VOLUME I

EXECUTIVE SUMMARY

ELLERBE CREEK WATERSHED MANAGEMENT IMPROVEMENT PLAN

Prepared for
City of Durham

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Brown AND Caldwell
5410 Trinity Road
Raleigh, North Carolina 27607
NC License No. F0785

EXECUTIVE SUMMARY

Introduction

Clean water is important to all of us. The City of Durham (City) wants to keep our creeks, rivers, and lakes safe for recreational activities, aquatic species, and ultimately, drinking water. As a result of decades of growth and development, these bodies of water have been affected by flooding, erosion, land development and road construction, littering, landscaping and lawn care, and other activities. To protect our creeks, rivers, and lakes, we must protect and maintain the health of our watersheds - those land areas and their network of creeks that convey stormwater runoff to a common body of water.

The City realizes the importance of protecting our natural resources, which includes the ways in which we protect and enhance our creeks, rivers and lakes. Over the years the City has undertaken efforts to protect water quality within the Ellerbe Creek Watershed including upgrades at the North Durham Water Reclamation Facility, undertaking a program to rehabilitate old sewer lines, closing the landfill, and identification and elimination of illicit discharges. The City participated in the Ellerbe Creek Local Watershed Plan and have worked with many partners on water quality projects such as stream restorations within the watershed. The City launched the Ellerbe Creek Watershed Management Improvement Plan (WMIP) at the end of 2007 as a way to continue to proactively address water quality regulations and to improve the health of the Ellerbe Creek Watershed.

The Ellerbe Creek Watershed, as shown on the attached Figure ES-1, covers 37-square miles with approximately half of the watershed inside the Durham city limits. Ellerbe Creek has two main tributaries, South Ellerbe Creek and Goose Creek, and drains into Falls Lake and the Neuse River, both of which have been identified as nutrient sensitive waters. Nitrogen, phosphorus, and bacteria and excess sediment in the watershed are of particular concern. Since 1998, Ellerbe Creek from its headwaters to Falls Lake has been on the North Carolina Department of Environment and Natural Resources (NC DENR) 303(d) list as impaired for ecological/biological integrity. This indicates that the aquatic habitat and water quality conditions cannot support a healthy population of native aquatic species. Ellerbe Creek is also expected to be added to the 303(d) list as impaired for water contact recreation due to violations of the water quality standard for fecal coliform bacteria.

Protecting and improving the water quality and aquatic health of Ellerbe Creek is a primary goal of the City. The purpose of the Watershed Management Improvement Plan (WMIP) is to provide the City with the necessary information and tools to accomplish this goal by:

- Assessing current stream and watershed conditions;
- Identifying existing water quality problems;
- Engaging the stakeholders through a public involvement program ;
- Identifying high-value stream and riparian areas where protection and preservation is critical;
- Developing a Riparian Area Management Plan for publicly-maintained riparian areas;
- Evaluating the feasibility and benefits of better site design techniques and low impact development (LID) practices;
- Evaluating the existing and projected future water quality conditions in the watershed;

- Identifying effective pollution control measures to minimize the water quality impacts from point source and non-point source control measures; and
- Developing the recommended water quality improvement plan for the Ellerbe Creek Watershed to enable the City to meet its goals for water quality and watershed health.

Organization of the WMIP

The WMIP is organized into three volumes:

1. **Volume I – Executive Summary**. A brief document that describes the project goals, the watershed evaluation methods, the water quality improvement measures that were evaluated, the results for each watershed improvement scenario, the recommendations, and next steps for implementing the WMIP. This is the only volume that contains the specific high-priority stormwater BMP retrofits, new stormwater BMPs, and stream restoration and stabilization projects recommended in the WMIP for the Ellerbe Creek Watershed.
2. **Volume II – Watershed Management Improvement Plan**. The main report that summarizes the overall approach used to evaluate the Ellerbe Creek Watershed, the data used to complete the watershed characterization, the development and application of the watershed modeling tools, the water quality improvement measures that were evaluated, the results for each watershed improvement scenario, and the recommendations for the WMIP.
3. **Volume III – Technical Appendices**. Series of memoranda prepared throughout the project that describe in more detail the technical approach used to complete the watershed characterization, develop the watershed modeling tools, and evaluate each watershed improvement scenario.

City and Stakeholder Involvement

One primary objective of the project was to engage City staff and interested stakeholders to assist with developing the WMIP through a public involvement program. This was accomplished through a series of technical meetings, public workshops, and a City-hosted project website.

