub.	

Species	Total #	Length	Length	Length	Length	Length	Length	Length	Length	Length	Length
Redbreast Sunfish	9	83	78	125	117	90	110	75	83	72	
Tessellated Darter	47	45	48	58	60	58	62	47	56	64	45
		55	48	52	44	50	50	52	47	53	42
		43	44	50	47	42	40	50	48	42	45
		45	42	42	44	45	43	40			
White Sucker	9	125	135	135	135	102	103	128	140	132	
Fantail Darter	9	55	62	43	55	52	42	47	45	37	
Bluegill	14	75	105	90	70	80	60	80	77	63	74
		65	52	65	67						
Bluehead Chub	55	115	90	75	74	63	87	78	80	75	57
		90	50	55	105	110	110	115	147	160	80
		85	147	184	103	108	68	67	80	85	78
		66	70	128	114	75	87	114	98	97	90
		68	139	80	115	84	70	80	66	75	63

Stoneroller	42	77	85	97	67	75	75	63	64	75	77
		60	92	70	60	72	72	67	60	60	80
		72	62	65	60	96	72	73	70	65	67
		90	79	76	78	60	77	70	63	65	62
		63	64								
Creek Chub	35	78	60	57	68	65	67	125	83	57	85
		82	55	72	62	95	72	58	57	57	93
		110	65	68	69	92	63	63	77	67	63
		65	60	60	55	52					
Greenhead Shiner	16	68	55	63	55	58	58	60	62	62	58
		47	54	45	70	60	50				
Rosyside Dace	51	70	72	77	70	80	65	75	82	67	67
		72	77	81	45	55	54	45	77	82	72
		72	55	84	77	49	46	65	70	67	53
		48	78	74	42	55	57	54	57	68	57
		45	44	47	67	40	54	47	64	45	50

Family	Common Name	Trophic Status	Tolerance	Multiple Age	Number
Catostomidae	White Sucker	Omnivore	Tolerant	Yes	9
Centrarchidae	Redbreast Sunfish	Insectivore	Tolerant	Yes	9
Centrarchidae	Bluegill	Insectivore	Intermediate	Yes	14
Cyprinidae	Stoneroller	Herbivore	Intermediate	Yes	42
Cyprinidae	Rosyside Dace	Insectivore	Intermediate	Yes	51
Cyprinidae	Bluehead Chub	Omnivore	Intermediate	Yes	55
Cyprinidae	Creek Chub	Insectivore	Tolerant	Yes	35
Cyprinidae	Greenhead Shiner	Insectivore	Intermediate	Yes	16
Percidae	Fantail Darter	Insectivore	Intermediate	Yes	9
Percidae	Tessellated Darter	Insectivore	Intermediate	Yes	47

Metric	Value	Score
No. of Species	10	3
No. of Fish	287	5
No. Darter Species	2	5
No. Sunfish, Bass, & Trout	2	3
No. Sucker Species	1	3
No. Intolerant Species	0	1
Percent Tolerant Fish	19	5
Percent Omnivore + Herbivore	37	3
Percent Insectivores	63	5
Percent Piscivores	0	1
Percent Diseased Fish	1.1	3
Percent Species Multiple Ages	100	5
	NCIBI Score	42
	NCIBI Rating	Good-Fair

Site 5: Fiddlers Run
Date: 5/27/10

Site ID: 5	Date: 5/27/2010
Stream: Fiddlers Run	Time: 2:00 pm
Location: Carswell Property – Upstream from NC 18	No. of Shocking Units: 1
County: Burke	Duration (sec): 3880
River Basin: Catawba	Personnel: WT & KM
Sub-basin: 03-08-31	Reach Location: See GIS waypoints. Started at UT and extended 600 ft upstream.
Drainage Area (sq.mi.): 1.83	Seine Used (Y/N): NO
Elevation: 1080	Avg Stream Width: 4.2 meters
Avg Stream Depth: 6 inches	Water Clarity (clear, turbid, etc): Clear
Substrate Type(s): Primarily sand with some cobble and gravel in the riffles. Some areas with bedrock.	
Habitat Description: Fish habitat somewhat isolated. Run areas within reach had limited habitat. LWD present with some overhanging vegetation providing habitat. Reach was not overly incised but appeared overly wide with habitat availability primarily associated with narrow thalweg areas.	
Notes (Abnormalities, YOY presence, etc): YOY – present for rosyside dace, bluehead chub	

Species	Total #	Length	Length	Length	Length	Length	Length	Length	Length	Length	Length
White Sucker	8	215	255	235	222	167	186	232	103		
Fantail Darter	19	47	50	72	52	67	54	55	59	52	47
		53	45	55	52	55	55	57	50	40	
Tesselated Darter	33	62	58	57	53	60	55	57	57	58	62
		52	55	55	55	65	47	65	57	50	53
		58	60	55	52	52	55	55	52	55	50
		51	48	62							
Stoneroller	40	125	90	100	95	98	92	97	85	87	87
		87	78	87	117	90	110	77	79	87	89
		77	109	88	84	100	115	88	77	80	85
		79	85	77	70	97	65	81	79	105	90
Creek Chub	21	128	112	133	113	115	77	82	65	115	115
		92	81	80	115	75	104	82	70	95	104
		56									
Bluehead Chub	22	197	140	142	120	145	100	138	105	67	67
		55	67	67	100	105	88	85	82	73	70
		60	72								
Greenhead Shiner	18	67	70	68	60	62	52	57	57	57	55
		57	60	57	55	55	46	50	65		
Rosyside Dace	142	90	72	93	73	62	76	65	100	82	78
		75	92	75	78	70	60	68	65	77	82
		60	65	85	70	67	65	100	72	75	72
		73	65	85	84	90	77	65	75	82	80
		65	68	70	66	67	62	65	78	77	78

Family	Common Name	Trophic Status	Tolerance	Multiple Age	Number
Catostomidae	White Sucker	Omnivore	Tolerant	YES	8
Percidae	Tesselated Darter	Insectivore	Intermediate	YES	33
Cyprinidae	Stoneroller	Herbivore	Intermediate	YES	40
Cyprinidae	Rosyside Dace	Insectivore	Intermediate	YES	142
Cyprinidae	Bluehead Chub	Omnivore	Intermediate	YES	22
Cyprinidae	Greenhead Shiner	Insectivore	Intermediate	YES	18
Cyprinidae	Creek Chub	Insectivore	Tolerant	YES	21
Percidae	Fantail Darter	Insectivore	Intermediate	YES	19

Metric	Value	Score
No. of Species	8	5
No. of Fish	303	5
No. Darter Species	2	5
No. Sunfish, Bass, & Trout	0	1
No. Sucker Species	1	3
No. Intolerant Species	0	1
Percent Tolerant Fish	10	5
Percent Omnivore + Herbivore	23	5
Percent Insectivores	77	5
Percent Piscivores	0	1
Percent Diseased Fish	0	5
Percent Species Multiple Ages	100	5
	NCIBI Score	46
	NCIBI Rating	Good-Fair

Site 6: East Prong Hunting Creek
Date: 5/28/10

Site ID: 1	Date: 5/28/2010
Stream: East Prong Hunting Creek	Time: 12:00 pm
Location: Stroup Property	No. of Shocking Units: 1
County: Burke	Duration (sec): 5095
River Basin: Catawba	Personnel: WT & KM
Sub-basin: 03-08-31	Reach Location: See GIS waypoints. Started at highly sinuous area and extended 600 ft upstream.
Drainage Area (sq.mi.): 4.60	Seine Used (Y/N): NO
Elevation: 1080	Avg Stream Width: 3.3 meters
Avg Stream Depth: 6 inches	Water Clarity (clear, turbid, etc): Clear
Substrate Type(s): Primarily sand with short riffles comprised of gravel.	
Habitat Description: Sinuous stream reach with pools in bends. Pool depth limited due to sedimentation. Good habitat associated with LWD, undercut banks, and roots. Riffles present with majority short, but some were relatively long but narrow. Highly incised stream with some vertical eroding banks even with riparian area comprised of mature forest.	
Notes (Abnormalities, YOY presence, etc): YOY – present for rosyside dace, greenhead shiner, bluehead chub, redbreast sunfish, white sucker, striped jumprock Conductivity: 70.1 Temperature: 18.1 C	

Species	Total #	Length	Length	Length	Length	Length	Length	Length	Length	Length	Length
Creek	26	84	89	62	75	88	100	62	70	105	152

Chub											
		162	122	95	84	77	62	88	117	108	104
		52	65	107	88	107	50				
Rosyside Dace	59	70	80	68	82	91	70	77	68	51	50
		62	67	50	57	81	88	67	74	80	92
		92	75	60	71	70	65	72	75	64	97
		74	70	65	67	84	65	67	80	87	67
		80	82	68	50	55	72	52	62	77	75
Stoneroller	5	68	72	78	92	75					
Greenhead Shiner	89	58	65	68	65	55	62	63	57	60	65
		58	65	62	58	43	52	63	60	60	64
		55	67	55	63	55	60	57	60	62	58
		60	62	53	61	60	60	62	55	70	65
		67	58	62	55	62	60	42	53	60	60
Fantail Darter	28	48	52	55	57	45	47	52	62	38	55
		55	54	51	45	52	47	42	52	45	42
		47	39	42	40	59	42	42	46		
Bluehead Chub	53	135	94	185	130	129	137	124	85	83	110
		94	158	112	70	93	115	138	92	83	118
		78	112	87	85	88	89	85	85	67	62
		83	112	118	104	115	78	98	78	90	82
		102	95	88	85	83	85	90	88	67	70
Redbreast Sunfish	62	152	92	78	90	110	106	125	115	97	90
		77	92	83	80	92	90	83	82	54	67
		57	65	105	93	84	92	77	78	73	83
		82	58	65	65	58	60	77	75	64	98
		67	57	66	70	72	64	67	63	55	67
White Sucker	9	152	144	162	142	210	152	100	290	137	
Striped Jumprock	15	175	154	130	125	145	159	215	164	167	157
		190	132	127	154	137					
Northern Hogsucker	1	118									

Family	Common Name	Trophic Status	Tolerance	Multiple Age	Number
Catostomidae	White Sucker	Omnivore	Tolerant	YES	9
Centrarchidae	Redbreast Sunfish	Insectivore	Tolerant	YES	62
Cyprinidae	Stoneroller	Herbivore	Intermediate	YES	5
Cyprinidae	Rosyside Dace	Insectivore	Intermediate	YES	59
Cyprinidae	Bluehead Chub	Omnivore	Intermediate	YES	53
Cyprinidae	Greenhead Shiner	Insectivore	Intermediate	YES	89
Cyprinidae	Creek Chub	Insectivore	Tolerant	YES	26
Percidae	Fantail Darter	Insectivore	Intermediate	YES	28
Catostomidae	Striped Jumprock	Insectivore	Intermediate	YES	15
Catostomidae	Northern Hog Sucker	Insectivore	Intermediate	NO	1

Metric	Value	Score
No. of Species	10	5
No. of Fish	347	5
No. Darter Species	1	3
No. Sunfish, Bass, & Trout	1	1
No. Sucker Species	3	5
No. Intolerant Species	0	1
Percent Tolerant Fish	28	3
Percent Omnivore + Herbivore	19	5
Percent Insectivores	81	5
Percent Piscivores	0	1
Percent Diseased Fish	0	5
Percent Species Multiple Ages	90	5
	NCIBI Score	44
	NCIBI Rating	Good-Fair

Appendix C Benthic Macro Invertebrate Community Sampling Methods and Data

Draft Memorandum
October 8, 2010

To: Andrea Leslie, NCEEP
Through: Steve Kroeger, NCDWQ
From: Cathy Tyndall, NCDWQ

Subject: Macroinvertebrate sampling results – Hunting Creek Watershed, Burke County, Catawba River Basin. HUC 03050101 060050.

Note: This memorandum represents the completion of Task 2 in the Hunting Creek watershed Area Scope of Work.

Background

Benthic macroinvertebrate sampling was conducted within the Hunting Creek watershed to help identify stream stressors and their sources. This information will be useful among the Carolina Land & Lakes Resource Conservation and Development Council, the NC Ecosystem Enhancement Program (NCEEP) the NC Division of Water Quality (NCDWQ) and Equinox Environmental Consultation and Design, Inc (Equinox) to address the water quality impairment of Hunting Creek. The ultimate goal of this process is to restore water and habitat quality in the Hunting Creek watershed such that the condition of the aquatic community improves sufficiently so that the stream is no longer considered impaired.

The NCDWQ considers Hunting Creek to be impaired based upon two fish community samples collected at a site near the downstream end of the creek. NCDWQ first sampled the creek in 2002 and a Fair bioclassification was assigned. The site was re-sampled in 2003, with similar results. The NCDWQ notes (NCDWQ, 2003) that the sampling location has easily erodible vertical banks and a sandy substrate with no true rock riffles, indicating poor in-stream habitats. The NCDWQ further notes that there was an absence of pollution intolerant fish species and a high percentage of diseased fish. The causes of the fish community impairment have not been determined. Also, the limited amount of water quality data makes it difficult to accurately determine the actual spatial extent of impairment (currently 7.4 miles). Currently, the listed length of impairment appears to be defined in terms of changes in stream classification.

Other than the NCDWQ fish community sampling data, aquatic community data for the watershed are limited. No previous benthic work has been conducted in the Hunting Creek watershed. It is anticipated that the benthic results will help identify stressors and guide stakeholders in developing strategies to address these stressors.

Benthic samples were collected in June and August 2010 at the same six sites in the Hunting Creek watershed where the NCDWQ collected fecal coliform bacteria samples for the 5x/30 day sampling in September 2009 (Table 1 and Figure 1). Stacey Creek was selected as a macro invertebrate comparison site for the small streams in the study. It was later discovered that Stacy Creek is in a different ecoregion than the six Hunting Creek sites. As Figure 2 shows, a small portion of the Eastern Blue Ridge foothills extends into the Northern Inner Piedmont. The Stacey Creek sample is included in this discussion since it is so geographically close to the Hunting Creek watershed, but mountain criteria were used to derive its bioclassifcation. Piedmont criteria were used for the other six sites.

Table 1. Sampling locations for 5x/30 fecal coliform bacteria and macroinvertebrates, Hunting Creek watershed and Stacey Creek. 2009 and 2010.

	Stream						
Summary	Hunting Creek at SR 1950 (Poteat Road)	Fiddlers Run off SR 1704 (Bethel Road)	E. Prong Hunting Cr off SR 1704 (Bethel Road)	Hunting Creek at SR 1704 (Bethel Road)	Pee Dee Branch off SR 1443 (Kirksey Road)	Hunting Creek at SR 1571 (Causby Quarry Road)	Stacey Creek at SR 1918 (Watershed Road)
Map number	1	2	3	4	5	6	
Benthic Sample date	1-Jun-10	1-Jun-10	1-Jun-10	11-Aug-10	2-Jun-10	11-Aug-10	4-Jun-10
Subbasin	31	31	31	31	31	31	35
Latitude (º)	35.6943	35.7400	35.7400	35.7430	35.7630	35.7680	35.6584
Longitude (º)	-81.6875	-81.6610	-81.6600	-81.6700	-81.6640	-81.6620	-81.6496
Drainage area (mi^2)	2.5	2.5	6.5	8.9	1.2	25.5	1.0
Stream Index	11-36-(0.3)	11-36-1-1	11-36-1	11-36-(0.7)	11-36-2	11-36-(0.7)	11-129-1-7

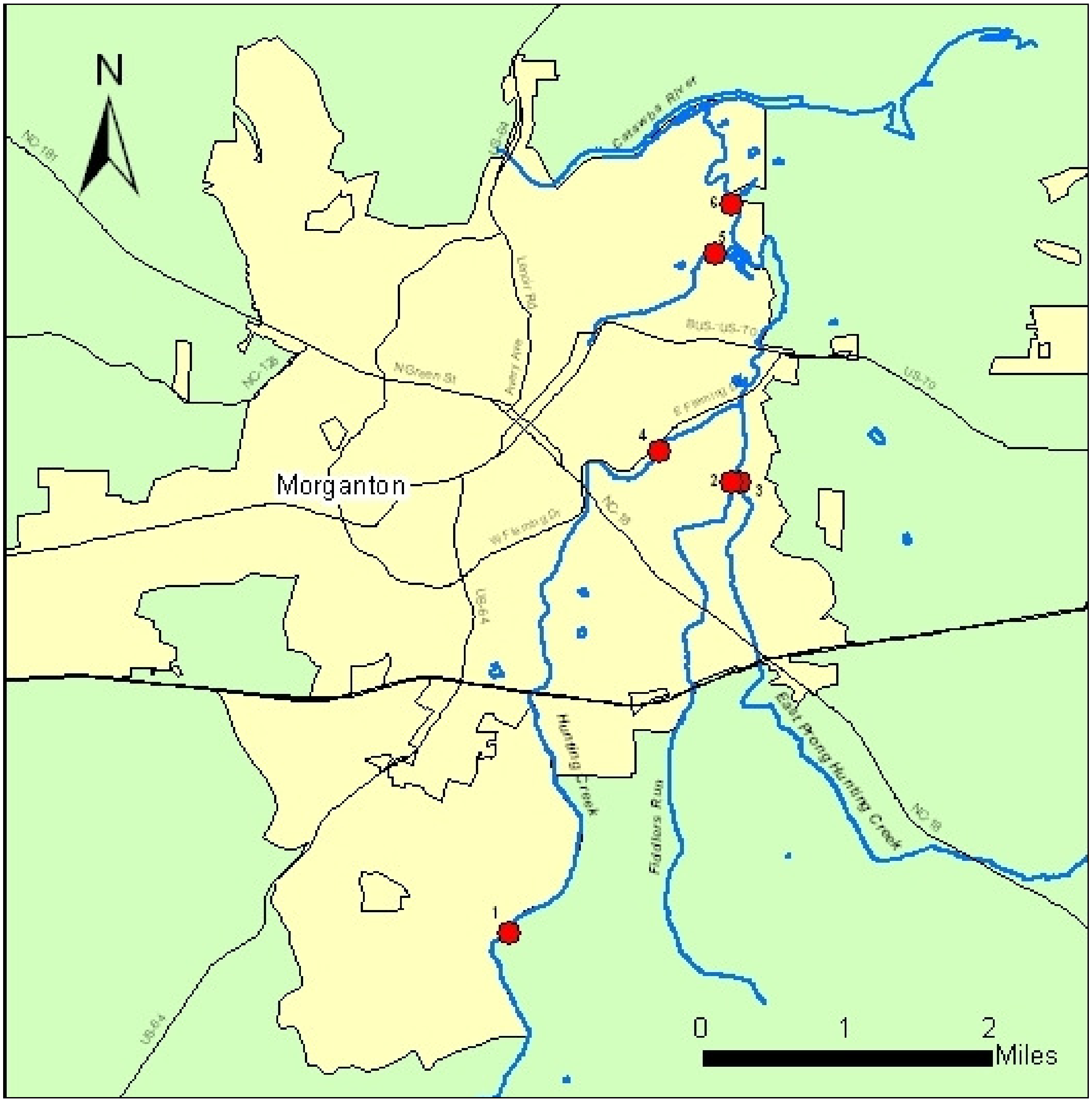

Figure 1. Sampling locations in the Hunting Creek watershed for 5x/30 fecal coliform bacteria and macroinvertebrates, 2009 and 2010.

