



Volume I Executive Summary

August 2021

New Hope Creek and Little Creek Watershed Improvement Plan

Durham, North Carolina

PREPARED FOR:



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Acronyms and Abbreviations

µg	Micrograms	NPDES	National Pollutant Discharge Elimination System
CAPP.....	Critical Area Protection Plan	NSW	Nutrient Sensitive Water
CCC	Criterion Continuous Concentration	PCSWMM.....	Personal Computer Storm Water Management Model
cfu	Colony Forming Unit	RAMP	Riparian Area Management Plan
City.....	City of Durham	ReGIn	Residential Green Infrastructure
ELU.....	Existing Land Use	RSAT	Rapid Stream Assessment Technique
ft3/s	Cubic Feet Per Second	SCM.....	Stormwater Control Measure
FLU.....	Future Land Use	SR.....	State Route
GIS.....	Geographic Information Systems	TMDL.....	Total Maximum Daily Load
GSI.....	Green Stormwater Infrastructure	TN.....	Total Nitrogen
JLOW	Jordan Lake One Water	TP.....	Total Phosphorus
L	Liter	UCFRBA.....	Upper Cape Fear River Basin Association
LID.....	Low Impact Development	UDO.....	Unified Development Ordinance
mg.....	Milligrams	USEPA.....	U.S. Environmental Protection Agency
mL	Milliliter	USGS	U.S. Geological Survey
MS4	Municipal Separate Storm Sewer System	WIP	Watershed Improvement Plan
NCDEQ.....	North Carolina Department of Environmental Quality	WQI.....	Water Quality Index
NewDStds.....	Stormwater Performance Standards for New Development		

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1 Introduction

Healthy rivers and watersheds are essential for maintaining habitat for wildlife and plants, providing safe drinking water and food, and promoting sustainable economic growth. To maintain clean water within its city limits, the City of Durham (City) has developed watershed improvement plans (WIP) to understand the condition of waterbodies and watersheds and to identify effective ways of protecting and improving water quality.

Watershed improvement plans help the City in its goal to balance environmental protection with equitable and economic growth and development and help the City fulfill its mission to “make Durham a great place to live, work, and play” and its vision to be “a leading city in providing an excellent and sustainable quality of life”. The City’s 2019-2021 Strategic Plan serves as an action plan to achieve this vision. One of the 5 goals of the Strategic Plan is to “guide equitable, efficient, and environmentally sound investments in the City’s built and green infrastructure assets.” This WIP aligns with this goal and the related objective to “create a more Sustainable Durham” with initiatives to improve water quality through best management practices of stormwater, land use, and stream restoration and protection. This WIP also helps in implementing and tracking the progress of the 2018 Sustainability Roadmap (City of Durham, 2018a), which is derived from the Strategic Plan and provides priority strategies to meet the City’s sustainability goals of protecting and restoring Durham’s natural systems and environmental equity and justice.

Since initiating its watershed management program in 2007, the City has developed WIPs for the following watersheds:

- Ellerbe Creek (City of Durham, 2010)
- Third Fork Creek (City of Durham, 2012a)
- Northeast and Crooked Creek (City of Durham, 2013)
- Little Lick Creek (City of Durham, 2016)
- Eno River (City of Durham, 2018c)

The New Hope Creek and Little Creek WIP continues the City’s watershed program of protecting and restoring water quality.

1.1 Background

The New Hope Creek and Little Creek watersheds are located within the Upper Cape Fear River Basin within Durham and Orange counties. The watersheds cover approximately 80 square miles, 45% of which lies within City limits. New Hope Creek and Little Creek discharge into Jordan Lake and the Cape Fear River before ultimately reaching the Atlantic Ocean.

The three major tributaries to New Hope Creek are Sandy Creek, Mud Creek, and Third Fork Creek. Little Creek forms at the confluence of Bolin Creek and Booker Creek northeast of Chapel Hill and flows southeast, joining New Hope Creek in the northern arm of Jordan Lake.

The study area for the WIP includes the portion of the New Hope Creek and Little Creek watershed that is in Durham County and within the City boundary. The City already completed a WIP for Third Fork Creek in 2012 (City of Durham, 2012a). The study area covers approximately 30.2 square miles (19,322 acres) and extends from the

Durham/Orange County boundary to Stagecoach Road for New Hope Creek and Farrington Road for Little Creek. For the purposes of the WIP, the study area was divided into 56 subwatersheds.

Some sections of New Hope Creek, Little Creek, and their tributaries are listed on North Carolina's 303(d) list of impaired waters (NCDEQ, 2018). New Hope Creek is listed as impaired for benthos (fair rating) along State Route (SR) 2220 (Old Chapel Hill Road) and from SR 2220 to Interstate 40 (assessment units 16-41-1-(11.5) a, b). A 5-mile portion of Little Creek (assessment unit 16-41-1-15-(0.5)), from its source at the confluence of Booker and Bolin Creeks to 0.7 miles downstream of SR 1110 (Farrington Rd), is listed due to poor benthos conditions. A 2-mile segment of Third Fork Creek (assessment unit 16-41-1-12-(1)) that discharges into New Hope Creek is also identified as impaired for copper upstream of NC Highway 54.

These creeks discharge into Jordan Lake, which is impaired for nutrients (total nitrogen [TN] and total phosphorus [TP]), pH, and turbidity. It is classified as a Nutrient Sensitive Water (NSW; NCDEQ, 2020), and a total maximum daily load (TMDL) was enacted for nutrients in 2007 and for pH and turbidity in 2014.

Jordan Lake is subject to the Jordan Lake Water Supply Nutrient Management Strategy (Jordan Lake Rules) (NCDEQ, 2009), which aims to restore and protect the lake from water quality issues due to excessive nutrients. New Hope Creek and Little Creek watersheds must adhere to both the TMDLs and Jordan Lake Rules. The Jordan Lake Rules are currently being revised and the City is participating in the groups looking at how to revise the rules (Triangle J Council of Governments, 2021).

1.2 Goals

The primary goal of the New Hope Creek and Little Creek WIP is to provide a plan for enhancing the water quality and watershed health of the New Hope Creek and Little Creek watersheds. Additional goals of the New Hope Creek and Little Creek WIP are as follows:

- Help the City address local water quality issues and federal and state requirements under the City's National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) permit (permit number NCS000249; effective October 10, 2018 – October 9, 2023).
- Present a prioritized list of new or retrofitted watershed improvement projects to reduce nutrient loading to Jordan Lake.
- Focus on ways to improve water quality and increase Green Stormwater Infrastructure (GSI) on existing development so that the City may successfully achieve the goals set forth in their Strategic Plan and Sustainability Roadmap.
- Develop and implement strategies for engaging traditionally under-represented communities in the watershed planning process. This goal serves to achieve the equitable outreach initiatives set forth in the City's Equitable Engagement Blueprint, the Strategic Plan, and the Sustainability Roadmap.

Developing the WIP included the following tasks:

- Preparation of an Equitable Community Engagement Plan to encourage participation from historically underrepresented communities in the City's planning, policy, and decision-making and to provide a framework that guides the decision-making process of the WIP.
- Assessment of the existing water quality and health of the streams and aquatic habitats in the New Hope Creek and Little Creek watersheds by reviewing previous studies, watershed data, and field investigation.
- Identification of the major point and nonpoint pollution sources contributing to watershed degradation.

- Identification of potential projects that could improve watershed health such as stormwater control measures (SCMs), stream restoration projects, regulatory compliance, and stakeholder goals.
- Prioritization of the watershed improvement projects that were identified through field work.
- Identification and prioritization of high-quality riparian preservation projects on private property for conservation or protection to preserve water quality and watershed health and include this information in an update to the city-wide Critical Area Protection Plan (CAPP) (see Volume III, Appendix F, of the WIP).
- Identification of maintenance practices that will enhance or extend riparian buffers or improve existing maintenance practices on city-owned property near and along streams and include this information in an update the city-wide Riparian Area Management Plan (RAMP) (see Volume III, Appendix N, of the WIP).
- Development of partnerships between residents, local watershed organizations, and governmental agencies to increase public awareness of the issues surrounding watershed health with the aim of improving water quality and protecting aquatic habitats.

The WIP addresses the nine elements that are required in watershed plans by Section 319 of the Clean Water Act. The elements are described in the U.S. Environmental Protection Agency's (USEPA) *Handbook for Developing Watershed Plans to Restore and Protect Our Waters* (USEPA, 2008). Table 1-1 lists the nine elements along with cross references to the sections of the WIP that most directly correspond to each key element.

1.3 Organization

The New Hope Creek and Little Creek WIP is divided into the following three volumes:

- **Volume I: Executive Summary.** Description of project goals, watershed evaluation methods, results of the watershed improvement scenarios, recommended projects, high-priority project fact sheets, and next steps for evaluating progress.
- **Volume II: Improvement Plan.** Summary of the approach used to develop the WIP, including: data used to develop the watershed model, stream and SCM inventory and assessments, watershed improvement scenarios, watershed improvement project evaluation and prioritization, public outreach and involvement efforts, recommended strategies, implementation schedule, and measurable milestones.
- **Volume III: Technical Appendices.** Reports and memoranda which provide details describing the technical approach used in developing the WIP and the subtasks within it, including model development and field survey results.

Table 1-1. USEPA's nine key elements for watershed plans and corresponding section in the WIP

Element	Description	Section in WIP
1	Identify the causes and sources of pollution	Vol. II, Section 2, Watershed Assessment
2	Estimate pollutant loading into the watershed and expected management measures and load reductions	Vol. II, Section 5, Evaluation of Watershed Improvement Scenarios
3	Describe the management measures to achieve load reductions and identify the critical areas in which those measures will be implemented	Vol. II, Section 5, Evaluation of Watershed Improvement Scenarios and Vol. II, Section 6, Prioritization of Watershed Improvement Projects
4	Estimate the associated costs, amounts of technical and financial assistance needed, and the authorities needed to implement the plan	Vol. II, Section 6, Prioritization of Watershed Improvement Projects
5	Implement a public information and education component that will be used to enhance public understanding of the project	Vol. II, Section 7, Public Outreach and Involvement
6	Provide a schedule for implementing the nonpoint source management measures identified in the plan	Vol. II, Section 8, Watershed Improvement Plan
7	Describe interim, measurable milestones for verifying whether nonpoint source management measures or other control actions are being implemented effectively	Vol. II, Section 8, Watershed Improvement Plan
8	Describe a set of criteria that can be used to determine whether loading reductions are being achieved over time and substantial progress is being made toward attaining water quality standards	Vol. II, Section 8, Watershed Improvement Plan
9	Describe a monitoring plan to evaluate the effectiveness of the implementation efforts over time, measured against the criteria established under Element 8	Vol. II, Section 8, Watershed Improvement Plan

2 Watershed Concerns

The New Hope Creek and Little Creek watersheds exhibit overall fair water quality according to the 2019 State of Our Streams report (City of Durham, 2019a), existing water quality data (City of Durham, 2020a), and field assessments (see Volume III, Appendix E, of this WIP). Field investigations identified indicators of degraded aquatic habitat, including elevated turbidity, headcuts, and highly eroded streambanks. Water quality monitoring indicates the presence of elevated fecal coliform and nutrient concentrations throughout the study area. The primary sources of pollution and watershed concerns are presented in Table 2-1.

For more information, see the *New Hope Creek and Little Creek Watershed Assessment Report* in Volume III, Appendix E, of this WIP.

Table 2-1. Summary of New Hope Creek and Little Creek watershed pollution sources

Source	Description
Stormwater runoff from impervious surfaces	<ul style="list-style-type: none"> Increased impervious cover can result in increased stormwater runoff, higher peak flows, lower base flows, and reduced groundwater recharge. Impervious cover accounts for approximately 19% of the study area. The percentage of impervious cover in 27 of the 56 subwatersheds in the study area was found to be 15% or above. Eight of the 14 subwatersheds in the Sandy Creek watershed have relatively large amounts of impervious cover that account for between 25% and 45% of their respective subwatershed areas.
Animal waste	<ul style="list-style-type: none"> Animal waste deposits from both domestic house pets and wild animals such as deer and geese are potential sources of fecal coliform within urban areas. Additional information is needed to determine if pet waste is a contributor to fecal coliform exceedances in the New Hope Creek and Little Creek watersheds.
Headcuts	<ul style="list-style-type: none"> A headcut is an abrupt vertical drop in the stream bed that is an active erosional feature. Potentially major source of sedimentation in a stream. 55 headcuts were observed by field crews during stream assessments
Illicit discharges	<ul style="list-style-type: none"> Examples of illicit discharges include petroleum spills, improper disposal of yard waste, public sanitary sewer overflows (SSO), and cooking related wastes like oil, grease, food that is discharged into storm drains or enter storm drains from overland runoff, and mobile car washing operations. Field biologists noted evidence of potential illicit discharges while performing stream assessments in the New Hope Creek and Little Creek watersheds (see Exhibit 12). These observations were reported to the Public Works Department staff who investigate and resolve any illicit discharges. Illicit discharges are documented in the City's State of Our Streams Reports (City of Durham, 2019a) and NPDES Annual Report (City of Durham, 2020b).

Table 2-1. Summary of New Hope Creek and Little Creek watershed pollution sources (continued)

Source	Description
Elevated Levels of TN, TP, turbidity, and copper	<ul style="list-style-type: none"> • Nutrients and fecal coliform associated with wastewater reduce water quality, contribute to growth of aquatic macrophytes, and reduce dissolved oxygen levels. • Turbidity reduces light penetration and copper is toxic. These can affect the ecological productivity and habitat quality within streams. • Average annual TN values exceeded the City of Durham benchmark (0.8 mg/L TN) in Little Creek, Sandy Creek, and Mud Creek for most of the sampling years. Little Creek and Sandy Creek exceeded TP most of the years, and New Hope Creek exceeded the threshold about 40% of the years. • The CCC (Criterion Continuous Concentration) for copper was exceeded at least 1 month out of the year for all subwatersheds.
Degraded riparian buffer	<ul style="list-style-type: none"> • Degraded riparian buffers result in increased bank erosion and sediment inputs to surface waters. • In the study area, field investigations identified about 75,000 linear feet of stream in 39 reaches that would benefit from restoration and more than 90,000 linear feet that could undergo enhancement or stabilization.
Degraded habitat	<ul style="list-style-type: none"> • The abundance and diversity of fish and benthic macroinvertebrates are impacted by the physical characteristics, substrate composition, and riparian area features of a stream. • Healthy stream habitat in the Piedmont physiographic province of North Carolina is characterized by a diversity of riffles and pools as well as healthy, riparian buffers that stabilize banks, moderate temperatures, and filter pollutants from overland runoff. • Rapid Stream Assessment Technique (RSAT) assessments in the New Hope Creek and Little Creek Watershed revealed that, among the 35.8 stream miles assessed, 18% are rated "good", 70% are rated "fair", and 9% are rated "poor", and 3% were not rated due to the presence of a beaver impoundment or other environmental factor. Nearly all the assessed subwatersheds were either "good" and "fair" or "fair" and "poor," with the majority being "fair". See Exhibit 13 for the RSAT assessments within the study area. • Streams surveyed in the New Hope Creek and Little Creek watersheds are located mostly in the Triassic Basin. Streams in this area tend to score lower on biological assessments, which is a component of the RSAT, due, in part, to a relative lack of benthic macroinvertebrates.

3 Watershed Improvement Scenarios

The recommendations presented in this WIP are based on an evaluation of cost-effective pollution control strategies within the New Hope Creek and Little Creek watershed. Improvement projects such as new and retrofitted SCMs and stream restoration opportunities were identified and prioritized to protect and restore water quality within the New Hope Creek and Little Creek watershed.

Watershed improvement scenarios were developed to assess the potential water quality benefits offered by various improvement projects. The selected scenarios include practices that have demonstrated nutrient reduction and are considered feasible in the New Hope Creek and Little Creek watersheds. The modeling results from the watershed improvement scenarios from previous WIPs (see Volume III, Appendix K, of this WIP) and the current nutrient crediting in North Carolina were all considered in formulating the watershed scenarios for this WIP.

The following watershed scenarios were selected for the New Hope Creek and Little Creek watersheds:

- **Scenario 1: Existing Land Use with Existing SCMs (Baseline for Current Conditions).** Existing conditions in the watershed, incorporating current land use conditions and the water quality benefits provided by existing SCMs.
- **Scenario 2: Future Land Use Conditions with Existing SCM Repairs (Baseline for Future Conditions).** Future conditions in the watershed, assuming no new watershed improvement projects or pollution control measures.
- **Scenario 3: Future Land Use with Stormwater Performance Standards for New Development.** Developed to assess the impact of implementing the City's Stormwater Performance Standards for New Development Ordinance (City of Durham, 2012b).
- **Scenario 4: Stormwater Performance Standards for New Development with Recommended SCM Retrofits and New SCM Projects.** Determines the annual pollutant load reduction that could be achieved on a watershed scale by implementing the proposed 29 existing SCM retrofit projects and 35 potential new SCM projects identified in the study area in addition to the SCMs expected from new development.
- **Scenario 5: Stormwater Performance Standards for New Development with Stream Restoration Projects.** Quantifies the annual pollutant load reductions that could be achieved on a watershed scale by implementing the 28 proposed stream projects (10.7 miles) that were identified in the stream inventory and assessment.
- **Scenario 6: Stormwater Performance Standards for New Development with Green Infrastructure and Low Impact Development.** Developed to quantify the annual pollutant load reductions that could be achieved on a watershed scale if Green Stormwater Infrastructure and Low Impact Development (GSI-LID) practices were installed in residential and commercial areas that lack stormwater controls. Eligible portions of the study area were determined from the City's Residential Green Infrastructure (ReGI) analysis, future land use and parcel data (City of Durham, 2017; see Volume III, Appendix A, of this WIP).

- **Scenario 7: Additional On-site Treatment for Pre-1980s Development and Commercial Land Uses.** Evaluates the impact of treating portions of the project study area that were developed pre-1980 or have commercial land use. This scenario was developed in response to the modeling effort of Miller et al. (2019), where areas of pre-1980 development in the Jordan Lake watershed were found to have pollutant export rates substantially higher than areas of post-1980 development.
- **Scenario 8: Stormwater Performance Standards for New Development using Oversized SCMs.** Characterizes the benefit associated with oversizing new SCMs and SCM retrofits to 150% of their design volume. All SCMs were eligible for oversizing except wet and dry swales. In total, 29 new and 29 retrofit SCMs were simulated as oversized under this Scenario.
- **Scenario 9: Stormwater Performance Standards for New Development with Street Sweeping.** Evaluates the impact of increasing street sweeping practices within the project study area. The enhanced street sweeping scenario involves the sweeping of an additional 105 miles of roadways within the New Hope Creek and Little Creek watersheds.
- **Scenario 10: Combined Nonpoint Source Pollution Projects.** Evaluates reduction from implementing all pollution prevention strategies under Scenarios 4-9.

3.1 Stormwater Management Modeling

The data collected during the watershed field assessment was used to develop and calibrate a Personal Computer Storm Water Management Model (PCSWMM). PCSWMM was selected because of its ability to simulate the existing storm drainage system in the New Hope Creek and Little Creek watersheds and estimate pollutant loadings and the transport of water quality constituents through the drainage system. The model was used to estimate changes in pollutant loadings associated with all scenarios except Scenario 5, Stormwater Performance Standards for New Development with Stream Restoration Projects, which was developed using Microsoft Excel.

3.2 Scenario Results

Results from the watershed improvement scenarios suggest that TN, TP, and TSS loadings will increase under changes in future land use, but that management practices can significantly reduce nutrient and sediment loading, as shown in Table 3-1 and Table 3-2. Under future land use conditions with existing SCM repairs, TN loads increase 6.1%, TP loads increase 4.2% and TSS loads increase 4.2%. The new development standards, when applied to future land use conditions, provide a 2.5% reduction in TN, 2.9% reduction in TP, and 5.0% reduction in TSS compared to loads under future conditions.

Estimated nutrient and sediment load reductions for the different watershed improvement scenarios is presented in Table 3-2 and discussed below:

Total Nitrogen. Treating pre-1980 developed land produced the largest reduction in TN exported from the study area under the future land use condition (8.2%), with stream projects producing the second highest reduction (7.8%), and enhanced street sweeping the third (6.8%). GSI-LID resulted in a 2.6% reduction in TN, SCM projects resulted in 0.9% reduction in TN, and oversizing SCMs resulted in 0.2% reduction in TN.

Total Phosphorus. Similar to Total Nitrogen, treating pre-1980 developed land produced the largest reduction in TP exported from the study area under the future land use condition (7.9%). For TP, however, the second highest reduction resulted from enhanced street sweeping (6.5%) rather than stream projects (1.4%). GSI-LID resulted in a 2.6% reduction in TP, SCMs provided a 0.7% reduction in TP, and oversizing SCMs resulted in 0.1 reduction in TP.

Total Suspended Solids. Stream projects are projected to provide the largest reduction in total suspended solids (TSS; 31.0%) while treating pre-1980 developed land producing the second largest reduction at 23.5%. Enhanced street sweeping resulted in 7.8% reduction in TSS, GSI-LID resulted in 6.6% reduction in TSS, and SCMs resulted in 0.3% reduction in TSS. As earlier noted, changes in TSS loading were not estimate for oversizing SCMs scenario.

Treating pre-1980 developed land produced the largest benefit for both TN and TP and the second largest for TSS. These results suggest that targeting older development areas with various stormwater improvement strategies may be a cost-effective approach for reducing nutrient and sediment loads within the New Hope Creek and Little Creek watershed. Since most lands developed prior to 1980 were not subject to onsite water quality requirements, these lands may contribute a larger amount of nutrient and sediment loads into the watershed than those developed more recently.

Stream projects produced the largest reduction in TSS and the second highest reductions for TN but produced much smaller reductions for TP. Enhanced street sweeping also resulted in substantial reductions in TN and TP and comparatively modest reductions in TSS; however, TSS reductions were based on a percentage reduction and should be evaluated in the future when additional data is available. GSI-LID, oversizing SCMs and SCM projects resulted in much smaller TN, TP, and TSS reductions. Since DEQ has not yet finalized the TP and TP reduction values for stream restoration projects, the projected pollutant load reductions associated with stream projects may be subject to change.

The planning level costs for implementing the stream restoration projects are nearly double that of SCMs. Stream projects, however, provide much greater reductions than SCMs (nearly 8 times more TN and 88 times more TSS reduced) indicating that stream projects are more cost effective and should be prioritized over SCM projects.

Table 3-1. Estimated change in TN, TP, and sediment annual loads and reductions for watershed improvement scenarios evaluated in the New Hope Creek and Little Creek Watershed study area

Watershed Management Scenario	Total Nitrogen			Total Phosphorus			Total Suspended Sediment		
	Annual Load (lb/yr)	Reduction from FLU ⁽¹⁾ (lb/yr)	Relative Reduction from FLU ⁽¹⁾ (%)	Annual Load (lb/yr)	Reduction from FLU ⁽¹⁾ (lb/yr)	Relative Reduction from FLU ⁽¹⁾ (%)	Annual Load (tons/yr)	Reduction from FLU ⁽¹⁾ (tons/yr)	Relative Reduction from FLU ⁽¹⁾ (%)
1 ELU	92,195	—	—	8,829	—	—	867	—	—
2 FLU and existing SCM repairs	97,863	—	—	9,196	—	—	904	—	—
3 FLU and NewDStds	95,444	-2,419	-2.5%	8,933	-263	-2.9%	859	-45	-5.0%
4 FLU, NewDStds, and SCM Projects	94,556	-3,307	-3.4%	8,871	-325	-3.5%	856	-48	-5.3%
5 FLU, NewDStds, and Stream Projects	87,100	-10,763	-11.0%	8,749	-447	-4.9%	591	-313	-34.7%
6 FLU, NewDStds, and GSI-LID	92,136	-5,727	-5.9%	8,640	-556	-6.0%	800	-104	-11.5%
7 FLU, NewDStds, and treatment of pre-1980 developed land	86,805	-11,058	-11.3%	8,167	-1,029	-11.2%	655	-249	-27.5%
8 FLU, NewDStds, and oversized SCMs ⁽²⁾	94,377	-3,486	-3.6%	8,858	-338	-3.7%	856	-48	-5.3%
9 FLU, NewDStds, and enhanced street sweeping	88,293	-9,570	-9.8%	8,310	-886	-9.6%	794	-110	-12.2%
10 FLU, NewDStds, and combination of nonpoint source pollution projects	71,739	-26,124	-26.7%	7,340	-1,856	-20.2%	308	-596	-66.0%

(1) Annual load reduction percentages are based on a comparison to Scenario 2, which represents the future land use condition with repairs to existing SCMs and without stormwater performance standards for new development.