Technical Workshops

Technical workshops were held with City staff and the consultant team throughout the project to facilitate discussion and consensus on key technical aspects of the project. These technical workshops allowed City staff to review and discuss topics such as (1) field assessment protocols and data collection methods; (2) water quality evaluation methods and pollutant loading rates; (3) project evaluation criteria; (4) development and application of the GIS-based water quality model; (5) results of the water quality modeling for the point source and non-point source control measures; and (6) the organization and review of the Ellerbe Creek WMIP.

Public Workshops

Three public workshops were held at key milestones in the project to engage interested stakeholders, including concerned property owners, environmental groups, and the general public:

Public Workshop – April 2, 2008. A brief overview of the goals and schedule for the Ellerbe Creek WMIP was presented to the Environmental Affairs Board (EAB), followed by a question and answer period for EAB members, City staff, and the general public. Immediately after the EAB meeting, the City held two smaller meetings for interested stakeholders to present the results of the inventory of existing stormwater best management practices (BMPs) and stream conditions, and to solicit feedback on the project prioritization criteria.

Public Workshop – October 22, 2008. The second workshop presented the project evaluation criteria, the draft Critical Area Protection Plan, and a description of the five selected pilot study areas and the watershed analyses methods, which included an overview of the Watershed Improvement Planning (WIP) Tools model.

Public Workshop – November 19, 2009. The third public workshop summarized the watershed evaluation, including a description of the potential water quality improvement projects and stormwater management measures that were evaluated, the water quality goals established for the watershed, the results of each watershed management scenario, and the preliminary recommendations for the WMIP. The final Critical Area Protection Plan, Riparian Area Management Plan, and Better Site Design and Low Impact Development Report were also presented to the stakeholders.

City-Hosted Project Website

A project website hosted by the City was implemented to update the general public on the schedule, field work activities, and project milestones. The WMIP brochures, press releases, and presentations from the public workshops were also posted to the website. The website is currently at this address: http://www.ci.durham.nc.us/departments/works/stormwater_ellerbe.cfm.

Watershed Assessment

The watershed assessment used existing data on watershed characteristics, such as land use, soils, and stream flow; and was supplemented with the City's ambient water quality monitoring data to understand the current health of Ellerbe Creek and the most likely causes of degraded water quality and loss of watershed function. Much of the watershed assessment was based on spatial data compiled in a geographic information system (GIS) by the City and State agencies and on information available from previous watershed studies, such as:

- Existing land use
- Future land use (projected in 2025)
- Topography
- Parcel boundaries
- Stream, lakes, and rivers
- Floodplains
- Impervious cover
- Soil types

Additionally, water quality data is available from January 2004 through December 2007 at 11 water quality monitoring stations located in the Ellerbe Creek watershed.

Based on the analysis of the GIS-based spatial data and the water quality data, several important characteristics of the Ellerbe Creek Watershed were identified:

- The Ellerbe Creek Watershed lies mainly within the Triassic Basin, which has erodible soils. Therefore, sedimentation can lead to water quality impairment in many Triassic Basin streams. Triassic Basin soils are also characterized as poorly drained with very little porosity and very low permeability, which results in low rainfall infiltration. These factors limit the use and effectiveness of stormwater BMPs and low impact development (LID) measures that rely on infiltration.
- Approximately 80 percent of the watershed within the Durham city limits has been developed. This restricts the ability to use better site design techniques and low impact development (LID) measures to improve water quality. Opportunities for LID will occur primarily in undeveloped areas north of I-85 and in the eastern portion of the watershed.
- Ellerbe Creek's predominance of impervious area makes it prone to flooding, especially within the highly urbanized center of the watershed. To help alleviate this flooding, the City maintains the main channel of Ellerbe Creek as a flood control channel according to an agreement reached with the U.S. Army Corps of Engineers (USACE). Due to this agreement, Ellerbe Creek was converted into a uniformly-shaped stream channel with little woody vegetation and poor aquatic habitat conditions.

- Water quality is affected by the City's sanitary sewer collection and treatment facilities. The City has documented approximately 180 sanitary sewer overflows in Ellerbe Creek between 1999 and 2007 due to the aging sanitary sewer collection system. The North Durham Water Reclamation Facility (WRF) discharges approximately 8.4 million gallons per day of treated wastewater into Ellerbe Creek near the city limits.

Field Inventories

The City's Stormwater Performance Standards for Development require most new development and redevelopment sites to provide on-site stormwater quality BMPs to remove nutrients and sediment from the stormwater runoff. Unfortunately, almost 80 percent of the Ellerbe Creek Watershed has already been developed. The majority of the development occurred prior to adoption of the current stormwater performance standards. Although the City's stormwater performance standards will help minimize the further degradation of water quality in Ellerbe Creek resulting from new development and redevelopment, it has a limited affect on runoff from existing developed areas. A major focus of the WMIP has been to find cost-effective measures to improve the water quality in developed areas. Three potential approaches to meet this goal are:

- Retrofits to existing stormwater BMPs to improve their efficiency and water quality benefits;
- Integrating new BMPs into the existing drainage system to treat previously developed areas; and
- Stream restoration and stabilization projects to reduce stream bank erosion, improve aquatic habitat, and restore riparian buffers.