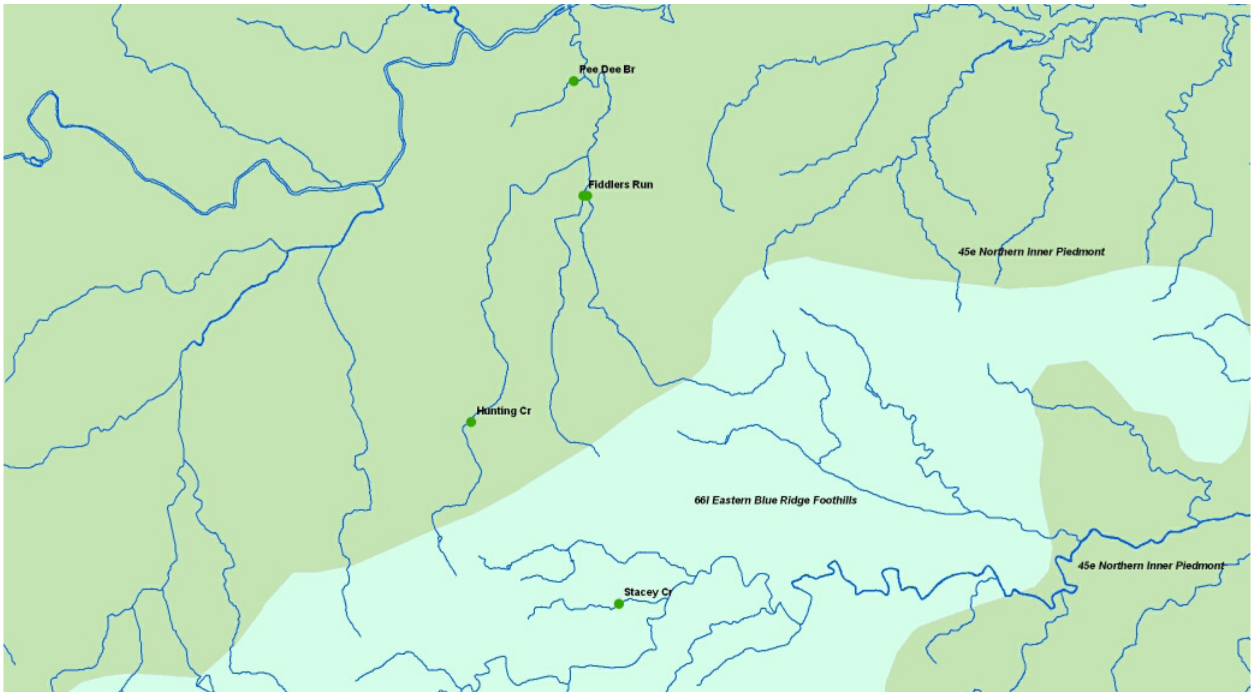

Figure 2. Level III Ecoregions in the Hunting Creek watershed sampling area. All sampling sites are not depicted on the map.

Methods

Benthic Macroinvertebrates

Benthic macroinvertebrates were collected in June and August 2010 using the NCDWQ Biological Assessment Unit's Qual 4 method (NCDWQ 2006a). This method is typically used for streams that have a drainage area of three square miles or less, however due to time and to maintain sample consistency, the Qual 4 method was used for all seven sites. For the three sites with drainage areas greater than three square miles, a bioclassification based on the EPT taxa was assigned. This is possible since the collection method for Qual 4 samples and EPT samples is the same. For the remaining four sites that are less than three square miles, the DWQ small stream criteria that was approved in May 2009 (NCDWQ 2009) was used to determine the bioclassifications. Previously, small streams were assigned a rating of Not Rated or Not Impaired.

The Qual 4 collection method is comprised of four samples including the collection of one riffle-kick, one bank/root mat sweep, one leaf pack, and visual collections. These collections are used to inventory the aquatic fauna and produce an indication of the relative abundance for each taxon. Organisms are identified to the lowest possible taxon and enumerated as Rare (1-2 specimens, denoted by "R" on taxa tables), Common (3-9 specimens, "C"), or Abundant (≥10 specimens, "A").

Several data analysis summaries (metrics) are calculated from the benthic data to facilitate the detection of physical habitat and/or water quality problems. These metrics are based on a long history of observations and studies that show unstressed streams and rivers have higher invertebrate diversity and a relatively high proportion of intolerant species. Taxa within the three EPT insect orders (Ephemeroptera, Plecoptera and Trichoptera) are generally intolerant of many kinds of pollution. Therefore, higher EPT taxa richness values indicate better water quality. Conversely, polluted streams have lower invertebrate diversity and are dominated by tolerant species.

The diversity of the invertebrate fauna is evaluated using taxa richness (i.e. the total number of distinct taxa present); the tolerance of the stream community is evaluated using a Biotic Index (derived from the general response of each taxon to the presence of stressors). Both tolerance values for individual taxa and the final biotic index values for the sample have a range of 0-10 with higher numbers indicating more tolerant taxa and more polluted conditions respectively. Criteria for Piedmont sites were used to assign bioclassifications based upon EPT richness and NCBI values for the six sites in the Hunting Creek watershed. Mountain criteria were applied to the comparison site (Stacey Creek).

Habitat Evaluation

Habitat evaluations were conducted at the seven monitoring locations using the NCDWQ Biological Assessment Unit's (BAU's) Habitat Assessment method for Mountain/Piedmont Streams (NCDWQ 2006a). The habitat assessment assigns a numerical score from 1-100 for the reach of stream sampled, based on channel modification, instream habitat, bottom substrate, pool variety, riffle habitats, bank stability and vegetation, light penetration, and width of the riparian zone. More specifically, these habitat evaluations assess the quality and quantity of instream habitat, the quality and quantity of the stream's riparian zone, and also evaluate detrimental impacts on stream habitat such as bank erosion and substrate embeddedness. No criteria have been developed to rate habitat scores, but the higher the score, the better the overall habitat. Habitat submetrics are depicted in Table 2.

The Hunting Creek site at Causby Quarry Road scored the highest (84) score of the seven sites. This is the most downstream site, capturing most of the watershed. This site scored high in the submetrics of instream habitat, pool variety, riffles, and riparian zone. Stacey Creek, the comparison site scored the next highest (71) for habitat. Stacey Creek's overall habitat score suffered due to narrow riparian zones and pool habitat. Pools were rare in this small riffle-run stream. Pee Dee Branch scored 52. This small urban tributary scored low for in-stream habitat, pool variety, and riffles. Hunting Creek at Poteat Road and Hunting Creek at Bethel Road scored 44 and 42, respectively. Both of these sites were very sandy and scored low for bottom substrate. Hunting Creek at Bethel Road had no woody vegetation in the riparian zone at the sampling location. The two remaining sites, Fiddlers Run (32) and East Prong Hunting Creek (25) both scored low. Both streams are very straight, have poor sandy bottom substrates, poor pool habitat, and narrow riparian zones. Five of the seven streams were noticeably sandy and scored only three of fifteen possible points in the bottom substrate category.

Table 2. Habitat metrics for the Hunting Creek watershed sites and Stacey Creek

	Stream						
Stream	Hunting Cr at SR 1950 (Poteat Road)	Fiddlers Run off SR 1704 (Bethel Road)	E Prong Hunting Cr off SR 1704 (Bethel Road)	Hunting Cr at SR 1704 (Bethel Road)	Pee Dee Br off SR 1443 (Kirksey Drive)	Hunting Cr at SR 1571 (Causby Quarry Road)	Stacey Cr at SR 1918 (Watershed Road)
Sub-metric Habitat Scores[1]							
Channel modification (5)	4	2	2	4	4	4	4
In-stream habitat (20)	8	8	8	12	8	16	14
Bottom substrate (15)	3	3	3	3	3	8	10
Pool variety (10)	4	4	0	4	4	10	4
Riffle habitats (16)	3	3	3	3	7	16	16
Bank stability/vegetation (14)	8	8	7	6	9	10	10
Light penetration (10)	10	2	2	10	10	10	9
Riparian zone width (10)	4	2	0	0	7	10	4
Total Habitat Score (range 0 to 100)	**44**	**32**	**25**	**42**	**52**	**84**	**71**
Other Habitat							
Average stream width (m)	3	1.5	2	7	4	9	2
Average stream depth (m)	0.2	0.1	0.3	0.2	0.2	0.4	0.2
Canopy (%)	80	30	10	70	90	75	70
Substrate (%)							
Boulder	0	5	0	0	0	30	5
Cobble	0	0	0	0	5	30	15
Gravel	10	5	0	10	10	15	20
Sand	85	85	100	80	75	20	55
Silt	5	5	0	10	10	5	5
Physicochemical							
Temperature (ºC)	18.0	20.0	20.0	23.0	19.0	23.0	17.0
Dissolved oxygen (mg/L)	8.2	7.4	8.0	8.9	6.2	8.6	8.8
Specific conductance (µmhos/cm)	63	86	81	96	75	81	22
pH	6.0	6.4	6.7	7.1	6.4	6.3	6.5

[1] Numbers in parenthesis represent the maximum score for the sub-metric.

Physical-Chemical

Measurements for pH were collected from each site using an Accumet AP61 meter. Data for temperature, dissolved oxygen, and specific conductance were collected using a YSI-85 multimeter for all sites. All measurements were made in accordance with standard operating procedures (NCDWQ 2006b). Physical measurements are included in Table 2.

At the time of sampling, the physical-chemical measurements were within typical ranges for the area. As expected, and consistent with typical agricultural areas and urban measurements, the specific conductance values were elevated in the Hunting Creek watershed (63 to 96 µmhos/cm). Specific conductance is a measure of the ability of water to conduct an electric current and is a useful indicator of water quality conditions. Thus, higher values for specific conductance are associated with higher concentrations of dissolved substances. The dissolved substances may or may not represent pollution. Specific conductance generally increases with increasing concentrations of nitrite+nitrate (NOx) nitrogen. The lowest conductance values were recorded at the uppermost site on Hunting Creek at Poteat Road (63 µmhos/cm) and in Stacey Creek (22 µmhos/cm). Stacey Creek's specific conductance value could have been influenced by different geology, as it is in the mountain ecoregion as opposed to the piedmont ecoregion; however, it does primarily drain forested land. The highest value was recorded at the Bethel Road site (96 µmhos/cm) which is located in the middle portion of the Hunting Creek watershed. Dissolved oxygen and pH values were within normal ranges.

Sampling Results

Table 3. Macroinvertebrate sampling results for the Hunting Creek watershed sites and Stacey Creek

	Stream						
Summary	Hunting Cr at SR 1950 (Poteat Road)	Fiddlers Run off SR 1704 (Bethel Road)	E Prong Hunting Cr off SR 1704 (Bethel Road)	Hunting Cr at SR 1704 (Bethel Road)	Pee Dee Br off SR 1443 (Kirksey Drive)	Hunting Cr at SR 1571 (Causby Quarry Road)	Stacey Cr at SR 1918 (Watershed Road)
Map number (Figure 1)	1	2	3	4	5	6	
Collection date	1-Jun-10	1-Jun-10	1-Jun-10	11-Aug-10	2-Jun-10	11-Aug-10	4-Jun-10
Sample method	Qual 4	Qual 4	Qual 4	Qual 4	Qual 4	Qual 4	Qual 4
Criteria	Summer/ Piedmont	Summer/ Piedmont	Summer/ Piedmont	Summer/ Piedmont	Summer/ Piedmont	Summer/ Piedmont	Summer/ Mountain
Richness							
Ephemeroptera	15	7	8	5	6	7	14
Plecoptera	5	2	2	1	0	1	9
Trichoptera	6	6	6	4	4	7	14
Total EPT	26	15	16	10	10	15	37
Odonata	6	5	7	6	5	6	5
Megaloptera	1	0	1	1	0	1	3
Coleoptera	6	3	4	3	2	2	6
Chironomidae	9	14	14	4	10	6	10
non-Chironomidae Diptera	4	3	4	2	4	1	5
Oligochaeta	1	2	5	2	2	2	2
Mollusca	1	1	1	0	1	0	1
Other taxa	0	0	0	2	0	0	1
Total taxa richness	54	43	52	30	34	33	70
Other biological metrics							
EPT abundance	130	45	41	25	57	47	112
EPT Biotic Index	3.78	3.75	3.72	5.69	4.17	4.70	2.56
NCBI	4.30	5.27	4.85	6.26	5.50	5.29	3.22
Bioclassification	Excellent	Good-Fair	Good-Fair	Fair	Good-Fair	Good -Fair	Excellent

Hunting Creek at SR 1950 (Poteat Road)

This site is located in the Hunting Creek headwaters, upstream of most of the development. There is agriculture in the catchment representing crops and farm animals. Based on the taxa collected and using the small stream rating methodology (NCDWQ 2009), this site received an Excellent bioclassification. Twenty-six EPT taxa were collected, including five stone fly taxa. Fifteen mayfly taxa were collected, which is double the number of any of the other Hunting Creek drainage sites. Seven of the mayfly taxa were in the Baetidae family, which feed mostly by scraping and grazing periphyton and associated algae on surfaces. This high number of Baetidae mayflies could be an indicator of elevated nutrient levels. *Elimia*, a mollusk that is also a grazer was noticeably abundant. Taking into consideration the bioclassification, EPT richness, EPT BI, NC BI, and the specific conductance (63 µmhos/cm), this headwater site is the least impacted site of any sampled in the Hunting Creek watershed and supports the most intolerant benthic community.

Fiddlers Run off SR 1704 (Bethel Road)

Fiddlers Run is the largest tributary to East Prong Hunting Creek, which is in turn, a main tributary to Hunting Creek. The upper portion of Fiddlers Run is located in a less developed watershed, but the lower portion flows through the urban watershed of Morganton. The sampling location was located in a city park in Morganton just upstream of the confluence with East Prong Hunting Creek. The drainage area of Fiddlers Run is practically the same as Hunting Creek at Poteat Road (2.45 versus 2.5 square miles). Based on the taxa collected and using the small stream rating methodology (NCDWQ 2009), this site received a Good-Fair bioclassification. Fifteen EPT taxa were collected in Fiddlers Run as opposed to twenty-six taxa in Hunting Creek. The EPT BI was the same at the two sites, but the NC BI was higher in Fiddlers Run, indicating an overall more tolerant benthic community than in Hunting Creek at Poteat Road. It is interesting that the caddisflies *Glossosoma* and *Neophylax* were collected at the Fiddlers Run site, but not in Hunting Creek at Poteat Road. These two taxa are found on rock surfaces and typically decrease in number as the amount of sediment increases. Another interesting aspect of the Fiddlers Run sample was the high numbers (35 individuals) of the midge, *Phaenopsectra*, that were collected. *Phaenopsectra* is reported to be resistant of drought, but it is not considered to be an indicator species of organics or toxic chemicals (Epler 2001). *Chironomous*, a very tolerant midge that is an indicator of enrichment and organic pollution was also abundant in number. However, *Chironomous* was not found in high enough numbers to conduct a midge deformity analysis (Lenat 1993). The specific conductance was higher in Fiddlers Run (86 µmhos/cm) than in Hunting Creek (63 µmhos/cm).

East Prong Hunting Creek off SR 1704 (Bethel Road)

East Prong Hunting Creek is a large tributary to Hunting Creek and has a drainage area of 6.5 square miles. Based on the EPT taxa collected, E. Prong Hunting Creek received a Good-Fair bioclassification. Sixteen EPT taxa were collected, including eight mayfly taxa, two stonefly taxa, and six caddis fly taxa. Most of the taxa collected were moderately tolerant. If the Biotic Index had been used to derive the bioclassifcation rather than just the EPT taxa, the rating would have been Good. The EPT abundance, EPT biotic index, and the NC BI are very similar for Fiddlers Run and East Prong Hunting Creek. The benthic communities in these two streams are similar and comparable. Generally, one would expect more taxa in East Prong Hunting Creek, considering the larger drainage area.

Hunting Creek at SR 1704 (Bethel Road)

At this location on Hunting Creek, the drainage area is 8.9 square miles. The fewest EPT taxa (10) were collected here and at Pee Dee Branch (10). This site received the lowest bioclassification (Fair) of the seven sites. Hunting Creek at Bethel Road had the highest EPT BI (5.69) and he highest NC BI (6.26) indicating the most tolerant benthic community of all the sites. The specific conductance was the highest at this site (96 µmhos/cm). From the uppermost site on Hunting Creek at Poteat Road to the Bethel Road site, the benthic community and the water quality clearly declined. The distance between the two Hunting Creek sites is approximately four miles. The number of EPT taxa decreased from 26 to 10 and the EPT BI increased from 3.78 to 5.69. The specific conductance increased from 63 µmhos/cm to 96 µmhos/cm. One of the most noticeable changes in the benthic fauna was the number of stonefly taxa found at the upper site as compared to the Bethel Road site. Only one individual stonefly was collected at Bethel Road while five stonefly taxa were collected at the Poteat Road site. In addition, the number of mayfly taxa decreased from fifteen to five. Both the Poteat Road site and the Bethel Road location scored low for habitat (44 and 42) and both received low scores for bottom substrate due to high amounts of sand. Considering that the habitat scores were similar for the two sites, the decrease in taxa of the stoneflies and mayflies points to water quality issues rather than habitat. Of the seven locations sampled, this site demonstrated the most tolerant benthic community.

Pee Dee Branch off SR 143 (Kirksey Road)

Pee Dee Branch is a small urban tributary that flows through the City of Morganton. Ten EPT taxa were collected. This was the only site where no stoneflies were collected. Using the small stream criteria (NCDWQ 2009), Pee Dee Branch received a Good-Fair bioclassification. A high number (27 individuals) of the midge, *Chironomous* were collected and approximately half were mounted and observed for signs of mentum deformity, which is an indication of toxicity (Lenat 1993). No deformities were noted upon inspection. *Chironomous* is very tolerant and is an indicator species of nutrient enrichment. Another midge taxa that is very tolerant and considered an indicator of toxicity, *Thienemannimyia* gr. was abundant at this site. It is interesting that this is the only site where the caddisfly, *Dolophilodes* was collected. *Dolophilodes* is a filter feeder and is considered relatively intolerant. The NC BI (5.50) was the second highest after the Hunting Creek Bethel Road site.

Hunting Creek at SR 1571 (Causby Quarry Road)

The drainage area at this site is 25 square miles and captures most of the Hunting Creek watershed before it enters the Catawba River. Fifteen EPT taxa were collected, including seven mayfly taxa, one stonefly taxa, and seven caddisflies. Like the Hunting Creek Bethel Road site, only one individual stonefly was collected, which is low for a stream that encompasses such a large drainage area. This site received a Good-Fair bioclassification. The EPT BI and the NC BI were both lower at this site than the Hunting Creek Bethel Road site, which is located in the mid portion of the drainage. The lower numbers indicate some improvement in the benthic community in Hunting Creek downstream from the Bethel Road site. Several taxa were collected only here and at the comparison site, Stacey Creek. These were *Rhyacophila fuscula*, *Epeorus vitreus*, and *Maccaffertium pudicum*. This site scored the highest for habitat (84) and was noticeably less sandy than at Bethel Road. Although, the overall benthic fauna improved slightly from the Bethel Road site, the collection of only one individual stonefly at this site is an indication of water quality issues.

Stacey Creek at SR 1918 (Watershed Road)

Stacey Creek is a small tributary to Henry Fork, located just south of Morganton and the Hunting Creek watershed. Thirty seven EPT taxa were collected in this small stream. Based on the taxa collected and using the small stream rating methodology (NCDWQ 2009) for mountain streams, this site received an Excellent bioclassification. Nine different stone fly taxa were collected. Based on the taxa collected, the EPT abundance, EPT BI, NC BI, this site is clearly the least impacted and has the most intolerant benthic fauna of any of the seven sites.

Conclusions

Hunting Creek begins in a less developed area, but quickly becomes an urban stream and several of its tributaries are entirely urban. The benthic communities indicate that Hunting Creek is impacted by nutrients which could originate from agriculture and from urban runoff. The benthic fauna at the Poteat Road site contained a large number of scrapers and grazers that eat periphyton and associated algae from surfaces. Most likely, the nutrients at this upper site are from agriculture. Nutrients are also known to increase from runoff as streams flow through developed, urban areas. The benthic communities in Hunting Creek downstream of the Poteat Road site (Bethel Road and Causby Quarry Road) support that nutrients and severe water quality degradation from urban runoff are a concern as Hunting Creek flows through Morganton. Only one individual stonefly was collected at both of these sites and the number of mayflies collected also decreased. The fact that no stoneflies were collected in Pee Dee Branch is an indicator of severe water quality issues in this small tributary to Hunting Creek. Poor habitat is certainly a concern in the Hunting Creek drainage; however, the high habitat score (84) at the most downstream site (Causby Quarry Road) and the collection of only one stonefly there implies that severe water quality issues and possibly toxicity are as important a concern in the Hunting Creek watershed as is poor habitat.