(2) It was not possible to estimate the added benefit that oversizing SCMs would have on TSS because Part C of the NC SCM Credit Document does not provide effluent event mean concentrations for TSS, a necessary parameter to complete the calculations for this scenario.

"—" = not applicable

GSI-LID = green infrastructure – low impact development

ELU = existing land use

NewDStds = Stormwater Performance Standards for New Development

FLU = future land use

SCM = stormwater control measure

lb/yr = pounds per year

Table 3-2. Estimated TN, TP, and sediment annual load reductions for each practice evaluated in the New Hope Creek and Little Creek watershed study area

Scenario and Watershed Management Practice	Annual Load Reduction					
	Total Nitrogen		Total Phosphorus		Total Suspended Sediment	
	lb/yr	Percent	lb/yr	Percent	tons/yr	Percent
3 Stormwater Performance Standards for New Development ⁽¹⁾	2,419	2.5%	263	2.9%	45	5.0%
4 Recommended SCM Retrofits and New SCM Projects ⁽²⁾	888	0.9%	62	0.7%	3	0.3%
5 Recommended stream restoration projects ⁽³⁾	7,456	7.8%	122	1.4%	266	31.0%
6 Green Infrastructure/Low Impact Development ⁽⁴⁾	2,420	2.5%	231	2.5%	56	6.5%
7 Additional On-site Treatment for Pre-1980 Development and Commercial Land Uses ⁽⁴⁾	7,751	8.1%	704	7.9%	201	23.4%
8 Oversize new SCMs and SCM retrofits ⁽⁴⁾⁽⁵⁾	179	0.2%	13	0.1%	0	0.0%
9 Enhanced street sweeping ⁽⁴⁾	6,263	6.6%	561	6.3%	62	7.2%
10 Combination of nonpoint source pollution projects ⁽²⁾	23,705	24.8%	1,593	17.8%	551	64.1%

(1) Annual load reduction percentages are based on a comparison to Scenario 2, which represents the future land use condition without stormwater performance standards for new development.

(2) Annual load reduction percentages are based on a comparison to Scenario 3, which represents the future land use condition with stormwater performance standards for new development.

(3) Scenario 5 load reductions were calculated in Microsoft Excel. Reductions shown represent the change in load compared to Scenario 3, which represents the future land use condition with stormwater performance standards for new development.

(4) Annual load reduction percentages are based on a comparison to Scenario 4, which represents the future land use condition with stormwater performance standards for new development and recommended SCM retrofit and new SCM projects. The models used to evaluate these scenarios included recommended SCM retrofits and new SCM projects so comparing loads to Scenario 4 loads removes the reductions gained from those practices.

(5) It was not possible to estimate the added benefit that oversizing SCMs would have on TSS because Part C of the NC SCM Credit Document does not provide effluent event mean concentrations for TSS, a necessary parameter to complete the calculations for this scenario.

"—" = not applicable

ELU = existing land use

FLU = future land use

lb/yr = pounds per year

GSI-LID = green infrastructure – low impact development

NewDStds = Stormwater Performance Standards for New Development

SCM = stormwater control measure

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4 Watershed Improvement Project Prioritization

Using field assessments, hydrologic and hydraulic modeling, and water quality modeling, potential improvement projects were identified throughout the New Hope Creek and Little Creek watersheds. These projects were then prioritized based on which projects would provide the most benefit. While all projects provide benefits, the type and degree of benefit and the cost vary widely. This prioritization step allows the City to select which projects to implement in a systematic and transparent way. This process is similar to that used in other WIPs so that projects within the New Hope Creek and Little Creek watershed can be compared with those in other watersheds.

A total of 179 feasible projects in the New Hope Creek and Little Creek watersheds, including 29 retrofits to existing SCMs, 35 new SCM projects, and 115 stream projects, were scored based on the following six categories of criteria:

- **Water Quality Treatment:** Amount of pollutant(s) removed and the associated cost-effectiveness.
- **Habitat and Biological Integrity:** Benefit to the ecological function of the stream and the stream's ability to support aquatic life.
- **Stream Bank Protection:** The ability of a project to reduce erosion of stream banks during high flow events.
- **Community Enhancement:** Benefit to the surrounding community such as property protection and environmental equity, landowner acceptance, opportunities for public education through proximity to schools, parks, libraries, and other public locations.
- **Implementation Issues:** Difficulty and cost of implementing a project, such as property ownership, accessibility, permitting requirements, and environmental impacts.
- **Public Safety and Public Property Considerations:** Amount of flood reduction or protection for streets, infrastructure, or property.

A total of 14 criteria within the six categories (see Table 4-1) were used to prioritize the 179 projects. Each criterion within a project received a score that was adjusted using a pre-determined weighing factor to create a weight-adjusted score. Additional information on the methods used to determine project scores is provided in *Prioritization of Proposed Watershed Improvement Projects* (see Volume III, Appendix K, of this WIP).

Using the criteria listed in Table 4-1, 15 high-priority SCM projects and 15 high-priority stream projects were selected. The high-priority SCM projects included four new SCMs and eleven retrofits to existing SCMs (Table 4-2). The high-priority stream projects include 11 reaches proposed for restoration, two reaches proposed for Enhancement I, one reach proposed for Enhancement II, and one reach proposed for bank stabilization (Table 4-3). Fact sheets for high-priority projects are provided in Volume I, Appendix A, of this WIP.

There are five additional high-scoring stream projects located on parcels owned by Duke University. All five projects are proposed for restoration and have mostly been impacted by development in the watershed and clearing of riparian buffers. These projects are listed in Table 4-4.

Table 4-1. Prioritization criteria with scoring ranges and weighting factors

Category	Criteria	Score Range	Weighting Factor	Results of Score x Weighting Factor
Water Quality Treatment	Nitrogen	0 – 5	2	0 – 10
	Phosphorus	0 – 5	2	0 – 10
	Sediment	0 – 5	1.5	0 – 7.5
	Fecal Coliform	0 – 5	1.5	0 – 7.5
Habitat and Biological Integrity	Habitat/Biology	0 – 5	3	0 – 15
Stream Bank Protection	Stream Bank Protection	0 – 5	2	0 – 10
Community Enhancement ⁽¹⁾	Property Protection and Environmental Equity	0 – 5	1	0 – 5
	Landowner Acceptance	0 – 5	1	0 – 5
	Public Education Potential	0 – 5	1	0 – 5
Implementation Issues	Property Ownership	0 – 5	1	0 – 5
	Accessibility for Construction and Operations and Maintenance	0 – 5	1	0 – 5
	City program compatibility	0 – 5	1	0 – 5
	Permitting/Adverse Environmental Impacts	0 – 5	1	0 – 5
Public Safety and Public Property Considerations	Public Safety and Public Property	0 – 5	1	0 – 5
Total Possible Score				0 – 100

(1) Updates were made to the *Community Enhancement* category to ensure these criteria reflect current City strategies of environmental equity-based decision-making while remaining comparable across previous WIPs. Specifically, the former criterion of *Property Protection* was revised to *Property Protection and Environmental Equity* in order to better serve the flood-prone residential areas located in previously identified priority (Tier 1) areas. *Property Owner and Neighborhood Acceptance* was revised to *Landowner Acceptance* to better define and prioritize projects on public and private lands. *Public Education* was revised to *Public Education Potential* to capture the potential of projects to increase public awareness due to their strategic location in highly visible and accessible areas. Specific details about each criteria are provided in the *Community Enhancement* section.

Table 4-2. High-priority SCM projects in the New Hope Creek and Little Creek watersheds

Project ID	Project Description	Sub-watershed	SCM Drainage Area (ac)	Annual Load Reduction (lbs/yr)			Total Capital Costs (2018 Dollars) ⁽¹⁾	Total Project Prioritization Score (100 Max)
				TN	TP	Sediment		
00497	Convert Existing Dry Pond to Constructed Wetland	NHC32	23	26	2	5,591	\$202,000	68.5
NHCMC0068	Water Quality Improvements to an Existing Wet Pond	NHC47	24	36	3	1,604	\$240,000	64.0
NHCMC0054	New Constructed Wetland	NHC51	4	12	1	403	\$310,000	58.5
00111	Convert Existing Wet Pond to Constructed Wetland	NHC09	10.1	31	3	1,782	\$230,000	56.5
NHCSC0039	New Constructed Wetland	NHC46	3.3	15	1	302	\$265,000	54.5
NHCSC0027	New Constructed Wetland	NHC35	10.6	46	3	1,752	\$218,000	53.5
00103	Convert Existing Wet Pond to Constructed Wetland	NHC12	7.8	26	2	1,218	\$201,000	53.5
00276	Convert Existing Wet Pond to Constructed Wetland	NHC09	7.9	28	3	1,060	\$223,000	53.5
00267	Convert Existing Dry Pond to a Pocket Wetland	NHC47	32.8	26	2	4,001	\$216,000	52.5
NHCMC0069	Convert Existing Water Retention Feature to a Wet Pond	NHC56	16.9	31	4	2,154	\$172,000	52.0
NHCMC0070	Convert Existing Dry Pond to a Wet Pond	NHC56	14.1	7	1	1,390	\$201,000	51.0
00511	Convert Existing Dry Pond to Constructed Wetland	NHC31	2.6	2	0	452	\$193,000	50.0
NHCMC0071	Convert Existing Dry Pond to Constructed Wetland	NHC56	10.2	5	1	1,039	\$223,000	48.5
00316	Lower Water Level in Wet Pond to Gain Storage	NHC25	9.4	24	2	1,466	\$211,000	48.0
NHC0014	New Treatment Swale – Wet	NHC27	0.28	1	0	61	\$39,000	46.5
Totals			176.98	316	28	24,275	\$3,144,000	

(1) Total capital costs consist of administrative, engineering, surveying, permitting, land acquisition, construction, and construction administration costs and 20 years of annual maintenance. Costs presented in this table are not adjusted to present day. Given that the United States economy, and the construction industry in particular, is experiencing major supply-chain disruptions, staffing difficulties, and exceptionally steep and fast-rising costs for a variety of materials (Associated General Contractors of America, 2021), the capital costs presented in this table may be low. As such, the information provided in this table should be used with caution and additional investigations or evaluations may be required to develop more accurate cost assessments.

Table 4-3. High priority stream improvement projects in the New Hope Creek and Little Creek watersheds

Project ID	Project Description	Sub-watershed ⁽¹⁾	Watershed	Stream Reach Length (ft)	Annual Load Reduction (lbs/yr)			Total Capital Costs (2018 Dollars) ⁽²⁾	Total Project Prioritization Score (100 Max)
					TN	TP	Sediment		
LNHC1006	Restoration	NH28	Lower NHC	1,446	137	7	61,663	\$118,000	74.5
LNHC1002	Restoration	NH29	Lower NHC	7,219	1,304	35	307,750	\$591,000	73.5
SC2038	Restoration	NH33	Sandy Creek	5,186	857	19	165,878	\$319,000	65.5
LNHC1014	Restoration	NH30	Lower NHC	1,395	195	11	91,977	\$171,000	65.5
MC1015	Restoration	NH47	Mud Creek	6,313	717	16	138,363	\$517,000	64.5
LNHC1024	Restoration	NH26	Lower NHC	949	100	7	62,558	\$78,000	63.5
MC1026	Restoration	NH48	Mud Creek	2,523	241	6	49,914	\$207,000	61.5
LNHC1003	Stabilization	NH27	Lower NHC	2,251	66	17	148,410	\$115,000	61.5
LNHC1015	Restoration	NH30	Lower NHC	3,926	334	9	76,278	\$482,000	59.5
MC1027	Enhancement 1	NH48	Mud Creek	2,466	31	8	69,245	\$151,000	57.6
LNHC2017	Enhancement 1	NH11	Lower NHC	2,222	19	5	42,964	\$136,000	57.0
SC2034	Restoration	NH35	Sandy Creek	952	123	7	62,757	\$78,000	56.5
LNHC2005	Restoration	NH22	Lower NHC	1,180	109	6	50,292	\$97,000	54.5
LNHC1008	Enhancement 2	NH28	Lower NHC	1,066	20	5	45,459	\$44,000	52.7
LNHC1007	Restoration	NH28	Lower NHC	3,278	165	1	10,921	\$268,000	51.0
Totals				42,372	4,418	159	1,384,429	\$3,372,000	

(1) NH28 (3 projects) and NH48 (2 projects) are located within the same subwatershed, could be combined into a single project. This would reduce cost relative to the cost of implementing individual projects

(2) Total capital costs consist of administrative, engineering, surveying, permitting, land acquisition, construction, and construction administration costs and 20 years of annual maintenance. Costs presented in this table are not adjusted to present day. Given that the United States economy, and the construction industry in particular, is experiencing major supply-chain disruptions, staffing difficulties, and exceptionally steep and fast-rising costs for a variety of materials (Associated General Contractors of America, 2021), the capital costs presented in this table may be low. As such, the information provided in this table should be used with caution and additional investigations or evaluations may be required to develop more accurate cost assessments.

Table 4-4. High priority stream improvement projects located on parcels owned by Duke University in the New Hope Creek and Little Creek watersheds

Project ID	Project Description	Sub-watershed	Watershed	Stream Reach Length (ft)	Annual Load Reduction (lbs/yr)			Total Capital Costs (2018 Dollars) ⁽¹⁾	Total Project Prioritization Score (100 Max)
					TN	TP	Sediment		
SC2025	Restoration	NH40	Sandy Creek	3,693	509	28	243,441	\$302,000	73.5
SC2026	Restoration	NH40	Sandy Creek	2,205	268	17	145,337	\$181,000	73.5
MC1023	Restoration	NH51	Mud Creek	1,342	46	7	57,213	\$110,000	67.5
SC2024	Restoration	NH40	Sandy Creek	974	69	5	41,532	\$80,000	66.5
SC2005	Restoration	NH45	Sandy Creek	2,269	234	9	76,596	\$279,000	64.5
Totals				10,483	1,126	66	564,119	\$952,000	

(1) Total capital costs consist of administrative, engineering, surveying, permitting, land acquisition, construction, and construction administration costs and 20 years of annual maintenance. Costs presented in this table are not adjusted to present day. Given that the United States economy, and the construction industry in particular, is experiencing major supply-chain disruptions, staffing difficulties, and exceptionally steep and fast-rising costs for a variety of materials (Associated General Contractors of America, 2021), the capital costs presented in this table may be low. As such, the information provided in this table should be used with caution and additional investigations or evaluations may be required to develop more accurate cost assessments.

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5 Public Outreach and Involvement

Public involvement is a critical component of the watershed planning process, as residents bring local knowledge that is invaluable in developing a comprehensive plan. A variety of tools were used to engage and inform the public, key stakeholders, City staff, and elected officials. The tools included an Equitable Community Engagement Plan, three public information sessions, a City-hosted project webpage, social media, project fact sheets, an educational radio spot, and two educational videos. Outreach included both English and Spanish language materials.

5.1 Equitable Community Engagement Plan

An Equitable Community Engagement Plan (“Plan”) was developed early in the New Hope Creek and Little Creek WIP project to develop strategies that would encourage participation from historically underrepresented communities and provide a framework for decision-making throughout the project. The Plan provides a description of the communities that work and live in the watershed, potential community partner organizations, and recommendations for engagement events and other public participation. Additional information is available in the *Equitable Community Engagement Plan* provided in Volume III, Appendix G, of this WIP.

5.2 Public Information and Outreach Sessions

Three information sessions were hosted during 2020 and 2021. The sessions were held at key project milestones to provide an update on progress and receive input from attendees on important topics.

The first public information session presented an overview of the New Hope Creek and Little Creek WIP. The presentation described the City’s watershed planning program in general and summarized the process of developing the New Hope Creek and Little Creek WIP, touching on topics such as conducting field analysis of streams and SCMs, computer modeling, and project prioritization. An online survey was used in conjunction with the first public information session to solicit feedback from the public and refine the WIP.

The second outreach session consisted of live, virtual, and interactive presentations focused on 7th grade science classes at Rogers-Herr Middle School in Durham. The presentations covered topics such as the importance of watershed health, sources of harmful pollutants, managing pollutants, and microbial source tracking as a method for identifying sources of fecal coliform contamination. The presentation concluded with “What Can I Do to Help” actions, in which the following topics were discussed: items that should not be flushed in toilets, proper disposal of oil and grease, and picking up pet waste. The individual classroom presentations were not recorded due to student privacy concerns; however, a recorded version of the presentation with voice-over narration was produced and is available for other science classes or interested individuals.

The third and final public information session was held on June 29, 2021. Topics discussed during this session included an overview of stormwater and the City’s watershed improvement planning process, New Hope Creek and Little Creek WIP project goals, public outreach survey results, SCM and stream prioritization results, watershed modeling and scenario analysis, and project recommendations from the WIP.

5.3 New Hope Creek and Little Creek Watershed Improvement Plan Webpage

A City-hosted webpage was used to communicate progress and schedule updates, field activities, public information session dates, and key documents to the public during the project. The webpage was updated

throughout the project with schedule updates, field activities, project milestones, and literature such as project factsheets, recordings of public information sessions, and project reports. The project website is available at <https://durhamnc.gov/3766>.

5.4 Project StoryMap

The City prepared an ArcGIS StoryMap that provides a high-level description of watersheds and stormwater, the Jordan Lake nutrient management strategy, New Hope Creek and Little Creek watershed, and WIP progress updates, including an interactive SCM and stream map. The StoryMap is available online at: <https://storymaps.arcgis.com/stories/98876c442ac842e5b8bb07444bfa24eb>.

5.5 Social Media Updates

Social media tools, including Facebook (<https://www.facebook.com/durhamncstormwater/>) and Twitter (@DurhamStormH2O), were used to communicate important WIP progress updates, links to educational videos, and volunteer events in the watershed. Twenty-five social media posts were prepared over the course of the project, including 20 in English and five in Spanish.

5.6 Project Fact Sheets

Four project factsheets were developed for the New Hope Creek and Little Creek watershed improvement project to communicate to the public project progress and key findings. One factsheet was developed in both English and Spanish to be inclusive of diverse populations within Durham. The Spanish factsheet provides a summary of the watershed, stream and SCM field work, scenario modeling results, and overview of public involvement. The two-page factsheets were distributed during public information sessions and made available on the project webpage.

5.7 Educational Radio Spots

A radio spot was developed in Spanish and broadcasted on the channel La Ley 101.1FM to reach the Spanish-speaking population. The radio message was focused on recycling motor oil and keeping the watershed clean. A recording of the radio message can be found at <https://durhamnc.gov/3766>.

5.8 Educational Videos

Two videos were developed for the public outreach and education effort:

1. "Durham Doody" addresses pet waste wash-off within the watershed. The video touches on the importance of picking up pet waste and provides information on the harmful impacts of pet waste on receiving streams. The video ends with a pledge drive that encourages people to take a selfie picking up their pet waste with the hash tag #DurhamDoodyPledge. Captions in English and Spanish were developed for the video to support digital accessibility and are available through the media player. The video can be found online at https://youtu.be/XwBw3_TnLlc.
2. "What's that Pond?" educates on the purpose and function of wet detention basins in collecting stormwater runoff and mitigating downstream water quality issues. The video explains the function of the wet detention basin in retaining and cleaning stormwater and the importance of keeping the watershed clean from dog and other animal feces. Captions in English and Spanish captions were developed for the video to support digital accessibility and are available through the media player. The video can be found online at: <https://youtu.be/leiRzHpq7Z0>.

6 Watershed Improvement Plan

Achieving and maintaining water quality goals and watershed health in the New Hope Creek and Little Creek watersheds will be assisted by the implementation of protective measures such as pollution controls and management practices. These measures will help achieve water quality goals and restore and maintain the physical, chemical, and biological integrity of the receiving waterbodies by:

- Reducing or avoiding pollutant inputs
- Controlling discharges that could alter natural hydrology
- Mitigating other stressors that may contribute to impairment

Watershed protection requires creative water quality improvement projects and effective partnerships with state and local agencies (including other City departments), watershed associations, and stakeholder groups to implement the projects. The City leads and supports a number of projects and programs that protect and enhance the New Hope Creek and Little Creek watershed. The recommendations presented in this section add to these initiatives and highlight opportunities for future consideration. Additional information on each recommendation is provided in Volume II, Section 8, of this WIP.

6.1 Stormwater Runoff Treatment from Older Urban Areas

Studies in the Jordan Lake watershed have shown a strong relationship between poor water quality and the age of development, density of development, and connectedness of impervious surfaces (Carle et al., 2007 and Miller et al., 2019). Urban land developed before 1980 has been shown to contribute larger nutrient loads within the Jordan Lake watershed (Miller et al., 2019), suggesting that pre-1980 developed lands should be prioritized for stormwater retrofits, investigation of illicit discharges and inspections of sanitary sewer infrastructure. In areas where site constraints limit retrofit opportunities, nonstructural controls such as expanded street sweeping may reduce pollutant loads.

6.2 High-Priority Stream Improvement Projects

One hundred fifteen stream improvement projects were identified as feasible projects in the New Hope Creek and Little Creek watershed. The 15 high-priority stream improvement projects that were selected based on the prioritization criteria are presented in Table 4-3.

These projects would help re-establish general stream and river structure, function, and self-sustaining behavior by helping to increase aquatic habitat and fauna diversity and decrease streambank erosion. Many restoration projects feature aspects of the natural channel design method such as modification of channel dimension, pattern, and profile. Stream enhancement and stream stabilization are narrower in scope than stream restoration and focus on improving the floodplain and streambank areas, respectively.

6.3 High-Priority SCM Projects

Of the 64 possible SCM projects, 35 are retrofits to existing SCMs and 29 are new SCMs. The top 15 high priority SCMs identified using the prioritization criteria presented in Section 4 are listed in Table 4-2.

These projects provide the most cost-effective reduction of pollutant load contributions from stormwater runoff. If implemented, the SCMs could reduce the existing impacts of increased peak flows, excess nutrients, metals, and low dissolved oxygen present in portions of the New Hope Creek and Little Creek watershed.

6.4 Green Stormwater Infrastructure and Low Impact Development Opportunities

Green stormwater infrastructure (GSI), such as rain gardens and disconnecting downspouts, combines elements of the natural environment and traditional stormwater drainage systems to improve water quality and restore ecosystems. GSI is a cost-effective, resilient approach to treating stormwater by reducing and treating it at its source.

The City implements GSI practices by incorporating them into larger City projects through research projects and grants, partnerships with local organizations, and by working with other City departments. In 2018 the City published the Sustainability Roadmap (City of Durham, 2018b) which identified implementing GSI practices as a strategy to protect and restore Durham's natural resources and ecosystem. Low Impact Development (LID) is implemented through the Stormwater Performance Standards for Development (City of Durham, 2012b) and the Durham City-County UDO (Unified Development Ordinance; Durham City-County Planning Department, 2021).

The evaluation of GSI-LID opportunities in the New Hope Creek and Little Creek watershed involved field evaluation of a Geographic Information Systems (GIS) based ReGIn analysis that was conducted in 2017 (City of Durham, 2017). Because many of these potential sites are located on private property and some areas of the watershed contained soils with low hydraulic conductivity, GSI-LID practices will likely not be implemented on all sites.