To identify these opportunities, field crews visited each of the existing stormwater BMPs in the watershed to evaluate potential retrofit options. A total of 48 existing sites were visited, and of those, 27 provide retrofit opportunities to improve BMP water quality benefits. Fifty-nine potential sites for new BMPs were also assessed to determine the feasibility of integrating new stormwater quality BMPs to treat the stormwater runoff from developed areas. The field crews found 46 of the 59 sites have potential for new stormwater BMPs.

During the stream inventory, field crews assessed approximately 35 miles of stream. The majority of Ellerbe Creek and its tributaries rated "Fair" or "Poor" quality, which means the stream banks are moderately unstable and have a high potential for erosion, and the streams have degraded aquatic habitat. To improve the stream conditions, restoration and stabilization projects were identified on approximately 28 miles of Ellerbe Creek and its tributaries. The most degraded conditions were found on South Ellerbe Creek and Goose Creek, likely due to the dense development along these creeks over the past several decades.

Watershed Evaluation Tools

The goal of the Ellerbe Creek WMIP is to improve water quality and restore watershed function. This goal will be achieved by implementing an effective water quality improvement plan to meet specific water quality goals. A sound approach must be used to evaluate and prioritize potential watershed improvement projects for the WMIP. Computer models were developed as the foundation for evaluating projects and analyzing the hydrologic, hydraulic, and water quality characteristics of the watershed and the water quality benefits of watershed improvement projects and stormwater management measures.

Watershed Modeling Tools

- **PCSWMM.NET.** Watershed-scale hydrologic and hydraulic evaluation model
- **Watershed Improvement Planning Tools Model (WIP Tools Model)**. A planning level GIS-based water quality model

- **Project Prioritization Tool.** A spreadsheet-based cost-estimating and project evaluation tool

Pollutant Sources and Loading Rates

- **Land Use-based Non-Point Source Pollutant Loading Rates**. Land use-based pollutant export coefficients for total nitrogen, total phosphorus, sediment, and fecal coliform were developed based on local and regional monitoring data for twelve land use types found within the Ellerbe Creek watershed.
- **In-stream Sediment Production.** The sediment contribution from the eroding stream banks on Ellerbe Creek and its tributaries was estimated based on the stream stability ratings collected during the field surveys of the creek and the physical properties of the stream channel (e.g., bank height, length).
- **Point Source Pollutant Loading Rates.** To accurately assess the water quality conditions in Ellerbe Creek and the overall pollutant loads from Ellerbe Creek into Falls Lake, an estimate of the pollutant contribution from the sanitary sewer collection system and the North Durham WRF is required for total nitrogen, total phosphorus, sediment, and fecal coliform. For the WIP Tools Model, the collective pollutant load from the sanitary sewer collection system was consolidated into ten point sources. An eleventh point source was added to represent the North Durham WRF.

BMP and Stream Restoration Pollutant Removal Efficiencies

To evaluate the water quality benefits of each potential watershed improvement project in the WIP Tools Model, average annual pollutant removal efficiencies were developed for each type of stormwater quality BMP (e.g., dry ponds, wet ponds, wetlands, sand filters, etc.) for total nitrogen, total phosphorus, sediment, and fecal coliform bacteria. The removal efficiencies were based on recent monitoring studies on the water quality performance of each type of BMP. If the field inspection of an existing BMP indicated a deficiency in its design or construction, then the pollutant removal efficiencies for that BMP were reduced accordingly.

Stream restoration and stabilization projects will also reduce sedimentation, remove pollutants, and improve overall water quality. Sediment input from eroding stream banks was reduced within the WIP Tools Model once the stream banks were stabilized with woody vegetation. Healthy streams can also remove sediment and nutrients from the stream flow. Therefore, pollutant removal efficiencies (in pounds per linear foot) were also assigned for total nitrogen, total phosphorus, and sediment; no removal efficiency for fecal coliform bacteria was credited to stream restoration and stabilization projects.