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Appendix 1. List of taxa in the Hunting Creek drainage sites and Stacey Creek

			Hunting Cr at SR 1950 (Poteat Road)	Fiddlers Run off SR 1704 (Bethel Road)	E Prong Hunting Cr off SR 1704 (Bethel Road)	Hunting Cr at SR 1704 (Bethel Road)	Pee Dee Br off SR 1443 (Kirksey Drive)	Hunting Cr at SR 1571 (Causby Quarry Road)	Stacey Cr at SR 1918 (Watershed Road)
Ephemeroptera									
	Baetidae	ACENTRELLA PARVULA	R						
		BAETIS FLAVISTRIGA				R	A		
		BAETIS INTERCALARIS	C		C		R		
		BAETIS PLUTO	C	R	C	R	A	C	C
		BAETIS TRICAUDATUS	R						
		PLAUDITUS CESTUS	R						
		PLAUDITUS DUBIUS GR	A		C				R
		PSEUDOCLOEON FRONDALE							R
		PSEUDOCLOEON PROPINQUUM	R	R	R	R		C	
	Caenidae	BRACHYCERCUS SPP	C		R				C
		CAENIS SPP	A	R	R				
	Ephemerellidae	ATTENELLA ATTENUATA							R
		DANNELLA LITA							R
		DANNELLA SIMPLEX	R						
		EPHEMERELLA CATAWBA							R
		EPHEMERELLA DOROTHEA							R
		EURYLOPHELLA VERISIMILIS	R						A
		TELAGONOPSIS DEFICIENS	A	C	C			C	A
	Heptageniidae	EPEORUS VITREUS						R	R
		MACCAFFERTIUM MODESTUM	A	A	C	A	C	A	
		MACCAFFERTIUM PUDICUM						R	A
		MACCAFFERTIUM TERMINATUM					R		
		STENACRON PALLIDUM		R		R		R	
	Isonychiidae	ISONYCHIA SPP	A	C					A
	Leptophlebiidae	PARALEPTOPHLEBIA SPP	R				R		C
Plecoptera									
	Leuctridae	LEUCTRA SPP							C
	Nemouridae	AMPHINEMURA SPP							C
	Peltoperlidae	TALLAPERLA SPP							A
	Perlidae	ACRONEURIA ABNORMIS							C
		ECCOPTURA XANTHENES				R			C
		PERLESTA SPP	A	C	A				R
		PERLIDAE	C						

			Hunting Cr at SR 1950 (Poteat Road)	Fiddlers Run off SR 1704 (Bethel Road)	E Prong Hunting Cr off SR 1704 (Bethel Road)	Hunting Cr at SR 1704 (Bethel Road)	Pee Dee Br off SR 1443 (Kirksey Drive)	Hunting Cr at SR 1571 (Causby Quarry Road)	Stacey Cr at SR 1918 (Watershed Road)
	Perlodidae	ISOPERLA HOLOCHLORA	R						C
		REMENUS BILOBATUS	R						
	Pteronarcyidae	PTERONARCYS PROTEUS	A	R	C			R	C
		PTERONARCYS SPP							R
Trichoptera									
	Brachycentridae	BRACHYCENTRUS NIGROSOMA	C					R	
	Calamoceratidae	HETEROPLECTRON AMERICANUM							R
	Glossosomatidae	GLOSSOSOMA SPP		C	R				
	Hydropsychidae	CERATOPSYCHE SPARNA	A	A	R			C	C
		CHEUMATOPSYCHE SPP	A	C	C	C	A	A	C
		DIPLECTRONA MODESTA							C
		HYDROPSYCHE BETTENI	C	R	C	C	R	C	R
	Lepidostomatidae	LEPIDOSTOMA SPP		R	R				R
	Leptoceridae	TRIAENODES IGNITUS	A			C		C	
	Limnephilidae	PYCNOPSYCHE SPP	C		R			R	C
	Philopotamidae	DOLOPHILODES SPP					A		
	Polycentropodidae	NYCTIOPHYLAX CELTA							R
		POLYCENTROPUS SPP							R
	Psychomyiidae	LYPE DIVERSA				R			R
	Rhyacophilidae	RHYACOPHILA CAROLINA							R
		RHYACOPHILA FUSCULA						C	C
	Uenoidae	NEOPHYLAX MITCHELLI							R
		NEOPHYLAX OLIGIUS		C			A		C
Odonata									
	Aeshnidae	BOYERIA VINOSA	R	R	R	R	R	C	
	Calopterygidae	CALOPTERYX SPP	C	C	C	A	C	C	R
	Coenagrionidae	ARGIA SPP				R	C		
		ENALLAGMA SPP			R				
	Cordulegasteridae	CORDULEGASTER SPP	C						R
	Gomphidae	GOMPHIDAE						C	
		GOMPHUS SPP	R	R	R	R			C
		LANTHUS SPP	R	R	R		R		C
		OPHIOGOMPHUS SPP	A	C	C				C
		PROGOMPHUS OBSCURUS				R		R	
	Lestidae	ARCHILESTES GRANDIS					R		

			Hunting Cr at SR 1950 (Poteat Road)	Fiddlers Run off SR 1704 (Bethel Road)	E Prong Hunting Cr off SR 1704 (Bethel Road)	Hunting Cr at SR 1704 (Bethel Road)	Pee Dee Br off SR 1443 (Kirksey Drive)	Hunting Cr at SR 1571 (Causby Quarry Road)	Stacey Cr at SR 1918 (Watershed Road)
	Macromiidae	MACROMIA SPP			C	R		C	
Hemiptera									
	Gerridae	GERRIDAE				R			
Megaloptera									
	Corydalidae	NIGRONIA FASCIATUS							R
		NIGRONIA SERRICORNIS	R		R	R		C	R
	Sialidae	SIALIS SPP							R
Coleoptera									
	Dryopidae	HELICHUS SPP	A		R				A
	Dytiscidae	NEOPORUS SPP		R			R		
	Elmidae	ANCYRONYX VARIEGATUS				C		C	
		MACRONYCHUS GLABRATUS			R	R		A	
		OPTIOSERVUS OVALIS	R		R				
		PROMORESIA TARDELLA							R
		STENELMIS SPP	R	R		R	C		C
	Gyrinidae	GYRINUS SPP	R	R	R				R
	Hydrophilidae	SPERCHOPSIS TESSELLATUS	R						
	Psephenidae	PSEPHENUS HERRICKI							C
	Ptilodactylidae	ANCHYTARSUS BICOLOR	R						R
Chironomidae									
	Chironomidae	BRILLIA SPP	R	C	C		R	C	
		CARDIOCLADIUS SPP		C					
		CHIRONOMUS SPP		A	R		A		
		CRICOTOPUS INFUSCATUS		R					
		CRYPTOCHIRONOMUS SPP		R			C		
		DIAMESA SPP	A	C	C				C
		DICROTENDIPES NEOMODESTUS					R		
		MICROTENDIPES SPP							R
		NANOCLADIUS SP 5	R						
		PARAMETRIOCNEMUS SPP	C	C					C
		PARATENDIPES SPP	R		R				
		PENTANEURA INCONSPICUA				R			
		PHAENOPSECTRA OBEDIENS GR		A	R		R		
		POLYPEDILUM AVICEPS	R	C	C	R		R	R
		POLYPEDILUM FALLAX/SP A			R				

			Hunting Cr at SR 1950 (Poteat Road)	Fiddlers Run off SR 1704 (Bethel Road)	E Prong Hunting Cr off SR 1704 (Bethel Road)	Hunting Cr at SR 1704 (Bethel Road)	Pee Dee Br off SR 1443 (Kirksey Drive)	Hunting Cr at SR 1571 (Causby Quarry Road)	Stacey Cr at SR 1918 (Watershed Road)
		POLYPEDILUM FLAVUM	A		R		C	C	
		POLYPEDILUM ILLINOENSE GR				C		C	
		POLYPEDILUM SCALAENUM GR		R	R				
		RHEOCRICOTOPUS ROBACKI		R		R		R	
		RHEOTANYTARSUS SPP	C		R		C		C
		STICTOCHIRONOMUS SPP							R
		THIENEMANIELLA SP B			R				R
		THIENEMANIELLA XENA							R
		THIENEMANNIMYIA GR		C	R		A		C
		TRIBELOS SPP		C			A	R	
		TVETENIA BAVARICA GR	C	R	R		C		R
		TVETENIA SPP			R				
non-Chironomidae Diptera									
	Ceratopogonidae	PALPOMYIA COMPLEX			R				
	Dixidae	DIXA SPP					R		R
	Simuliidae	SIMULIUM SPP	C	R	A	C	C	C	A
	Tipulidae	ANTOCHA SPP	A	A	C		A		
		DICRANOTA SPP							A
		HEXATOMA SPP	R						R
		TIPULA SPP	C		C				
		TIPULIDAE		A		R	C		C
Oligochaeta									
	Lumbriculidae	LUMBRICULIDAE			R	R		R	R
	Megadrile	MEGADRILE OLIGOCHAETE	R	A	A	R	R		
	Naididae	NAIS SPP		R	R		R	R	R
	Tubificidae	AULODRILUS PLURISETA			R				
		ILYODRILUS TEMPLETONI			R				
Crustacea									
	Cambaridae	CAMBARIDAE				C		C	R
Gastropoda									
	Pleuroceridae	ELIMIA SPP	A	R	C		R		C

Appendix D Water Chemistry Sampling Methods and Data

Water samples were collected June 23, 2009, December 17, 2009, June 30, 2010 and December 9, 2010 by Equinox. Laboratory analysis for the June 23, 2009 sample was conducted by University of North Carolina – Asheville's Environmental Quality Institute (EQI) Laboratory under the direction of Dr. Steve Patch. Ann Marie Traylor was the Laboratory Supervisor and the Assistant Laboratory Manager was Diane Morgan. The other samples events were analyzed by Environmental Testing Solutions, Inc. with Kelley Keenan as the Laboratory Director.

Nutrients, specifically ammonia, nitrate/nitrite and total phosphorus as well as total suspended solids (TSS) were analyzed at six sites in the watershed Table D.1). Samples were collected during baseflow conditions. Water quality field parameters (dissolved oxygen, temperature and specific conductance) were also measured on these occasions. In addition to the 6 established monitoring sites, additional monitoring of field parameters were conducted at bridge crossings during the windshield survey, selected to represent all tributaries that are accessible by public roadway.

Table D.1 Regularly Scheduled Chemical Monitoring Site Locations

Site ID	Stream Name	Location	Notes
1	Hunting Creek	Poteat Rd (SR 1950)	Located in Hunting Creek headwaters, above most development. Some agricultural activity in catchment. Most upstream right of way access point.
2	Hunting Creek	Bethel Road (SR 1704)	Middle portion of the watershed, within City of Morganton but upstream of confluence with East Prong.
3	Hunting Creek	Causby Quarry Rd (SR 1571)	Furthest downstream site capturing the entire watershed.
4	East Prong Hunting Creek	Bethel Road (SR 1704)	Just above confluence with Fiddlers Run. Located on City property.
5	Fiddlers Run	Bethel Road (SR 1704)	Lower end of East Prong's largest tributary. Located on City property.
6	Pee Dee Branch	Kirksey Dr (SR 1443)	Lower end of largest tributary draining dense areas of Morganton.

Quality objectives for water quality field parameters are shown in Table A.3. Typical reporting limits for laboratory parameters are given below. See Appendix I for additional laboratory information.

- Ammonia - 0.02 mg/L as N;
- Nitrate - 0.1 mg/L as N;
- Total P - 0.01 mg/L as P;
- TSS - 4 mg/L.

Table D.2 Quality Objectives for Water Quality Field Parameters

Matrix	Parameter	Measurement Range*	Accuracy*	Precision*
Water	Dissolved oxygen	0-20 mg/L	± 0.3 mg/L	0.01 mg/L
Water	Conductivity	0-4999 µS/cm	± 0.5%	1 µS/cm
Water	Temperature	-5 to +65 ºC	± 0.1 ºC	0.1 ºC

*Source: YSI model 85 specifications (www.YSI.com)

Sampling Methods

Field sampling methods and equipment are summarized in Table D.3 and discussed in more detail below.

Table D.3 Sampling Methods

Parameter	**Sampling Equipment**	**Sampling Method**
Temperature, conductivity and dissolved oxygen	YSI model 85	It situ measurement using field meter.
Ammonia, nitrate, TP and TSS	Bottles provided by UNCA Laboratory.	Base flow grab samples collected by *Equinox*

Field Sampling Methods.

Chemical monitoring – containers

High-density polyethylene containers were used for sample collection. Minimum sample volume for laboratory analysis is 250 ml (500 ml for duplicate laboratory analysis). Preparation of sample containers was conducted by the laboratory. All bottles are pre-labeled at the laboratory with the site number and the type of analysis to be carried out. Samples were collected directly into the sample containers and other sampling equipment is not used.

Water sample collection procedures

Surface grab samples were be collected using the general procedures are as follows.

1. Sample collections were made by wading, from the stream bank, or from bridges or other crossings.
2. Samples were collected using the actual sample container provided by the laboratory.
3. Care was taken to not disturb the stream bottom with the sampling container or equipment.
4. If the samples were taken while wading, the stream was entered from downstream of the sampling point. The sampler would wait for the water to clear of any disturbed sediments and stand downstream from sample container while collecting the sample.
5. Samples were collected at the standard depth of measurement is 0.15 meters (6 inches) below the water surface in the thalweg or mid channel area carrying the predominant portion of flow.
6. To collect the sample container was place in the flow of the stream with the opening facing straight down and then at the standard depth, the bottle opening is turned up so that water would fill the container.

Field parameter measurement procedures

Basic procedures are described below.

1. Measurements were made by wading, from the stream bank, or from bridges or other crossings.
2. When monitoring from bridges, traffic was observed closely. Staff did not monitor from bridges unless an adequate road shoulder exists to insure safe operations.
3. Care should be exercised in keeping the meter out of the water. The instruments are splash resistant but should not be submerged.
4. If the measurements are taken while wading, enter the stream downstream from the sampling point, and walk upstream to the sampling location. Stand downstream from the probe at all times. Care should be taken not to disturb the stream bottom with the probe. Wait for the water to clear of any disturbed sediments.
5. The standard depth of measurement is 0.15 meters (6 inches) below the water surface. This is considered to be a surface measurement. Other depths may be used if warranted by project objectives.
6. A velocity of 1 foot/sec or greater is required for DO measurement. If ambient velocity is insufficient, the probe should be moved through the water by hand.
7. DO measurements should not be made directly below areas of high turbulence or in stagnant water, unless these conditions are typical of the reach or unless such measurements are necessary for specific objectives.
8. Measurements should generally be made in the thalweg or mid channel area carrying the predominant portion of flow.

7. Staff should allow sufficient time for the probe readings to stabilize before recording measurements.
8. Measurement should be recorded on the field sheet developed for the project. If no sheet has been developed, record measurements immediately in a field book. At a minimum, the recorded information should include: the field measurements, including units; the site name and ID # (if established); date and time; personnel; and observations on stream flow level and color/turbidity.
9. Precision of measurements should generally be recorded as follows: dissolved oxygen should be recorded to the nearest 1/100 (0.01) of a unit (e.g. 8.05 mg/L); specific conductance should be recorded to the nearest 1/10 (0.1) of a unit (e.g. 56.2 µS/cm); temperature should be recorded to the nearest 1/10 (0.1) of a unit (e.g. 14.7 degrees Celsius).
10. Take care that temperature-compensated conductivity is recorded and not the uncompensated reading.
11. The conductivity cell should be rinsed with deionized water or clean tap water prior to storage.
12. Departures from established procedures must be adequately documented on a field form or field book, along with the reasons those departures were necessary.

Sample Handling and Custody

Bottles used for all parameters followed protocols used by the Environmental Quality Institute Laboratory at the University of North Carolina – Asheville (UNCA EQI Laboratory) and Environmental Testing Solutions. See Appendix I for additional protocol details. All bottle labels included a station ID, site location, the date and time of sampling and the name of the sample collector. The chain of custody form provided by the laboratory was completed at the time of collection. This data sheet includes the site name and number, the date and time of collection, the name and phone number of the person collecting the sample.

Samples were iced to ≤4ºC and transported by Equinox staff to the laboratory within 24 hours after they are collected. Upon arrival at the lab, samples were logged into the facility and assigned a laboratory number, which is recorded on the Sample Request Custody Form.

Holding time and preservation information is summarized in Table D.4.

Table D.4 Preservation and Holding Time Requirements

Parameter	Maximum Holding Time	Preservation
TSS	7 days	Refrigeration at 1-4° C
Total Phosphorus	48 hours	Refrigeration at 1-4° C *
Ammonia-N	48 hours	Refrigeration at 1-4° C *
Nitrate-N	48 hours	Refrigeration at 1-4° C *

*Chemical preservation is not required with a 48 hour holding time.

Sample handling procedures are summarized as follows. See Appendices I and IV for additional details.

1. Clean, nontalc gloves should be worn in the field during all operations involving the handling of sampling apparatus, samples and blanks.
2. Caution must be exercised to avoid contact with the container mouth, inside of the container or with the container cap.
3. When collecting samples, individual containers should be uncapped only when they are about to be filled. Containers should be recapped immediately.
4. Where preservatives are required and have not been previously added to the sample container, they should be added as soon as practical after sample collection. Preservation on site is preferred. Ideally, field preservation should be carried out in a location sheltered from airborne contaminants, including dust, solvents and vehicle emissions. The sample handling area should be as clean as practical.
5. Where preservatives have previously been added to the container, care should be taken not to overfill the container.
6. Samples should be immediately placed in a cooler and iced. Samples stored in an ice chest should not be submerged, which can result in cross contamination.
7. Sample containers should be handled as little as possible. When handling is necessary care should be taken to prevent contamination.

Analytical Methods

All laboratory analyses for this project were carried out by the UNCA EQI Laboratory and Environmental Testing Solutions. Analytical methods are listed below:

- Total Suspended Solids are measured by EPA method 160.2 Gravimetric Dried at 103 - 105 degrees C (Standard Method 2540 D).
- Total Phosphorus sample preparation is by Standard Method 4500 B Persulfate Digestion Method (without filtration) (Hach Method 8190) and measurement is by Standard Method 4500 PE Ascorbic Acid Method (EPA method 365.2) (Hach Method 8048).
- Nitrogen (Ammonia) is measured by EPA Method 350.2 (Hach Method 8038 - Nessler Method).
- Nitrate sample preparation is by Standard Method 4500 B Persulfate Digestion Method (without filtration) (Hach Method 8190); measurement is by Standard Method 4500 PE Ascorbic Acid Method (EPA method 365.2) (Hach Method 8048) methods.

Appendix E Fecal Coliform Bacteria Sampling Methods and Data

Memorandum
December 10, 2009

To: Andrea Leslie, NCEEP
Through: Steve Kroeger, NCDWQ
From: Cathy Tyndall, NCDWQ

Subject: Fecal Coliform Bacteria Sample Results – Hunting Creek Watershed, Catawba River Basin; HUC 030501010608

This memorandum represents the completion of Task 3 of the Scope of Work Water Quality Monitoring for Support 319-Funded LWP in Hunting Creek Watershed. Catawba River Basin. HUC 030501010608.

The NC Division of Water Quality (NCDWQ) was requested by the NC Ecosystem Enhancement Program (NCEEP) in 2009 to conduct 5x/30 sampling at six sites in the Hunting Creek watershed (Table 1). Three sites were located on Hunting Creek and three were located on tributaries to Hunting Creek. The goal was to determine whether water quality standards are being met for fecal coliform bacteria. North Carolina Department of Environment and Natural Resources Administrative Code[1] 15A NCAC 02B .0219 states that, "*fecal coliforms are not to exceed geometric mean of 200/100 ml (MF count) based on at least five consecutive samples examined during any 30-day period and not to exceed 400/100 ml in more than 20 percent of the samples examined during such period*."

Table 1. Fecal Coliform Bacteria Sample Site Locations.