Watershed improvement scenario results show that using GSI-LID practices reduces TN by 2.6%, TP by 2.6%, and TSS by 6.6% compared to Scenario 4 (future land use with stormwater performance standards for new development ordinance).

6.5 Street Sweeping

The City regularly sweeps the streets within city limits to remove trash, sediment, and debris. Street sediments and debris can contain pollutants such as nutrients, fecal bacteria, trace metals, hydrocarbons, and pesticides. Collecting and disposing such pollutants before they enter the storm drain can significantly enhance the water quality of streams within the New Hope Creek and Little Creek watershed and Jordan Lake.

Watershed improvement scenario results show that enhancing street sweeping within City limits has the potential to reduce TN by 6.8%, TP by 6.5%, and TSS by 7.8% under future development conditions.

6.6 Protection and Preservation of High-Quality Riparian Areas

While a significant portion of the riparian buffers along the mainstem and tributaries of New Hope Creek and Little Creek are already protected through public ownership or development restrictions, additional opportunities for protection exist.

The City's Riparian Area Management Plan (RAMP) identifies maintenance practice opportunities to enhance or extend riparian buffers or to improve existing maintenance practices on city-owned property near and along streams. The document has been updated for this WIP to include field data collection on no mow buffer zones and provide strategies to implement new no mow sites.

The City's Critical Areas Protection Plan (CAPP) identifies privately-owned parcels with high-quality riparian buffers that could be prioritized for conservation or protection to preserve water quality and watershed health. These buffers protect and maintain vegetative systems along streams and provide biological and hydrologic benefits by diffusing and treating stormwater runoff. For the New Hope Creek and Little Creek study area, 103 keystone parcels and 14 urban gems were identified. See Volume III, Appendix F of this WIP for definitions of keystone and urban gem properties.

Twenty of the 103 keystone parcels and 1 of the 14 urban gems were located within the Mud Creek subwatershed. Eight parcels have riparian buffers along the main stem of Mud Creek which could link the Duke Forest parcels in the north with the publicly protected open space in the south that are located adjacent to New Hope Creek.

Twenty-two keystone parcels and 1 urban gem were located within the Sandy Creek subwatershed. Three parcels bordering four schools (Cresset Christian Academy, Durham Academy Lower School, Durham Academy Upper School, and the Hill Center) could provide a habitat connection between Duke Forest and the Sandy Creek park. South of Sandy Creek park, 3 keystone parcels would help connect Sandy Creek Park to publicly protected open space along New Hope Creek.

Fifty-one keystone parcels and 12 urban gems were located within the New Hope Creek subwatershed. Most of the high scoring parcels in this subwatershed are located to the north, near the confluence of Mud Creek and Sandy Creek into New Hope Creek and contain several existing trails. Protection of the riparian buffers of these parcels would help link to other protected open spaces in the Mud and Sandy Creek subwatersheds. Most of the urban gem properties are vacant parcels adjacent to keystone parcels or protected open space.

Ten keystone parcels were located within the Little Creek watershed. The two highest scoring keystone parcels border each other and have the same owner. Both parcels are large (54 acres and 20 acres), mostly forested, and contain a stream that flows into Little Creek approximately 1,700 feet downstream. The largest and the highest rated vacant keystone parcel is 64 acres. This parcel also contains the only segment of stream that was rated as a high-quality stream. The CAPP analysis and subsequent engagement with various stakeholders did not identify any urban gems within the Little Creek Watershed. Within this watershed, there were very few parcels within the City Limits that contained a stream segment that were not already identified as either a keystone property or as protected open space.

A complete list of keystone parcels and urban gems identified in the New Hope Creek and Little Creek watershed is provided in Volume III, Appendix F, of this WIP.

6.7 Continuation of Existing City Programs and Practices

The City's Stormwater & GIS Services Division is actively engaged in many activities that improve and protect watershed and water quality conditions in the New Hope Creek and Little Creek watershed. Examples of ongoing City activities and partnerships that help to manage stormwater and reduce pollutants of concern in the watershed include:

KEYSTONE properties are the highest-priority parcels identified for protection in each watershed that can expand high-quality riparian areas that are already protected, such as existing parks, or that could serve as parcels around which larger protected areas might be built.

URBAN GEMS are properties that contain high-quality riparian areas in heavily urbanized portions of each watershed which are isolated or lack connectivity to other protected open spaces. Although Urban Gems would not qualify as a keystone property, they still hold specific individual characteristics that are deemed particularly worthy of protection.

- Jordan Lake One Water (JLOW) partnership
- Street sweeping
- Environmental equity and inclusion
- Upper Cape Fear River Basin Association (UCFRBA) partnership
- Illicit discharge detection and elimination
- Post-construction runoff control
- Watershed protection ordinances
- Pollutant source tracking
- Water quality and biological monitoring
- Wastewater treatment improvements
- Stormwater research
- Flood prevention and mitigation
- Environmental education programs
- Collaboration among City departments

Additional information on each program is presented in Section 8.1 of Volume II of this WIP.

6.8 Evaluating Progress

Progress toward protecting water quality in the New Hope Creek and its tributaries is an ongoing process in which new information is used to inform actions needed to protect or restore water quality. The City assesses the effectiveness of existing controls, programs, and practices toward achieving the desired water quality goals. This information is then used to adjust project implementation plans as needed.

Current monitoring and assessment tools used to protect the New Hope Creek and Little Creek watershed and implement nutrient management strategies for Jordan Lake are presented in Table 6-1.

Table 6-1. Information used to track the effectiveness of controls in the New Hope Creek and Little Creek watershed

Category	Collected or Reported Information	Implementation Schedule
Water quality	Ambient water chemistry is collected at 11 locations in the New Hope Creek and Little Creek watershed, and WQI and water quality analyses are reported annually in the City's State of Our Streams Report (City of Durham, 2019a). Water quality data are available through the City's web portal (http://www.durhamwaterquality.org). Chemical water quality monitoring is also performed by the North Carolina Department of Environmental Quality (NCDEQ) and UCFRBA throughout the watershed.	Ongoing
Benthic community and freshwater mussels	Biological data including benthic macroinvertebrate data have been collected by the City, NCDEQ, and UCFRBA. The City has collected benthic macroinvertebrate data at two stations within the watershed, one on Mud Creek and other on Sandy Creek.	Every other year
Nutrient loading	Jordan Lake undergoes continual water quality monitoring as required by the Jordan Lake Nutrient Management Strategy. A three-year study of Jordan Lake nutrient loading (Jordan Lake Study) was conducted by researchers at multiple universities within North Carolina and submitted in 2020. The study sought to provide actionable information for decision-makers regarding sustaining water quality in Jordan Lake.	2020 and future updates
Sediment chemistry	The City conducted a comprehensive water quality study for Sandy Creek watershed between February 2018 and January 2019 that included sediment sampling (City of Durham, 2019b). This information will serve as a reference and baseline for future sediment sampling.	2018-2019
Streamflow and flooding	Streamflow and stage are recorded at two U.S. Geological Survey (USGS) gages located on Sandy Creek and New Hope Creek. The City manages a flood warning gage monitoring system for portions of the New Hope Creek watershed.	Ongoing
SCM retrofits	The City maintains a database of all SCMs installed by the City or others within the city under the Stormwater Performance Standards for Development Ordinance (City of Durham, 2012b) as well as completed retrofit SCMs that were not installed under these requirements.	Ongoing with frequent updates
SCM retrofits (potential)	The City tracks potential or proposed SCM retrofits and new SCMs identified through watershed planning studies and, on an annual basis, selects projects for CIP funding.	Ongoing with frequent updates
SCM maintenance	The City tracks SCM inspection and maintenance actions for all SCMs.	Ongoing with frequent updates
GSI-LID Implementation	The City tracks the implementation of GSI-LID practices throughout the city.	Ongoing with frequent updates

CIP = capital improvement plan

GSI-LID = green infrastructure – low impact development

SCM = stormwater control measure

WQI = Water Quality Index

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7 References

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**Appendix A:
Fact Sheets for Recommended
High-Priority Projects**

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**CITY OF DURHAM STORMWATER AND GIS SERVICES
PROPOSED PROJECT FACT SHEET**

Watershed: **Lower NHC**

Project ID: **00497**

Project: **SCM**

Project Type: **Constructed Wetland**

Project Description **SCM Type: existing**

Convert a dry pond to a constructed wetland. The existing SCM appears to have been designed under earlier SCM standards. There is some room on the site to accommodate an appropriately-sized constructed wetland.

Watershed and Site Characteristics **Subwatershed: NHC32**

Location: 3105 TOWER BLVD	
Date of Field Evaluation: 12/16/2019	Number of Parcels Affected: 1
Projects Within Subwatershed: 14	Ownership: Private
Contributing Drainage Area: 23.0 ac	Property Owner: BRE/ESA TX PROPERTIES
Slope of the Drainage Area: 10.9 %	Willingness to Cooperate: Not yet contacted
Impervious Cover: 59 %	Land Use of Site: Commercial
Accessibility to Retrofit Site: Accessible by Foot	Receiving Water: Jordan Lake
Land Use in Contributing Drainage Area:	DWQ Class: WS-V; NSW
Residential: 28%	Use Support Rating: No data
Commercial: 52%	Sensitive Areas:
Industrial: 0%	Existing Volume (ac-ft): 0.56
Institutional: 0%	Proposed Volume (ac-ft): 0.56
Agricultural: 0%	Land Area of Retrofit Project (acres): 0.08
Parks and Open Space: 0%	Water Quality (1") Design Volume (ac-ft): 0.24
Roads and Road Right-of-Way: 20%	1-Year Storm Runoff Volume (ac-ft): 4.60
RTP: 0%	10-Year Storm Runoff Volume (ac-ft): 10.37

Implementation Costs and Water Quality Benefits Provided by the Project

Estimated Costs (Includes 20 Years of O&M)	Water Quality Parameter	Pollutant Removal		
		Per Year	\$ Per Year	Efficiency
Construction: \$122,900	Total Nitrogen (lbs/yr):	26.0	\$7,770	10 %
Eng./Admin/Permitting: \$65,000	Total Phosphorus (lbs/yr):	2.0	\$101,000	10 %
Other Costs (Land, Site Factors): \$14,000	Sediment (lbs/yr):	5,591	\$40	85 %
20-year O&M: \$0	Fecal Coliform (cfu*109/yr):			%
Total Cost: \$202,000	Copper (lbs/yr):			%
Proposed Implementation: 2020	Zinc (lbs/yr):			%

Photos



PROPOSED PROJECT FACT SHEET

Subwatershed NHC32

Project ID: 00497

Project: SCM

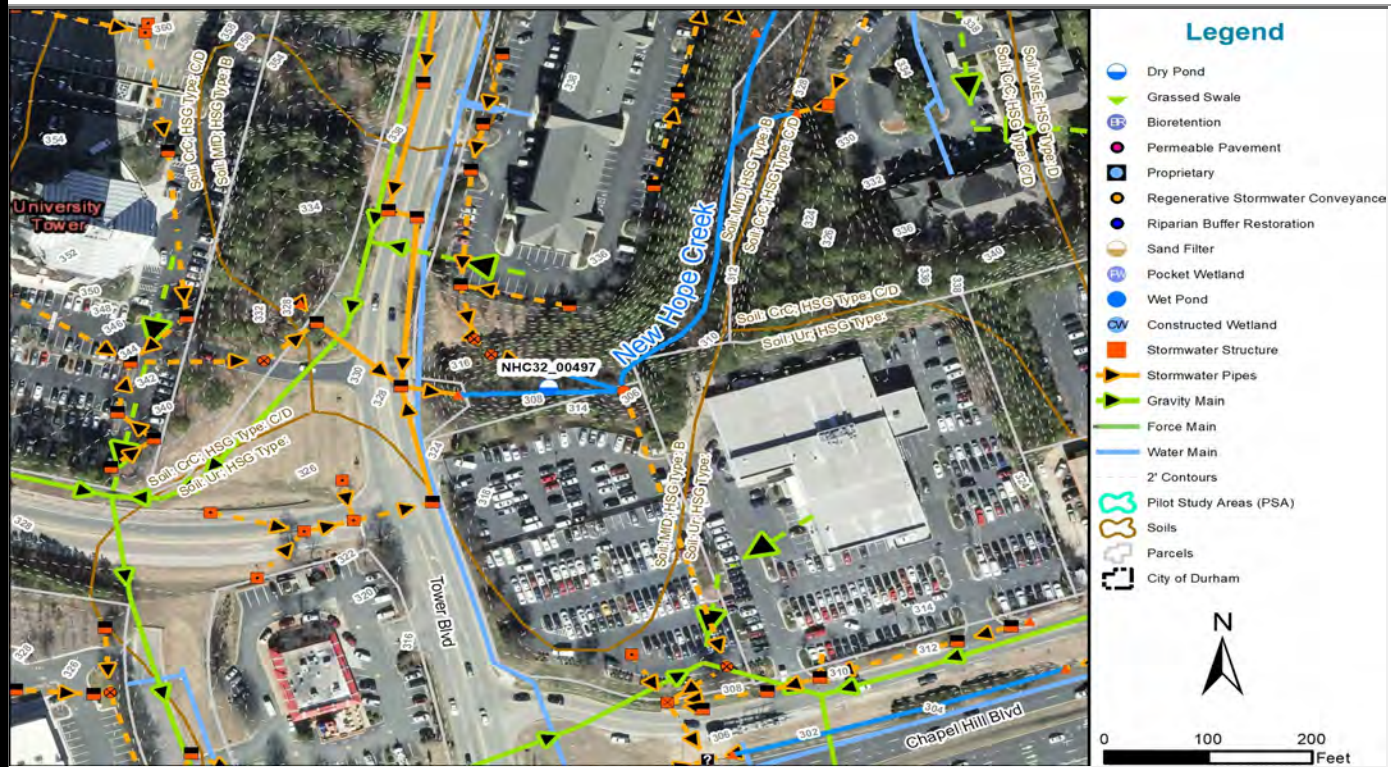


Figure 1 - Plan View of SCM Project

Prioritization Criteria Scores

Criteria	Score	Criteria	Score
<u>Water Quality Benefits</u>		<u>Community Enhancement</u>	
TN	10.0	Property Protection	0.0
TP	10.0	Property Protection Bonus	
Sediment	7.5	Property Owner/Acceptance	2.0
Fecal Coliform	6.0	Acceptance Bonus	
Copper		Public Education	3.0
Zinc		<u>Implementation Issue</u>	
Water Quality Bonus		Property Ownership	3.0
<u>Habitat and Biological Integrity</u>		Accessibility for Construction	2.0
Habitat/Biology	15.0	City Program Compatibility	5.0
Habitat/Biology Bonus		Permitting/Adverse Env. Impacts	5.0
<u>Stream Bank Protection</u>		Permitting Bonus	
Stream Bank Protection	0.0	Total Project Score	
<u>Public Safety and Public Property</u>			
Public Safety and Property	0.0		
Safety Bonus			

NCDEQ Stormwater Nitrogen And Phosphorus (SNAP) Tool (version 4.1 Draft Final)

	Total Nitrogen	Total Phosphorus
Existing Unit Area Load:	6.07 lbs/ac/yr	2.21 lbs/ac/yr
Existing Annual Load:	139.54 lbs/yr	50.87 lbs/yr
Percent Reduction:	46 %	76 %
Post-SCM Annual Load	75.51 lbs/yr	11.97 lbs/yr
Post-SCM Unit Area Load:	3.29 lbs/ac/yr	0.52 lbs/ac/yr
Annual Load Reduction:	64.03 lbs/yr	38.9 lbs/yr
Annual Unit Area Load Reduction:	2.78 lbs/ac/yr	1.69 lbs/ac/yr

Notes

PIDs: 0810-06-28-5687



**CITY OF DURHAM STORMWATER AND GIS SERVICES
PROPOSED PROJECT FACT SHEET**

Watershed: **Mud Creek**

Project ID: **NHCMC0068**

Project: **SCM**

Project Type: **Wet Pond**

Project Description

SCM Type: **existing**

Simple control structure modification at an existing wet pond. This wet pond appears to have been designed to previous SCM standards. An updated design could be implemented to improve water quality treatment.

Watershed and Site Characteristics

Subwatershed: NHC47

Location: N/A	Number of Parcels Affected: 1
Date of Field Evaluation: 12/20/2019	Ownership: Private
Projects Within Subwatershed: 6	Property Owner: SPYGLASS-DURHAM LLC
Contributing Drainage Area: 23.9 ac	Willingness to Cooperate: Not yet contacted
Slope of the Drainage Area: 9.9 %	Land Use of Site: High Density Residential
Impervious Cover: 30 %	Receiving Water: Jordan Lake
Accessibility to Retrofit Site: Accessible by Vehicle	DWQ Class: WS-V; NSW
Land Use in Contributing Drainage Area:	Use Support Rating: No data
Residential: 97%	Sensitive Areas: Wetland
Commercial: 0%	Existing Volume (ac-ft): 0.43
Industrial: 0%	Proposed Volume (ac-ft): 0.43
Institutional: 0%	Land Area of Retrofit Project (acres): 0.89
Agricultural: 0%	Water Quality (1") Design Volume (ac-ft): 0.53
Parks and Open Space: 0%	1-Year Storm Runoff Volume (ac-ft): 4.11
Roads and Road Right-of-Way: 3%	10-Year Storm Runoff Volume (ac-ft): 9.97
RTP: 0%	

Implementation Costs and Water Quality Benefits Provided by the Project

Estimated Costs (Includes 20 Years of O&M)	Water Quality Parameter	Pollutant Removal		
		Per Year	\$ Per Year	Efficiency
Construction: \$20,800	Total Nitrogen (lbs/yr):	36.0	\$6,670	30 %
Eng./Admin/Permitting: \$65,000	Total Phosphorus (lbs/yr):	3.0	\$80,000	30 %
Other Costs (Land, Site Factors): \$154,000	Sediment (lbs/yr):	1,604	\$150	85 %
20-year O&M: \$0	Fecal Coliform (cfu*109/yr):			%
Total Cost: \$240,000	Copper (lbs/yr):			%
Proposed Implementation: 2020	Zinc (lbs/yr):			%

Photos



PROPOSED PROJECT FACT SHEET

Subwatershed NHC47

Project ID: NHCMC0068

Project: SCM

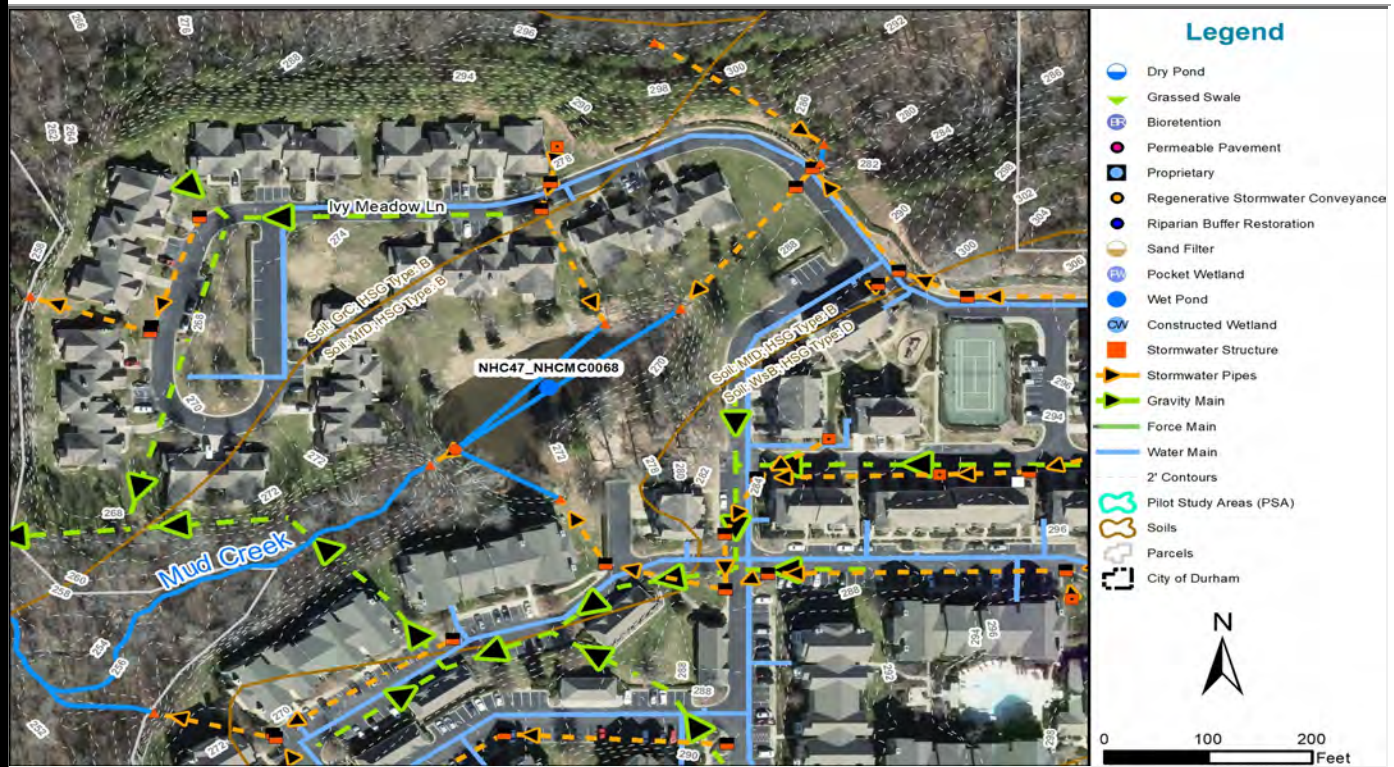


Figure 1 - Plan View of SCM Project

Prioritization Criteria Scores

Criteria	Score	Criteria	Score
<u>Water Quality Benefits</u>		<u>Community Enhancement</u>	
TN	10.0	Property Protection	0.0
TP	10.0	Property Protection Bonus	
Sediment	4.5	Property Owner/Acceptance	2.0
Fecal Coliform	1.5	Acceptance Bonus	
Copper		Public Education	3.0
Zinc		<u>Implementation Issue</u>	
Water Quality Bonus		Property Ownership	3.0
<u>Habitat and Biological Integrity</u>		Accessibility for Construction	5.0
Habitat/Biology	15.0	City Program Compatability	5.0
Habitat/Biology Bonus		Permitting/Adverse Env. Impacts	5.0
<u>Stream Bank Protection</u>		Permitting Bonus	
Stream Bank Protection	0.0	Total Project Score	
<u>Public Safety and Public Property</u>			
Public Safety and Property	0.0		
Safety Bonus			

NCDEQ Stormwater Nitrogen And Phosphorus (SNAP) Tool (version 4.1 Draft Final)

	Total Nitrogen	Total Phosphorus
Existing Unit Area Load:	4.17 lbs/ac/yr	0.59 lbs/ac/yr
Existing Annual Load:	96.63 lbs/yr	13.76 lbs/yr
Percent Reduction:	23 %	32 %
Post-SCM Annual Load	74.03 lbs/yr	9.39 lbs/yr
Post-SCM Unit Area Load:	3.19 lbs/ac/yr	0.41 lbs/ac/yr
Annual Load Reduction:	22.6 lbs/yr	4.37 lbs/yr
Annual Unit Area Load Reduction:	0.98 lbs/ac/yr	0.18 lbs/ac/yr

Notes

PIDs: 0800-02-66-1814



**CITY OF DURHAM STORMWATER AND GIS SERVICES
PROPOSED PROJECT FACT SHEET**

Watershed: **Mud Creek**

Project ID: **NHCMC0054**

Project: **SCM**

Project Type: **Constructed Wetland**

Project Description **SCM Type: new**

Proposed 15,000 square foot constructed wetland located in a city park that also collects runoff from an apartment complex.