Watershed Improvement Scenarios and Results

One objective of the Ellerbe Creek WMIP is to develop watershed-wide scenarios and alternatives to improve the water quality of Ellerbe Creek and the overall health of the watershed. For the Ellerbe Creek watershed, total nitrogen, total phosphorus, sediment, and fecal coliform bacteria are used as indicators of overall watershed health. The water quality goals are specified as "pollutant yield," where pollutant yield is defined as pounds per acre per year (lbs/ac/yr) for total nitrogen, total phosphorus, and sediment; and as colony forming units per acre per year (cfu/ac/yr) for fecal coliform bacteria. The following water quality goals were established for each of these four parameters:

- **Total Nitrogen**. 7.5 lbs/ac/yr based on the Interim Strategy for Falls Lake, which represents a 40 percent reduction of existing (2006) total nitrogen yield from the Ellerbe Creek Watershed at the city limits
- **Total Phosphorus**. 0.38 lbs/ac/yr based on the Interim Strategy for Falls Lake, which represents a 77 percent reduction of existing (2006) total nitrogen yield from the Ellerbe Creek Watershed at the city limits
- **Sediment.** 1,600 lbs/ac/yr based on field studies relating healthy aquatic communities to sediment yields in streams in the northern Piedmont region of Georgia

- **Fecal Coliform.** 5.1 cfu x 10^9/ac/yr based on meeting the 200 cfu/100 mL water quality standard for North Carolina and the average annual flow measured by the USGS

The PCSWMM and WIP Tools models were used to evaluate individual watershed improvement projects (e.g., BMPs, stream restoration, etc.) and the watershed improvement scenarios that typically combined the watershed improvement projects with other stormwater management measures and point source controls. Each scenario was evaluated based on its pollutant reduction potential and the cost to meet specific watershed goals.

Project Prioritization Criteria

When developing a WMIP a sound approach must be used to evaluate and prioritize potential projects. One evaluation method is to develop prioritization criteria. The prioritization criteria cover a range of considerations that are important in the implementation of a potential watershed improvement project. The criteria may include constructability of the project; water quality and environmental benefits; permitting issues; public benefits and acceptance; and capital and long-term maintenance costs. By applying the criteria in a systematic method, each potential project may be objectively evaluated and compared.

Table ES-1 outlines the prioritization criteria that were applied to each potential project for the Ellerbe Creek WMIP. There are six categories with a total possible score ranging from 0 to 100. Embedded within the scoring process are weighting factors that gave higher value to projects that provide water quality benefits, improve habitat and biological integrity, protect the stream banks, and provide opportunities for public education.

Table ES-1. Proposed Prioritization Criteria

Category	Score Range
Water Quality Treatment: ability to remove nitrogen, phosphorus, sediment, and fecal coliform	0 – 35
Habitat and Biological Integrity: ability to improve aquatic habitat conditions	0 – 15
Stream Bank Protection: ability to protect stream banks from erosion	0 – 10
Community Enhancement: based on ability to protect private property, acceptance by adjacent property owners, and opportunities for public education	0 – 20
Implementation Issues: considers issues such as existing site ownership, accessibility, compatibility with other City programs, and potential permitting issues	0 – 15
Public Safety and Public Property: based on potential flood protection benefits	0 – 5
Total Potential Score	100

Watershed Improvement Scenarios

Ten watershed improvement scenarios were evaluated to assess the effectiveness of stormwater quality BMPs, stream restoration and stabilization projects, other non-point source management practices, and point source controls on improving water quality and watershed function within the Ellerbe Creek watershed. The first two scenarios were developed to better understand the water quality conditions throughout the watershed based on existing conditions:

- **Scenario 1 – Baseline Conditions** provides the water quality results under existing land use conditions (2007) and future land use conditions (2025) without any existing or proposed water quality measures in place.
- **Scenario 2 – Existing BMPs and Stream Conditions** provides the water quality results under existing land use conditions (2007) and future land use conditions (2025) accounting for the water quality benefits of the existing stormwater quality BMPs and stream conditions.

The results at the City Limits for these two watershed improvement scenarios are presented in Table ES-2. The total pollutant yield reported at the City Limits is based on future land use conditions projected in 2025. The existing stormwater quality BMPs will reduce the pollutant yield at Falls Lake by less than 1 percent once full build-out occurs. The water quality goals will still be exceeded for all four water quality parameters.

Table ES-2. Summary of Watershed Improvement Scenarios 1 and 2

Scenario	Pollutant Yield at the City Limits (% Reduction from Scenario 1)			
	Nitrogen (lb/ac/yr)	Phosphorus (lb/ac/yr)	Sediment (lb/ac/yr)	Fecal Coliform (10^9 cfu/ac/yr)
Scenario 1: Baseline Conditions	12.7	1.6	2,260	15.6
Scenario 2: Existing Stormwater BMPs and Stream Conditions	12.6 (<1%)	1.6 (0%)	2,250 (<1%)	15.6 (0%)
Water Quality Goals	7.5	0.38	1,600	5.1

Note: Pollutant yields are based on future land use conditions projected in 2025. The water quality goals are described on page ES-5.