Map No.	Waterbody	Class	Stream Index #	Latitude	Longitude
1	Hunting Creek at Poteat Road	C	11-36-(0.3)	35.694	-81.687
2	Fiddlers Run at City Park	WS-IV	11-36-1-1	35.740	-81.661
3	East Prong Hunting Cr. at City Park	WS-IV	11-36-1	35.740	-81.660
4	Hunting Creek at Bethel Road	WS-IV	11-36-(0.7)	35.743	-81.670
5	Pee Dee Branch at Kirksey Drive	WS-IV	11-36-2	35.763	-81.664
6	Hunting Cr.at Causby Quarry Rd	WS-IV CA	11-36-(3)	35.768	-81.662

Five consecutive samples for fecal coliform bacteria were collected within a 30 day period between September 3, through September 29, 2009. A Quality Assurance Program Plan was not prepared for this sampling, however, samples were collected in accordance with the standard operating procedures manual for physical and chemical monitoring (NCDWQ 2006) and with the quality assurance and quality control measures required by the NCDWQ Laboratory Section (http://h2o.enr.state.nc.us/lab/qa.htm). All samples met the NCDWQ's Laboratory Section's six-hour holding time and were collected at base flow conditions.

All six sites had geometric means greater than the water quality standard of 200 cfu/100ml (Table 2). Hunting Creek at Bethel Road had the highest geometric mean (2024 cfu/100 ml) followed by Hunting Creek at Causby Quarry Road (1054 cfu/100 ml). Hunting Creek at Bethel Road is in the middle portion of the watershed, within the City of Morganton and upstream of the confluence of East Prong Hunting Creek. Hunting Creek at Causby Quarry Road is the furthest accessible downstream location prior to Hunting Creek's confluence with the Catawba River.

This site captures the entire watershed. The most upstream site in the watershed, Hunting Creek at Poteat Road is located in the headwaters and there is agriculture in the catchment. It appears that the elevated fecal coliform bacteria in the Hunting Creek watershed may have a variety of sources which could include agriculture, wildlife, failing or improper use of septic systems and failures in the city sewer system.

Table 2. Fecal coliform results from the 5 Samples in 30 days, September 2009.

Map Number	Waterbody	9/3/2009	9/4/2009	9/14/2009	9/15/2009	9/29/2009	% over 400/100 ml	Geometric mean
1	Hunting Creek at Poteat Road	1400	740	900	1000	740	100	928
2	Fiddlers Run at City Park	3600	3300	1300	1100	2000	100	2024
3	East Prong Hunting Creek at City Park	770	980	360	360	740	60	591
4	Hunting Creek at Bethel Road	3600	3300	1300	1100	2000	100	1018
5	Pee Dee Branch at Kirksey Drive	470	980	1300	440	640	100	700
6	Hunting Creek at Causby Quarry Road	1100	2000	330	780	2300	80	1054

Results were assigned the B4 data qualifier by the NCDWQ Laboratory Section. "Filters have counts of both >60 or 80 and <20. Reported value is a total of the counts from all countable filters reported per 100 ml." See: http://h2o.enr.state.nc.us/lab/documents/QualifierCodes_05052008.pdf

References:

NCDWQ 2006. Intensive Survey Unit Standard Operating Procedures Manual: Physical and Chemical Monitoring. Version 1.3. December 2006.
See: http://h2o.enr.state.nc.us/esb/documents/PHYSICAL-CHEMICAL%20SOP.pdf

Appendix F Windshield Survey Methods and Data

A windshield survey was conducted to provide a general impression of stream and watershed conditions. It was a rapid exercise designed to facilitate the early stages of watershed assessment and planning. One day was spent driving around the watershed observing streams at 30 bridge crossings. Water quality parameters such as temperature, dissolved oxygen, and specific conductance were collected with a portable YSI Model 85 instrument. Additional information such as riparian zone activity, bank stability, channel conditions, in-stream habitat, channel modification, and BMP potential was also observed and recorded on a datasheet.

Stream:________________________ **Site ID:**__________ **Site Location** :______________________________
Staff:__________________________________ **Date**____________________ **Time**_______________ ☐AM ☐PM

Tracking Information

Waypoint No. ____________ Lat________________________ Long________________________
Photo number(s) and description____

Water Quality Field Parameters and Observed Conditions

Field Params: Specific conductance _______μS/cm Temperature________ ^{0}C DO___________mg/L *Last Rainfall* (if known)____________________________	*Water Appearance*: ☐ turbid ☐ clear ☐ other (list) ________________ *Flow Conditions*: ☐ high ☐ normal ☐ low

> Site Characteristics <

Upstream	Downstream
Riparian Zone Activity	**Within 30 Feet of Stream**
Nature of activity (check all that apply, circle major):	Nature of activity (check all that apply, circle major):
LB RB: ☐ ☐ None ☐ ☐ Roads ☐ ☐ Industrial ☐ ☐ Commercial ☐ ☐ Institutional ☐ ☐ Construction Site ☐ ☐ Golf Course ☐ ☐ Other ______________________ *LB RB::* ☐ ☐ Resid. yards ☐ ☐ Houses ☐ ☐ Apts ☐ ☐ Pasture/hay ☐ ☐ Cultivated land ☐ ☐ Animal Oper ☐ ☐ Nursery Check if incidental ☐ Check if within 10 ft ☐	*LB RB:* ☐ ☐ None ☐ ☐ Roads ☐ ☐ Industrial ☐ ☐ Commercial ☐ ☐ Institutional ☐ ☐ Construction Site ☐ ☐ Golf Course ☐ ☐ Other ______________________ *LB RB::* ☐ ☐ Resid. yards ☐ ☐ Houses ☐ ☐ Apts ☐ ☐ Pasture/hay ☐ ☐ Cultivated land ☐ ☐ Animal Oper ☐ ☐ Nursery Check if incidental ☐ Check if within 10 ft ☐
Riparian Hot Spot Concerns	**(if Applicable)**
LB RB: ☐ ☐ Highly impervious ☐ ☐ Gas station/car wash ☐ ☐ Materials storage ☐ ☐ Vehicle maint/storage Access ☐ ☐ Other__________________ *LB RB:* ☐ ☐ Waste Manage. ☐ ☐ Junk yard ☐ ☐ Nursery ☐ ☐ Livestock Check if stream/storm drain inputs likely ☐	*LB RB:* ☐ ☐ Highly impervious ☐ ☐ Gas station/car wash ☐ ☐ Materials storage ☐ ☐ Vehicle maint/storage ☐ ☐ Other__________________ *LB RB:* ☐ ☐ Waste Manage. ☐ ☐ Junk yard ☐ ☐ Nursery ☐ ☐ Livestock Access Check if stream/storm drain inputs likely ☐

Bank Stability (Rate Each Bank)

Left Bank: ☐ Good ☐ Fair ☐ Poor ☐ Can't Evaluate *Right Bank:* ☐ Good ☐ Fair ☐ Poor ☐ Can't Evaluate ____	*Left Bank:* ☐ Good ☐ Fair ☐ Poor ☐ Can't Evaluate *Right Bank:* ☐ Good ☐ Fair ☐ Poor ☐ Can't Evaluate ____

Channel Substrate and Sediment Sources

☐ Good (abundant coarse material, limited embeddedness) ☐ Fair (some coarse material, but excessive sedimentation) ☐ Poor (dominated by sand and silt) Obvious sediment sources (list) ______________________	☐ Good (abundant coarse material, limited embeddedness) ☐ Fair (some coarse material, but excessive sedimentation) ☐ Poor (dominated by sand and silt) Obvious sediment sources (list) ______________________

Instream Habitat

Riffle habitat: ☐ Poor ☐ Fair ☐ Good ☐Excellent Pool habitat: ☐ Poor ☐ Fair ☐ Good ☐Excellent Other habitat: ☐ Poor ☐ Fair ☐ Good ☐Excellent (LWD, root mats, etc)	Riffle habitat: ☐ Poor ☐ Fair ☐ Good ☐Excellent Pool habitat: ☐ Poor ☐ Fair ☐ Good ☐Excellent Other habitat: ☐ Poor ☐ Fair ☐ Good ☐Excellent (LWD, root mats, etc)

Channel Modification and Floodplain Access

Channel straightened: ☐ No ☐ Recent (< 10 years) ☐ Historic Bank hardening: ☐ None ☐ Minor ☐ Major Piped? ☐ Yes ☐ No Potential Fish Barrier ☐ Yes ☐ No ☐ Can't Tell Other channel modification__________________________ Channel at least moderately incised ☐ Yes ☐ No	Channel straightened: ☐ No ☐ Recent (< 10 years) ☐ Historic Bank hardening: ☐ None ☐ Minor ☐ Major Piped? ☐ Yes ☐ No Potential Fish Barrier ☐ Yes ☐ No ☐ Can't Tell Other channel modification__________________________ Channel at least moderately incised ☐ Yes ☐ No

Upstream	Downstream

BMP Potential

☐ Stormwater (follow up during retrofit survey) ☐ On-site ☐ Storage ☐ Other_____________ ☐ Probably Not ☐ Agricultural ☐exclusion ☐ conserve tillage ☐ Other_______	☐ Stormwater (follow up during retrofit survey) ☐ On-site ☐ Storage ☐ Other_____________ ☐ Probably Not ☐ Agricultural ☐exclusion ☐ conserve tillage ☐ Other_______

Other Features of Interest

☐ Large tracts of mature forest ☐ Livestock fenced from stream ☐ Conservation tillage ☐ Major bank failure ☐ Active incision ☐ Recent clearcutting ☐ Other____________________________________ ____	☐ Large tracts of mature forest ☐ Livestock fenced from stream ☐ Conservation tillage ☐ Major bank failure ☐ Active incision ☐ Recent clearcutting ☐ Other____________________________________

Notes:

Windshield Survey Data

Site ID	Stream	Road #	Road Name/Location	Date	Time	Temp (°C)	Specific Conduct (µS/cm)	DO (mg/L)	Water Appearance	Flow Conditions
1	UT	SR 1941	Williams Rd	2/10/2009	8:30am	8.2	104.2	13.42	clear	normal
2	UT	SR 2002	Western Ave	2/10/2009	9:00am	9.1	65.3	11.90	clear	low
3	Hunting Ck	SR 1950	Poteat Rd	2/10/2009	9:20am	9.0	60.5	9.86	clear	low
4	Hunting Ck	SR 1940	Pete Brittain Rd	2/10/2009	9:38am	8.8	67.7	9.25	clear	low
5	UT Hunting Ck	SR 1938	Oaktree Rd	2/10/2009	9:50am	7.9	36.9	9.55	clear	low
6	UT Hunting Ck	SR 1922	Enola Rd	2/10/2009	10:11am	9.4	29.4	9.00	clear	low
7	Fiddlers Run	SR 1940	Old Colony Rd	2/10/2009	10:25am	10.0	51.4	8.70	clear	low
8	Fiddlers Run	SR 1933	Skyland Dr	2/10/2009	10:40am	10.5	70.1	6.23	clear	low
9	UT East Prong	SR 1931	Mount Home Church Rd	2/10/2009	11:05am	10.2	68.3	9.26	clear	low
10	East Prong	SR 1931	Mount Home Church Rd	2/10/2009	11:10am	10.4	69.5	9.39	clear	low
11	East Prong	SR 1811	Zero Mull Rd	2/10/2009	11:25am	9.5	34.5	9.75	clear	low
12	UT East Prong	NC 18	NC 18	2/10/2009	11:30am	10.8	63.1	9.38	clear	low
13	East Prong	SR 1972	Brookwood Rd	2/10/2009	12:05pm	11.1	81.4	9.62	clear	low
14	Fiddlers Run	SR 1924	Old NC 18	2/10/2009	12:15pm	11.0	78.2	9.24	clear	low
15	East Prong	SR 1708	Parker Rd	2/10/2009	12:35pm	11.6	84.7	7.17	clear	low
16	UT East Prong	SR 1711	Blanton Rd	2/10/2009	12:40pm	10.2	94.2	9.11	clear	low
17	UT Hunting Ck	SR 1831	Parton Ave	2/10/2009	12:55pm	11.8	53.0	9.73	clear	low
18	Fiddlers Run		City of Morganton Park	2/10/2009	1:10pm	12.3	87.0	9.70	clear	low
19	East Prong		City of Morganton Park	2/10/2009	1:15pm	12.7	81.3	10.06	clear	low
20	UT Hunting Ck	US 70	US 70	2/10/2009	1:30pm	11.2	56.6	10.09	clear	low
21	UT to UT to Hunting	SR 1715	Watts St	2/10/2009	1:50pm	11.6	39.5	8.70	clear	low
22	UT to UT to Hunting		Eastbrook Circle	2/10/2009	2:00pm	14.1	61.8	8.45	clear	low
23	UT to UT to Hunting	SR 1713	Summers Rd	2/10/2009	2:15pm	11.4	54.9	9.59	turbid	
24	PeeDee Branch	SR 1443	Kirksey Dr	2/10/2009	2:30pm	11.3	64.3	10.31	clear	low
25	Hunting Ck	SR 1571	Causby Quarry Rd	2/10/2009	3:10pm	11.7	81.6	11.06	clear	low
26	Hunting Ck	SR 1312	Amherst Rd	2/10/2009	3:15pm	12.6	80.1	10.35	clear	low
27	UT Hunting Ck	SR1512	Amherst Rd	2/10/2009	3:25pm	10.9	34.5	9.26	clear	low
28	Pee Dee Branch	Hwy 70 Business		2/10/2009	3:40pm	12.2	45.0	9.06	clear	low
29	Hunting Ck		Coal Chute Rd	2/10/2009	4:00pm	13.1	70.7	9.89	clear	low
30	Hunting Ck		Bethel Rd	2/10/2009	4:15pm	12.1	89.1	10.22	clear	low

Site ID	Upstream																
	Riparian Activity LB/RB[1]	Activity within 10 ft	Hot Spot LB/RB[2]	Storm Drain Input	Bank Stability LB/RB	Substrate	Sediment Source	Riffle Habitat	Pool Habitat	Other Habitat	Channel Straight	Bank Hardened	Piped	Fish Barrier	Moderate Incision	BMP Potential[3]	Other Features*
1	NA/Yard, O	Yes	NA/Mat, Veh	No	Good/Fair	Fair		Fair	Poor	Fair	Historic	None	No	No	Yes	No	None
2	P, O/O	No	NA/NA	No	Good/Fair	Poor		Poor	Poor	Fair	Historic	None	No	No	Yes	Ag Other	None
3	O/P	No	NA/NA	Yes	Poor/Fair	Fair		Poor	Poor	Fair	Historic	None	No	No	Yes	Ag Other	None
4	P/P	Yes	NA/NA	Yes	Poor/Poor	Poor	Bank Erosion	Poor	Fair	Fair	Historic	Minor	No	No	Yes	Ag Other	Bank Failure
5	Yard, P/NA	Yes	NA/NA	Yes	Fair/Fair	Good		Good	Fair	Fair	Historic	None	No	No	Yes	Ag Other	None
6	Yard/Yard	Yes	NA/NA	No	Fair/Fair	Fair		Poor	Poor	Poor	Historic	None	No	No	Yes	Ag Other	None
7	O/P	No	NA/NA	Yes	CE/CE	Poor		Poor	Poor	Fair	Historic	Minor	No	No	Yes	SW Other & Ag Other	None
8	P/Yard	Yes	NA/NA	No	CE/CE	Poor		Fair	Fair	Fair	Historic	None	No	No	Yes	Ag Other	None
9	O,Yard/Yard	Yes	Other/NA	Yes	Poor/Poor	Poor	Bank Erosion	Poor	Poor	Fair	Historic	None	No	No	Yes	Ag Other	None
10	P/Yard	Yes	NA/NA	No	Poor/Poor	Poor		Fair	Poor	Fair	Historic	None	No	No	Yes	Ag Other	None
11	NA/Yard	Yes	NA/NA	No	Fair/Poor	Good		Good	Fair	Fair	Historic	None	No	No	Yes	Ag Other	None
12	N/SR,Com, O	Yes	N/WM, O	No	CE/CE	Good		Good	Fair	Fair	Historic	None	No	No	Yes	SW Other & Ag Other	None
13	C/C, Yard	No	NA/NA	No	Fair/Fair	Poor		Poor	Poor	Fair	Historic	Minor	No	No	Yes	Ag Other	None
14	NA/NA	No	NA/NA	No	CE/CE	CE		CE	CE	CE	CE	CE	CE	CE	CE	No	None
15	O/O	Yes	NA/NA	No	Poor/Poor	Poor		Poor	Poor	Fair	Historic	None	No	No	Yes	Ag Other	None
16	Yard/P	Yes	NA/NA	No	Poor/Poor	Fair		Fair	Fair	Fair	Historic	None	No	No	Yes	Ag Other	Fenced
17													Yes			No	None
18	NA/O	Yes	NA/NA	No	Fair/Poor	Poor	Bank Erosion	Poor	Poor	Fair	Historic	Minor		No	Yes	SW On-site & Ag Other	Bank Failure
19	O/O	Yes	NA/NA	No	Poor/Poor	Poor	Bank Erosion	Poor	Poor	Fair	Historic	None	No	No	Yes	SW On-site & Ag Other	Bank Failure
20	Com/Com, Yard	No	Imp/O	Yes	Fair/Fair	Poor		Poor	Poor	Fair	Historic	None	No	No	Yes	SW On-site & Ag Other	None
21	Yard/Yard	Yes	NA/NA	No	CE/CE	CE		CE	CE	CE	Historic	None	No	No	Yes	Ag Other	None
22	NA/Yard	Yes	NA/NA	Yes	Fair/Fair	Fair		Good	Good	Fair	No	None	No	No	Yes	Ag Other	None
23	O/Yard	Yes	NA/NA	No	Fair/Fair	Fair		Good	Fair	Fair	Historic	None	No	No	Yes	Ag Other	None
24	NA/NA	No	NA/NA	No	CE/Fair	Poor		Poor	Poor	Fair	No	None	No	No	Yes	No	None
25	NA/NA	No	NA/NA	No	Fair/Good	Good		Excellent	Good	Good	No	None	No	No	Yes	No	Forest
26	NA/NA,P	No	NA/NA	No	Good/Fair	Poor		Poor	Poor	Fair	No	None	No	No	Yes	No	None
27	O/Yard	No	NA/NA	No	Fair/Fair	Fair		Good	Fair	Fair	No	None	No	No	Yes	Ag Other	None
28				Yes									Yes				
29	O/Inst	No	NA/NA	No	Fair/Fair	Poor		Poor	Poor	Fair	Historic	None	No	No	Yes	SW On-site & Ag Other	None
30	Ind/P	Yes	O/NA	Yes	Fair/Poor	Poor	Bank Erosion	Poor	Poor	Fair	Historic	None	No	No	Yes	SW On-site & Ag Other	Bank Failure

[1] Riparian Zone Activity: NA-None, SR-Roads, PVT-Private/Dirt/Gravel Road, Ind-Industrial, Com-commercial, Inst-Institutional, Yard-Residential Yard, P-Pasture/Hay, C-Cultivated land, N-Nursery, O-Other
[2] Riparian Hot Spot Concerns: NA-None, Imp-Highly Impervious, Mat-Materials Storage, Veh-Vehicle Maintenace/Storage, WM-Waster Management, Junk-Junk Yard, N-Nursery, O-Other
[3] BMP Potential: SW On-site-Stormwater On-site, SW Other-Stormwater Other, No-Probably Not, Ag Till-Agricultural Conservation Tillage, Ag Other-Agricultural Other
* Other Features: Forest-Large tracts of mature forest, Fenced-Livestock fenced from stream, Bank Failure-Major bank failure