Watershed and Site Characteristics **Subwatershed: NHC51**

Location: 1102 MORREENE RD	Number of Parcels Affected: 1
Date of Field Evaluation: 12/20/2019	Ownership: Public
Projects Within Subwatershed: 7	Property Owner: CITY OF DURHAM ATTN
Contributing Drainage Area: 4.0 ac	Willingness to Cooperate: Not yet contacted
Slope of the Drainage Area: 8.0 %	Land Use of Site: Parks & Open Space
Impervious Cover: 24 %	Receiving Water: Jordan Lake
Accessibility to Retrofit Site: Accessible by Vehicle	DWQ Class: WS-V; NSW
Land Use in Contributing Drainage Area:	Use Support Rating: No data
Residential: 0%	Sensitive Areas:
Commercial: 0%	Existing Volume (ac-ft):
Industrial: 0%	Proposed Volume (ac-ft): 0.12
Institutional: 47%	Land Area of Retrofit Project (acres): 0.34
Agricultural: 0%	Water Quality (1") Design Volume (ac-ft): 0.00
Parks and Open Space: 48%	1-Year Storm Runoff Volume (ac-ft): 0.83
Roads and Road Right-of-Way: 5%	10-Year Storm Runoff Volume (ac-ft): 1.87
RTP: 0%	

Implementation Costs and Water Quality Benefits Provided by the Project

Estimated Costs (Includes 20 Years of O&M)	Water Quality Parameter	Pollutant Removal		
		Per Year	\$ Per Year	Efficiency
Construction: \$106,500	Total Nitrogen (lbs/yr):	12.0	\$25,830	44 %
Eng./Admin/Permitting: \$65,000	Total Phosphorus (lbs/yr):	1.0	\$310,000	40 %
Other Costs (Land, Site Factors): \$59,000	Sediment (lbs/yr):	403	\$770	85 %
20-year O&M: \$79,000	Fecal Coliform (cfu*109/yr):			%
Total Cost: \$310,000	Copper (lbs/yr):			%
Proposed Implementation:	Zinc (lbs/yr):			%

Photos



PROPOSED PROJECT FACT SHEET

Subwatershed NHC51

Project ID: NHCMC0054

Project: SCM



Figure 1 - Plan View of SCM Project

Prioritization Criteria Scores

Criteria	Score	Criteria	Score
<u>Water Quality Benefits</u>		<u>Community Enhancement</u>	
TN	10.0	Property Protection	0.0
TP	6.0	Property Protection Bonus	
Sediment	7.5	Property Owner/Acceptance	5.0
Fecal Coliform	6.0	Acceptance Bonus	
Copper		Public Education	5.0
Zinc		<u>Implementation Issue</u>	
Water Quality Bonus		Property Ownership	5.0
<u>Habitat and Biological Integrity</u>		Accessibility for Construction	5.0
Habitat/Biology	0.0	City Program Compatability	5.0
Habitat/Biology Bonus		Permitting/Adverse Env. Impacts	4.0
<u>Stream Bank Protection</u>		Permitting Bonus	
Stream Bank Protection	0.0	Total Project Score	
<u>Public Safety and Public Property</u>			
Public Safety and Property	0.0		
Safety Bonus			

NCDEQ Stormwater Nitrogen And Phosphorus (SNAP) Tool (version 4.1 Draft Final)

	Total Nitrogen	Total Phosphorus
Existing Unit Area Load:	2.85 lbs/ac/yr	0.45 lbs/ac/yr
Existing Annual Load:	11.44 lbs/yr	1.82 lbs/yr
Percent Reduction:	9 %	10 %
Post-SCM Annual Load	10.43 lbs/yr	1.63 lbs/yr
Post-SCM Unit Area Load:	2.6 lbs/ac/yr	0.41 lbs/ac/yr
Annual Load Reduction:	1.01 lbs/yr	0.19 lbs/yr
Annual Unit Area Load Reduction:	0.25 lbs/ac/yr	0.04 lbs/ac/yr

Notes

PIDs: **0812-18-31-0457**



**CITY OF DURHAM STORMWATER AND GIS SERVICES
PROPOSED PROJECT FACT SHEET**

Watershed: **Lower NHC**

Project ID: **00111**

Project: **SCM**

Project Type: **Constructed Wetland**

Project Description

SCM Type: **existing**

Convert a wet pond to a constructed wetland. The site has room to expand the footprint of the SCM to accommodate an appropriately-sized constructed wetland.

Watershed and Site Characteristics

Subwatershed: **NHC09**

Location: 4 Bobcat Court	Number of Parcels Affected: 2
Date of Field Evaluation: 12/18/2019	Ownership: Private
Projects Within Subwatershed: 12	Property Owner: HUNTINGTON RIDGE HO
Contributing Drainage Area: 10.1 ac	Willingness to Cooperate: Not yet contacted
Slope of the Drainage Area: 7.3 %	Land Use of Site: High Density Residential
Impervious Cover: 45 %	Receiving Water: Jordan Lake
Accessibility to Retrofit Site: Accessible by Vehicle	DWQ Class: WS-IV; NSW
Land Use in Contributing Drainage Area:	Use Support Rating: No data
Residential: 63%	Sensitive Areas: NSW
Commercial: 0%	Existing Volume (ac-ft): 0.36
Industrial: 0%	Proposed Volume (ac-ft): 0.36
Institutional: 0%	Land Area of Retrofit Project (acres): 0.25
Agricultural: 0%	Water Quality (1") Design Volume (ac-ft): 0.56
Parks and Open Space: 7%	1-Year Storm Runoff Volume (ac-ft): 2.21
Roads and Road Right-of-Way: 29%	10-Year Storm Runoff Volume (ac-ft): 4.79
RTP: 0%	

Implementation Costs and Water Quality Benefits Provided by the Project

Estimated Costs (Includes 20 Years of O&M)	Water Quality Parameter	Pollutant Removal		
		Per Year	\$ Per Year	Efficiency
Construction: \$122,900	Total Nitrogen (lbs/yr):	31.0	\$7,420	30 %
Eng./ Admin/Permitting: \$65,000	Total Phosphorus (lbs/yr):	3.0	\$76,670	30 %
Other Costs (Land, Site Factors): \$42,000	Sediment (lbs/yr):	1,782	\$130	85 %
20-year O&M: \$0	Fecal Coliform (cfu*109/yr):			%
Total Cost: \$230,000	Copper (lbs/yr):			%
Proposed Implementation: 2020	Zinc (lbs/yr):			%

Photos



PROPOSED PROJECT FACT SHEET

Subwatershed NHC09

Project ID: 00111

Project: SCM



Figure 1 - Plan View of SCM Project

Prioritization Criteria Scores

Criteria	Score	Criteria	Score
<u>Water Quality Benefits</u>		<u>Community Enhancement</u>	
TN	10.0	Property Protection	0.0
TP	10.0	Property Protection Bonus	
Sediment	7.5	Property Owner/Acceptance	2.0
Fecal Coliform	6.0	Acceptance Bonus	
Copper		Public Education	3.0
Zinc		<u>Implementation Issue</u>	
Water Quality Bonus		Property Ownership	3.0
<u>Habitat and Biological Integrity</u>		Accessibility for Construction	5.0
Habitat/Biology	0.0	City Program Compatability	5.0
Habitat/Biology Bonus		Permitting/Adverse Env. Impacts	5.0
<u>Stream Bank Protection</u>		Permitting Bonus	
Stream Bank Protection	0.0	Total Project Score	
<u>Public Safety and Public Property</u>			
Public Safety and Property	0.0		
Safety Bonus			

NCDEQ Stormwater Nitrogen And Phosphorus (SNAP) Tool (version 4.1 Draft Final)

	Total Nitrogen	Total Phosphorus
Existing Unit Area Load:	4.05 lbs/ac/yr	0.54 lbs/ac/yr
Existing Annual Load:	40.85 lbs/yr	5.43 lbs/yr
Percent Reduction:	21 %	2 %
Post-SCM Annual Load	32.42 lbs/yr	5.34 lbs/yr
Post-SCM Unit Area Load:	3.22 lbs/ac/yr	0.53 lbs/ac/yr
Annual Load Reduction:	8.43 lbs/yr	0.09 lbs/yr
Annual Unit Area Load Reduction:	0.83 lbs/ac/yr	0.01 lbs/ac/yr

Notes

PIDs: 0717-02-59-4534; 0717-02-69-6600



**CITY OF DURHAM STORMWATER AND GIS SERVICES
PROPOSED PROJECT FACT SHEET**

Watershed: **Sandy Creek**

Project ID: **NHCSC0039**

Project: **SCM**

Project Type: **Constructed Wetland**

Project Description

SCM Type: **new**

Proposed 3,600 square foot constructed wetland collecting parking lot and roof runoff at a high-density residential area.

Watershed and Site Characteristics

Subwatershed: NHC46

Location: 2724 CAMPUS WALK AVE

Date of Field Evaluation: 12/19/2019

Number of Parcels Affected: 1

Projects Within Subwatershed: 25

Ownership: Private

Contributing Drainage Area: 3.3 ac

Property Owner: TRINITY PROPERTIES LLC

Slope of the Drainage Area: 7.3 %

Willingness to Cooperate: Not yet contacted

Impervious Cover: 46 %

Land Use of Site: High Density Residential

Accessibility to Retrofit Site: Accessible by Vehicle

Receiving Water: Jordan Lake

Land Use in Contributing Drainage Area:

DWQ Class: WS-V; NSW

Residential: 100%

Use Support Rating: No data

Commercial: 0%

Sensitive Areas:

Industrial: 0%

Existing Volume (ac-ft):

Institutional: 0%

Proposed Volume (ac-ft): 0.17

Agricultural: 0%

Land Area of Retrofit Project (acres): 0.08

Parks and Open Space: 0%

Water Quality (1") Design Volume (ac-ft): 0.00

Roads and Road Right-of-Way: 0%

1-Year Storm Runoff Volume (ac-ft): 0.74

RTP: 0%

10-Year Storm Runoff Volume (ac-ft): 1.60

Implementation Costs and Water Quality Benefits Provided by the Project

Estimated Costs (Includes 20 Years of O&M)	Water Quality Parameter	Pollutant Removal		
		Per Year	\$ Per Year	Efficiency
Construction: \$106,500	Total Nitrogen (lbs/yr):	15.0	\$17,670	44 %
Eng./Admin/Permitting: \$65,000	Total Phosphorus (lbs/yr):	1.0	\$265,000	40 %
Other Costs (Land, Site Factors): \$14,000	Sediment (lbs/yr):	302	\$880	85 %
20-year O&M: \$79,000	Fecal Coliform (cfu*109/yr):			%
Total Cost: \$265,000	Copper (lbs/yr):			%
Proposed Implementation:	Zinc (lbs/yr):			%

Photos



PROPOSED PROJECT FACT SHEET

Project ID: **NHCSC0039**

Subwatershed **NHC46**

Project: **SCM**

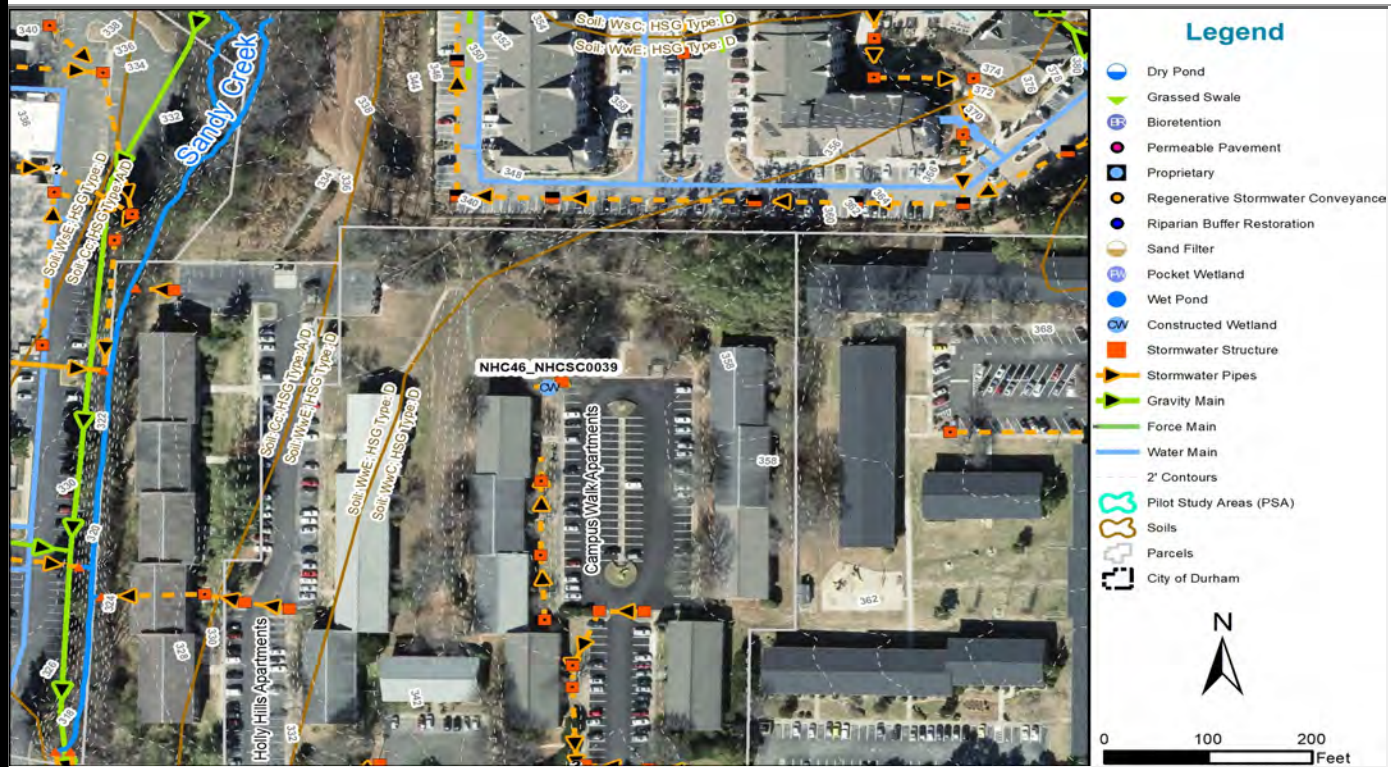


Figure 1 - Plan View of SCM Project

Prioritization Criteria Scores

Criteria	Score	Criteria	Score
<u>Water Quality Benefits</u>		<u>Community Enhancement</u>	
TN	10.0	Property Protection	1.0
TP	10.0	Property Protection Bonus	
Sediment	7.5	Property Owner/Acceptance	4.0
Fecal Coliform	6.0	Acceptance Bonus	
Copper		Public Education	3.0
Zinc		<u>Implementation Issue</u>	
Water Quality Bonus		Property Ownership	3.0
<u>Habitat and Biological Integrity</u>		Accessibility for Construction	5.0
Habitat/Biology	0.0	City Program Compatability	0.0
Habitat/Biology Bonus		Permitting/Adverse Env. Impacts	5.0
<u>Stream Bank Protection</u>		Permitting Bonus	
Stream Bank Protection	0.0	Total Project Score	
<u>Public Safety and Public Property</u>			
Public Safety and Property	0.0		
Safety Bonus			

NCDEQ Stormwater Nitrogen And Phosphorus (SNAP) Tool (version 4.1 Draft Final)

	Total Nitrogen	Total Phosphorus
Existing Unit Area Load:	5.47 lbs/ac/yr	0.72 lbs/ac/yr
Existing Annual Load:	18.13 lbs/yr	2.38 lbs/yr
Percent Reduction:	28 %	16 %
Post-SCM Annual Load	13.07 lbs/yr	2 lbs/yr
Post-SCM Unit Area Load:	3.95 lbs/ac/yr	0.61 lbs/ac/yr
Annual Load Reduction:	5.06 lbs/yr	0.38 lbs/yr
Annual Unit Area Load Reduction:	1.52 lbs/ac/yr	0.11 lbs/ac/yr

Notes

PIDs: **0812-14-42-5719**



**CITY OF DURHAM STORMWATER AND GIS SERVICES
PROPOSED PROJECT FACT SHEET**

Watershed: **Sandy Creek**

Project ID: **NHCSC0027**

Project: **SCM**

Project Type: **Constructed Wetland**

Project Description **SCM Type: new**

Proposed 6,600 square foot constructed wetland converted from an existing drainage ditch at the sports fields of a private school.

Watershed and Site Characteristics **Subwatershed: NHC35**

Location: 3601 RIDGE RD	Number of Parcels Affected: 1
Date of Field Evaluation: 12/19/2019	Ownership: Private
Projects Within Subwatershed: 12	Property Owner: DURHAM ACADEMY INC
Contributing Drainage Area: 10.6 ac	Willingness to Cooperate: Not yet contacted
Slope of the Drainage Area: 8.4 %	Land Use of Site: Institutional
Impervious Cover: 48 %	Receiving Water: Jordan Lake
Accessibility to Retrofit Site: Accessible by Vehicle	DWQ Class: WS-V; NSW
Land Use in Contributing Drainage Area:	Use Support Rating: No data
Residential: %	Sensitive Areas: FEMA
Commercial: %	Existing Volume (ac-ft):
Industrial: %	Proposed Volume (ac-ft): 0.56
Institutional: %	Land Area of Retrofit Project (acres): 0.15
Agricultural: %	Water Quality (1") Design Volume (ac-ft): 0.05
Parks and Open Space: %	1-Year Storm Runoff Volume (ac-ft): 2.33
Roads and Road Right-of-Way: %	10-Year Storm Runoff Volume (ac-ft): 5.06
RTP: %	

Implementation Costs and Water Quality Benefits Provided by the Project

Estimated Costs (Includes 20 Years of O&M)	Water Quality Parameter	Pollutant Removal		
		Per Year	\$ Per Year	Efficiency
Construction: \$72,700	Total Nitrogen (lbs/yr):	46.0	\$4,740	44 %
Eng./ Admin/Permitting: \$65,000	Total Phosphorus (lbs/yr):	3.0	\$72,670	40 %
Other Costs (Land, Site Factors): \$26,000	Sediment (lbs/yr):	1,752	\$120	85 %
20-year O&M: \$54,000	Fecal Coliform (cfu*109/yr):			%
Total Cost: \$218,000	Copper (lbs/yr):			%
Proposed Implementation:	Zinc (lbs/yr):			%

Photos



PROPOSED PROJECT FACT SHEET

Project ID: **NHCSC0027**

Subwatershed **NHC35**

Project: **SCM**



Figure 1 - Plan View of SCM Project

Prioritization Criteria Scores

Criteria	Score	Criteria	Score
<u>Water Quality Benefits</u>		<u>Community Enhancement</u>	
TN	10.0	Property Protection	0.0
TP	10.0	Property Protection Bonus	
Sediment	7.5	Property Owner/Acceptance	2.0
Fecal Coliform	6.0	Acceptance Bonus	
Copper		Public Education	4.0
Zinc		<u>Implementation Issue</u>	
Water Quality Bonus		Property Ownership	4.0
<u>Habitat and Biological Integrity</u>		Accessibility for Construction	5.0
Habitat/Biology	0.0	City Program Compatability	0.0
Habitat/Biology Bonus		Permitting/Adverse Env. Impacts	5.0
<u>Stream Bank Protection</u>		Permitting Bonus	
Stream Bank Protection	0.0	Total Project Score	
<u>Public Safety and Public Property</u>			
Public Safety and Property	0.0		
Safety Bonus			

NCDEQ Stormwater Nitrogen And Phosphorus (SNAP) Tool (version 4.1 Draft Final)

	Total Nitrogen	Total Phosphorus
Existing Unit Area Load:	5.73 lbs/ac/yr	0.8 lbs/ac/yr
Existing Annual Load:	60.71 lbs/yr	8.5 lbs/yr
Percent Reduction:	31 %	24 %
Post-SCM Annual Load	41.82 lbs/yr	6.5 lbs/yr
Post-SCM Unit Area Load:	3.94 lbs/ac/yr	0.61 lbs/ac/yr
Annual Load Reduction:	18.89 lbs/yr	2 lbs/yr
Annual Unit Area Load Reduction:	1.79 lbs/ac/yr	0.19 lbs/ac/yr

Notes

PIDs: **0801-03-90-6758**



**CITY OF DURHAM STORMWATER AND GIS SERVICES
PROPOSED PROJECT FACT SHEET**

Watershed: **Lower NHC**

Project ID: **00103**

Project: **SCM**

Project Type: **Constructed Wetland**

Project Description

SCM Type: **existing**

Convert a wet pond to a constructed wetland. There appears to be room to expand the footprint of the SCM if necessary, and a constructed wetland would be safer (because the water would not be as deep) and more appealing than the existing wet pond (because of the vegetation).