Scenarios 3 through 8 were developed to determine the effectiveness of various control measures for non-point sources and point sources of pollutants. Scenarios 9 and 10 were then developed to understand the effectiveness of the non-point source and point source control measures when used in combination. These eight watershed improvement scenarios are:

- **Scenario 3 – Identified Stormwater Quality BMP and Stream Restoration Projects** provides the water quality results based on the stormwater BMP retrofits, new stormwater BMPs, and stream restoration and stabilization projects (165 potential projects) identified during the BMP and stream field inventories.
- **Scenario 4 – Pilot Study Areas** provides the water quality results based on the water quality benefits achieved in the five pilot study areas projected onto the entire watershed.
- **Scenario 5 – Stormwater Performance Standards for Development** provides the water quality results based on the City's stormwater quality requirements for new development and redevelopment.
- **Scenario 6 – Better Site Design Techniques** provides the water quality results based on application of better site design techniques and low impact development (LID) measures.
- **Scenario 7 – Proprietary Stormwater Quality BMPs** provides the water quality results based on the use of proprietary BMPs integrated as retrofits in heavily urbanized areas with fully-piped drainage systems where space limitations prevent use of more traditional stormwater BMPs (e.g., ponds and wetlands). The proprietary BMPs can be installed underground as a replacement of a traditional manhole structure within a piped drainage system or as a retrofit to a catch basin inlet.
- **Scenario 8 – Point Source Controls** provides the water quality results based on the City's on-going sanitary sewer rehabilitation and replacement program and upgraded nutrient controls at the North Durham WRF
- **Scenario 9 – Combination of Non-point Source Controls** provides the water quality results based on the combined non-point sources controls evaluated under Scenarios 4, 5, 6, and 7
- **Scenario 10 – Combination of Non-point Source and Point Source Controls** provides the water quality results based on the combined non-point source and point source control evaluated under Scenarios 4 through 8

The results for these eight watershed improvement scenarios are presented in Table ES-3. The total pollutant yield at the City Limits, the anticipated reduction in pollutant yield compared to Scenario 2, and the total estimated cost of each watershed improvement scenario are presented. The total pollutant yield reported at the City Limits for each scenario is based on future land use conditions projected in 2025.

Based on these results, the highest-priority water quality improvement measure is to implement further point source controls within the watershed through the City's on-going sanitary sewer rehabilitation and replacement program to reduce sanitary sewer overflow reductions, and by implementing best available technology for nutrient control at the North Durham WRF. By combining point-source controls and non-point source controls (Scenario 10), significant water quality improvement can be reached (i.e., a 24% to 65% reduction in pollutant yield at the City limits), even though the goals established for the Ellerbe Creek Watershed for each parameter are not met.

Table ES-3. Summary of Watershed Improvement Scenarios 3 through 10

Scenario	Pollutant Yield at the City Limits (% Reduction from Scenario 2 – Existing BMPs and Stream Conditions)				Cost (millions)
	Nitrogen (lb/ac/yr)	Phosphorus (lb/ac/yr)	Sediment (lb/ac/yr)	Fecal Coliform (10^9 cfu/ac/yr)	
Scenario 3: Identified Stormwater Quality BMP and Stream Restoration Projects	12.2 (3%)	1.5 (6%)	1,890 (16%)	15.3 (2%)	$130
Scenario 4: Pilot Study Area Evaluations Projected onto Entire Watershed	11.6 (8%)	1.4 (13%)	1,720 (24%)	15.2 (3%)	$220 - $260
Scenario 5: Stormwater Performance Standards for Development	12.1 (4%)	1.5 (6%)	2,190 (3%)	15.4 (1%)	Private
Scenario 7: Proprietary Stormwater Quality Devices	12.0 (5%)	1.4 (13%)	1,960 (13%)	14.0 (10%)	$103 - $110
Scenario 8: Point Source Controls for Sewer Collection System and North Durham Water Reclamation Facility*	12.1 (4%)	1.3 (19%)	2,250 (0%)	6.4 (59%)	$56 - $60*
Scenario 9: Combined Non-Point Source Controls (Scenarios 4, 5, 6, and 7)	11.0 (13%)	1.3 (19%)	1,700 (24%)	14.7 (6%)	$320 - $370
Scenario 10: Combined Point and Non-Point Source Controls (Scenarios 4 through 8)	8.5 (33%)	1.0 (38%)	1,700 (24%)	5.5 (65%)	$376 - $430
Water Quality Goals	7.5	0.38	1,600	5.1	

Note: Pollutant yields are based on future land use conditions projected in 2025. The water quality goals are described on page ES-5.