Site ID	Downstream																
	Riparian Activity LB/RB[1]	Activity within 10 ft	Hot Spot LB/RB[2]	Storm Drain Input	Bank Stability LB/RB	Substrate	Sediment Source	Riffle Habitat	Pool Habitat	Other Habitat	Channel Straight	Bank Hardened	Piped	Fish Barrier	Moderate Incision	BMP Potential[3]	Other Features*
1	NA/PVT	No	NA/NA	No	Fair/Good	Poor		Poor	Poor	Fair	Historic	None	No	Yes	Yes	No	None
2	P/O	No	NA/NA	Yes	Fair/CE	Fair	Bank Erosion	Good	Fair	Fair	Historic	None	No	No	Yes	SW Other & Ag Other	Bank Failure
3	NA/O	No	NA/NA	No	Poor/Poor	Fair		Fair	Poor	Fair	Historic	None	No	No	Yes	No	None
4	C/P	Yes	NA/NA	No	Poor/Poor	Poor	Bank Erosion	Poor	Poor	Fair	Historic	Minor	No	No	Yes	Ag Till & Ag Other	Bank Failure
5	P/NA	Yes	NA/NA	Yes	Poor/Poor	Good		Good	Fair	Good	Historic	None	No	Yes	Yes	Ag Other	Bank Failure, Fenced
6	Yard/SR	No	Veh/NA	No	Fair/Fair	Fair		Fair	Fair	Good	No	None	No	Yes	Yes	No	None
7	O/P	No	NA/NA	No	Fair/Fair	Fair	Bank Erosion	Poor	Poor	Poor	Historic	Minor	No	No	Yes	SW Other & Ag Other	None
8	Yard/NA	Yes	NA/NA	No	Fair/Fair	Fair		Fair	Fair	Fair	No	None	No	No	Yes	Ag Other	None
9	P/P	Yes	NA/NA	No	Fair/Fair	Poor		Poor	Poor	Fair	Historic	None	No	No	Yes	Ag Other	None
10	P/P	Yes	NA/NA	Yes	Poor/Poor	Fair	Bank Erosion	Fair	Fair	Fair	Historic	None	No	No	Yes	Ag Other	None
11	Yard/Yard	Yes	NA/NA	No	Poor/Poor	Fair		Fair	Fair	Fair	Historic	None	No	No	Yes	Ag Other	None
12	C/SR	Yes	NA/NA	No	Fair/Fair	Fair		Poor	Poor	Fair	Historic	None	No	No	Yes	Ag Other	None
13	C/C	No	NA/NA	No	Fair/Fair	Poor		Fair	Poor	Fair	Historic	None	No	No	Yes	Ag Other	None
14	Yard/Yard	No	NA/NA	Yes	Fair/Fair	Poor		Poor	Poor	Fair	Historic	None	No	Yes		Ag Other	None
15	Yard/O	No	NA/NA	No	Poor/Poor	Poor		Poor	Fair	Fair	Historic	None	No	No	Yes	Ag Other	None
16	P/Yard	Yes	NA/NA	No	Poor/Poor	Fair		Poor	Poor	Fair	Historic	None	No	Yes	Yes	Ag Other	Fenced
17	P/P	Yes	Junk/NA	No	Poor/Poor	Fair		Fair	Fair	Fair	No	None	No	No	Yes	Ag Other	None
18	O/O	Yes	NA/NA	No	Poor/Poor	Poor	Bank Erosion	Poor	Poor	Fair	Historic	None	No	No	Yes	SW on-site & Ag Other	Bank Failure
19	O/O	Yes	NA/NA	No	Poor/Poor	Poor	Bank Erosion	Poor	Poor	Fair	Historic	None	No	No	Yes	SW on-site & Ag Other	None
20	Com/Com	No	NA/NA	Yes	Fair/Fair	Poor	Spoil Piles	Fair	Fair	Fair	Historic	None	No	No	Yes	Ag Other	None
21	P/P	No	NA/NA	No	CE/CE	Poor		CE	CE	CE	Historic	None	No	No	Yes	Ag Other	None
22	NA/NA	No	NA/NA	No	Good/Good	Fair		Good	Good	Good	No	None	No	No	Yes	No	None
23	SR/O, N	No	NA/NA	No	Fair/Fair	Fair		Fair	Poor	Fair	Historic	None	No	No	Yes	Ag Other	None
24	NA/NA	No	NA/NA	Yes	Fair/Fair	Poor		Poor	Poor	Fair	No	None	No	No	Yes	No	None
25	NA/SR	No	NA/O	Yes	Good/Good	Poor		Poor	Poor	Poor	No	None	No	No	Yes	SW Other	Forest

26	NA/NA	No	NA/NA	No	Poor/Fair	Poor	Bank Erosion	Poor	Poor	Fair	No	None	No	No	Yes	No	None
27	NA/NA,O	No	NA/NA	No	Fair/Fair	Fair		Fair	Good	Good	No	None	No	No	Yes	No	None
28	Com/Com,SR	No	O/NA	Yes	Fair/Fair	Poor		Poor	Poor	Fair	Historic	None	No	No	Yes	SW on-site	None
29	O/NA	No	NA/NA	No	Fair/Fair	Poor		Poor	Poor	Fair	Historic	None	No	No	Yes	Ag Other	None
30	NA/NA	No	NA/NA	No	Fair/Fair	Poor		Poor	Poor	Fair	Historic	None	No	No	Yes	No	None

[1] Riparian Zone Activity: NA-None, SR-Roads, PVT-Private/Dirt/Gravel Road, Ind-Industrial, Com-commercial, Inst-Institutional, Yard-Residential Yard, P-Pasture/Hay, C-Cultivated land, N-Nursery, O-Other
[2] Riparian Hot Spot Concerns: NA-None, Imp-Highly Impervious, Mat-Materials Storage, Veh-Vehicle Maintenance/Storage, WM-Waste Management, Junk-Junk Yard, N-Nursery, O-Other
[3] BMP Potential: SW On-site-Stormwater On-site, SW Other-Stormwater Other, No-Probably Not, Ag Till-Agricultural Conservation Tillage, Ag Other-Agricultural Other
* Other Features: Forest-Large tracts of mature forest, Fenced-Livestock fenced from stream, Bank Failure-Major bank failure

Appendix G Stream Walk Methods and Data

To thoroughly investigate the main stem of Hunting Creek and identify in-stream problems and impacts, 8.6 miles of Hunting Creek were walked from Vine Arden Road at the northern extent of the watershed upstream to Poteat Street in the southern portion of the watershed. Twenty-nine stream reaches with an average length of 1500 feet were delineated in GIS prior to stream walking in order to divide Hunting Creek into manageable segments for field assessment and data management.

Five days were spent documenting stormwater outfalls and drainage ditches, erosion sites, utility crossings, dump sites, channel modification, structural crossings, impacted buffers, and other potential stream impacts in Hunting Creek. When encountered, a datasheet was completed and the location was recorded with a Garmin 72 GPS unit. Latitude and longitude coordinates were uploaded into ArcGIS 9.2 to spatially view the location of these potential impacts on a watershed level. Photographs were taken at representative impacts as well as at the start and end of each reach to document typical conditions. Methods developed by the Center for Watershed Protection's Unified Stream Assessment were used and adapted by Equinox to fit the objectives of the Hunting Creek Watershed Assessment (CWP, 2004).

Reach Level Assessment **RCH**

SURVEY REACH ID:	**DATE:** ___/_____/___	**STAFF:**
START TIME:___:____AM/PM **END TIME:**___:____AM/PM		**WP#** ______ **TO** ______

REACH START **CONDUCTIVITY** __________**umhos/c** **TEMPERATURE** ___________ **^{0}C**

RAIN LAST 24 HOURS ☐ Heavy rain ☐ Steady rain ☐ Intermittent ☐ Trace ☐ None

PRESENT CONDITIONS ☐ Heavy rain ☐ Steady rain ☐ Intermittent ☐ Clear ☐ Trace ☐ Overcast ☐ Partly cloudy

WATER CLARITY ☐ Clear ☐Turbid *(suspended matter)* ☐ Stained *(clear, naturally colored)* ☐ Opaque *(milky)* ☐ Other *(chemicals, dyes)*____

ODOR ☐ None ☐Sewage ☐Gas ☐ Detergent ☐Sour ☐Sulfide ☐Other_________________________

ADJACENT LAND USE: ☐ Industrial ☐ Commercial ☐ Urban/Residential ☐ Suburban/Res ☐ Forested ☐ Institutional ☐ Golf course ☐ Park ☐ Crop ☐ Pasture ☐ Other:________________

DOMINANT RIPARIAN COVER (50 FEET):	Paved	Structures	Bare Ground	Turf/Lawn	Tall Grass	Shrub/Scrub	Trees	Other
LT Bank	☐	☐	☐	☐	☐	☐	☐	☐:____
(Looking Downst) RT Bank	☐	☐	☐	☐	☐	☐	☐	☐:____

Channel Dynamics ☐ Unknown ☐ Downcutting ☐ Widening ☐ Headcutting ☐ Aggrading ☐ Sed. deposition ☐ Bed scour ☐ Bank failure ☐ Bank scour ☐ Slope failure ☐ Channelized (recent) ☐ Re-establishing meander

	OPTIMAL	**Suboptimal**	**Marginal**	**Poor**
DEGREE OF ENTRENCHMENT	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.
FLOODPLAIN ENCROACHMENT	No evidence of floodplain encroachment in the form of fill material, land development, or manmade structures	Minor floodplain encroachment in the form of fill material, land development, or manmade structures, but not effecting floodplain function	Moderate floodplain encroachment in the form of filling, land development, or manmade structures, some effect on floodplain function	Significant floodplain encroachment (i.e. fill material, land development, or man-made structures). Significant effect on floodplain function

Notes:

OT

Outfalls & Tributaries

SURVEY REACH ID:	DATE: ___/____/___	STAFF:
WP #:	PHOTO ID #:	TIME:___:____AM/PM
SOURCE ☐ Stream ☐ Outfall ☐ Unknown	BANK ☐LT ☐RT ☐ Head	

Flow: ☐ None ☐ Trickle ☐ Moderate ☐ Substantial ☐ Other:	*Type:*	*Material:*	*Dimensions:*
	☐ ***CLOSED PIPE***	☐ Concrete ☐Metal ☐ PVC/Plastic ☐Brick ☐ Other:____________	Diameter:_____ (in)
	☐ Open channel	☐ Concrete ☐ Earthen ☐ Other:____________	

Flowing Only	***SPECIFIC COND.*** ____*µmhos/cm*	**Color:** ☐ Clear ☐ Brown ☐ Grey ☐ Yellow ☐ Green ☐ ***ORANGE*** ☐ ***RED*** ☐ ***OTHER:____________***
	TEMP______^{0}C	**TURBIDITY:** ☐ None ☐ Slight Cloudiness ☐ Cloudy ☐ ***OPAQUE*** ☐ ***OTHER:________________***

Origin of Outfall:	***Odor:***	Deposits/Stains:	***CAUSE OF EROSION:***
☐ Wastewater ☐ Straight Pipe ☐ Industrial Facility List type if known:________________ ☐ Commercial Facility List type if known:________________ ☐ Other:______________________ ☐ Stormwater ☐ Gutter ☐ Parking lot ☐ Street/Road Way ☐ Other:______________________ ☐ Unknown	☐ ***NONE*** ☐Gas ☐ Sewage ☐Rancid/Sour ☐ Sulfide ☐ Other::	☐ None ☐Oily ☐ Flow Line ☐ Paint ☐ Suds ☐ Colors ☐ Floatables ☐ Algae ☐Other	☐ Yes ☐ Discharge scour ☐ Outfall height excessive ☐ Outfall angle ☐ Other:______________ ☐No

DEGREE OF CONCERN:	☐ High ☐ Medium ☐ Low ☐ Can't Evaluate [If High or Medium, discuss:]____ Follow up recommended ☐ Yes ☐ No

Severe Bank Erosion

ER

SURVEY REACH ID:	DATE: ___/_____/___	STAFF:
WP #:	PHOTO #	

BANK OF CONCERN: ☐ LT ☐ RT ☐ Both *(looking downstream)*
LOCATION: ☐ Meander bend ☐ Straight section ☐ Steep slope/valley wall ☐ Other:_______________________
Dimensions:
Bank Ht LT_______ft and/or RT__________ft
Bank Angle LT________° and/or RT________°
Est. Length LT_______ft and/or RT_________ft

PROCESS:	TYPE:	LAND COVER:
☐ Downcutting ☐ Widening ☐ Headcutting ☐ Aggrading ☐ Sed. Deposition ☐ Bed Scour ☐ Meander Re-establishment ☐ Currently unknown	☐ Bank slumping/failure during normal flow ☐ Bank scour during high flows ☐ Slope failure ☐ Active channelization ☐ Currently unknown	☐ Forest ☐ Field/Ag ☐ Developed ☐ Other:____________________________ **EXISTING RIPARIAN WIDTH:** ☐ ≤10 ft ☐ 10 – 25 ft ☐ 25 - 50 ft ☐ >50ft

THREAT TO PROPERTY/INFRASTRUCTURE: ☐ No ☐ Yes (Describe):

Recent Channel Modification

CM

SURVEY REACH ID:	DATE: ___/_____/___	STAFF:
WP #:	PHOTO #	

Type:	Material:	Degree of Incision:	IS CHANNEL CONNECTED TO FLOODPLAIN:
☐ Recent or Active Channelization ☐ Bank armoring ☐ Other:_______________________ ***Dimensions:*** Height:_____________(ft) Length:_____________(ft)	☐ Concrete ☐ Rip rap ☐ Metal ☐ Gabion ☐ Earthen ☐ Other:_______	☐ High ☐ Medium ☐ Low	☐ Yes ☐ No

Impacted Buffer **IB**

SURVEY REACH ID:		**DATE: ___/_____/___**	**STAFF:**
WP #:		**PHOTO #**	
Impacted Bank: *(Looking Downstream)* ☐ LT ☐ RT ☐ Both	***Left Bank:*** Length (ft): ______ Width (ft): _______ **RT BANK:** Length (ft): ______ Width (ft): _______	**IMPACTS:** ☐ Lack of vegetation ☐ Too narrow ☐ Structures ☐ Recently planted ☐ Paved ☐ Utility ROW parallel ☐ Utility ROW crossing ☐ Agriculture ☐ Other:	

Utility Impacts **UT**

SURVEY REACH ID:		**DATE: ___/_____/___**	**STAFF:**
WP #:		**PHOTO #**	
Potential Concerns: ☐ None ☐ Evidence of discharge ☐ Susceptible to stream flow damage ☐ Fish barrier ☐ Causing bed/bank erosion ☐ Other:_______________________	***TYPE:*** ☐ Sewer line ☐ Manhole ☐ Electrical ☐ Unknown Pipe ☐ Other:_______	***Location:*** ☐ Floodplain ☐ Stream bank ☐ Above stream ☐ Stream bottom ☐ Other:_____________________	**CONDITION:** ☐ Good ☐ Joint failure ☐ Pipe corrosion/cracking ☐ Protective covering broken ☐ Manhole cover absent ☐ Other:_________________________
EVIDENCE OF DISCHARGE:	**Color**	☐ None ☐ Clear ☐ Dark Brown ☐ Lt Brown ☐ Yellowish ☐ Greenish ☐ Other:_______________________	
	ODOR	☐ None ☐ Sewage ☐ Oily ☐ Sulfide ☐ Chlorine ☐ Other:_________	
	DEPOSITS	☐ None ☐ Tampons/Toilet Paper ☐ Lime ☐ Surface oils ☐ Stains ☐ Other:____	

Dumpsites

DP

SURVEY REACH ID:	**DATE:** ___/_____/___	**STAFF:**
WP #:	**PHOTO #**	

Type:	***Potential concerns:***	***Location:***
☐ Industrial ☐ Commercial ☐ Residential ☐ Other	☐ ***TOXIC INPUTS*** ☐ Other:	☐ Stream ☐ Riparian Area ☐ Lt bank ☐ Rt bank

Description & Materials:

Stream Crossing

SC

SURVEY REACH ID:	**DATE:** ___/_____/___	**STAFF:**
WP #:	**PHOTO #**	

TYPE	***Potential Concerns:***	***Alignment:***
☐ Road Crossing – Bridge ☐ Road Crossing – Culvert ☐ Railroad Crossing – Bridge ☐ Railroad Crossing – Culvert ☐ Manmade Dam ☐ Other:_________________	☐ None ☐ Potential fish barrier ☐ Failing embankment ☐ Downstream scour hole ☐ Improper alignment causing bank erosion ☐ Debris blockage ☐ Other:________________	☐ Flow-aligned ☐ Flow- not aligned ☐ Could not determine

Cause of Fish Barrier: ☐ ***Drop too high*** ☐ ***Flow too shallow*** ☐ ***Excessive gradient*** ☐ ***OTHER:*****____________________**

Miscellaneous

MI

SURVEY REACH ID:	**DATE:** ___/_____/___	**STAFF:**
WP #:	**PHOTO #**	

Describe:

NCDWQ Biological Assessment Unit Protocol for Habitat Assessment of Mountain – Piedmont Streams
(2006 version)

Adapted by Equinox Environmental Consultation and Design, February 2008

Instructions (consult SOP document for additional details):

1. Select the reach to be assessed based on project objectives and site selection procedures.
2. Assessment of a reach 200 yards in length is recommended. Reach length should be a minimum of 100 yards.
3. The assessment should be conducted by a team by two or more observers.
4. The Field Data Sheet should be completed only after walking and observing the entire reach.
5. The assessment should reflect average or most typical reach conditions.
6. Complete the information in the Reach Identification block on this cover page.
7. The Ancillary Information section on this cover page should generally be completed unless similar information is included on other project field forms completed at the site. Status of this information is at the discretion of the project manager.
8. Complete the assessment of the eight component metrics on the Field Data Sheet. For each metric, select the description which best fits the observed habitats and circle the score.
9. If the observed habitat falls between two descriptions, select an intermediate score.
10. The final score is determined by adding the scores of the component metrics.

Reach Identification:

Project: ______________________________ **Date:**______________
Stream: ______________________ **Reach ID:**__________ **Staff:**______________________

Reach Location: ______________________________ **Drainage Area:**________________

Approximate Length of Reach Assessed:________________________

Notes: ____
____

Ancillary Information:

Lat.______________________ **Long.**______________________ **Waypoint #**________

Width (ft): Stream (wetted)________ Channel (at top of bank)_______ **Water Depth**: (ft) Avg______Max ____
☐ Width variable ☐ Large river >25m wide
Bank Height (from deepest part of channel (in riffle) to top of bank): (ft)________

Conditions (check all that apply):
☐ Channelized Ditch
☐ Deeply incised-steep, straight banks ☐Both banks undercut at bend ☐Channel filled in with sediment
☐ Recent overbank deposits ☐Bar development ☐Buried structures ☐Exposed bedrock
☐ Excessive periphyton growth ☐ Heavy filamentous algae growth ☐Green tinge ☐ Sewage smell
Manmade Stabilization: ☐N ☐Y: ☐Rip-rap, cement, gabions ☐ Sediment/grade-control structure ☐Berm/levee

Channel Flow Status ☐High ☐Normal ☐Low

A. Water reaches base of both lower banks, minimal channel substrate exposed .... ☐
B. Water fills >75% of available channel, or <25% of channel substrate is exposed....................... ☐
C. Water fills 25-75% of available channel, many logs/snags exposed... ☐
D. Root mats out of water.. ☐
E. Very little water in channel, mostly present as standing pools.. ☐

Turbidity: ☐Clear ☐ Slightly Turbid ☐Turbid ☐Tannic ☐Milky ☐Colored (from dyes)

Water Quality: Temperature_________^{0}C DO _________mg/L Specific conductance (corrected)________µmhos/cm

Weather Conditions:______________________ **Photos:** ☐N ☐Y #s________________________________

I. Channel Modification	Score
A. channel natural, frequent bends	5
B. channel natural, infrequent bends (channelization could be old)	4
C. some channelization present	3
D. more extensive channelization, >40% of stream disrupted	2
E. no bends, completely channelized or rip rapped or gabioned, etc	0

☐ Evidence of dredging ☐Evidence of desnagging=no large woody debris in stream ☐Banks of uniform shape/height Remarks____

Subtotal____

II. Instream Habitat: Consider the percentage of the reach that is favorable for benthos colonization or fish cover. EG: 40% of the reach is rocks, mark as A; sticks and snags are 5% each mark as R; undercut banks A but only 10% coverage so circle 16. Definition: leafpacks consist of older leaves that are packed together and have begun to decay (not piles of leaves in pool areas).