Watershed and Site Characteristics

Subwatershed: **NHC12**

Location: 5210 Highgate Drive	Number of Parcels Affected: 3
Date of Field Evaluation: 12/18/2019	Ownership: Private
Projects Within Subwatershed: 28	Property Owner: HIGHGATE TOWNHOMES
Contributing Drainage Area: 7.8 ac	Willingness to Cooperate: Not yet contacted
Slope of the Drainage Area: 10.3 %	Land Use of Site: High Density Residential
Impervious Cover: 44 %	Receiving Water: Jordan Lake
Accessibility to Retrofit Site: Accessible by Vehicle	DWQ Class: WS-IV; NSW
Land Use in Contributing Drainage Area:	Use Support Rating: No data
Residential: 68%	Sensitive Areas: NSW
Commercial: 29%	Existing Volume (ac-ft): 0.21
Industrial: 0%	Proposed Volume (ac-ft): 0.21
Institutional: 0%	Land Area of Retrofit Project (acres): 0.15
Agricultural: 0%	Water Quality (1") Design Volume (ac-ft): 0.29
Parks and Open Space: 0%	1-Year Storm Runoff Volume (ac-ft): 1.75
Roads and Road Right-of-Way: 3%	10-Year Storm Runoff Volume (ac-ft): 3.74
RTP: 0%	

Implementation Costs and Water Quality Benefits Provided by the Project

Estimated Costs (Includes 20 Years of O&M)	Water Quality Parameter	Pollutant Removal		
		Per Year	\$ Per Year	Efficiency
Construction: \$109,700	Total Nitrogen (lbs/yr):	26.0	\$7,730	30 %
Eng./Admin/Permitting: \$65,000	Total Phosphorus (lbs/yr):	2.0	\$100,500	30 %
Other Costs (Land, Site Factors): \$26,000	Sediment (lbs/yr):	1,218	\$170	85 %
20-year O&M: \$0	Fecal Coliform (cfu*109/yr):			%
Total Cost: \$201,000	Copper (lbs/yr):			%
Proposed Implementation: 2020	Zinc (lbs/yr):			%

Photos



PROPOSED PROJECT FACT SHEET

Subwatershed NHC12

Project ID: 00103

Project: SCM

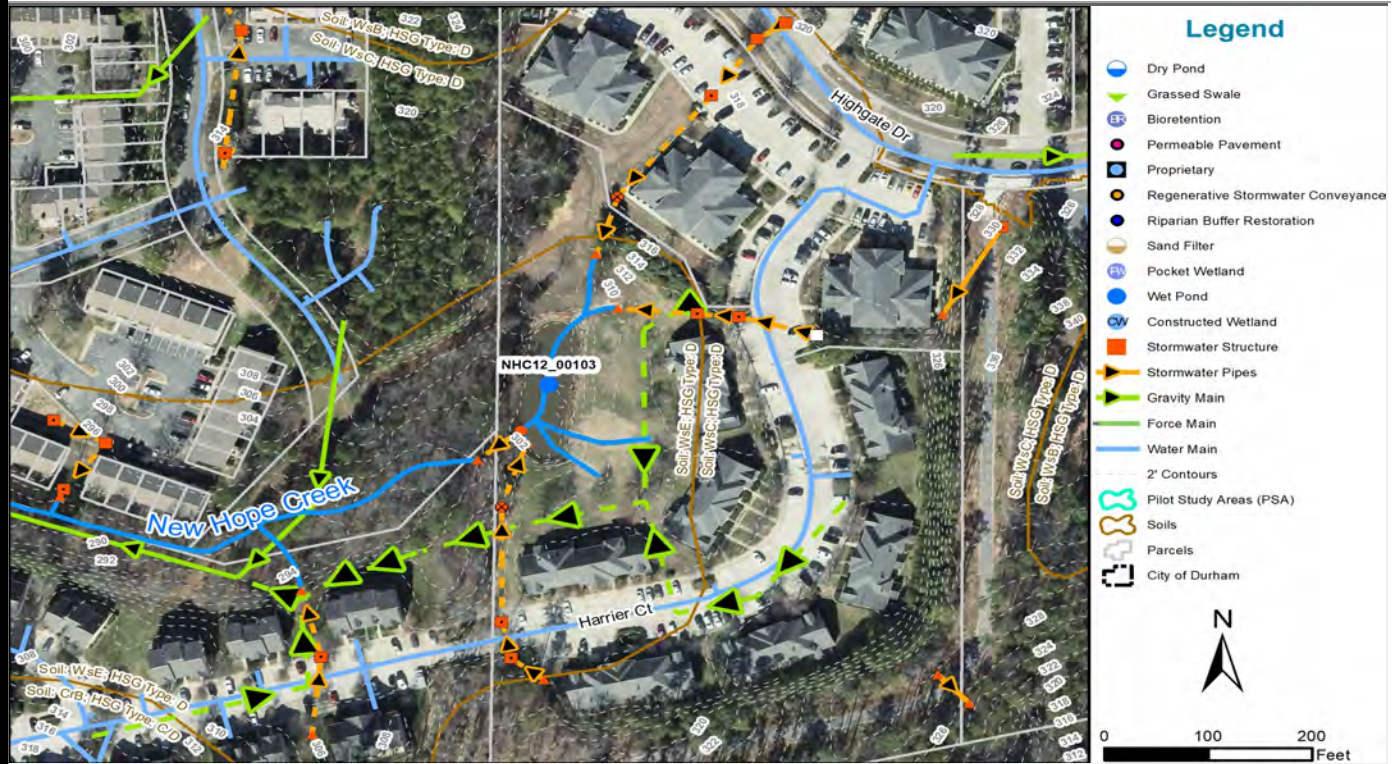


Figure 1 - Plan View of SCM Project

Prioritization Criteria Scores

Criteria	Score	Criteria	Score
<u>Water Quality Benefits</u>		<u>Community Enhancement</u>	
TN	10.0	Property Protection	0.0
TP	10.0	Property Protection Bonus	
Sediment	4.5	Property Owner/Acceptance	2.0
Fecal Coliform	6.0	Acceptance Bonus	
Copper		Public Education	3.0
Zinc		<u>Implementation Issue</u>	
Water Quality Bonus		Property Ownership	3.0
<u>Habitat and Biological Integrity</u>		Accessibility for Construction	5.0
Habitat/Biology	0.0	City Program Compatability	5.0
Habitat/Biology Bonus		Permitting/Adverse Env. Impacts	5.0
<u>Stream Bank Protection</u>		Permitting Bonus	
Stream Bank Protection	0.0	Total Project Score	
<u>Public Safety and Public Property</u>			
Public Safety and Property	0.0		
Safety Bonus			

NCDEQ Stormwater Nitrogen And Phosphorus (SNAP) Tool (version 4.1 Draft Final)

	Total Nitrogen	Total Phosphorus
Existing Unit Area Load:	4.93 lbs/ac/yr	0.63 lbs/ac/yr
Existing Annual Load:	38.38 lbs/yr	4.89 lbs/yr
Percent Reduction:	25 %	8 %
Post-SCM Annual Load	28.96 lbs/yr	4.52 lbs/yr
Post-SCM Unit Area Load:	3.72 lbs/ac/yr	0.58 lbs/ac/yr
Annual Load Reduction:	9.42 lbs/yr	0.37 lbs/yr
Annual Unit Area Load Reduction:	1.21 lbs/ac/yr	0.05 lbs/ac/yr

Notes

PIDs: 0718-02-65-9783; 0718-02-66-6098; 0718-55-85-6630



**CITY OF DURHAM STORMWATER AND GIS SERVICES
PROPOSED PROJECT FACT SHEET**

Watershed: **Lower NHC**

Project ID: **00276**

Project: **SCM**

Project Type: **Constructed Wetland**

Project Description **SCM Type: existing**

Convert a dry pond to a constructed wetland. The site has room to expand the footprint of the SCM to accommodate an appropriately-sized constructed wetland. The existing dry pond has standing water and wetland vegetation growing in it which indicates it may support a wetland.

Watershed and Site Characteristics **Subwatershed: NHC09**

Location: 8001 MASSEY CHAPEL RD		Number of Parcels Affected: 1	
Date of Field Evaluation: 12/18/2019		Ownership: Private	
Projects Within Subwatershed: 12		Property Owner: CHELSEA MEADOWS HO	
Contributing Drainage Area: 7.9 ac		Willingness to Cooperate: Not yet contacted	
Slope of the Drainage Area: 7.9 %		Land Use of Site: Low Density Residential	
Impervious Cover: 35 %		Receiving Water: Jordan Lake	
Accessibility to Retrofit Site: Accessible by Vehicle		DWQ Class: WS-IV; NSW	
Land Use in Contributing Drainage Area:		Use Support Rating: No data	
Residential: 60%		Sensitive Areas: NSW	
Commercial: 0%		Existing Volume (ac-ft): 0.32	
Industrial: 0%		Proposed Volume (ac-ft): 0.32	
Institutional: 0%		Land Area of Retrofit Project (acres): 0.31	
Agricultural: 0%		Water Quality (1") Design Volume (ac-ft): 0.04	
Parks and Open Space: 23%		1-Year Storm Runoff Volume (ac-ft): 1.69	
Roads and Road Right-of-Way: 17%		10-Year Storm Runoff Volume (ac-ft): 3.71	
RTP: 0%			

Implementation Costs and Water Quality Benefits Provided by the Project

Estimated Costs (Includes 20 Years of O&M)	Water Quality Parameter	Pollutant Removal		
		Per Year	\$ Per Year	Efficiency
Construction: \$105,100	Total Nitrogen (lbs/yr):	28.0	\$7,960	44 %
Eng./ Admin/Permitting: \$65,000	Total Phosphorus (lbs/yr):	3.0	\$74,330	40 %
Other Costs (Land, Site Factors): \$53,000	Sediment (lbs/yr):	1,060	\$210	85 %
20-year O&M: \$0	Fecal Coliform (cfu*109/yr):			%
Total Cost: \$223,000	Copper (lbs/yr):			%
Proposed Implementation: 2020	Zinc (lbs/yr):			%

Photos



PROPOSED PROJECT FACT SHEET

Subwatershed NHC09

Project ID: 00276

Project: SCM



Figure 1 - Plan View of SCM Project

Prioritization Criteria Scores

Criteria	Score	Criteria	Score
<u>Water Quality Benefits</u>		<u>Community Enhancement</u>	
TN	10.0	Property Protection	0.0
TP	10.0	Property Protection Bonus	
Sediment	4.5	Property Owner/Acceptance	2.0
Fecal Coliform	6.0	Acceptance Bonus	
Copper		Public Education	3.0
Zinc		<u>Implementation Issue</u>	
Water Quality Bonus		Property Ownership	3.0
<u>Habitat and Biological Integrity</u>		Accessibility for Construction	5.0
Habitat/Biology	0.0	City Program Compatability	5.0
Habitat/Biology Bonus		Permitting/Adverse Env. Impacts	5.0
<u>Stream Bank Protection</u>		Permitting Bonus	
Stream Bank Protection	0.0	Total Project Score	
<u>Public Safety and Public Property</u>			
Public Safety and Property	0.0		
Safety Bonus			

NCDEQ Stormwater Nitrogen And Phosphorus (SNAP) Tool (version 4.1 Draft Final)

	Total Nitrogen	Total Phosphorus
Existing Unit Area Load:	4.2 lbs/ac/yr	0.55 lbs/ac/yr
Existing Annual Load:	33.02 lbs/yr	4.3 lbs/yr
Percent Reduction:	18 %	-1 %
Post-SCM Annual Load	27.03 lbs/yr	4.34 lbs/yr
Post-SCM Unit Area Load:	3.44 lbs/ac/yr	0.55 lbs/ac/yr
Annual Load Reduction:	5.99 lbs/yr	-0.04 lbs/yr
Annual Unit Area Load Reduction:	0.76 lbs/ac/yr	0 lbs/ac/yr

Notes

PIDs: 9798-04-91-2487



**CITY OF DURHAM STORMWATER AND GIS SERVICES
PROPOSED PROJECT FACT SHEET**

Watershed: **Mud Creek**

Project ID: **00267**

Project: **SCM**

Project Type: **Pocket Wetland**

Project Description **SCM Type: existing**

Convert dry pond to a pocket wetland. The site is likely too small to accommodate a full-sized wetland, but water quality could be improved with a pocket wetland and the site appears to be able to support a wetland since the existing dry pond has standing water.

Watershed and Site Characteristics **Subwatershed: NHC47**

Location: 3603 Keohane Drive	Number of Parcels Affected: 1
Date of Field Evaluation: 12/16/2019	Ownership: Private
Projects Within Subwatershed: 6	Property Owner: CARILLON FOREST HOM
Contributing Drainage Area: 32.8 ac	Willingness to Cooperate: Not yet contacted
Slope of the Drainage Area: 6.9 %	Land Use of Site: Low Density Residential
Impervious Cover: 33 %	Receiving Water: Jordan Lake
Accessibility to Retrofit Site: Accessible by Vehicle	DWQ Class: WS-V; NSW
Land Use in Contributing Drainage Area:	Use Support Rating: No data
Residential: 66%	Sensitive Areas:
Commercial: 0%	Existing Volume (ac-ft): 1.08
Industrial: 0%	Proposed Volume (ac-ft): 1.08
Institutional: 0%	Land Area of Retrofit Project (acres): 0.35
Agricultural: 0%	Water Quality (1") Design Volume (ac-ft): 0.73
Parks and Open Space: 11%	1-Year Storm Runoff Volume (ac-ft): 6.90
Roads and Road Right-of-Way: 23%	10-Year Storm Runoff Volume (ac-ft): 15.28
RTP: 0%	

Implementation Costs and Water Quality Benefits Provided by the Project

Estimated Costs (Includes 20 Years of O&M)	Water Quality Parameter	Pollutant Removal		
		Per Year	\$ Per Year	Efficiency
Construction: \$90,300	Total Nitrogen (lbs/yr):	26.0	\$8,310	10 %
Eng./ Admin/Permitting: \$65,000	Total Phosphorus (lbs/yr):	2.0	\$108,000	10 %
Other Costs (Land, Site Factors): \$61,000	Sediment (lbs/yr):	4,001	\$50	85 %
20-year O&M: \$0	Fecal Coliform (cfu*109/yr):			%
Total Cost: \$216,000	Copper (lbs/yr):			%
Proposed Implementation: 2020	Zinc (lbs/yr):			%

Photos



PROPOSED PROJECT FACT SHEET

Subwatershed NHC47

Project ID: 00267

Project: SCM

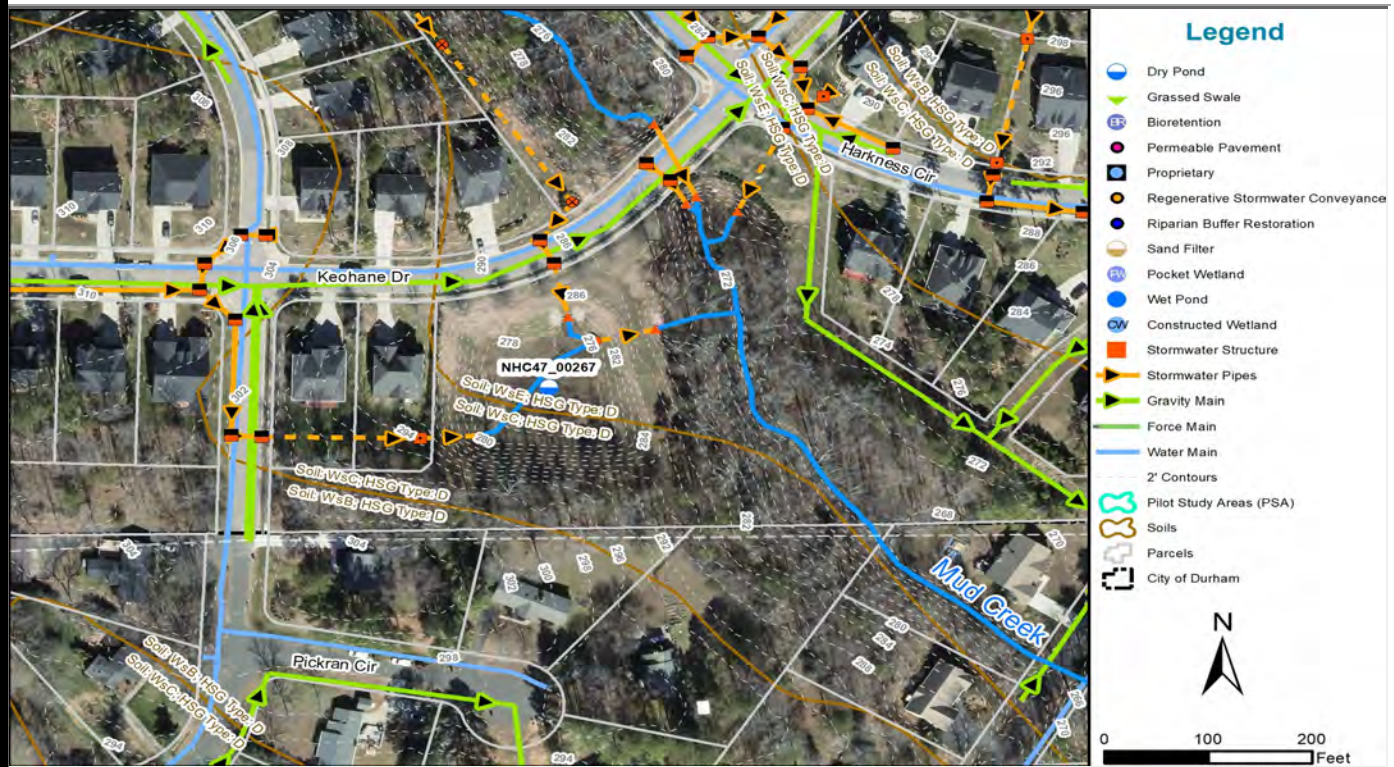


Figure 1 - Plan View of SCM Project

Prioritization Criteria Scores

Criteria	Score	Criteria	Score
<u>Water Quality Benefits</u>		<u>Community Enhancement</u>	
TN	10.0	Property Protection	0.0
TP	6.0	Property Protection Bonus	
Sediment	7.5	Property Owner/Acceptance	2.0
Fecal Coliform	6.0	Acceptance Bonus	
Copper		Public Education	3.0
Zinc		<u>Implementation Issue</u>	
Water Quality Bonus		Property Ownership	3.0
<u>Habitat and Biological Integrity</u>		Accessibility for Construction	5.0
Habitat/Biology	0.0	City Program Compatability	5.0
Habitat/Biology Bonus		Permitting/Adverse Env. Impacts	5.0
<u>Stream Bank Protection</u>		Permitting Bonus	
Stream Bank Protection	0.0	Total Project Score	
<u>Public Safety and Public Property</u>			
Public Safety and Property	0.0		
Safety Bonus			

NCDEQ Stormwater Nitrogen And Phosphorus (SNAP) Tool (version 4.1 Draft Final)

	Total Nitrogen	Total Phosphorus
Existing Unit Area Load:	4.34 lbs/ac/yr	1.6 lbs/ac/yr
Existing Annual Load:	142.64 lbs/yr	52.71 lbs/yr
Percent Reduction:	42 %	74 %
Post-SCM Annual Load	82.58 lbs/yr	13.78 lbs/yr
Post-SCM Unit Area Load:	2.51 lbs/ac/yr	0.42 lbs/ac/yr
Annual Load Reduction:	60.06 lbs/yr	38.93 lbs/yr
Annual Unit Area Load Reduction:	1.83 lbs/ac/yr	1.18 lbs/ac/yr

Notes

PIDs: 0801-03-20-4677



**CITY OF DURHAM STORMWATER AND GIS SERVICES
PROPOSED PROJECT FACT SHEET**

Watershed: **Mud Creek**

Project ID: **NHCMC0069**

Project: **SCM**

Project Type: **Wet Pond**

Project Description **SCM Type: existing**

Convert an existing water retention feature to a wet pond. This existing water feature/pond could be redesigned as a water quality treatment device by adding forebays and modifying the outlet structure.

Watershed and Site Characteristics **Subwatershed: NHC56**

Location: 50 DURBIN PL	Number of Parcels Affected: 1
Date of Field Evaluation: 12/20/2019	Ownership: Private
Projects Within Subwatershed: 11	Property Owner: WALDEN POND HOME0
Contributing Drainage Area: 16.9 ac	Willingness to Cooperate: Not yet contacted
Slope of the Drainage Area: 10.8 %	Land Use of Site: High Density Residential
Impervious Cover: 39 %	Receiving Water: Jordan Lake
Accessibility to Retrofit Site: Accessible by Vehicle	DWQ Class: WS-V; NSW
Land Use in Contributing Drainage Area:	Use Support Rating: No data
Residential: 85%	Sensitive Areas:
Commercial: 0%	Existing Volume (ac-ft): 0.38
Industrial: 0%	Proposed Volume (ac-ft): 0.38
Institutional: 0%	Land Area of Retrofit Project (acres): 0.57
Agricultural: 0%	Water Quality (1") Design Volume (ac-ft): 0.45
Parks and Open Space: 0%	1-Year Storm Runoff Volume (ac-ft): 2.79
Roads and Road Right-of-Way: 15%	10-Year Storm Runoff Volume (ac-ft): 6.84
RTP: 0%	

Implementation Costs and Water Quality Benefits Provided by the Project

Estimated Costs (Includes 20 Years of O&M)	Water Quality Parameter	Pollutant Removal		
		Per Year	\$ Per Year	Efficiency
Construction: \$8,800	Total Nitrogen (lbs/yr):	31.0	\$5,550	30 %
Eng./ Admin/Permitting: \$65,000	Total Phosphorus (lbs/yr):	4.0	\$43,000	30 %
Other Costs (Land, Site Factors): \$98,000	Sediment (lbs/yr):	2,154	\$80	85 %
20-year O&M: \$0	Fecal Coliform (cfu*109/yr):			%
Total Cost: \$172,000	Copper (lbs/yr):			%
Proposed Implementation: 2020	Zinc (lbs/yr):			%

Photos



PROPOSED PROJECT FACT SHEET

Project ID: **NHCMC0069**

Subwatershed **NHC56**

Project: **SCM**



Figure 1 - Plan View of SCM Project

Prioritization Criteria Scores

Criteria	Score	Criteria	Score
<u>Water Quality Benefits</u>		<u>Community Enhancement</u>	
TN	10.0	Property Protection	0.0
TP	10.0	Property Protection Bonus	
Sediment	7.5	Property Owner/Acceptance	2.0
Fecal Coliform	1.5	Acceptance Bonus	
Copper		Public Education	3.0
Zinc		<u>Implementation Issue</u>	
Water Quality Bonus		Property Ownership	3.0
<u>Habitat and Biological Integrity</u>		Accessibility for Construction	5.0
Habitat/Biology	0.0	City Program Compatibility	5.0
Habitat/Biology Bonus		Permitting/Adverse Env. Impacts	5.0
<u>Stream Bank Protection</u>		Permitting Bonus	
Stream Bank Protection	0.0	Total Project Score	
<u>Public Safety and Public Property</u>			
Public Safety and Property	0.0		
Safety Bonus			

NCDEQ Stormwater Nitrogen And Phosphorus (SNAP) Tool (version 4.1 Draft Final)

	Total Nitrogen	Total Phosphorus
Existing Unit Area Load:	4.92 lbs/ac/yr	0.72 lbs/ac/yr
Existing Annual Load:	78.66 lbs/yr	11.55 lbs/yr
Percent Reduction:	21 %	31 %
Post-SCM Annual Load	62.32 lbs/yr	7.95 lbs/yr
Post-SCM Unit Area Load:	3.9 lbs/ac/yr	0.5 lbs/ac/yr
Annual Load Reduction:	16.34 lbs/yr	3.6 lbs/yr
Annual Unit Area Load Reduction:	1.02 lbs/ac/yr	0.22 lbs/ac/yr

Notes

PIDs: **0812-01-17-4363**



**CITY OF DURHAM STORMWATER AND GIS SERVICES
PROPOSED PROJECT FACT SHEET**

Watershed: **Mud Creek**

Project ID: **NHCMC0070**

Project: **SCM**

Project Type: **Wet Pond**

Project Description **SCM Type: existing**

Convert dry pond to a wet pond. The existing SCM appears it may pre-date the SCM standards and has many deficiencies and maintenance issues. It could be redesigned to a wet pond to improve water quantity treatment and add water quality treatment.

Watershed and Site Characteristics **Subwatershed: NHC56**

Location: 400 MAYFIELD CIR		Number of Parcels Affected: 1	
Date of Field Evaluation: 12/20/2019		Ownership: Private	
Projects Within Subwatershed: 11		Property Owner: LENOX EAST LLC	
Contributing Drainage Area: 14.1 ac		Willingness to Cooperate: Not yet contacted	
Slope of the Drainage Area: 7.7 %		Land Use of Site: High Density Residential	
Impervious Cover: 36 %		Receiving Water: Jordan Lake	
Accessibility to Retrofit Site: Accessible by Vehicle		DWQ Class: WS-V; NSW	
Land Use in Contributing Drainage Area:		Use Support Rating: No data	
Residential: 81%		Sensitive Areas:	
Commercial: 0%		Existing Volume (ac-ft): 0.22	
Industrial: 0%		Proposed Volume (ac-ft): 0.22	
Institutional: 2%		Land Area of Retrofit Project (acres): 0.17	
Agricultural: 0%		Water Quality (1") Design Volume (ac-ft): 0.05	
Parks and Open Space: 0%		1-Year Storm Runoff Volume (ac-ft): 2.15	
Roads and Road Right-of-Way: 17%		10-Year Storm Runoff Volume (ac-ft): 5.25	
RTP: 0%			

Implementation Costs and Water Quality Benefits Provided by the Project

Estimated Costs (Includes 20 Years of O&M)	Water Quality Parameter	Pollutant Removal		
		Per Year	\$ Per Year	Efficiency
Construction: \$106,700	Total Nitrogen (lbs/yr):	7.0	\$28,710	10 %
Eng./ Admin/Permitting: \$65,000	Total Phosphorus (lbs/yr):	1.0	\$201,000	10 %
Other Costs (Land, Site Factors): \$29,000	Sediment (lbs/yr):	1,390	\$140	85 %
20-year O&M: \$0	Fecal Coliform (cfu*109/yr):			%
Total Cost: \$201,000	Copper (lbs/yr):			%
Proposed Implementation: 2020	Zinc (lbs/yr):			%

Photos



PROPOSED PROJECT FACT SHEET

Project ID: **NHCMC0070**

Subwatershed **NHC56**

Project: **SCM**



Figure 1 - Plan View of SCM Project

Prioritization Criteria Scores

Criteria	Score	Criteria	Score
<u>Water Quality Benefits</u>		<u>Community Enhancement</u>	
TN	2.0	Property Protection	0.0
TP	2.0	Property Protection Bonus	
Sediment	7.5	Property Owner/Acceptance	2.0
Fecal Coliform	1.5	Acceptance Bonus	
Copper		Public Education	3.0
Zinc		<u>Implementation Issue</u>	
Water Quality Bonus		Property Ownership	3.0
<u>Habitat and Biological Integrity</u>		Accessibility for Construction	5.0
Habitat/Biology	15.0	City Program Compatability	5.0
Habitat/Biology Bonus		Permitting/Adverse Env. Impacts	5.0
<u>Stream Bank Protection</u>		Permitting Bonus	
Stream Bank Protection	0.0	Total Project Score	
<u>Public Safety and Public Property</u>			
Public Safety and Property	0.0		
Safety Bonus			

NCDEQ Stormwater Nitrogen And Phosphorus (SNAP) Tool (version 4.1 Draft Final)

	Total Nitrogen	Total Phosphorus
Existing Unit Area Load:	4.11 lbs/ac/yr	0.67 lbs/ac/yr
Existing Annual Load:	56.67 lbs/yr	9.27 lbs/yr
Percent Reduction:	27 %	41 %
Post-SCM Annual Load	41.4 lbs/yr	5.45 lbs/yr
Post-SCM Unit Area Load:	3 lbs/ac/yr	0.39 lbs/ac/yr
Annual Load Reduction:	15.27 lbs/yr	3.82 lbs/yr
Annual Unit Area Load Reduction:	1.11 lbs/ac/yr	0.28 lbs/ac/yr

Notes

PIDs: **0812-01-08-7352**



**CITY OF DURHAM STORMWATER AND GIS SERVICES
PROPOSED PROJECT FACT SHEET**

Watershed: **Lower NHC**

Project ID: **00511**

Project: **SCM**

Project Type: **Constructed Wetland**

Project Description

SCM Type: **existing**

Convert a dry pond to a constructed wetland. The site has room to expand the footprint of the SCM to accommodate an appropriately-sized constructed wetland. The existing dry pond has standing water and wetland vegetation growing in it which indicates it may support a wetland.