**Costs for North Durham Water Reclamation Facility include only those costs to meet the proposed Stage 1 Falls Lake reductions.*

Recommendations

Efforts to improve water quality in Ellerbe Creek have been underway for several decades. Restoring the water quality and watershed function of Ellerbe Creek will take decades and require a considerable commitment in funds and staff time by the City. Although the watershed goals may not be realized immediately, the results of the watershed scenarios indicate that a significant improvement in water quality and watershed function can be achieved over time. The next step towards meeting these goals will be to implement the recommended strategies contained in the WMIP to minimize the water quality impacts from point source and non-point sources of pollution. These recommendations include implementing the point source controls in Scenario 8, the top 16 prioritized stormwater BMP projects and the top 16 prioritized

stream restoration projects (a prioritized subset of Scenarios 3 and 4), the Riparian Area Management Plan, and the Critical Area Protection Plan.

A brief overview of each component of the WMIP is provided below. When combined, these strategies will not achieve all of the pollutant reductions shown for Scenario 10, but will provide a significant first step towards meeting that goal.

Implement Point Source Controls

Over 180 sanitary sewer overflows were recorded by the City in the Ellerbe Creek Watershed from 1999 to 2007. The highest-priority recommendation to improve water quality within the watershed is to complete the on-going sanitary sewer rehabilitation and replacement program to eliminate the sanitary sewer overflows and remove illicit connections. Approximately 85 percent of the sanitary sewer overflows and illicit connections could be removed at an estimated cost of $18 to $22 million.

Further reductions in nutrient loads to Ellerbe Creek can be achieved by upgrading the nutrient control technology at the North Durham WRF, which discharges into Ellerbe Creek near the city limits. By implementing best available technology for nutrient removal, the average annual load of total nitrogen from the North Durham WRF could be reduced by 8 percent and by 66 percent for total phosphorus.

When combined, the on-going sanitary sewer rehabilitation and replacement program and the nutrient control upgrades at the North Durham WRF could reduce the average annual load of total nitrogen by 4 percent, total phosphorus by 20 percent, and fecal coliform by 59 percent (Scenario 9). The estimated cost to implement these point source controls within the Ellerbe Creek watershed is $56 to $60 million. The costs for North Durham WRF include only those costs to meet the Phase 1 Falls Lake reductions.

Improve Stormwater Quality

Although the City's stormwater performance standards will help minimize the further degradation of water quality in Ellerbe Creek resulting from new development and redevelopment, it has a limited affect on runoff from existing developed areas. A major focus of the WMIP has been to find cost-effective measures to improve the water quality in developed areas. Two approaches to meet this goal are retrofitting existing stormwater BMPs to improve their water quality benefits and integrating new stormwater BMPs into the existing drainage system to treat developed areas. Twenty-seven existing BMPs provide retrofit opportunities to improve their water quality benefits. Forty-six sites provide opportunities for new stormwater BMPs to treat the stormwater runoff from developed areas. The stormwater BMP retrofits and new stormwater BMP opportunities were evaluated based on the project prioritization criteria. Based on this evaluation, 16 high-priority BMP projects were selected, and are prioritized based on a focus on improving water quality on South Ellerbe Creek and Goose Creek; likely implementation schedule; and project prioritization score. The high-priority BMPs are summarized in Table ES-5 and their locations are shown on the attached Figure ES-2.

Implement Stream Restoration and Stabilization Projects

Streams provide many functions that affect watershed condition including water storage and supply, water and sediment transport, habitat for aquatic species, and recreational opportunities for local residents. Degradation of stream function can lead to a decline in water quality, degradation of instream habitat, and loss of aquatic species diversity. In general, Ellerbe Creek and its tributaries rated "fair" and "poor" quality based on the field assessments. In several locations, stream restoration projects have already been completed to improve water quality and instream habitat. The water quality benefits of these projects have been accounted for in the development of the WMIP.

To improve the stream conditions on the remainder of Ellerbe Creek and its tributaries, restoration and stabilization projects were identified on approximately 28 miles of Ellerbe Creek and its tributaries. Implementation of these projects should be prioritized based on their water quality efficiency, overall project benefits, and the City's ability to acquire the land or negotiate conservation easements. Based on this evaluation, 16 high-priority stream restoration and stabilization projects were selected, which are summarized in Table ES-5. These projects are prioritized based on a focus on improving stream conditions on South Ellerbe Creek, Goose Creek, and the main channel of Ellerbe Creek downstream of Roxboro Road; property ownership; likely implementation schedule; and project prioritization score. The locations of these high-priority stream restoration and stabilization projects are shown on the attached Figure ES-2.