Mark as **R**are, **C**ommon, or **A**bundant.

___Rocks ____Macrophytes ____Sticks and leafpacks ____Snags and logs ____Undercut banks or root mats

AMOUNT OF REACH FAVORABLE FOR COLONIZATION OR COVER

	>70% Score	40-70% Score	20-40% Score	<20% Score
4 or 5 types present	20	16	12	8
3 types present	19	15	11	7
2 types present	18	14	10	6
1 type present	17	13	9	5
No types present	0			

☐ No woody vegetation in riparian zone

Remarks____ Subtotal_____

III. Bottom Substrate (silt, sand, detritus, gravel, cobble, boulder) look at entire reach for substrate scoring, but only look at riffle for embeddedness.

A. substrate with good mix of gravel, cobble and boulders	**Score**
1. embeddedness <20% (very little sand, usually only behind large boulders)	15
2. embeddedness 20-40%	12
3. embeddedness 40-80%	8
4. embeddedness >80%(rocks are almost completely buried)	3
B. substrate gravel and cobble	
1. embeddedness <20%	14
2. embeddedness 20-40%	11
3. embeddedness 40-80%	6
4. embeddedness >80%	2
C. substrate mostly gravel	
1. embeddedness <50%	8
2. embeddedness >50%	2
D. substrate homgeneous	
1. substrate nearly all bedrock	3
2. substrate nearly all sand	3
3. substrate nearly all detritus	2
4. substrate nearly all silt/clay	1

Remarks____

Subtotal____

IV. Pool Variety Pools are areas of deeper than average maximum depths with little or no surface turbulence. Water velocities associated with pools are always slow. Pools may take the form of "pocket water", small pools behind boulders or obstructions, in large high gradient streams.

	Score
A. Pools present	
1. Pools Frequent (>30% of 200m area surveyed)	
a. variety of pool sizes..	10
b. pools mostly the same size (may indicate pool is filling in)...	8
2. Pools Infrequent (<30% of the 200m area surveyed)	
a. variety of pool sizes..	6
b. pools mostly the same size..	4
B. Pools absent	
1. Runs present..	3
2. Runs absent...	0

Remarks____Subtotal_____
_

V. Riffle Habitats

Definition: Riffle is area of reaeration-can be debris dam, or narrow channel area.

	Riffles **Frequent** Score	Riffles **Infrequent** Score
A. well defined riffle and run, riffle as wide as stream and extends 2X width of stream....	16	12
B. riffle as wide as stream but riffle length is not 2X stream width	14	7
C. riffle not as wide as stream and riffle length is not 2X stream width	10	3
D. riffles absent....	0	

Channel Slope: ☐Typical for area ☐Steep=fast flow ☐Low=like a coastal stream

Subtotal_____

VI. Bank Stability and Vegetation

FACE DOWNSTREAM

	Left Bank Score	Rt Bank Score
A. Banks stable		
1. little evidence of erosion or bank failure(except outside of bends), little erosion potential....	7	7
B. Erosion areas present		
1. diverse **trees**, shrubs, grass; plants healthy with good root systems....................................	6	6
2. few trees or small trees and **shrubs**; vegetation appears generally healthy...........................	5	5
3. sparse **mixed** vegetation; plant types and conditions suggest poorer soil binding................	3	3
4. mostly **grasses**, few if any trees and shrubs, high erosion and failure potential at high flow..	2	2
5. little or no bank vegetation, mass erosion and bank failure evident......................................	0	0

Subtotal______

Remarks____

VII. Light Penetration (Canopy is defined as tree or vegetative cover directly above the stream's surface. Canopy would block out sunlight when the sun is directly overhead).

	Score
A. Stream with **good** canopy with some breaks for light penetration	10
B. Stream with **full canopy** - breaks for light penetration absent..	8
C. Stream with **partial** canopy - sunlight and shading are essentially equal..................................	7
D. Stream with **minimal** canopy - full sun in all but a few areas..	2
E**. No canopy cover** and no shading...	0

Subtotal______

Remarks____

VIII. Riparian Vegetative Zone Width

Definition: A break in the riparian zone is any area which allows sediment to enter the stream. Breaks refer to the near-stream portion of the riparian zone (banks); places where pollutants can directly enter the stream.

	Left Bank Score	Rt Bank Score
1. Riparian zone **intact** (no breaks)		
a. zone width > 18 meters	5	5
b. zone width 12-18 meters	4	4
c. zone width 6-12 meters	3	3
d. zone width < 6 meters	2	2
2. Riparian zone **not intact** (breaks)		
a. breaks rare		
i. zone width > 18 meters	4	4
ii. zone width 12-18 meters	3	3
iii. zone width 6-12 meters	2	2
iv. zone width < 6 meters	1	1
b. breaks common		
i. zone width > 18 meters	3	3
ii. zone width 12-18 meters	2	2
iii. zone width 6-12 meters	1	1
iv. zone width < 6 meters	0	0
		Subtotal______

Remarks____

Total Score▢

Stream Walk Data

Stream Reach Data

Reach ID	Date	Stream	Time Start	Time End	Temp (°C)	Specific Conductance (µS/cm)	Rain	Clarity	Riparian Conditions		Channel Dynamics	Entrenchment	Encroachment
									Left Bank	Right Bank			
1	4/16/2009	Hunting Creek	9:45	10:30	10.9	80.1	none	clear	trees	shrub/scrub	Re-establishing Meander	Suboptimal	Suboptimal
2	4/16/2009	Hunting Creek	10:30	11:00	10.9	79.4	none	clear	trees	trees	Re-establishing Meander	Suboptimal	Suboptimal
3	4/16/2009	Hunting Creek	11:00	11:30	11.5	79.0	none	clear	trees	trees	unknown	Optimal	Optimal
4	4/16/2009	Hunting Creek	11:30	12:10	12.0	78.8	none	clear	trees	trees	Re-establishing Meander	Suboptimal	Suboptimal
5	4/16/2009	Hunting Creek	12:10	12:30	12.7	76.6	none	clear	trees	trees	unknown	Optimal	Suboptimal
6	4/16/2009	Hunting Creek	1:00	2:00	13.2	76.6	none	clear	trees	trees	Re-establishing Meander	Suboptimal	Suboptimal
7	4/16/2009	Hunting Creek	2:00	2:25	14.7	76.5	none	clear	trees	trees	Re-establishing Meander	Suboptimal	Suboptimal
8	4/16/2009	Hunting Creek	2:25	3:00	15.4	76.8	none	clear	trees	trees	Re-establishing Meander	Suboptimal	Suboptimal
9	4/17/2009	Hunting Creek	9:35	10:40	10.1	78.5	none	clear	shrub/scrub	trees	Re-establishing Meander	Suboptimal	Suboptimal
10	4/17/2009	Hunting Creek	10:50	11:25	10.7	78.7	none	clear	shrub/scrub	trees	Re-establishing Meander	Suboptimal	Suboptimal
11	4/17/2009	Hunting Creek	11:30	12:15	11.8	81.8	none	clear	shrub/scrub	bare ground	unknown	Marginal	Poor
12	4/17/2009	Hunting Creek	12:30	1:30	12.5	85.3	none	clear	structures	tall grass	Re-establishing Meander	Marginal	Poor
13	4/17/2009	Hunting Creek	1:40	2:15	13.9	86.2	none	clear	trees	trees	Re-establishing Meander	Marginal	Marginal
14	4/16/2009	Hunting Creek	3:35	4:10	16.1	83.7	none	clear	trees	tall grass	Re-establishing Meander	Marginal	Marginal
15	4/16/2009	Hunting Creek	4:20	4:30	16.5	83.8	none	clear	shrub/scrub	trees	Re-establishing Meander	Marginal	Marginal
16	4/16/2009	Hunting Creek	4:40	5:10	17.0	83.4	none	clear	paved	shrub/scrub	unknown	Marginal	Marginal
17	4/16/2009	Hunting Creek			17.4	80.2	none	clear	paved	paved	piped	Poor	Poor
18	4/9/2009	Hunting Creek	1:54	3:00	14.6	84.0	trace	opaque/milky	tall grass, shrub/scrub	shrub/scrub	unknown	Suboptimal	Optimal
19	3/24/2009	Hunting Creek	10:00	12:45	10.3	77.8	none	clear	tall grass	tall grass	Sediment Deposition, Bank Failure, Bank Scour, Channelization, Re-establishing Meander	Marginal	Marginal
20	3/24/2009	Hunting Creek	1:20	1:50	14.0	76.5	none	clear	tall grass	shrub/scrub	Sediment Deposition	Marginal	Marginal
21	3/24/2009	Hunting Creek	2:00	2:40	14.6	76.3	none	clear	tall grass, shrub/scrub	trees	Sediment Deposition	Suboptimal	Marginal
22	3/24/2009	Hunting Creek	2:40	3:45	15.0	61.9	none	clear	turf/lawn	tall grass	Sediment Deposition	Suboptimal	Suboptimal
23	4/3/2009	Hunting Creek	2:45	3:19	16.5	68.5	intermittent	turbid	tall grass	tall grass	unknown	Marginal	Marginal
24	4/3/2009	Hunting Creek	3:20	4:10	16.5	68.4	intermittent	turbid	trees	trees	Re-establishing Meander	Suboptimal	Suboptimal
25	4/9/2009	Hunting Creek	9:54	11:00	9.9	66.1	trace	clear	shrub/scrub, trees	turf/lawn	Widening, Sediment Deposition, Bank Scour, Re-establishing Meander	Suboptimal	Optimal
26	4/9/2009	Hunting Creek	11:00	11:44	10.9	66.4	trace	clear	shrub/scrub, trees	tall grass	Widening, Sediment Deposition, Re-establishing Meander	Suboptimal	Optimal
27	4/9/2009	Hunting Creek	12:00	12:48	11.9	66.8	trace	clear	tall grass	tall grass	Widening, Sediment Deposition, Re-establishing Meander	Suboptimal	Optimal
28	4/3/2009	Hunting Creek	10:20	12:26	12.7	63.2	intermittent	turbid	tall grass	tall grass	Re-establishing Meander	Suboptimal	Suboptimal
29	4/3/2009	Hunting Creek	12:42	1:34	13.8	65.3	intermittent	turbid	shrub/scrub	shrub/scrub	Re-establishing Meander	Suboptimal	Suboptimal
29	4/3/2009	Hunting Creek	1:34		14.9	63.6							

Outfall Data

OT ID	Reach ID	Date	Source	Bank	Flow	Type	Material	Dimension (in)	Temp °C	Specific Conductance (µS/cm)	Color	Turbidity	Origin	Origin Type	Odor	Stains	Erosion	Concern
OT-1	1	4/16/2009	outfall	RBD	none	channel	earthen						stormwater	overland flow	none	none	headcut	low
OT-2	1	4/16/2009	unknown	RBD	trickle	channel	earthen		11.6	291.6	clear	none	unknown		none	none	none	high
OT-3	4	4/16/2009	stream	RBD	none	channel	earthen						unknown		none	none	headcut	can't evaluate
OT-4	4	4/16/2009	stream	RBD	trickle	channel	earthen		12.9	773.0	clear	none	unknown		none	none	headcut	high
OT-5	4	4/16/2009	unknown	LBD	moderate	pipe	metal	24	11.6	464.4	clear	none	unknown	unknown	none	none	scour	medium
OT-6	4	4/16/2009	unknown	LBD	moderate	pipe	metal	24	11.7	995.0	clear	none	unknown		chemical	suds	scour	high
OT-7	6	4/16/2009	unknown	RBD	trickle	channel	earthen		11.9	109.5	clear	none	unknown		none	none	headcut	medium
OT-8	6	4/16/2009	stream	LBD	moderate	channel	earthen		13.9	75.3	clear	none	stream		none	none	none	low
OT-9	6	4/16/2009	stream	LBD	trickle	channel	earthen		15.1	124.8	clear	none	unknown		none	none	none	medium
OT-10	8	4/16/2009	stream	RBD	moderate	channel	earthen		14.4	36.9	clear	none	stream		none	none	none	low
OT-11	8	4/16/2009	outfall	LBD	none	channel	earthen						stormwater	street	none	none	headcut	low
OT-12	9	4/17/2009	stream	RBD	moderate	channel	earthen		9.6	47.9	clear	none	stream		none	none	none	low
OT-13	9	4/17/2009	outfall	LBD	other	channel	earthen				orange	none	unknown		none	colors	headcutting	can't evaluate
OT-14	9	4/17/2009	outfall	LBD	none	channel	earthen						unknown		none	none	headcutting	can't evaluate
OT-15	10	4/17/2009	outfall	LBD	none	channel	rip rap						stormwater	street	none	none	scour, headcut	can't evaluate
OT-16	10	4/17/2009	stream	RBD	moderate	channel	earthen		11.5	89.1	clear	none	stream		none	none	headcutting	medium
OT-17	10	4/17/2009	outfall	LBD	none	channel	earthen						unknown		none	none	headcutting	can't evaluate
OT-18	10	4/17/2009	stream	RBD	moderate	channel	earthen		11.8	54.1	clear	none	stream		none	none	none	low
OT-19	11	4/17/2009	outfall	RBD	none	channel	earthen						stormwater	mobile home sale	none	none	scour	low
OT-20	11	4/17/2009	outfall	RBD	none	pipe	concrete	20					unknown		none	none	scour	can't evaluate
OT-21	11	4/17/2009	outfall	RBD	none	channel	rip rap						stormwater	street	none	none	scour	low
OT-22	11	4/17/2009	outfall	LBD	none	channel	rip rap						stormwater	street	none	none	scour	low
OT-23	11	4/17/2009	outfall	LBD	trickle	pipe	metal	20	12.7	772.0	clear	none	unknown		none	oily, suds	scour	high
OT-24	11	4/17/2009	stream	RBD	moderate	channel	earthen		13.0	78.5	clear	none	stream		none	none	none	low
OT-25	12	4/17/2009	outfall	LBD	none	channel	earthen						stormwater	commercial area	none	none	scour	low
OT-26	12	4/17/2009	outfall	LBD	none	channel	earthen						stormwater		none	none	scour	low
OT-27	12	4/17/2009	outfall	LBD	none	pipe	metal	20					unknown		none	none	scour	can't evaluate

OT-28	12	4/17/2009	unknown	LBD	moderate	channel	earthen		13.6	74.9	clear	none	unknown		none	none	headcutting	medium
OT-29	12	4/17/2009	unknown	LBD	other	channel	earthen		18.5	131.7	clear	none	unknown		none	none	headcutting	medium
OT-30	12	4/17/2009	outfall	RBD	trickle	pipe	metal	20	14.1	88.4	clear	none	unknown		none	none	scour	medium
OT-31	12	4/17/2009	outfall	LBD	none	pipe	metal	12					unknown		none	none	scour	can't evaluate
OT-32	12	4/17/2009	unknown	LBD	none	channel	earthen						unknown		none	none	scour	can't evaluate
OT-33	13	4/17/2009	unknown	LBD	trickle	channel	earthen		16.3	227.1	orange	none	unknown		none	none	headcutting	medium
OT-34	14	4/17/2009	unknown	LBD	none	pipe	concrete	20					unknown		none	none	headcut	can't evaluate
OT-35	14	4/16/2009	unknown	RBD	trickle	pipe	PVC/plastic	4	12.1	68.3	clear	none	unknown		none	algae	none	medium
OT-36	14	4/16/2009	outfall	LBD	none	pipe	metal	14					unknown		none	none	none	can't evaluate
OT-37	14	4/16/2009	outfall	RBD	none	pipe	clay	10					unknown		none	none	headcut, scour	can't evaluate
OT-38	14	4/16/2009	stream	LBD	moderate	channel	earthen		15.0	91.0	clear	slightly cloudy	stream		none	none	none	medium
OT-39	14	4/16/2009	unknown	RBD	trickle	channel	earthen		12.9	72.0	clear	none	unknown		none	none	headcut	can't evaluate
OT-40	15	4/16/2009	outfall	RBD	none	pipe	clay	20					unknown		none	none	none	can't evaluate
OT-41	16	4/16/2009	unknown	LBD	none	pipe	metal	24					unknown		none	none	none	can't evaluate
OT-42	16	4/16/2009	unknown	LBD	moderate	pipe	concrete	60	17.0	226.3	clear	none	unknown		none	none	none	high
OT-43	16	4/16/2009	outfall	LBD	none	pipe	metal	20					unknown		none	none	none	can't evaluate
OT-44	16	4/16/2009	outfall	RBD	none	channel	earthen						stormwater	parking lot	none	none	none	low
OT-45	16	4/16/2009	outfall	RBD	none	channel	earthen						stormwater	parking lot	none	none	none	low
OT-46	18	4/9/2009	stream	LBD	none	channel	earthen						stormwater	parking lot	can't evaluate	can't evaluate	none	low
OT-47	18	4/9/2009	stream	RBD	moderate	channel	earthen		14.3	114.9	clear	none	stream		none	none	none	medium
OT-48	18	4/9/2009	stream	LBD	moderate	channel	earthen		14.3	86.3	clear	slightly cloudy	unknown		none	none	none	medium
OT-49	18	4/9/2009	stream	RBD	moderate	channel	earthen		19.6	143.0	clear	none	unknown		none	none	none	medium
OT-50	18	4/9/2009	stream	LBD	moderate	channel	earthen		16.4	146.8	clear	none	stream		chlorine/soa	none	none	high
OT-51	19	3/24/2009	outfall	RBD	none	channel	rock						stormwater	street	none	none	discharge scour	low
OT-52	19	3/24/2009	outfall	RBD	none	channel	rock						stormwater	parking lot	none	none	discharge scour	medium
OT-53	20	3/24/2009	unknown	LBD	none	pipe	clay	8					unknown		none	none	none	can't evaluate
OT-54	20	3/24/2009	outfall	LBD	none	channel	earthen						unknown		none	none	none	can't evaluate

OT-55	21	3/24/2009	stream	RBD	moderate	channel	earthen		20.4	55.5	brown	slightly cloudy	stream		none	none	none	low
OT-56	22	3/24/2009	stream	LBD	moderate	channel	earthen		13.2	108.7	clear	none	stream		sulfide	none	none	medium
OT-57	22	3/24/2009	outfall	LBD	none	pipe	concrete	18					unknown		none	none	none	can't evaluate
OT-58	24	4/3/2009	stream	RBD	moderate	channel	earthen		15.8	135.1	brown	slightly cloudy	stream		none	none	none	medium
OT-59	24	4/3/2009	stream	LBD	moderate	channel	earthen		16.8	84.7	other	slightly cloudy	stream		none	none	none	low
OT-60	25	4/9/2009	outfall	RBD	trickle	pipe	metal	12	11.5	93.2	clear	none	stormwater	powerline ROW	none	algae	none	medium
OT-61	25	4/9/2009	stream	RBD	moderate	channel	earthen		10.8	100.2	clear	none	stream		none	algae	none	medium
OT-62	25	4/9/2009	stream	RBD	none	channel	earthen					none	stream		none	none	none	low
OT-63	26	4/9/2009	stream	LBD	trickle	channel	earthen		10.9	35.2	clear	none	stormwater	powerline ROW &	none	none	none	low
OT-64	26	4/9/2009	stream	RBD	none	channel	earthen						stormwater	ag field	can't evaluate	can't evaluate	none	low
OT-65	26	4/9/2009	stream	LBD	moderate	channel	earthen		11.0	25.2	clear	none	stream		sulfide	algae	none	low
OT-66	27	4/9/2009	stream	RBD	none	channel	earthen						stream		none	none	none	low
OT-67	27	4/9/2009	stream	LBD	moderate	channel	earthen		14.4	25.5	clear	none	stream		sulfide	none	none	low
OT-68	27	4/9/2009	stream	LBD	moderate	channel	earthen		11.6	16.8	clear	none	stream		none	none	none	low
OT-69	28	4/3/2009	outfall	RBD	moderate	channel	earthen		11.3	61.2	clear	none	stormwater	street, pasture	none	none	none	low
OT-70	28	4/3/2009	outfall	RBD	trickle	channel	earthen						stormwater	pasture	none	none	headcut	low
OT-71	28	4/3/2009	stream	RBD	moderate	channel	earthen		13.2	62.4	orange	slightly cloudy	stormwater	pasture	none	none	headcut	low
OT-72	28	4/3/2009	outfall	LBD	trickle	pipe	PVC/plastic	4			clear	none	unknown		none	none	none	low
OT-73	28	4/3/2009	unknown	LBD	none	pipe	PVC/plastic	12					unknown		none	none	scour	low
OT-74	28	4/3/2009	outfall	LBD	none	pipe	PVC/plastic	4					unknown		none	none	none	low
OT-75	28	4/3/2009	outfall	LBD	unknown	pipe	PVC/plastic	3					unknown		can't evaluate	can't evaluate	none	low
OT-76	28	4/3/2009	stream	RBD	moderate	channel	earthen		13.5	76.8	orange	cloudy	stream		none	none	none	low
OT-77	28	4/3/2009	outfall	LBD	trickle	pipe	PVC/plastic	2	12.1	100.0	clear	none	unknown		none	none	none	medium
OT-78	28	4/3/2009	outfall	RBD	moderate	channel	earthen		17.8	69.3	clear	none	stormwater	pasture	none	none	none	low
OT-79	28	4/3/2009	stream	RBD	moderate	channel	earthen		14.1	55.6	brown	cloudy	stream		none	none	none	low
OT-80	29	4/3/2009	stream	RBD	moderate	channel	earthen		14.6	73.5	brown	slightly cloudy	stream		none	none	none	low
OT-81	29	4/3/2009	stream	LBD	moderate	channel	earthen		14.3	80.5	clear	none	stream		none	none	none	low
OT-82	29	4/3/2009	unknown	LBD	trickle	channel	earthen		12.9	58.4	brown	slightly cloudy	unknown		none	none	headcut	low
OT-83	29	4/3/2009	unknown	RBD	none	channel	earthen						unknown		none	none	headcut	low