Watershed and Site Characteristics

Subwatershed: **NHC31**

Location: 3605 Shannon Road	Number of Parcels Affected: 1
Date of Field Evaluation: 12/18/2019	Ownership: Public
Projects Within Subwatershed: 3	Property Owner: COUNTY OF DURHAM
Contributing Drainage Area: 2.6 ac	Willingness to Cooperate: Not yet contacted
Slope of the Drainage Area: 8.9 %	Land Use of Site: Institutional
Impervious Cover: 47 %	Receiving Water: Jordan Lake
Accessibility to Retrofit Site: Accessible by Vehicle	DWQ Class: WS-V; NSW
Land Use in Contributing Drainage Area:	Use Support Rating: No data
Residential: 3%	Sensitive Areas:
Commercial: 0%	Existing Volume (ac-ft): 0.05
Industrial: 0%	Proposed Volume (ac-ft): 0.05
Institutional: 87%	Land Area of Retrofit Project (acres): 0.16
Agricultural: 0%	Water Quality (1") Design Volume (ac-ft): 0.01
Parks and Open Space: 0%	1-Year Storm Runoff Volume (ac-ft): 0.46
Roads and Road Right-of-Way: 10%	10-Year Storm Runoff Volume (ac-ft): 1.07
RTP: 0%	

Implementation Costs and Water Quality Benefits Provided by the Project

Estimated Costs (Includes 20 Years of O&M)	Water Quality Parameter	Pollutant Removal		
		Per Year	\$ Per Year	Efficiency
Construction: \$100,700	Total Nitrogen (lbs/yr):	2.0	\$96,500	10 %
Eng./ Admin/Permitting: \$65,000	Total Phosphorus (lbs/yr):	0.0		10 %
Other Costs (Land, Site Factors): \$27,000	Sediment (lbs/yr):	452	\$430	85 %
20-year O&M: \$0	Fecal Coliform (cfu*109/yr):			%
Total Cost: \$193,000	Copper (lbs/yr):			%
Proposed Implementation: 2020	Zinc (lbs/yr):			%

Photos



PROPOSED PROJECT FACT SHEET

Subwatershed NHC31

Project ID: 00511

Project: SCM

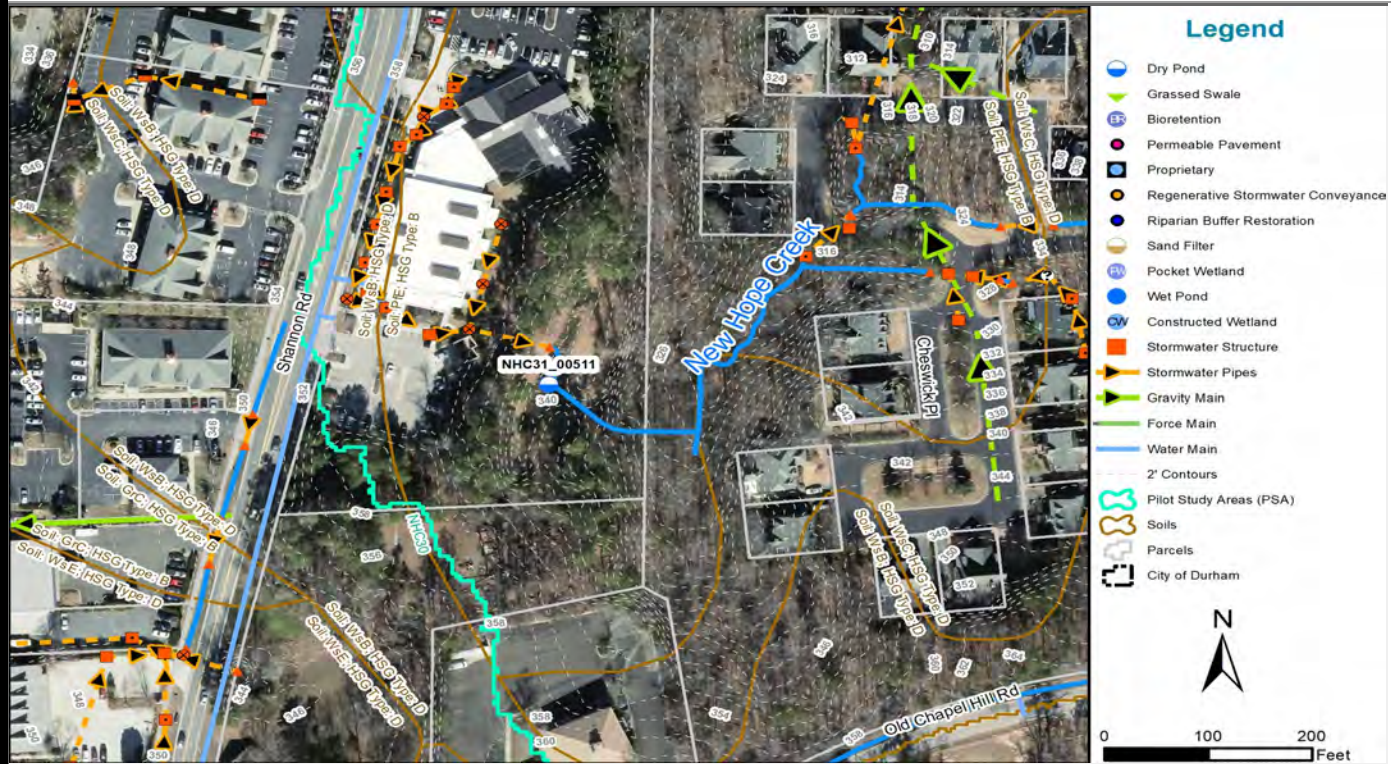


Figure 1 - Plan View of SCM Project

Prioritization Criteria Scores

Criteria	Score	Criteria	Score
<u>Water Quality Benefits</u>		<u>Community Enhancement</u>	
TN	0.0	Property Protection	1.0
TP	0.0	Property Protection Bonus	
Sediment	0.0	Property Owner/Acceptance	5.0
Fecal Coliform	6.0	Acceptance Bonus	
Copper		Public Education	5.0
Zinc		<u>Implementation Issue</u>	
Water Quality Bonus		Property Ownership	3.0
<u>Habitat and Biological Integrity</u>		Accessibility for Construction	5.0
Habitat/Biology	15.0	City Program Compatability	5.0
Habitat/Biology Bonus		Permitting/Adverse Env. Impacts	5.0
<u>Stream Bank Protection</u>		Permitting Bonus	
Stream Bank Protection	0.0	Total Project Score	
<u>Public Safety and Public Property</u>			
Public Safety and Property	0.0		
Safety Bonus			

NCDEQ Stormwater Nitrogen And Phosphorus (SNAP) Tool (version 4.1 Draft Final)

	Total Nitrogen	Total Phosphorus
Existing Unit Area Load:	8.03 lbs/ac/yr	2.92 lbs/ac/yr
Existing Annual Load:	20.86 lbs/yr	7.58 lbs/yr
Percent Reduction:	46 %	77 %
Post-SCM Annual Load	11.22 lbs/yr	1.72 lbs/yr
Post-SCM Unit Area Load:	4.32 lbs/ac/yr	0.66 lbs/ac/yr
Annual Load Reduction:	9.64 lbs/yr	5.86 lbs/yr
Annual Unit Area Load Reduction:	3.71 lbs/ac/yr	2.26 lbs/ac/yr

Notes

PIDs: 0810-14-33-4797



**CITY OF DURHAM STORMWATER AND GIS SERVICES
PROPOSED PROJECT FACT SHEET**

Watershed: **Mud Creek**

Project ID: **NHCMC0071**

Project: **SCM**

Project Type: **Constructed Wetland**

Project Description

SCM Type: **existing**

Convert a dry pond to a constructed wetland. The site has room to expand the footprint of the SCM to accommodate an appropriately-sized constructed wetland.

Watershed and Site Characteristics

Subwatershed: **NHC56**

Location: 200 MAYFIELD CIR	Number of Parcels Affected: 1
Date of Field Evaluation: 12/20/2019	Ownership: Private
Projects Within Subwatershed: 11	Property Owner: LENOX EAST LLC
Contributing Drainage Area: 10.2 ac	Willingness to Cooperate: Not yet contacted
Slope of the Drainage Area: 8.3 %	Land Use of Site: Low Density Residential
Impervious Cover: 34 %	Receiving Water: Jordan Lake
Accessibility to Retrofit Site: Accessible by Vehicle	DWQ Class: WS-V; NSW
Land Use in Contributing Drainage Area:	Use Support Rating: No data
Residential: 86%	Sensitive Areas:
Commercial: 0%	Existing Volume (ac-ft): 0.15
Industrial: 0%	Proposed Volume (ac-ft): 0.15
Institutional: 0%	Land Area of Retrofit Project (acres): 0.31
Agricultural: 0%	Water Quality (1") Design Volume (ac-ft): 0.03
Parks and Open Space: 0%	1-Year Storm Runoff Volume (ac-ft): 1.44
Roads and Road Right-of-Way: 14%	10-Year Storm Runoff Volume (ac-ft): 3.65
RTP: 0%	

Implementation Costs and Water Quality Benefits Provided by the Project

Estimated Costs (Includes 20 Years of O&M)	Water Quality Parameter	Pollutant Removal		
		Per Year	\$ Per Year	Efficiency
Construction: \$105,100	Total Nitrogen (lbs/yr):	5.0	\$44,600	10 %
Eng./Admin/Permitting: \$65,000	Total Phosphorus (lbs/yr):	1.0	\$223,000	10 %
Other Costs (Land, Site Factors): \$53,000	Sediment (lbs/yr):	1,039	\$210	85 %
20-year O&M: \$0	Fecal Coliform (cfu*109/yr):			%
Total Cost: \$223,000	Copper (lbs/yr):			%
Proposed Implementation: 2020	Zinc (lbs/yr):			%

Photos



PROPOSED PROJECT FACT SHEET

Subwatershed NHC56

Project ID: NHCMC0071

Project: SCM

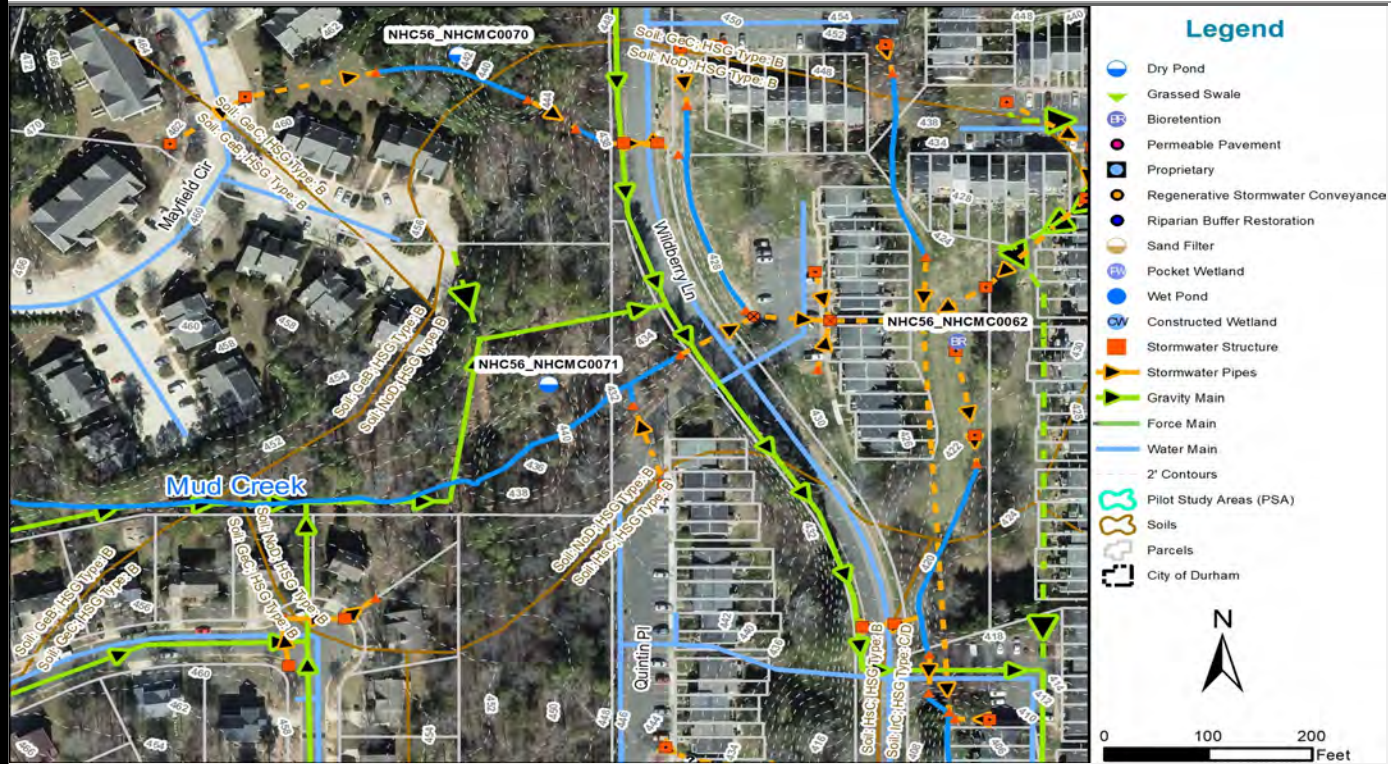


Figure 1 - Plan View of SCM Project

Prioritization Criteria Scores

Criteria	Score	Criteria	Score
<u>Water Quality Benefits</u>		<u>Community Enhancement</u>	
TN	0.0	Property Protection	0.0
TP	0.0	Property Protection Bonus	
Sediment	4.5	Property Owner/Acceptance	2.0
Fecal Coliform	6.0	Acceptance Bonus	
Copper		Public Education	3.0
Zinc		<u>Implementation Issue</u>	
Water Quality Bonus		Property Ownership	3.0
<u>Habitat and Biological Integrity</u>		Accessibility for Construction	5.0
Habitat/Biology	15.0	City Program Compatability	5.0
Habitat/Biology Bonus		Permitting/Adverse Env. Impacts	5.0
<u>Stream Bank Protection</u>		Permitting Bonus	
Stream Bank Protection	0.0	Total Project Score	
<u>Public Safety and Public Property</u>			
Public Safety and Property	0.0		
Safety Bonus			

NCDEQ Stormwater Nitrogen And Phosphorus (SNAP) Tool (version 4.1 Draft Final)

	Total Nitrogen	Total Phosphorus
Existing Unit Area Load:	4.35 lbs/ac/yr	0.65 lbs/ac/yr
Existing Annual Load:	43.45 lbs/yr	6.48 lbs/yr
Percent Reduction:	40 %	36 %
Post-SCM Annual Load	26.14 lbs/yr	4.12 lbs/yr
Post-SCM Unit Area Load:	2.62 lbs/ac/yr	0.41 lbs/ac/yr
Annual Load Reduction:	17.31 lbs/yr	2.36 lbs/yr
Annual Unit Area Load Reduction:	1.73 lbs/ac/yr	0.24 lbs/ac/yr

Notes

PIDs: 0812-01-07-6848



**CITY OF DURHAM STORMWATER AND GIS SERVICES
PROPOSED PROJECT FACT SHEET**

Watershed: **Lower NHC**

Project ID: **00316**

Project: **SCM**

Project Type: **Wet Pond**

Project Description

SCM Type: **existing**

Lower the water level of the wet pond to gain storage. Based on as-builts, the temporary storage volume of this wet pond is relatively small and could be increased.

Watershed and Site Characteristics

Subwatershed: **NHC25**

Location: 3891 Southwest Durham Drive		Number of Parcels Affected: 2	
Date of Field Evaluation: 12/18/2019		Ownership: Private	
Projects Within Subwatershed: 11		Property Owner: PATTERSON PARK LLC; R	
Contributing Drainage Area: 9.4 ac		Willingness to Cooperate: Not yet contacted	
Slope of the Drainage Area: 7.9 %		Land Use of Site: High Density Residential	
Impervious Cover: 32 %		Receiving Water: Jordan Lake	
Accessibility to Retrofit Site: Accessible by Vehicle		DWQ Class: WS-IV; NSW	
Land Use in Contributing Drainage Area:		Use Support Rating: No data	
Residential: 9%		Sensitive Areas: NSW	
Commercial: 4%		Existing Volume (ac-ft): 0.19	
Industrial: 0%		Proposed Volume (ac-ft): 0.19	
Institutional: 87%		Land Area of Retrofit Project (acres): 0.22	
Agricultural: 0%		Water Quality (1") Design Volume (ac-ft): 0.29	
Parks and Open Space: 0%		1-Year Storm Runoff Volume (ac-ft): 1.99	
Roads and Road Right-of-Way: 0%		10-Year Storm Runoff Volume (ac-ft): 4.42	
RTP: 0%			

Implementation Costs and Water Quality Benefits Provided by the Project

Estimated Costs (Includes 20 Years of O&M)	Water Quality Parameter	Pollutant Removal		
		Per Year	\$ Per Year	Efficiency
Construction: \$108,100	Total Nitrogen (lbs/yr):	24.0	\$8,790	30 %
Eng./ Admin/Permitting: \$65,000	Total Phosphorus (lbs/yr):	2.0	\$105,500	30 %
Other Costs (Land, Site Factors): \$38,000	Sediment (lbs/yr):	1,466	\$140	85 %
20-year O&M: \$0	Fecal Coliform (cfu*109/yr):			%
Total Cost: \$211,000	Copper (lbs/yr):			%
Proposed Implementation: 2020	Zinc (lbs/yr):			%

Photos



PROPOSED PROJECT FACT SHEET

Subwatershed NHC25

Project ID: 00316

Project: SCM



Figure 1 - Plan View of SCM Project

Prioritization Criteria Scores

Criteria	Score	Criteria	Score
<u>Water Quality Benefits</u>		<u>Community Enhancement</u>	
TN	10.0	Property Protection	0.0
TP	6.0	Property Protection Bonus	
Sediment	7.5	Property Owner/Acceptance	2.0
Fecal Coliform	1.5	Acceptance Bonus	
Copper		Public Education	3.0
Zinc		<u>Implementation Issue</u>	
Water Quality Bonus		Property Ownership	3.0
<u>Habitat and Biological Integrity</u>		Accessibility for Construction	5.0
Habitat/Biology	0.0	City Program Compatability	5.0
Habitat/Biology Bonus		Permitting/Adverse Env. Impacts	5.0
<u>Stream Bank Protection</u>		Permitting Bonus	
Stream Bank Protection	0.0	Total Project Score	
<u>Public Safety and Public Property</u>			
Public Safety and Property	0.0		
Safety Bonus			

NCDEQ Stormwater Nitrogen And Phosphorus (SNAP) Tool (version 4.1 Draft Final)

	Total Nitrogen	Total Phosphorus
Existing Unit Area Load:	4.4 lbs/ac/yr	0.55 lbs/ac/yr
Existing Annual Load:	41.49 lbs/yr	5.19 lbs/yr
Percent Reduction:	25 %	32 %
Post-SCM Annual Load	31.23 lbs/yr	3.53 lbs/yr
Post-SCM Unit Area Load:	3.31 lbs/ac/yr	0.37 lbs/ac/yr
Annual Load Reduction:	10.26 lbs/yr	1.66 lbs/yr
Annual Unit Area Load Reduction:	1.09 lbs/ac/yr	0.18 lbs/ac/yr

Notes

PIDs: 0709-02-59-1038; 0709-02-58-0994



**CITY OF DURHAM STORMWATER AND GIS SERVICES
PROPOSED PROJECT FACT SHEET**

Watershed: **Lower NHC**

Project ID: **NHC0014**

Project: **SCM**

Project Type: **Treatment Swale - We**

Project Description	SCM Type: new
Proposed 9,750 square foot, 650 foot long, treatment swale to collect runoff from a parking lot and roof on commercial property.	

Watershed and Site Characteristics	Subwatershed: NHC27
---	----------------------------

Location: 4702 GARRETT RD Date of Field Evaluation: 12/20/2019 Projects Within Subwatershed: 13 Contributing Drainage Area: 0.3 ac Slope of the Drainage Area: 4.6 % Impervious Cover: 52 % Accessibility to Retrofit Site: Accessible by Vehicle Land Use in Contributing Drainage Area: Residential: 0% Commercial: 100% Industrial: 0% Institutional: 0% Agricultural: 0% Parks and Open Space: 0% Roads and Road Right-of-Way: 0% RTP: 0%	Number of Parcels Affected: 1 Ownership: Private Property Owner: DANCE ENTERPRISES LL Willingness to Cooperate: Not yet contacted Land Use of Site: Commercial Receiving Water: Jordan Lake DWQ Class: WS-IV; NSW Use Support Rating: Supporting Sensitive Areas: Existing Volume (ac-ft): Proposed Volume (ac-ft): 0.00 Land Area of Retrofit Project (acres): 0.22 Water Quality (1") Design Volume (ac-ft): 0.01 1-Year Storm Runoff Volume (ac-ft): 0.06 10-Year Storm Runoff Volume (ac-ft): 0.12
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Implementation Costs and Water Quality Benefits Provided by the Project

Estimated Costs (Includes 20 Years of O&M)	Water Quality Parameter	Pollutant Removal		
		Per Year	\$ Per Year	Efficiency
Construction:	Total Nitrogen (lbs/yr):	1.0	\$39,000	30 %
Eng./Admin/Permitting:	Total Phosphorus (lbs/yr):	0.0		30 %
Other Costs (Land, Site Factors):	Sediment (lbs/yr):	61	\$640	85 %
20-year O&M:	Fecal Coliform (cfu*109/yr):			%
Total Cost:	Copper (lbs/yr):			%
Proposed Implementation:	Zinc (lbs/yr):			%

Photos



PROPOSED PROJECT FACT SHEET

Subwatershed NHC27

Project ID: NHC0014

Project: SCM



Figure 1 - Plan View of SCM Project

Prioritization Criteria Scores

Criteria	Score	Criteria	Score
<u>Water Quality Benefits</u>		<u>Community Enhancement</u>	
TN	10.0	Property Protection	0.0
TP	0.0	Property Protection Bonus	
Sediment	7.5	Property Owner/Acceptance	2.0
Fecal Coliform	0.0	Acceptance Bonus	
Copper		Public Education	0.0
Zinc		<u>Implementation Issue</u>	
Water Quality Bonus		Property Ownership	2.0
<u>Habitat and Biological Integrity</u>		Accessibility for Construction	5.0
Habitat/Biology	15.0	City Program Compatability	0.0
Habitat/Biology Bonus		Permitting/Adverse Env. Impacts	5.0
<u>Stream Bank Protection</u>		Permitting Bonus	
Stream Bank Protection	0.0	Total Project Score	
<u>Public Safety and Public Property</u>			
Public Safety and Property	0.0		
Safety Bonus			

NCDEQ Stormwater Nitrogen And Phosphorus (SNAP) Tool (version 4.1 Draft Final)

	Total Nitrogen	Total Phosphorus
Existing Unit Area Load:	5.97 lbs/ac/yr	0.82 lbs/ac/yr
Existing Annual Load:	1.65 lbs/yr	0.23 lbs/yr
Percent Reduction:	5 %	11 %
Post-SCM Annual Load	1.57 lbs/yr	0.2 lbs/yr
Post-SCM Unit Area Load:	5.7 lbs/ac/yr	0.73 lbs/ac/yr
Annual Load Reduction:	0.08 lbs/yr	0.03 lbs/yr
Annual Unit Area Load Reduction:	0.27 lbs/ac/yr	0.09 lbs/ac/yr

Notes

PIDs: **0800-04-72-8230**



**CITY OF DURHAM STORMWATER AND GIS SERVICES
PROPOSED PROJECT FACT SHEET**

Watershed: **Lower NHC**

Project ID: **LNHC1006**

Project: **Stream Restoration**

Project Type: **Restoration**

Project Description

Proposed Restoration of a 1446 foot long degraded reach.