Implement the Riparian Area Management Plan

Riparian buffers along streams are vitally important for protecting stream banks and shorelines from erosion and pollution, providing shade, dissipating stormwater flows into streams during storms, and providing fish and wildlife habitat. The Riparian Area Management Plan (RAMP), available as a separate report from the WMIP, contains riparian buffer management recommendations targeted for publicly-owned property that should be followed by management, design, and maintenance staff for design of new City facilities and infrastructure and for improving riparian buffers in City parks, utility easements, and greenway corridors. The City should implement the recommendations outlined in the RAMP on all publicly-owned property within the Ellerbe Creek watershed.

Implement the Critical Area Protection Plan

The Critical Area Protection Plan was developed for Ellerbe Creek to identify high-value properties to purchase and preserve. These properties are typically undeveloped properties with forested riparian buffers along the main channel of Ellerbe Creek or its tributaries. Protecting these critical areas will protect and improve water quality, prevent pollutants from entering the stream, protect valuable habitat, and provide recreational opportunities. Based on the watershed evaluation, the City should acquire or protect the 324 high-priority parcels valued at approximately $60 million, with an initial focus on seven high-priority areas in the watershed. The City should also acquire all recommended new BMP sites. This would prevent development of these sites and preserve the opportunity to implement these stormwater quality BMPs in the future.

A summary of the total cost of the recommended WMIP is tabulated in Table ES-4. Additional City staff will be required to implement the recommended WMIP in a timely fashion. The costs shown do not include any additional staffing.

Table ES-4. Cost Summary for Recommended Next Steps WMIP	
Component	Costs (millions)
Implement Point Source Controls: on-going sewer rehabilitation program, nutrient control upgrades at North Durham WRF	$60
Improve Stormwater Quality: implement 16 high-priority water quality projects (BMP retrofits and new BMPs) presented in Table ES-5	$31
Implement Stream Restoration and Stabilization Projects: 16 high-priority projects focused on South Ellerbe Creek, Goose Creek, and the lower portion of Ellerbe Creek presented in Table ES-5	$18
Implement the Riparian Area Management Plan: improved maintenance procedures on all City-owned riparian areas	n/a
Implement the Critical Area Protection Plan: acquire and/or protect 324 high-priority parcels with existing forested riparian buffers and proposed new BMP sites	$60
Total Estimated Costs	$169

Next Steps

The City has been undertaking efforts to protect water quality in Ellerbe Creek for several decades, and will continue those programs. As noted previously, implementing all of the recommendations of the WMIP will take decades and require a considerable commitment in funds and staff time by the City. The costs shown do not reflect the cost of this additional staffing and resources. The following initial program is recommended as the next steps towards achieving the City's long-term water quality goals for Ellerbe Creek:

1. **Coordinate with the City's Department of Water Management to implement $60 million in point source controls.** Prioritize the on-going sanitary sewer rehabilitation and replacement program within the Ellerbe Creek Watershed and upgrade the nutrient control technology at the North Durham WRF (to meet the Phase 1 Falls Lake reductions). Both of these improvements represent the most cost-effective methods to significantly reduce the impacts from point sources in the Ellerbe Creek Watershed.

2. **Complete the Stormwater Utility Rate Study (currently underway) to determine the annual funding level that will be available based on the existing and projected stormwater utility fee structures.** The results of the rate study should allow the City to determine the annual funding available to implement the watershed improvement projects (e.g., stormwater BMP retrofits, new BMPs, stream restoration and stabilization project).

3. **Implement $49 million in High-Priority Water Quality Improvement Projects for the Ellerbe Creek Watershed** consisting of the stormwater BMP retrofits, new stormwater BMPs, and stream restoration and stabilization projects presented in Table ES-5 based on the City's ability to purchase the property or negotiate easements, overall project prioritization score, and available funding.

4. **Implement the Riparian Area Management Plan.** Excessive stream bank erosion; trash and other debris getting into streams and riparian buffers; and encroachment and clearing of riparian buffers are common and visible problems along many Durham streams. The Riparian Area Management Plan (RAMP) has been prepared to address the current maintenance practices within riparian buffers on publicly-owned property, utility easements, and greenway corridors along Ellerbe Creek and its tributaries. Re-establishing the riparian buffers on publicly-owned property is important for protecting stream stability, water quality and ecological functions.

5. **Acquire or preserve the high-priority riparian buffers and new BMP sites valued at $60 million identified in the Critical Area Protection Plan.** The plan focuses on acquiring sites that are the most

ecologically intact and those that have important features and functions, such as preserving high-quality aquatic and terrestrial habitats, floodwater storage, and creating recreational and educational opportunities for local residents.