Erosion Site Data

ER ID	Reach ID	Date	Bank	Location	Bank Ht (ft)	Bank Angle (°)	Length (ft)	Process	Type	Land Cover	Riparian Width (ft)	Property Threat
ER-1	12	4/17/2009	RBD	straight section	10	80	70	Meander Re-establishment	Bank Scour during high flows	nursery	<10	no
ER-2	19	3/24/2009	RBD	meander bend	7	90	100	Meander Re-establishment	Bank Scour during high flows	field	<10	no
ER-3	19	3/24/2009	LBD	meander bend	7	90	85	Meander Re-establishment	Bank Slumping/failure during normal flow, Bank Scour during high flows	field	<10	no
ER-4	22	3/24/2009	LBD	meander bend	6	80	25	Meander Re-establishment	Bank Slumping/failure during normal flow, Bank Scour during high flows	field	<10	no
ER-5	22	3/24/2009	RBD	meander bend	9	80	60	Meander Re-establishment	Bank Slumping/failure during normal flow, Bank Scour during high flows	field	<10	no
ER-6	28	4/3/2009	RBD	meander bend	6	70	60	Meander Re-establishment	Bank Slumping/failure during normal flow, Bank Scour during high flows	field	<10	no
ER-7	28	4/3/2009	LBD	meander bend	10	60	60	Meander Re-establishment	Bank Slumping/failure during normal flow, Bank Scour during high flows	low density residential	<10	no
ER-8	28	4/3/2009	RBD	meander bend	13	75	40	Meander Re-establishment	Bank Slumping/failure during normal flow, Bank Scour during high flows	horse pasture	<10	yes

Channel Modification Site Data

CM ID	Reach ID	Date	Type	Height (ft)	Length (ft)	Material	Incision	Connected	Notes
CM-1	9	4/17/2009	bank armoring	10	120	rip rap	low	yes	modification at least 10 years old
CM-2	16	4/16/2009	bank armoring	15	800	rip rap	high	no	impacting LBD floodplian connection, primarily associated with road
CM-3	25	4/9/2009	bank armoring	40	8	concrete, rip rap	medium	no	

Impacted Buffer Site Data

IB ID	Reach ID	Date	Bank	Length (ft)	Width (ft)	Impacts	Notes
IB-1	6	4/16/2009	LBD	50	50	riparian alteration, utility ROW crossing	
IB-2	6	4/16/2009	RBD	50	50	riparian alteration, utility ROW crossing	
IB-3	9	4/17/2009	LBD	100	50	other	minor digging and ground disturbance
IB-4	12	4/17/2009	LBD	100	50	other	vegetation cut for utility rossing
IB-5	12	4/17/2009	RBD	100	50	other	vegetation cut for utility rossing
IB-6	15	4/16/2009	LBD	40	50	riparian alteration, utility ROW crossing	
IB-7	16	4/16/2009	LBD	450	50	riparian alteration, paved, utility ROW parallel	
IB-8	16	4/16/2009	RBD	450	50	riparian alteration, paved, utility ROW parallel	
IB-9	19	3/24/2009	LBD		15	riparian alteration, utility ROW parallel, utility ROW crossing	
IB-10	20	3/24/2009	LBD	150	20	riparian alteration, utility ROW parallel, utility ROW crossing	
IB-11	20	3/24/2009	RBD	150	50	riparian alteration, utility ROW parallel, utility ROW crossing	
IB-12	25	4/9/2009	LBD	80	30	utility ROW parallel	
IB-13	25	4/9/2009	RBD	75	25	utility ROW parallel, structures	
IB-14	28	4/3/2009	LBD	150	150	riparian alteration	bank erosion present but not classified as severe, adjacent land cover is turf/lawn
IB-15	28	4/3/2009	LBD	70	150	riparian alteration	lawn manicured to bank
IB-16	29	4/3/2009	LBD	250	150	riparian alteration	yard manicured to edge of stream, there are still some large trees along the bank

Utility Site Data

UT ID	Reach ID	Date	Concern	Type	Location	Condition	Color	Odor	Deposits	Notes
UT-1	1	4/16/2009	Susceptible to stream flow, Causing bed/bank erosion	sewer	above stream	weathered	none	none	none	condition of utility is weathered cement with weathered seam seals
UT-2	2	4/16/2009	Susceptible to stream flow, Causing bed/bank erosion	sewer	above stream	weathered	none	none	none	condition of utility is weathered cement with weathered seam seals
UT-3	2	4/16/2009	Susceptible to stream flow, Causing bed/bank erosion	unknown pipe	above stream	weathered	none	none	none	condition is weathered iron pipe
UT-4	2	4/16/2009	Susceptible to stream flow, Causing bed/bank erosion	unknown pipe	above stream	weathered	none	none	none	condition is weathered metal pipe
UT-5	4	4/16/2009	None	electrical	floodplain	good	none	none	none	
UT-6	6	4/16/2009	Susceptible to stream flow, Causing bed/bank erosion	sewer	above stream	weathered	none	none	none	weathered cement pipe
UT-7	6	4/16/2009	Susceptible to stream flow, Causing bed/bank erosion	sewer	above stream	weathered	none	none	none	weathered cement pipe
UT-8	8	4/16/2009	None	electrical	above stream	good	none	none	none	
UT-9	9	4/17/2009	None	electrical	above stream	good	none	none	none	
UT-10	9	4/17/2009	None	electrical	above stream	good	none	none	none	
UT-11	9	4/17/2009	None	unknown pipe	above stream	weathered	none	none	none	attached to bridge
UT-12	11	4/17/2009	Susceptible to stream flow, Causing bed/bank erosion	sewer	above stream	weathered	none	none	none	
UT-13	11	4/17/2009	Susceptible to stream flow	sewer	above stream	weathered	none	none	none	
UT-14	11	4/17/2009	None	unknown pipe	above stream	weathered	none	none	none	attached to bridge
UT-15	11	4/17/2009	None	electrical	above stream	good	none	none	none	two lines: one upstream and one downstream from bridge
UT-16	11	4/17/2009	Susceptible to stream flow	unknown pipe	above stream	dislodge footer	none	none	none	dislodged footer causing sagging pipe
UT-17	12	4/17/2009	None	electrical	above stream	good	none	none	none	

UT-18	12	4/17/2009	None	electrical	above stream	good	none	none	none	
UT-19	12	4/17/2009	Susceptible to stream flow	unknown pipe	above stream	weathered	none	none	none	
UT-20	12	4/17/2009	Susceptible to stream flow	sewer	stream bottom	weathered	none	none	none	
UT-21	15	4/16/2009	Susceptible to stream flow	unknown pipe	above stream	weathered	none	none	none	
UT-22	15	4/16/2009	None	electrical	above stream	good	none	none	none	
UT-23	15	4/16/2009	None	electrical	above stream	good	none	none	none	
UT-24	16	4/16/2009	None	electrical	above stream	good	none	none	none	
UT-25	16	4/16/2009	Susceptible to stream flow	unknown pipe	stream bottom	weathered	none	none	none	
UT-26	18	4/9/2009	Susceptible to stream flow	unknown pipe	stream bottom	good	none	none	none	
UT-27	18	4/9/2009	None	manhole	floodplain	good	none	none	none	
UT-28	18	4/9/2009	None	electrical	floodplain	good	none	none	none	
UT-29	18	4/9/2009	Susceptible to stream flow	sewer	stream bottom	good	none	none	none	
UT-30	19	3/24/2009	None	electrical	floodplain	good	none	none	none	
UT-31	19	3/24/2009	None	electrical	floodplain	good	none	none	none	
UT-32	19	3/24/2009	Susceptible to stream flow	sewer	stream bank	good	none	none	none	
UT-33	19	3/24/2009	Susceptible to stream flow	unknown pipe	stream bottom	old	none	none	none	

Dumpsite Data

DS ID	Reach ID	Date	Type	Concern	Location	Notes
DS-1	2	4/16/2009	unknown	several rusted out 55-gallon drums	RBD	several old metal appliances, does not appear to be active
DS-2	11	4/17/2009	commercial		RBD	plastic material (old weather stripping?) and various old metal appliances, does not appear to be active

Structural Crossing Data

SC ID	Reach ID	Date	Type	Concern	Alignment	Fish Barrier	Notes
SC-1	2	4/16/2009	ford	none	flow aligned	no	
SC-2	4	4/16/2009	road crossing - bridge	none	flow aligned	no	
SC-3	8	4/16/2009	road crossing - bridge	none	flow aligned	no	
SC-4	9	4/17/2009	road crossing - bridge	none	flow aligned	no	
SC-5	10	4/17/2009	railroad crossing - bridge	improper alignment causing bank erosion	flow not aligned	no	three crossings: one active railroad bridge, two historic crossings, footers from historic crossings casuing ersoion and debris blockage
SC-6	11	4/17/2009	road crossing - bridge	bank scour	flow aligned	no	drain holes from bridge scouring bank below, bank scour associated with scours
SC-7	13	4/17/2009	road crossing - culvert	other	flow aligned	no	3 box culverts, one box filled with sediment
SC-8	18	4/9/2009	spillway	potential fish barrier	flow aligned	yes	
SC-9	18	4/9/2009	road crossing - bridge	none	flow aligned	no	
SC-10	24	4/3/2009	road crossing- culvert	potential fish barrier	flow aligned	yes	dependent on flows
SC-11	24	4/3/2009	road crossing - bridge	debris blockage	flow not aligned	no	sediment clogging 2 of 3 boxes
SC-12	27	4/9/2009	road crossing - bridge	none	flow not aligned	no	
SC-13	28	4/3/2009	road crossing - culvert	debris blockage	flow aligned	no	
SC-14	29	4/3/2009	road crossing - bridge	improper alignment causing bank erosion	flow not aligned	no	

Miscellaneous Data

MI ID	Reach ID	Date	Notes
MI-1	28	4/3/2009	chicken coop with 100+ chickens in confined pin adjacent to stream bank

Appendix H Stormwater BMP Retrofit Inventory Methods and Data

To address impacts from potential sources of pollution and to improve the management of stormwater runoff in the Hunting Creek Watershed, opportunities for stormwater BMPs were explored. Land use data, aerial photos, and stormwater outfalls and ditches documented during the stream walk were utilized to guide and expedite field identification of stormwater BMP opportunities throughout the watershed. Aerial photos of commercial, institutional, and industrial land uses were examined in closer detail in GIS. Based on aerial photo analysis, areas containing large impervious surfaces, poor land use practices, and potential pollutant generating hot spots were flagged for field evaluation to assess potential impacts and opportunities for stormwater BMPs. The location of stormwater outfalls and ditches found during the stream walk were also viewed more closely in GIS. The area draining to outfalls with specific conductance greater than 200 µS/com were investigated in the field for potential sources of pollutants and for stormwater BMP opportunities. Through GIS analysis, 152 sites were identified as having opportunities for stormwater BMP retrofits.

Over the course of four non-consecutive days, the sites identified in GIS were evaluated in the field. During the field assessment, observations were made on the land use draining to the site, existing stormwater management practices, and site constraints to determine whether or not a stormwater BMP retrofit is feasible. If a retrofit was determined to be feasible, a datasheet was completed and photographs were taken to document existing conditions. Site sketches were made of the site with the type of retrofit being proposed. To view the datasheet for the stormwater BMP evaluation, see below.

Of the sites assessed in the field, the field evaluation identified 32 sites with 72 individual opportunities to treat stormwater. Several sites were rejected because there was no available space to install a BMP or site constraints such as utilities, traffic flow, or structures made installation prohibitive. As sites were evaluated, a relative priority was given to sites that have the potential to cumulatively treat larger impervious areas. Subjective priority was also given to sites with few observable constraints, sites that occur on public land, and sites with a greater likelihood for feasibility or acceptability. Table H.1 lists sites with opportunities for stormwater best management practices identified in this assessment. It also includes the name of the facility where the site occurs, the proposed BMP type, its priority, and supplemental notes. The location of these sites can be viewed in Figure 4.4, Stormwater BMP Retrofit Opportunities in the Hunting Creek Watershed.

Stormwater BMP Evaluation Datasheet

Subwatershed: __________ **BMP (desktop) ID Type:** __________ **Staff:**_________________
Date____________________ **Site Location** (Road):____

Tracking Information

Waypoint ___________ Lat________________________ Long________________________
Photo number(s) and description____

Reason for Assessment (check one; describe if further details are deemed appropriate)
☐ Large developed area (eg, mall, large strip development, industrial complex, large mixed use area)
____
☐ Large area of land clearing or disturbance (note nature if obvious)____
☐ Pollution potential (list if any are observed, eg storage tanks, trash receptors, etc)
____

Nature of Site
Name of Facility/Area (if obvious)____
(Check all that apply)
☐ Commercial ☐ Gov't ☐ Pasture ☐ Land disturbance ☐ Institutional ☐ Transport-related ☐ Row crops ☐ Animal operation ☐ Other_____________ ☐ Industrial ☐ Golf course ☐ Nursery ☐ Residential

Site Concerns (check all that apply):
Developed uses:
Vehicle Operations (circle): Fueled Washed Maintained Repaired Stored Sold None No Observation
Uncovered Outdoor Material Storage: ☐Yes ☐No ☐Unknown ☐ No Observation
Describe: ____
Waste Management: ☐Garbage ☐Construction ☐Hazardous ☐None ☐Other__________ ☐ No Observation
Dumpsters: ☐Leaking ☐Near storm drain ☐OK ☐ No Observation
Impervious Surface Condition: ☐Clean ☐Stained ☐Debris/Dirty ☐Breaking Up ☐ No Observation
☐ Other____
Impervious Surface Size: ☐<1 acre ☐1-5 acres ☐5-10 acres ☐>10 acres
Type of impervious surface: ☐ Parking lot ☐ Rooftop ☐ Roadway ☐ Other…
☐ Open space between outfall and property boundary
☐ Area drains directly to storm sewers
☐ Area drains directly to adjacent property
☐ Area in immediate proximity to stream or drainageway (with / with no controls)-circle one

Site Constraints:
Possible conflicts with other site functions (eg traffic flow) ☐No ☐Yes
(describe)____
Conflicts with existing utilities ☐ None

Yes	Possible	
☐	☐	Sewer
☐	☐	Water
☐	☐	Gas
☐	☐	Electric
☐	☐	Overhead utilities
☐	☐	Other___________________________________

Access Constraints (construction and maintenance) ☐No ☐Yes (describe-slopes, structures)
Possible Conflicts with Adjacent Land Use ☐No ☐Yes
describe)____

ST Potential☐1 ☐2 ☐3 ☐4 ☐ 5 ☐6 ☐7 ☐ 8-specifically ☐ Other-explain on back

Table H.1 Stormwater BMP Retrofit Opportunities in the Hunting Creek Watershed

Site	Site/BMP	Property Name	Type of BMP	Sub watershed	Drainage Area (DA) (Acres)	Impervious Cover (IC) (Acres)	Impervious Cover (IC) (%)	Site Field Notes
1		Burke County Recycling and Waste Center	bioretention	9	0.53	0.3	53%	Open space may be necessary for tractor trailer access; flat area difficult to determine drainage patterns; potential wetland to NE.
2	A	Foothills Medical Park	bioretention	7	0.47	0.2	50%	Utilize existing pocket parks and space available; clay soils visible; foresee infrastructure/utility issues.
2	B	Foothills Medical Park	bioretention	7	0.59	0.3	50%	
3		State Farm Insurance	bioretention	2	0.27	0.1	55%	Great beautification opportunity.
4	A	New Day Christian Church	extended detention	4	5.90	0.7	12%	open space available
4	B	New Day Christian Church	bioretention	4	1.60	0.1	5%	open space available
5	A	Bank of Granite, Restaurant	bioretention	4	0.14	0.1	47%	Island style treatments
5	B	Bank of Granite, Restaurant	bioretention	4	0.59	0.3	47%	Island style treatments
5	C	Bank of Granite, Restaurant	bioretention	4	0.87	0.4	47%	Island style treatments
6	A	Burke County Human Resources Center	bioretention	7	0.89	0.4	50%	Poorly maintained islands lack vegetation; area drains to pond with visible algal growth.
6	B	Burke County Human Resources Center	bioretention	7	0.65	0.3	50%	parking re-configuration will provide treatment location. Pond is located immediately adjacent, so some treatment is currently being provided.
7	A	Morganton Municipal Auditorium	bioretention (urban)	5	0.23	0.1	47%	Interior islands with shade trees; good site potential for urban treatment
7	B	Morganton Municipal Auditorium	bioretention (urban)	5	0.17	0.1	47%	Interior islands with shade trees; good site potential for urban treatment
7	C	Morganton Municipal Auditorium	bioretention	5	0.64	0.3	47%	Interior islands with shade trees; good site potential for urban treatment
7	D	Morganton Municipal Auditorium	bioretention	5	0.50	0.2	47%	Interior islands with shade trees; good site potential for urban treatment
7	E	Morganton Municipal Auditorium	bioretention	5	0.40	0.2	47%	Interior islands with shade trees; good site potential for urban treatment
8	A	North Carolina School for the Deaf	bioretention	5	1.03	0.5	50%	significant open space for treatment possibilities