Watershed and Site Characteristics

Subwatershed: NH28

Location: Located in a wooded area west of Mt Moriah Rd just south of the intersection of Mt Moriah Rd with

Date of Field Evaluation: 2/4/2020 5:

Number of Parcels Affected: 1

Projects Within Subwatershed: 3

Ownership: Public

Contributing Drainage Area: ac

Property Owner: CITY OF DURHAM

Slope of the Drainage Area: %

Willingness to Cooperate: Not yet contacted

Impervious Cover: %

Land Use of Site: Parks and Open Space - Poorly

Accessibility to Stream Site:

Receiving Water: Jordan Lake

Land Use in Contributing Drainage Area:

DWQ Class: WS-V;NSW

Residential: 17%

Use Support Rating: No data

Commercial: 43%

Sensitive Areas: NSW

Industrial: 0%

Project Length (ft): 1,446

Institutional: 0%

Project Setting: Semi-Urban

Agricultural: 0%

Bank Stability:

Parks and Open Space: 18%

Sediment Erosion Rate (lbs/yr):

Roads and Road Right-of-Way: 22%

1-Yr Storm Peak Discharge (cfs):

RTP: 0%

25-Yr Storm Peak Discharge (cfs):

Implementation Costs and Water Quality Benefits Provided by the Project

Estimated Costs (Includes 20 Years of O&M)	Water Quality Parameter	Pollutant Removal		
		Per Year	\$ Per Year	Efficiency
Construction: \$559,000	Total Nitrogen (lbs/yr):		\$6,230	%
Eng./ Admin/Permitting: \$167,700	Total Phosphorus (lbs/yr):		\$120,590	%
Other Costs (Land, Site Factors): \$10,000	Sediment (lbs/yr):		\$10	%
20-year O&M: \$118,000	Fecal Coliform (cfu*109/yr):			%
Total Cost: \$855,000	Copper (lbs/yr):			%
Proposed Implementation:	Zinc (lbs/yr):			%

Photos



PROPOSED PROJECT FACT SHEET

Subwatershed NH28

Project ID: LNHC1006

Project: **Stream Restoration**

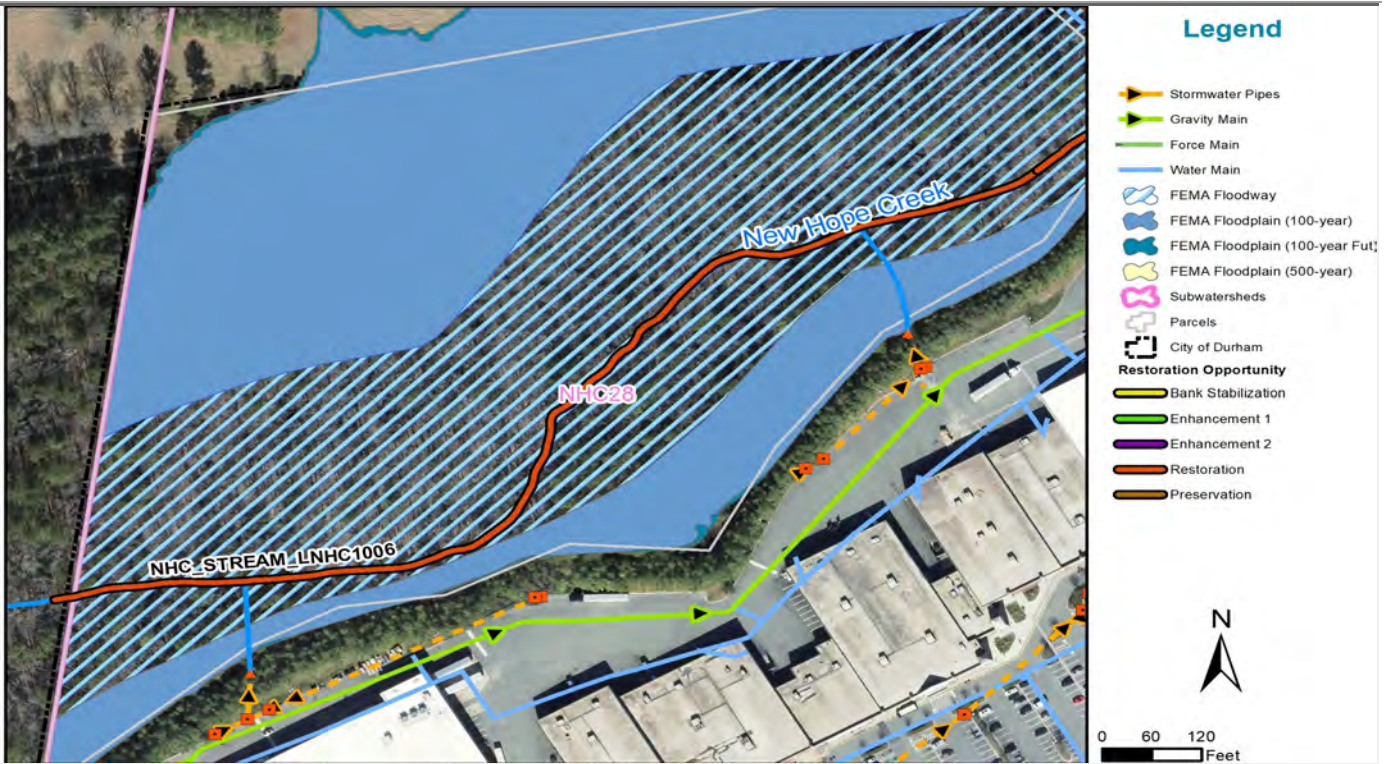


Figure 1 - Plan View of Stream Project

Prioritization Criteria Scores

Criteria	Score	Criteria	Score
<u>Water Quality Benefits</u>		<u>Community Enhancement</u>	
TN	10.0	Property Protection	3.0
TP	10.0	Property Protection Bonus	
Sediment	4.5	Property Owner/Acceptance	5.0
Fecal Coliform		Acceptance Bonus	
Copper		Public Education	5.0
Zinc		<u>Implementation Issue</u>	
Water Quality Bonus		Property Ownership	5.0
<u>Habitat and Biological Integrity</u>		Accessibility for Construction	5.0
Habitat/Biology	12.0	City Program Compatability	5.0
Habitat/Biology Bonus		Permitting/Adverse Env. Impacts	4.0
<u>Stream Bank Protection</u>		Permitting Bonus	
Stream Bank Protection		Total Project Score	
<u>Public Safety and Public Property</u>			
Public Safety and Property	0.0	74.5	
Safety Bonus			

Stream Restoration Crediting Protocol

Crediting Protocol	Sediment Reduction	TN Reduction	TP Reduction
Prevented Sediment Protocol:	lbs/yr	lbs/yr	lbs/yr
In-Stream Denitrification:	lbs/yr	lbs/yr	lbs/yr
Floodplain Reconnection:	lbs/yr	lbs/yr	lbs/yr

Notes

PIDs: **0800-03-21-1261.DO**



**CITY OF DURHAM STORMWATER AND GIS SERVICES
PROPOSED PROJECT FACT SHEET**

Watershed: **Lower NHC**

Project ID: **LNHC1002**

Project: **Stream Restoration**

Project Type: **Restoration**

Project Description

Proposed Restoration of a 7219 foot long degraded reach.

Watershed and Site Characteristics

Subwatershed: NH29

Location: Located in a wooded area approximately a quarter of a mile north of Durham-Chapel Hill Blvd and h

Date of Field Evaluation: 2/4/2020 5:

Number of Parcels Affected: 10

Projects Within Subwatershed: 2

Ownership: Public/Private

Contributing Drainage Area: ac

Property Owner: COUNTY OF DURHAM, D

Slope of the Drainage Area: %

Willingness to Cooperate: Not yet contacted

Impervious Cover: %

Land Use of Site: Low Density - Poorly Drained

Accessibility to Stream Site:

Receiving Water: Jordan Lake

Land Use in Contributing Drainage Area:

DWQ Class: WS-V;NSW

Residential: 38%

Use Support Rating: Meeting Criteria

Commercial: 8%

Sensitive Areas: NSW

Industrial: 0%

Project Length (ft): 7,219

Institutional: 2%

Project Setting: Semi-Urban

Agricultural: 0%

Bank Stability:

Parks and Open Space: 42%

Sediment Erosion Rate (lbs/yr):

Roads and Road Right-of-Way: 10%

1-Yr Storm Peak Discharge (cfs):

RTP: 0%

25-Yr Storm Peak Discharge (cfs):

Implementation Costs and Water Quality Benefits Provided by the Project

Estimated Costs (Includes 20 Years of O&M)	Water Quality Parameter	Pollutant Removal		
		Per Year	\$ Per Year	Efficiency
Construction: \$2,790,600	Total Nitrogen (lbs/yr):		\$3,190	%
Eng./ Admin/Permitting: \$697,650	Total Phosphorus (lbs/yr):		\$117,520	%
Other Costs (Land, Site Factors): \$80,000	Sediment (lbs/yr):		\$10	%
20-year O&M: \$591,000	Fecal Coliform (cfu*109/yr):			%
Total Cost: \$4,159,000	Copper (lbs/yr):			%
Proposed Implementation:	Zinc (lbs/yr):			%

Photos



PROPOSED PROJECT FACT SHEET

Subwatershed NH29

Project ID: LNHC1002

Project: **Stream Restoration**



Figure 1 - Plan View of Stream Project

Prioritization Criteria Scores

Criteria	Score	Criteria	Score
<u>Water Quality Benefits</u>		<u>Community Enhancement</u>	
TN	10.0	Property Protection	3.0
TP	10.0	Property Protection Bonus	
Sediment	4.5	Property Owner/Acceptance	5.0
Fecal Coliform		Acceptance Bonus	
Copper		Public Education	5.0
Zinc		<u>Implementation Issue</u>	
Water Quality Bonus		Property Ownership	3.0
<u>Habitat and Biological Integrity</u>		Accessibility for Construction	2.0
Habitat/Biology	12.0	City Program Compatability	5.0
Habitat/Biology Bonus		Permitting/Adverse Env. Impacts	4.0
<u>Stream Bank Protection</u>		Permitting Bonus	
Stream Bank Protection		Total Project Score	
<u>Public Safety and Public Property</u>			
Public Safety and Property	0.0		
Safety Bonus			

Stream Restoration Crediting Protocol

Crediting Protocol	Sediment Reduction	TN Reduction	TP Reduction
Prevented Sediment Protocol:	lbs/yr	lbs/yr	lbs/yr
In-Stream Denitrification:	lbs/yr	lbs/yr	lbs/yr
Floodplain Reconnection:	lbs/yr	lbs/yr	lbs/yr

Notes

PIDs: 0800-04-54-4748, 0800-04-44-8493, 0800-01-35-2795, 0800-03-34-6437, 0800-03-25-3354, 0800-01-16-9766, 0800-15-19-8550.DO, 0800-05-74-7663.DO, 0800-04-54-4748, 0800-04-44-8493



**CITY OF DURHAM STORMWATER AND GIS SERVICES
PROPOSED PROJECT FACT SHEET**

Watershed: **Sandy Creek**

Project ID: **SC2038**

Project: **Stream Restoration**

Project Type: **Restoration**

Project Description

Proposed Restoration of a 5186 foot long degraded reach.

Watershed and Site Characteristics **Subwatershed: NH33**

Location: Located in a wooded area south of Durham-Chapel Hill Blvd beginning approximately a quarter of a	
Date of Field Evaluation: 2/18/2020	Number of Parcels Affected: 16
Projects Within Subwatershed: 1	Ownership: Public/Private
Contributing Drainage Area: 4,343.4 ac	Property Owner: NC DEPT OF TRANSPRTN, S
Slope of the Drainage Area: %	Willingness to Cooperate: Not yet contacted
Impervious Cover: 1,153 %	Land Use of Site: High Density Residential and C
Accessibility to Stream Site:	Receiving Water: Jordan Lake
Land Use in Contributing Drainage Area:	DWQ Class: WS-V;NSW
Residential: 31%	Use Support Rating: No data
Commercial: 8%	Sensitive Areas: NSW
Industrial: 0%	Project Length (ft): 5,186
Institutional: 25%	Project Setting: Rural
Agricultural: 0%	Bank Stability:
Parks and Open Space: 22%	Sediment Erosion Rate (lbs/yr):
Roads and Road Right-of-Way: 14%	1-Yr Storm Peak Discharge (cfs):
RTP: 0%	25-Yr Storm Peak Discharge (cfs):

Implementation Costs and Water Quality Benefits Provided by the Project

Estimated Costs (Includes 20 Years of O&M)	Water Quality Parameter	Pollutant Removal		
		Per Year	\$ Per Year	Efficiency
Construction: \$1,503,500	Total Nitrogen (lbs/yr):		\$2,690	%
Eng./ Admin/Permitting: \$375,875	Total Phosphorus (lbs/yr):		\$120,960	%
Other Costs (Land, Site Factors): \$110,000	Sediment (lbs/yr):		\$10	%
20-year O&M: \$319,000	Fecal Coliform (cfu*109/yr):			%
Total Cost: \$2,308,000	Copper (lbs/yr):			%
Proposed Implementation:	Zinc (lbs/yr):			%

Photos



PROPOSED PROJECT FACT SHEET

Subwatershed NH33

Project ID: SC2038

Project: **Stream Restoration**



Figure 1 - Plan View of Stream Project

Prioritization Criteria Scores

Criteria	Score	Criteria	Score
<u>Water Quality Benefits</u>		<u>Community Enhancement</u>	
TN	10.0	Property Protection	3.0
TP	10.0	Property Protection Bonus	
Sediment	4.5	Property Owner/Acceptance	2.0
Fecal Coliform		Acceptance Bonus	
Copper		Public Education	0.0
Zinc		<u>Implementation Issue</u>	
Water Quality Bonus		Property Ownership	3.0
<u>Habitat and Biological Integrity</u>		Accessibility for Construction	2.0
Habitat/Biology	12.0	City Program Compatability	5.0
Habitat/Biology Bonus		Permitting/Adverse Env. Impacts	4.0
<u>Stream Bank Protection</u>		Permitting Bonus	
Stream Bank Protection		Total Project Score	
<u>Public Safety and Public Property</u>			
Public Safety and Property	0.0		
Safety Bonus			

Stream Restoration Crediting Protocol

Crediting Protocol	Sediment Reduction	TN Reduction	TP Reduction
Prevented Sediment Protocol:	76,926.9 lbs/yr	68.5 lbs/yr	17.7 lbs/yr
In-Stream Denitrification:	lbs/yr	892.6 lbs/yr	lbs/yr
Floodplain Reconnection:	lbs/yr	lbs/yr	lbs/yr

Notes

PIDs: 0811-19-72-1843, 0800-01-95-5572, 0800-02-85-6767, 0800-04-73-4399, 0800-13-94-3725, 0800-04-73-9962, 0800-04-83-4569, 0800-02-95-0689, 0800-72-35-4396, 0800-61-16-9329, 0800-72-35-4396, 0800-63-73-9382, 0800-72-35-4396, 0800-61-16-9329, 0800-72-35-4396,



**CITY OF DURHAM STORMWATER AND GIS SERVICES
PROPOSED PROJECT FACT SHEET**

Watershed: **Lower NHC**

Project ID: **LNHC1014**

Project: **Stream Restoration**

Project Type: **Restoration**

Project Description

Proposed Restoration of a 1395 foot long degraded reach.

Watershed and Site Characteristics

Subwatershed: NH30

Location: Located in a wooded area southeast of University Dr and southwest of the intersection of University	
Date of Field Evaluation: 2/10/2020	Number of Parcels Affected: 2
Projects Within Subwatershed: 3	Ownership: Private
Contributing Drainage Area: 895.3 ac	Property Owner: CORIUM LLC
Slope of the Drainage Area: %	Willingness to Cooperate: Not yet contacted
Impervious Cover: 414 %	Land Use of Site: High Density Residential and C
Accessibility to Stream Site:	Receiving Water: Jordan Lake
Land Use in Contributing Drainage Area:	DWQ Class: WS-V;NSW
Residential: 42%	Use Support Rating: No data
Commercial: 35%	Sensitive Areas: NSW
Industrial: 0%	Project Length (ft): 1,395
Institutional: 4%	Project Setting: Urban
Agricultural: 0%	Bank Stability:
Parks and Open Space: 3%	Sediment Erosion Rate (lbs/yr):
Roads and Road Right-of-Way: 16%	1-Yr Storm Peak Discharge (cfs):
RTP: 0%	25-Yr Storm Peak Discharge (cfs):

Implementation Costs and Water Quality Benefits Provided by the Project

Estimated Costs (Includes 20 Years of O&M)	Water Quality Parameter	Pollutant Removal		
		Per Year	\$ Per Year	Efficiency
Construction: \$808,800	Total Nitrogen (lbs/yr):		\$6,310	%
Eng./ Admin/Permitting: \$242,640	Total Phosphorus (lbs/yr):		\$116,450	%
Other Costs (Land, Site Factors): \$10,000	Sediment (lbs/yr):		\$10	%
20-year O&M: \$171,000	Fecal Coliform (cfu*109/yr):			%
Total Cost: \$1,232,000	Copper (lbs/yr):			%
Proposed Implementation:	Zinc (lbs/yr):			%

Photos



PROPOSED PROJECT FACT SHEET

Subwatershed NH30

Project ID: LNHC1014

Project: **Stream Restoration**



Figure 1 - Plan View of Stream Project

Prioritization Criteria Scores

Criteria	Score	Criteria	Score
<u>Water Quality Benefits</u>		<u>Community Enhancement</u>	
TN	10.0	Property Protection	5.0
TP	10.0	Property Protection Bonus	
Sediment	4.5	Property Owner/Acceptance	2.0
Fecal Coliform		Acceptance Bonus	
Copper		Public Education	0.0
Zinc		<u>Implementation Issue</u>	
Water Quality Bonus		Property Ownership	2.0
<u>Habitat and Biological Integrity</u>		Accessibility for Construction	2.0
Habitat/Biology	15.0	City Program Compatability	5.0
Habitat/Biology Bonus		Permitting/Adverse Env. Impacts	4.0
<u>Stream Bank Protection</u>		Permitting Bonus	
Stream Bank Protection		Total Project Score	
<u>Public Safety and Public Property</u>			
Public Safety and Property	0.0		
Safety Bonus			

Stream Restoration Crediting Protocol

Crediting Protocol	Sediment Reduction	TN Reduction	TP Reduction
Prevented Sediment Protocol:	42,654.7 lbs/yr	38.0 lbs/yr	9.8 lbs/yr
In-Stream Denitrification:	lbs/yr	225.2 lbs/yr	lbs/yr
Floodplain Reconnection:	lbs/yr	lbs/yr	lbs/yr

Notes

PIDs: 0810-13-04-9072, 0810-13-03-3457



**CITY OF DURHAM STORMWATER AND GIS SERVICES
PROPOSED PROJECT FACT SHEET**

Watershed: **Mud Creek**

Project ID: **MC1015**

Project: **Stream Restoration**

Project Type: **Restoration**

Project Description

Proposed Restoration of a 6313 foot long degraded reach.