Application to Falls Lake

The Ellerbe Creek WMIP was developed concurrently with the draft Falls Lake rules. While it was not explicitly designed to address the Falls Lake rules, the WMIP does provide a blueprint to move toward the nutrient reduction goals in the draft Falls Lake rules. The additional resources needed to implement the WMIP do not reflect the resources needed to implement the Falls Lake rules. An evaluation for additional resources, including staffing, will be needed when the rules are finalized.

Table ES-5. Recommended Water Quality Improvement Projects					
#	Sub-watershed	Stream Project / Locations	Total Estimated Life-Cycle Cost (2009 Dollars)	Annual Operations and Maintenance Cost (2009 Dollars)	Project Prioritization Score (100 max)
Stream Restoration and Stabilization Projects					
South Ellerbe Creek					
1	8	EC204 - South Ellerbe Creek	$488,000	$13,000	74
2	13	EC210 – Tributary	$916,000	$25,000	67
3	9	EC205 – Tributary	$238,000	$5,500	72
4	15	EC213 – Tributary	$227,000	$5,000	66
Goose Creek					
5	20	EC402 – Tributary	$861,000	$19,000	64
6	20	EC401 – Tributary	$779,000	$17,000	64
7	20	EC403 – Tributary	$1,784,000	$33,000	62
8	18	EC112 – Tributary	$3,245,000	$61,000	70
9	18	EC113 – Tributary	$2,444,000	$55,000	69
10	22	EC405 – Tributary	$2,982,000	$84,000	73
Ellerbe Creek					
11	27	EC132 - Tributary to Main Stem – DS of Goose Creek	$1,097,000	$30,000	78
12	10	EC301 - Tributary to Main Stem – US of South Ellerbe Creek	$720,000	$20,000	74
13	10	EC220 - Tributary to Main Stem – US of South Ellerbe Creek	$220,000	$5,000	66
14	26	EC133 - Tributary to Main Stem – DS of Goose Creek	$346,000	$9,000	63
15	4	EC105 - Tributary to Main Stem – Headwaters	$851,000	$23,000	69
16	4	EC104 - Tributary to Main Stem – Headwaters	$457,000	$12,000	67
		Total Estimated Present Value Cost	$17,655,000	-	-

Note: Total Estimated Present Value Cost includes land acquisition costs.

Table ES-5. Recommended Water Quality Improvement Projects					
#	Sub-watershed	BMP Project / Locations	Total Estimated Life-Cycle Cost (2009 Dollars)	Annual Operations and Maintenance Cost (2009 Dollars)	Project Prioritization Score (100 max)
Stormwater BMP Retrofits and New BMPs					
South Ellerbe, Goose Creek, and Ellerbe Creek downstream of Roxboro Road					
1	8	8001: New Wet Pond – South Ellerbe Creek	$3,149,000	$64,000	59
2	16	16002: New Wet Pond – Near Main Stem between South Ellerbe and Goose Creeks	$1,982,000	$41,000	55
3	21	21003: New Constructed Wetland - Goose Creek	$1,303,000	$44,000	49
4	24	24002: New Wet Pond – Goose Creek	$895,000	$23,000	60
5	21	21002b: New Dry Pond – Goose Creek	$686,000	$18,000	60
6	13	13002: New Wet Pond – South Ellerbe Creek	$905,000	$16,000	53
7	9	9002: New Wet Pond - South Ellerbe Creek	$834,000	$19,000	70
8	18	18003: New Constructed Wetland - Goose Creek	$609,000	$14,000	63
Headwaters and Ellerbe Creek upstream of Roxboro Road					
9	1	1004c: New Constructed Wetland – headwaters of Ellerbe Creek	$7,181,000	$241,000	56
10	4	4001: Retrofit of existing wet pond (Croasdale Golf Course)	$804,000	$20,000	62
11	4	4002: Retrofit of existing wet pond (Croasdale Golf Course)	$791,000	$20,000	63
12	4	4003: Retrofit of existing wet pond (Croasdale Golf Course)	$1,069,000	$27,000	63
13	1	1004b: New Dry Pond – headwaters of Ellerbe Creek	$1,771,000	$40,000	54
14	11	11001: New Constructed Wetland – Near Main Stem upstream of South Ellerbe	$4,729,000	$143,000	64
15	10	10001: New Constructed Wetland - Off Main Stem upstream of Murray Ave	$2,645,000	$80,000	57
16	15	15001: New Constructed Wetland – Just upstream of South Ellerbe off Main Stem	$1,239,000	$29,000	52
		Total Estimated Present Value Cost	$30,592,000	-	-

Note: Total Estimated Present Value Cost includes land acquisition costs.