Site	Site/BMP	Property Name	Type of BMP	Sub watershed	Drainage Area (DA) (Acres)	Impervious Cover (IC) (Acres)	Impervious Cover (IC) (%)	Site Field Notes
8	B	North Carolina School for the Deaf	constructed wetland	5	8.04	1.7	21%	Plenty of open space and treatment opportunities.
9	A	Liberty Middle School	bioretention	5	1.74	0.9	50%	
9	B	Liberty Middle School	constructed wetland	5	4.35	2.1	49%	
9	C	Liberty Middle School	bioretention	5	1.37	0.7	48%	
9	D	Liberty Middle School	bioretention	5	2.2	0.9	43%	
9	E	Liberty Middle School	extended detention	5	9.61	1.7	18%	
9	F	Liberty Middle School	extended detention	5	4.21	1.8	42%	
10		Bethel Park	bioretention	8	1.24	0.1	7%	Good educational opportunity; bioretention to supplement wetland/stream on site with potential stream restoration and wetland enhancement.
12		Drainage Way/Powerline Corridor (Right of Way?)	extended detention	5	53.32	22.0	41%	Existing detention area above road.
13		Mull , Inc	bioretention	4	3.42	1.6	47%	Considerable expense and re-routing necessary for existing sewer system. Would make a great stormwater pocket park
14		Roses, Shoe Show, Aaron's, Wachovia	bioretention	4	1.87	1.0	55%	Stream currently piped underground; interior islands in parking lot; potential to daylight stream.
15	A	Mull School	bioretention	4	0.63	0.3	50%	Half of storm drains connected underground and half drain to parking lot.
15	B	Mull School	extended detention	4	0.80	0.4	50%	
15	C	Mull School	constructed wetland	4	2.60	0.9	35%	
16		NAPA Auto Parts & Auto Zone	bioretention	4	2.12	1.2	56%	Entire area drains to one inlet; four dumpsters. Highly visible from major road.
17	A	Rooster Bush Chevrolet Car Dealership	structural bmp	7	0.90	0.5	55%	Car dealership with auto shop. High pollutant potential.
17	B	Rooster Bush Chevrolet Car Dealership	bioretention	7	2.00	1.1	55%	
18		El Paso Mexican Restaurant	bioretention	7	0.97	0.5	55%	Ample space for BMP; beautification opportunity.
19	A	J. Iverson Riddle Development Center	extended detention	7	53.03	15.4	29%	
19	B	J. Iverson Riddle Development Center	biorention	7	7.94	4.0	50%	

Site	Site/BMP	Property Name	Type of BMP	Sub watershed	Drainage Area (DA) (Acres)	Impervious Cover (IC) (Acres)	Impervious Cover (IC) (%)	Site Field Notes
19	C	J. Iverson Riddle Development Center	extended detention	7	10.94	5.5	50%	
20		JORDANS INC	bioretention	5	2.88	1.4	47%	Possible storm park location; treat parking if needs re-surfacing in future.
21	A	Sage Brush Steakhouse	bioretention	7	0.61	0.3	54%	Inner island bioretention; BMP would capture majority of site if landowner gave up 6 parking spaces (4 not currently in use).
21	B	Sage Brush Steakhouse	bioretention	7	0.56	0.3	49%	
21	C	Sage Brush Steakhouse	bioretention	7	0.20	0.1	55%	
22		I-40 West Entrance Ramp at NC-18	constructed wetland	7	4.54	3.3	74%	Potential retrofit upstream of I-40 culvert.
23	A	Grace Hospital, Blue Ridge Health Care	extended detention	7	7.92	0.8	10%	Potential bioretention area and islands in parking lot; full site study needed for comprehensive treatment.
23	B	Grace Hospital, Blue Ridge Health Care	extended detention	7	2.35	0.7	30%	
23	C	Grace Hospital, Blue Ridge Health Care	extended detention	7	3.07	1.0	32%	
23	D	Grace Hospital, Blue Ridge Health Care	swale	7	1.95	1.0	50%	
23	E	Grace Hospital, Blue Ridge Health Care	bioretention	7	0.96	0.5	50%	
23	F	Grace Hospital, Blue Ridge Health Care	bioretention	7	1.53	0.8	50%	
23	G	Grace Hospital, Blue Ridge Health Care	constructed wetland	7	11.16	5.5	49%	
24	A	Fiddlers Run Shopping Center	bioretention	8	1.62	0.9	55%	Existing wet pond is handling quantity; interior islands could provide quality treatment.
24	B	Fiddlers Run Shopping Center	bioretention	8	2.32	1.3	55%	
24	C	Fiddlers Run Shopping Center	bioretention	8	2.77	1.5	55%	
24	D	Fiddlers Run Shopping Center	bioretention	8	2.11	1.2	55%	
24	E	Fiddlers Run Shopping Center	bioretention	8	1.55	0.9	55%	

Site	Site/BMP	Property Name	Type of BMP	Sub watershed	Drainage Area (DA) (Acres)	Impervious Cover (IC) (Acres)	Impervious Cover (IC) (%)	Site Field Notes
25	A	The Outreach Center	bioretention	3	1.91	1.0	55%	Large, underutilized parking lot; Beautification opportunity; Interior Islands in parking lot.
25	B	The Outreach Center	bioretention	3	0.52	0.3	55%	
25	C	The Outreach Center	bioretention	3	0.44	0.2	55%	
25	D	The Outreach Center	bioretention	3	1.92	1.1	55%	
26	A	Viscotec	extended detention	1	27.81	4.3	15%	Unable to observe facility interior (security access required); Ample space for constructed wetland and extended detention.
26	B	Viscotec	constructed wetland	1	5.85	1.7	29%	Unable to observe facility interior (security access required); Ample space for constructed wetland and extended detention.
26	C	Viscotec	bioretention	1	6.95	3.7	54%	Unable to observe facility interior (security access required); Ample space for constructed wetland and extended detention.
27		MHA - Cognitive Con	bioretention	4	0.62	0.3	55%	Loss of 3-4 parking spaces, although not used.
28	A	Hillcrest Elementary School	bioretention	4	0.72	0.4	50%	Good educational opportunity, but not a lot of treatment necessary.
28	B	Hillcrest Elementary School	bioretention	4	0.58	0.3	50%	Good educational opportunity, but not a lot of treatment necessary.
29	A	Psalms Urgent Care, Pharmacy, Insurance Agency	bioretention	5	0.10	0.0	47%	Treatment option with trench drain in parking lot.
29	B	Psalms Urgent Care, Pharmacy, Insurance Agency	bioretention	5	0.31	0.1	47%	
29	C	Psalms Urgent Care, Pharmacy, Insurance Agency	bioretention	5	0.79	0.4	47%	
30		Burke County Junior High School	bioretention	5	0.62	0.3	47%	Needs better parking arrangement.
31		Environmental Ink	constructed wetland	5	1.36	0.9	63%	Ditch expansion.
32	A	Whisnant, C. Scott Et Al	extended detention	5	15.02	2.0	13%	utilize open space above roadway

Site	Site/BMP	Property Name	Type of BMP	Sub watershed	Drainage Area (DA) (Acres)	Impervious Cover (IC) (Acres)	Impervious Cover (IC) (%)	Site Field Notes
32	B	Burke County Board of Education	extended detention	5	11.80	4.0	34%	utilize open space above roadway

Appendix I Pollutant Reduction Calculations for all Stormwater BMPs

		TP				TN				TSS				Zinc			
SITE	Type of BMP	Annual Load (lbs)	Post Treatment Load (lbs)	Pollutant removal efficiency	Load Removed by BMP (lbs/year)	Annual Load (lbs)	Post Treatment Load (lbs)	Pollutant removal efficiency	Load Removed by BMP (lbs/year)	Annual Load (lbs)	Post Treatment Load (lbs)	Pollutant removal efficiency	Load Removed by BMP (lbs/year)	Annual Load (lbs)	Post Treatment Load (lbs)	Pollutant removal efficiency	Load Removed by BMP (lbs/year)
1	bioretention	0.9	0.5	45%	0.4	0.9	0.6	35%	0.3	16.0	2.4	85%	13.6	0.7	2.0	85%	11.6
2A	bioretention	0.6	0.3	45%	0.3	0.6	0.4	35%	0.2	10.9	1.6	85%	9.3	0.2	1.4	85%	7.9
2B	bioretention	0.8	0.4	45%	0.4	0.8	0.5	35%	0.3	13.6	2.0	85%	11.6	0.4	1.7	85%	9.9
3	bioretention	0.5	0.3	45%	0.2	0.5	0.3	35%	0.2	8.0	1.2	85%	6.8	0.1	1.0	85%	5.8
4A	extended detention	5.2	4.1	20%	1.0	5.2	3.9	25%	1.3	93.0	46.5	50%	46.5	79.5	23.3	50%	23.3
4B	bioretention	0.9	0.5	45%	0.4	0.9	0.6	35%	0.3	15.7	2.4	85%	13.3	0.7	2.0	85%	11.3
5A	bioretention	0.2	0.1	45%	0.1	0.2	0.2	35%	0.1	4.2	0.6	85%	3.6	0.0	0.5	85%	3.1
5B	bioretention	1.0	0.5	45%	0.4	1.0	0.6	35%	0.3	17.4	2.6	85%	14.8	0.9	2.2	85%	12.6
5C	bioretention	1.5	0.8	45%	0.7	1.5	1.0	35%	0.5	25.8	3.9	85%	22.0	3.0	3.3	85%	18.7
6A	bioretention	1.2	0.6	45%	0.5	1.2	0.8	35%	0.4	20.5	3.1	85%	17.4	1.5	2.6	85%	14.8
6B	bioretention	0.9	0.5	45%	0.4	0.9	0.6	35%	0.3	15.0	2.3	85%	12.8	0.6	1.9	85%	10.8
7A	bioretention (urban)	0.4	0.2	45%	0.2	0.4	0.3	35%	0.1	6.8	1.0	85%	5.8	0.1	0.9	85%	4.9
7B	bioretention (urban)	0.3	0.2	45%	0.1	0.3	0.2	35%	0.1	5.1	0.8	85%	4.3	0.0	0.7	85%	3.7
7C	bioretention	1.1	0.6	45%	0.5	1.1	0.7	35%	0.4	19.1	2.9	85%	16.2	1.2	2.4	85%	13.8
7D	bioretention	0.9	0.5	45%	0.4	0.9	0.6	35%	0.3	14.9	2.2	85%	12.6	0.6	1.9	85%	10.7
7E	bioretention	0.7	0.4	45%	0.3	0.7	0.4	35%	0.2	11.9	1.8	85%	10.1	0.3	1.5	85%	8.6
8A	bioretention	1.4	0.7	45%	0.6	1.4	0.9	35%	0.5	23.7	3.6	85%	20.2	2.3	3.0	85%	17.2
8B	constructed wetland	10.1	6.6	35%	3.5	10.1	6.1	40%	4.1	81.1	12.2	85%	69.0	262.4	10.3	85%	58.6
9A	bioretention	2.3	1.3	45%	1.0	2.3	1.5	35%	0.8	40.1	6.0	85%	34.1	11.1	5.1	85%	29.0
9B	constructed wetland	5.7	3.7	35%	2.0	5.7	3.4	40%	2.3	100.3	15.0	85%	85.2	226.9	12.8	85%	72.4
9C	bioretention	1.8	1.0	45%	0.8	1.8	1.2	35%	0.6	31.7	4.7	85%	26.9	5.5	4.0	85%	22.9
9D	bioretention	2.9	1.6	45%	1.3	2.9	1.9	35%	1.0	50.2	7.5	85%	42.7	21.8	6.4	85%	36.3
9E	extended detention	5.5	4.4	20%	1.1	5.5	4.1	25%	1.4	100.3	75.2	25%	25.1	36.9	18.8	25%	6.3
9F	extended detention	5.5	4.4	20%	1.1	5.5	4.1	25%	1.4	96.1	72.1	25%	24.0	33.8	18.0	25%	6.0
10	bioretention	0.7	0.4	45%	0.3	0.7	0.5	35%	0.2	12.8	1.9	85%	10.8	0.3	1.6	85%	9.2
12	extended detention	89.8	71.9	20%	18.0	89.8	67.4	25%	22.5	1570.5	785.2	50%	785.2	392,318.2	392.6	50%	392.6
13	bioretention	5.8	3.2	45%	2.6	5.8	3.8	35%	2.0	101.8	15.3	85%	86.5	181.5	13.0	85%	73.5
14	bioretention	3.2	1.8	45%	1.5	3.2	2.1	35%	1.1	56.4	8.5	85%	47.9	30.9	7.2	85%	40.7
15A	bioretention	0.8	0.5	45%	0.4	0.8	0.5	35%	0.3	14.5	2.2	85%	12.3	0.5	1.9	85%	10.5
15B	extended detention	1.1	0.9	20%	0.2	1.1	0.8	25%	0.3	18.6	9.3	50%	9.3	0.6	4.6	50%	4.6
15C	constructed wetland	3.4	2.2	35%	1.2	3.4	2.0	40%	1.3	58.6	8.8	85%	49.8	45.2	7.5	85%	42.3

		TP				TN				TSS				Zinc			
SITE	**Type of BMP**	**Annual Load (lbs)**	**Post Treatment Load (lbs)**	**Pollutant removal efficiency**	**Load Removed by BMP (lbs/year)**	**Annual Load (lbs)**	**Post Treatment Load (lbs)**	**Pollutant removal efficiency**	**Load Removed by BMP (lbs/year)**	**Annual Load (lbs)**	**Post Treatment Load (lbs)**	**Pollutant removal efficiency**	**Load Removed by BMP (lbs/year)**	**Annual Load (lbs)**	**Post Treatment Load (lbs)**	**Pollutant removal efficiency**	**Load Removed by BMP (lbs/year)**
16	bioretention	3.7	2.0	45%	1.6	3.7	2.4	35%	1.3	63.9	9.6	85%	54.3	44.9	8.1	85%	46.2
17A	structural bmp	1.6	0.6	60%	0.9	1.6	1.1	30%	0.5	27.1	4.1	85%	23.1	2.5	3.5	85%	19.6
17B	bioretention	3.5	1.9	45%	1.6	3.5	2.2	35%	1.2	60.4	9.1	85%	51.3	37.9	7.7	85%	43.6
18	bioretention	1.7	0.9	45%	0.8	1.7	1.1	35%	0.6	29.3	4.4	85%	24.9	4.3	3.7	85%	21.1
19A	extended detention	67.8	54.2	20%	13.6	67.8	50.8	25%	16.9	1182.9	591.4	50%	591.4	167,879.5	295.7	50%	295.7
19B	biorention	10.5	5.8	45%	4.7	10.5	6.8	35%	3.7	183.5	27.5	85%	155.9	1,064.5	23.4	85%	132.6
19C	extended detention	14.5	11.6	20%	2.9	14.5	10.9	25%	3.6	252.7	126.3	50%	126.3	1,635.9	63.2	50%	63.2
20	bioretention	4.9	2.7	45%	2.2	4.9	3.2	35%	1.7	85.5	12.8	85%	72.7	107.6	10.9	85%	61.8
21A	bioretention	1.0	0.6	45%	0.5	1.0	0.7	35%	0.4	18.3	2.7	85%	15.5	1.0	2.3	85%	13.2
21B	bioretention	1.0	0.5	45%	0.4	1.0	0.6	35%	0.3	16.8	2.5	85%	14.3	0.8	2.1	85%	12.2
21C	bioretention	0.4	0.2	45%	0.2	0.4	0.2	35%	0.1	6.1	0.9	85%	5.2	0.0	0.8	85%	4.4
22	constructed wetland	8.6	5.6	35%	3.0	8.6	5.2	40%	3.4	150.4	22.6	85%	127.8	763.0	19.2	85%	108.6
23A	extended detention	4.5	3.6	20%	0.9	4.5	3.4	25%	1.1	80.4	40.2	50%	40.2	51.4	20.1	50%	20.1
23B	extended detention	3.0	2.4	20%	0.6	3.0	2.3	25%	0.8	52.4	26.2	50%	26.2	14.6	13.1	50%	13.1
23C	extended detention	3.9	3.2	20%	0.8	3.9	3.0	25%	1.0	68.9	34.5	50%	34.5	33.2	17.2	50%	17.2
23D	swale	2.6	1.9	25%	0.6	2.6	1.2	55%	1.4	45.2	9.0	80%	36.1	46.3	7.2	80%	28.9
23E	bioretention	1.3	0.7	45%	0.6	1.3	0.8	35%	0.4	22.1	3.3	85%	18.8	1.9	2.8	85%	15.9
23F	bioretention	2.0	1.1	45%	0.9	2.0	1.3	35%	0.7	35.4	5.3	85%	30.1	7.6	4.5	85%	25.6
23G	constructed wetland	14.8	9.6	35%	5.2	14.8	8.9	40%	5.9	257.6	154.6	40%	103.0	3,408.2	61.8	40%	41.2
24A	bioretention	2.8	1.5	45%	1.3	2.8	1.8	35%	1.0	48.9	7.3	85%	41.6	20.2	6.2	85%	35.4
24B	bioretention	4.0	2.2	45%	1.8	4.0	2.6	35%	1.4	69.9	10.5	85%	59.4	58.8	8.9	85%	50.5
24C	bioretention	4.8	2.6	45%	2.1	4.8	3.1	35%	1.7	83.5	12.5	85%	71.0	100.2	10.6	85%	60.3
24D	bioretention	3.6	2.0	45%	1.6	3.6	2.4	35%	1.3	63.5	9.5	85%	53.9	44.0	8.1	85%	45.8
24E	bioretention	2.7	1.5	45%	1.2	2.7	1.7	35%	0.9	46.8	7.0	85%	39.8	17.6	6.0	85%	33.8
25A	bioretention	3.3	1.8	45%	1.5	3.3	2.1	35%	1.1	57.4	8.6	85%	48.8	32.6	7.3	85%	41.5
25B	bioretention	0.9	0.5	45%	0.4	0.9	0.6	35%	0.3	15.7	2.4	85%	13.4	0.7	2.0	85%	11.4
25C	bioretention	0.8	0.4	45%	0.3	0.8	0.5	35%	0.3	13.3	2.0	85%	11.3	0.4	1.7	85%	9.6
25D	bioretention	3.3	1.8	45%	1.5	3.3	2.2	35%	1.2	57.9	8.7	85%	49.2	33.3	7.4	85%	41.8
26A	extended detention	15.9	12.7	20%	3.2	15.9	11.9	25%	4.0	284.9	142.5	50%	142.5	2,287.6	71.2	50%	71.2
26B	constructed wetland	10.3	6.7	35%	3.6	10.3	6.2	40%	4.1	180.1	27.0	85%	153.1	1,310.3	23.0	85%	130.1
26C	bioretention	12.7	7.0	45%	5.7	12.7	8.3	35%	4.5	222.9	33.4	85%	189.5	1,903.4	28.4	85%	161.1
27	bioretention	1.1	0.6	45%	0.5	1.1	0.7	35%	0.4	18.5	2.8	85%	15.8	1.1	2.4	85%	13.4
28A	bioretention	0.9	0.5	45%	0.4	0.9	0.6	35%	0.3	16.6	2.5	85%	14.1	0.8	2.1	85%	12.0
28B	bioretention	0.8	0.4	45%	0.3	0.8	0.5	35%	0.3	13.5	2.0	85%	11.5	0.4	1.7	85%	9.7

		TP				TN				TSS				Zinc			
SITE	**Type of BMP**	**Annual Load (lbs)**	**Post Treatment Load (lbs)**	**Pollutant removal efficiency**	**Load Removed by BMP (lbs/year)**	**Annual Load (lbs)**	**Post Treatment Load (lbs)**	**Pollutant removal efficiency**	**Load Removed by BMP (lbs/year)**	**Annual Load (lbs)**	**Post Treatment Load (lbs)**	**Pollutant removal efficiency**	**Load Removed by BMP (lbs/year)**	**Annual Load (lbs)**	**Post Treatment Load (lbs)**	**Pollutant removal efficiency**	**Load Removed by BMP (lbs/year)**
29A	bioretention	0.2	0.1	45%	0.1	0.2	0.1	35%	0.1	2.9	0.4	85%	2.5	0.0	0.4	85%	2.1
29B	bioretention	0.5	0.3	45%	0.2	0.5	0.3	35%	0.2	9.1	1.4	85%	7.7	0.1	1.2	85%	6.6
29C	bioretention	1.3	0.7	45%	0.6	1.3	0.9	35%	0.5	23.6	3.5	85%	20.0	2.2	3.0	85%	17.0
30	bioretention	1.1	0.6	45%	0.5	1.1	0.7	35%	0.4	18.5	2.8	85%	15.7	1.1	2.4	85%	13.3
31	constructed wetland	2.5	1.6	35%	0.9	2.5	1.5	40%	1.0	44.2	6.6	85%	37.6	19.4	5.6	85%	31.9
32A	extended detention	8.6	6.8	20%	1.7	8.6	6.4	25%	2.1	153.3	76.7	50%	76.7	356.3	38.3	50%	38.3
32B	extended detention	15.2	12.2	20%	3.0	15.2	11.4	25%	3.8	265.4	132.7	50%	132.7	1,896.0	66.3	50%	66.3