Watershed and Site Characteristics

Subwatershed: NH47

Location: Located in a wooded area south of Pickett Rd running perpendicular between Pickett Rd and Durha	
Date of Field Evaluation: 2/18/2020 5	Number of Parcels Affected: 9
Projects Within Subwatershed: 2	Ownership: Public/Private
Contributing Drainage Area: 3,696.4 ac	Property Owner: GARRETT FARMS HOME0
Slope of the Drainage Area: %	Willingness to Cooperate: Not yet contacted
Impervious Cover: 356 %	Land Use of Site: Low Medium Density Resident
Accessibility to Stream Site:	Receiving Water: Jordan Lake
Land Use in Contributing Drainage Area:	DWQ Class: WS-V;NSW
Residential: 37%	Use Support Rating: No data
Commercial: 0%	Sensitive Areas: NSW
Industrial: 0%	Project Length (ft): 6,313
Institutional: 1%	Project Setting: Semi-Urban
Agricultural: 13%	Bank Stability:
Parks and Open Space: 40%	Sediment Erosion Rate (lbs/yr):
Roads and Road Right-of-Way: 9%	1-Yr Storm Peak Discharge (cfs):
RTP: 0%	25-Yr Storm Peak Discharge (cfs):

Implementation Costs and Water Quality Benefits Provided by the Project

Estimated Costs (Includes 20 Years of O&M)	Water Quality Parameter	Pollutant Removal		
		Per Year	\$ Per Year	Efficiency
Construction: \$2,440,300	Total Nitrogen (lbs/yr):		\$5,100	%
Eng./ Admin/Permitting: \$610,075	Total Phosphorus (lbs/yr):		\$229,860	%
Other Costs (Land, Site Factors): \$90,000	Sediment (lbs/yr):		\$30	%
20-year O&M: \$517,000	Fecal Coliform (cfu*109/yr):			%
Total Cost: \$3,657,000	Copper (lbs/yr):			%
Proposed Implementation:	Zinc (lbs/yr):			%

Photos



PROPOSED PROJECT FACT SHEET

Subwatershed NH47

Project ID: MC1015

Project: Stream Restoration

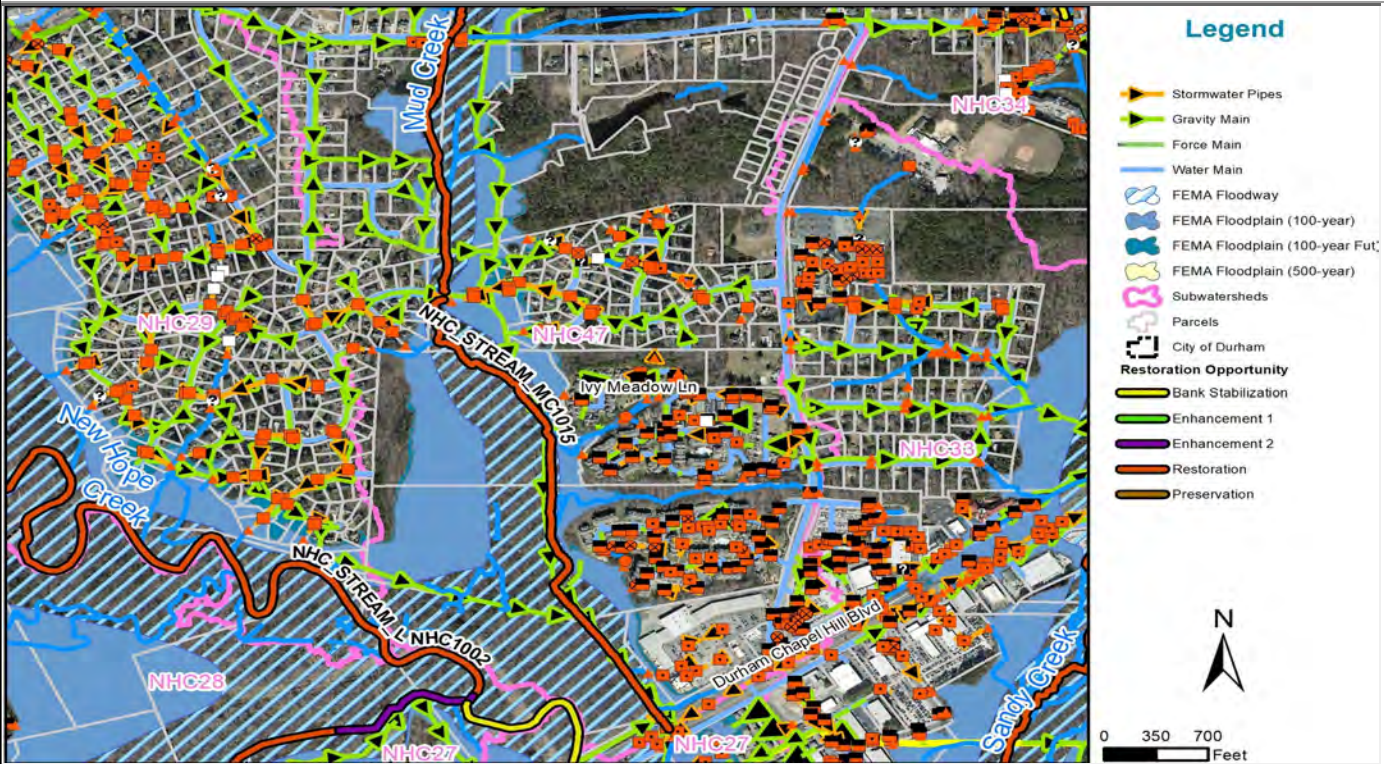


Figure 1 - Plan View of Stream Project

Prioritization Criteria Scores

Criteria	Score	Criteria	Score
<u>Water Quality Benefits</u>		<u>Community Enhancement</u>	
TN	10.0	Property Protection	4.0
TP	6.0	Property Protection Bonus	
Sediment	1.5	Property Owner/Acceptance	4.0
Fecal Coliform		Acceptance Bonus	
Copper		Public Education	3.0
Zinc		<u>Implementation Issue</u>	
Water Quality Bonus		Property Ownership	3.0
<u>Habitat and Biological Integrity</u>		Accessibility for Construction	2.0
Habitat/Biology	12.0	City Program Compatability	5.0
Habitat/Biology Bonus		Permitting/Adverse Env. Impacts	4.0
<u>Stream Bank Protection</u>		Permitting Bonus	
Stream Bank Protection		Total Project Score	
<u>Public Safety and Public Property</u>			
Public Safety and Property	0.0		
Safety Bonus			

Stream Restoration Crediting Protocol

Crediting Protocol	Sediment Reduction	TN Reduction	TP Reduction
Prevented Sediment Protocol:	64,166.5 lbs/yr	57.1 lbs/yr	14.8 lbs/yr
In-Stream Denitrification:	lbs/yr	791.1 lbs/yr	lbs/yr
Floodplain Reconnection:	lbs/yr	lbs/yr	lbs/yr

Notes

PIDs: 0800-01-47-7642, 0800-04-54-4748, 0800-02-55-4898, 0800-02-46-7865, 0800-48-60-8502, 0800-49-37-4839, 0800-49-33-2960, 0800-48-47-3472, 0800-59-31-4754



**CITY OF DURHAM STORMWATER AND GIS SERVICES
PROPOSED PROJECT FACT SHEET**

Watershed: **Lower NHC**

Project ID: **LNHC1024**

Project: **Stream Restoration**

Project Type: **Restoration**

Project Description

Proposed Restoration of a 949 foot long degraded reach.

Watershed and Site Characteristics

Subwatershed: NH26

Location: Located in a wooded area west of Garrett Rd approximately 700 feet northwest of the intersection of

Date of Field Evaluation: 2/5/2020 5:

Number of Parcels Affected: 3

Projects Within Subwatershed: 6

Ownership: Private

Contributing Drainage Area: ac

Property Owner: HAYWOOD COMPANY OF

Slope of the Drainage Area: %

Willingness to Cooperate: Not yet contacted

Impervious Cover: %

Land Use of Site: Low Density - Poorly Drained

Accessibility to Stream Site:

Receiving Water: Jordan Lake

Land Use in Contributing Drainage Area:

DWQ Class: WS-V;NSW

Residential: 74%

Use Support Rating: No data

Commercial: 6%

Sensitive Areas: NSW

Industrial: 2%

Project Length (ft): 949

Institutional: 2%

Project Setting: Semi-Urban

Agricultural: 0%

Bank Stability:

Parks and Open Space: 4%

Sediment Erosion Rate (lbs/yr):

Roads and Road Right-of-Way: 13%

1-Yr Storm Peak Discharge (cfs):

RTP: 0%

25-Yr Storm Peak Discharge (cfs):

Implementation Costs and Water Quality Benefits Provided by the Project

Estimated Costs (Includes 20 Years of O&M)	Water Quality Parameter	Pollutant Removal		
		Per Year	\$ Per Year	Efficiency
Construction: \$366,900	Total Nitrogen (lbs/yr):		\$5,850	%
Eng./ Admin/Permitting: \$110,070	Total Phosphorus (lbs/yr):		\$81,360	%
Other Costs (Land, Site Factors): \$30,000	Sediment (lbs/yr):		\$9	%
20-year O&M: \$78,000	Fecal Coliform (cfu*109/yr):			%
Total Cost: \$585,000	Copper (lbs/yr):			%
Proposed Implementation:	Zinc (lbs/yr):			%

Photos



PROPOSED PROJECT FACT SHEET

Subwatershed NH26

Project ID: LNHC1024

Project: **Stream Restoration**

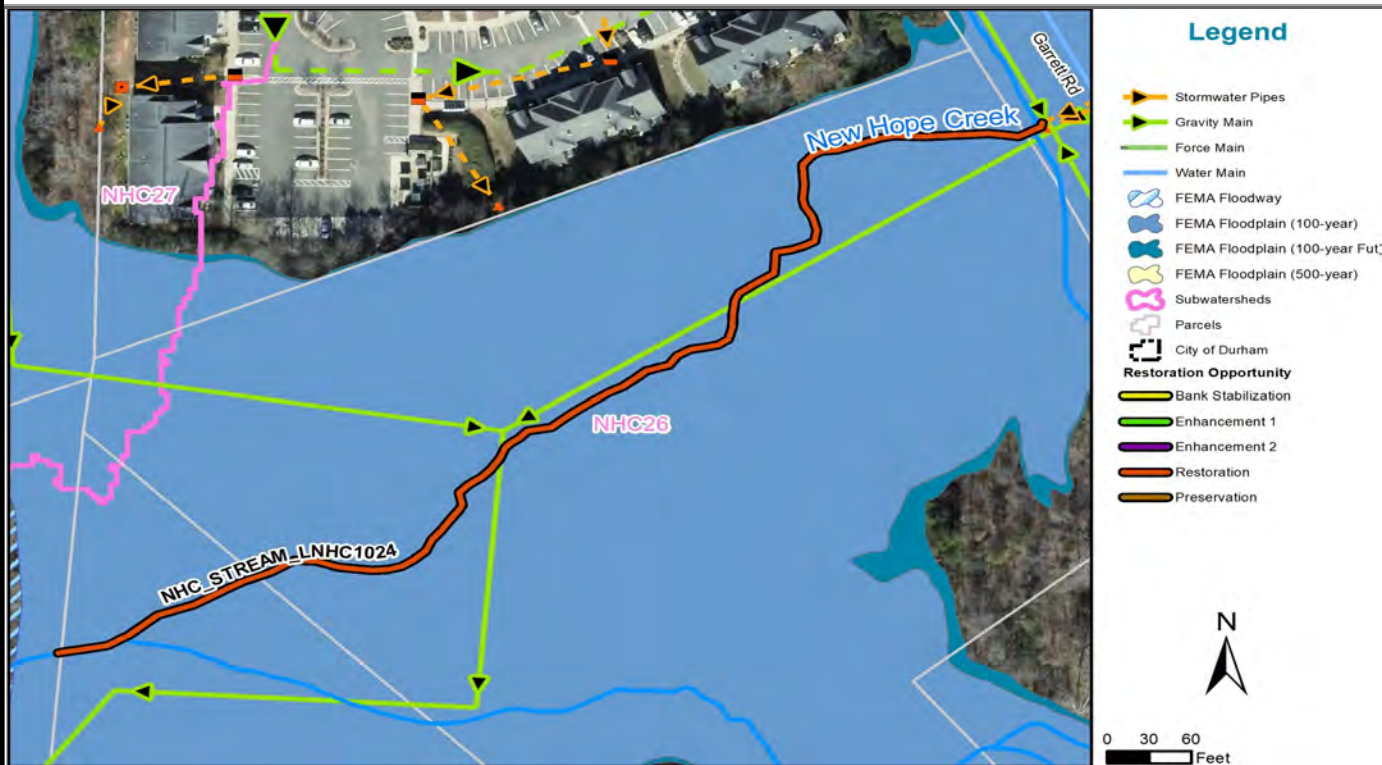


Figure 1 - Plan View of Stream Project

Prioritization Criteria Scores

Criteria	Score	Criteria	Score
<u>Water Quality Benefits</u>		<u>Community Enhancement</u>	
TN	10.0	Property Protection	4.0
TP	10.0	Property Protection Bonus	
Sediment	7.5	Property Owner/Acceptance	2.0
Fecal Coliform		Acceptance Bonus	
Copper		Public Education	0.0
Zinc		<u>Implementation Issue</u>	
Water Quality Bonus		Property Ownership	0.0
<u>Habitat and Biological Integrity</u>		Accessibility for Construction	2.0
Habitat/Biology	15.0	City Program Compatability	5.0
Habitat/Biology Bonus		Permitting/Adverse Env. Impacts	4.0
<u>Stream Bank Protection</u>		Permitting Bonus	
Stream Bank Protection		Total Project Score	
<u>Public Safety and Public Property</u>			
Public Safety and Property	0.0		
Safety Bonus			

Stream Restoration Crediting Protocol

Crediting Protocol	Sediment Reduction	TN Reduction	TP Reduction
Prevented Sediment Protocol:	lbs/yr	lbs/yr	lbs/yr
In-Stream Denitrification:	lbs/yr	lbs/yr	lbs/yr
Floodplain Reconnection:	lbs/yr	lbs/yr	lbs/yr

Notes

PIDs: 0709-02-89-3943, 0800-02-80-6473, 0709-79-47-0345



**CITY OF DURHAM STORMWATER AND GIS SERVICES
PROPOSED PROJECT FACT SHEET**

Watershed: **Mud Creek**

Project ID: **MC1026**

Project: **Stream Restoration**

Project Type: **Restoration**

Project Description

Proposed Restoration of a 2523 foot long degraded reach.

Watershed and Site Characteristics

Subwatershed: NH48

Location: Located in a wooded area approximately 300 feet east of Albritton Dr and Stonegate Dr

Date of Field Evaluation: 2/17/2020

Number of Parcels Affected: 3

Projects Within Subwatershed: 4

Ownership: Public/Private

Contributing Drainage Area: 602.8 ac

Property Owner: CARILLON FOREST HOM

Slope of the Drainage Area: %

Willingness to Cooperate: Not yet contacted

Impervious Cover: 50 %

Land Use of Site: New Development - Well Dra

Accessibility to Stream Site:

Receiving Water: Jordan Lake

Land Use in Contributing Drainage Area:

DWQ Class: WS-V;NSW

Residential: 46%

Use Support Rating: No data

Commercial: 0%

Sensitive Areas: NSW

Industrial: 0%

Project Length (ft): 2,523

Institutional: 3%

Project Setting: Semi-Urban

Agricultural: 25%

Bank Stability:

Parks and Open Space: 18%

Sediment Erosion Rate (lbs/yr):

Roads and Road Right-of-Way: 7%

1-Yr Storm Peak Discharge (cfs):

RTP: 0%

25-Yr Storm Peak Discharge (cfs):

Implementation Costs and Water Quality Benefits Provided by the Project

Estimated Costs (Includes 20 Years of O&M)	Water Quality Parameter	Pollutant Removal		
		Per Year	\$ Per Year	Efficiency
Construction: \$975,300	Total Nitrogen (lbs/yr):		\$6,250	%
Eng./ Admin/Permitting: \$292,590	Total Phosphorus (lbs/yr):		\$262,200	%
Other Costs (Land, Site Factors): \$30,000	Sediment (lbs/yr):		\$30	%
20-year O&M: \$207,000	Fecal Coliform (cfu*109/yr):			%
Total Cost: \$1,505,000	Copper (lbs/yr):			%
Proposed Implementation:	Zinc (lbs/yr):			%

Photos



PROPOSED PROJECT FACT SHEET

Subwatershed NH48

Project ID: MC1026

Project: Stream Restoration

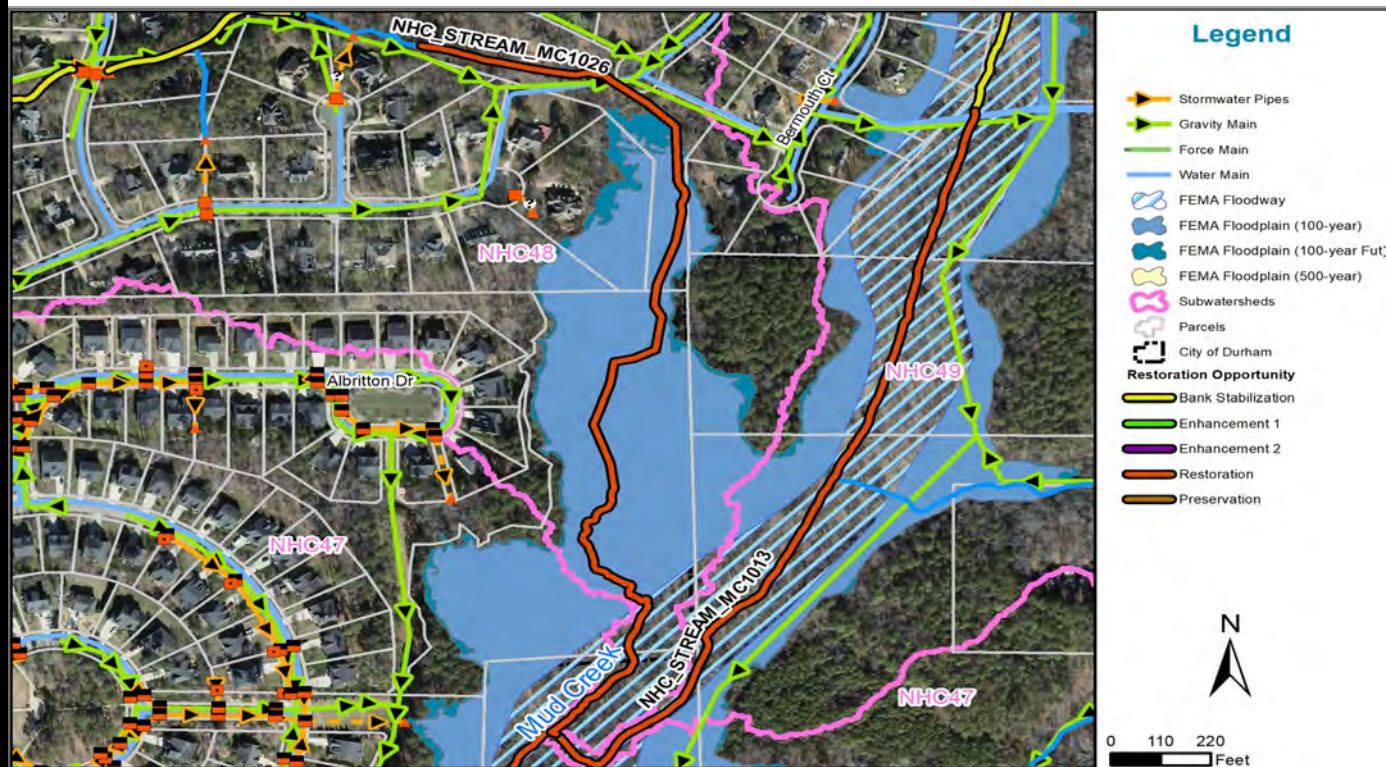


Figure 1 - Plan View of Stream Project

Prioritization Criteria Scores

Criteria	Score	Criteria	Score
<u>Water Quality Benefits</u>		<u>Community Enhancement</u>	
TN	10.0	Property Protection	3.0
TP	6.0	Property Protection Bonus	
Sediment	1.5	Property Owner/Acceptance	4.0
Fecal Coliform		Acceptance Bonus	
Copper		Public Education	3.0
Zinc		<u>Implementation Issue</u>	
Water Quality Bonus		Property Ownership	3.0
<u>Habitat and Biological Integrity</u>		Accessibility for Construction	2.0
Habitat/Biology	12.0	City Program Compatability	5.0
Habitat/Biology Bonus		Permitting/Adverse Env. Impacts	4.0
<u>Stream Bank Protection</u>		Permitting Bonus	
Stream Bank Protection		Total Project Score	
<u>Public Safety and Public Property</u>			
Public Safety and Property	0.0		
Safety Bonus			

Stream Restoration Crediting Protocol

Crediting Protocol	Sediment Reduction	TN Reduction	TP Reduction
Prevented Sediment Protocol:	23,148.0 lbs/yr	20.6 lbs/yr	5.3 lbs/yr
In-Stream Denitrification:	lbs/yr	259.6 lbs/yr	lbs/yr
Floodplain Reconnection:	lbs/yr	lbs/yr	lbs/yr

Notes

PIDs: 0801-04-52-3169, 0801-04-43-7668, 0801-51-81-5711



**CITY OF DURHAM STORMWATER AND GIS SERVICES
PROPOSED PROJECT FACT SHEET**

Watershed: **Lower NHC**

Project ID: **LNHC1003**

Project: **Stream Restoration**

Project Type: **Bank Stabilization**

Project Description

Proposed Bank Stabilization of a 2251 foot long degraded reach.

Watershed and Site Characteristics

Subwatershed: NH27

Location: Located in a wooded area and crossing Durham-Chapel Hill Blvd approximately a quarter of a mile so	
Date of Field Evaluation: 2/5/2020	Number of Parcels Affected: 7
Projects Within Subwatershed: 3	Ownership: Public/Private
Contributing Drainage Area: ac	Property Owner: COUNTY OF DURHAM, D
Slope of the Drainage Area: %	Willingness to Cooperate: Not yet contacted
Impervious Cover: %	Land Use of Site: Low Density - Poorly Drained
Accessibility to Stream Site:	Receiving Water: Jordan Lake
Land Use in Contributing Drainage Area:	DWQ Class: WS-V;NSW
Residential: 37%	Use Support Rating: Meeting Criteria
Commercial: 2%	Sensitive Areas: NSW
Industrial: 0%	Project Length (ft): 2,251
Institutional: 1%	Project Setting: Semi-Urban
Agricultural: 10%	Bank Stability:
Parks and Open Space: 40%	Sediment Erosion Rate (lbs/yr):
Roads and Road Right-of-Way: 9%	1-Yr Storm Peak Discharge (cfs):
RTP: 0%	25-Yr Storm Peak Discharge (cfs):

Implementation Costs and Water Quality Benefits Provided by the Project

Estimated Costs (Includes 20 Years of O&M)	Water Quality Parameter	Pollutant Removal		
		Per Year	\$ Per Year	Efficiency
Construction: \$1,087,750	Total Nitrogen (lbs/yr):		\$23,090	%
Eng./ Admin/Permitting: \$271,938	Total Phosphorus (lbs/yr):		\$89,340	%
Other Costs (Land, Site Factors): \$50,000	Sediment (lbs/yr):		\$10	%
20-year O&M: \$115,000	Fecal Coliform (cfu*109/yr):			%
Total Cost: \$1,525,000	Copper (lbs/yr):			%
Proposed Implementation:	Zinc (lbs/yr):			%

Photos



PROPOSED PROJECT FACT SHEET

Subwatershed NH27

Project ID: LNHC1003

Project: **Stream Restoration**



Figure 1 - Plan View of Stream Project

Prioritization Criteria Scores

Criteria	Score	Criteria	Score
<u>Water Quality Benefits</u>		<u>Community Enhancement</u>	
TN	6.0	Property Protection	1.2
TP	10.0	Property Protection Bonus	
Sediment	4.5	Property Owner/Acceptance	5.0
Fecal Coliform		Acceptance Bonus	
Copper		Public Education	5.0
Zinc		<u>Implementation Issue</u>	
Water Quality Bonus		Property Ownership	3.0
<u>Habitat and Biological Integrity</u>		Accessibility for Construction	5.0
Habitat/Biology	4.8	City Program Compatability	5.0
Habitat/Biology Bonus		Permitting/Adverse Env. Impacts	4.0
<u>Stream Bank Protection</u>		Permitting Bonus	
Stream Bank Protection		Total Project Score	
<u>Public Safety and Public Property</u>			
Public Safety and Property	0.0		
Safety Bonus			

Stream Restoration Crediting Protocol

Crediting Protocol	Sediment Reduction	TN Reduction	TP Reduction
Prevented Sediment Protocol:	lbs/yr	lbs/yr	lbs/yr
In-Stream Denitrification:	lbs/yr	lbs/yr	lbs/yr
Floodplain Reconnection:	lbs/yr	lbs/yr	lbs/yr

Notes

PIDs: 0800-04-53-9903, 0800-04-54-4748, 0800-04-54-4748, 0800-04-44-8493, 0800-04-54-6303, 0800-04-44-8493, 0800-53-70-6536



**CITY OF DURHAM STORMWATER AND GIS SERVICES
PROPOSED PROJECT FACT SHEET**

Watershed: **Lower NHC**

Project ID: **LNHC1015**

Project: **Stream Restoration**

Project Type: **Restoration**

Project Description

Proposed Restoration of a 3926 foot long degraded reach.

Watershed and Site Characteristics

Subwatershed: NH30

Location: Located in a wooded area approximately half a mile north of the intersection of University Dr and G	
Date of Field Evaluation: 2/10/2020	Number of Parcels Affected: 6
Projects Within Subwatershed: 3	Ownership: Private
Contributing Drainage Area: 5,390.6 ac	Property Owner: GA HC REIT II DURHAM A
Slope of the Drainage Area: %	Willingness to Cooperate: Not yet contacted
Impervious Cover: 1,617 %	Land Use of Site: High Density Residential and C
Accessibility to Stream Site:	Receiving Water: Jordan Lake
Land Use in Contributing Drainage Area:	DWQ Class: WS-V;NSW
Residential: 34%	Use Support Rating: No data
Commercial: 12%	Sensitive Areas: NSW
Industrial: 0%	Project Length (ft): 3,926
Institutional: 21%	Project Setting: Urban
Agricultural: 0%	Bank Stability:
Parks and Open Space: 19%	Sediment Erosion Rate (lbs/yr):
Roads and Road Right-of-Way: 14%	1-Yr Storm Peak Discharge (cfs):
RTP: 0%	25-Yr Storm Peak Discharge (cfs):

Implementation Costs and Water Quality Benefits Provided by the Project

Estimated Costs (Includes 20 Years of O&M)	Water Quality Parameter	Pollutant Removal		
		Per Year	\$ Per Year	Efficiency
Construction: \$2,276,500	Total Nitrogen (lbs/yr):		\$10,080	%
Eng./ Admin/Permitting: \$569,125	Total Phosphorus (lbs/yr):		\$384,040	%
Other Costs (Land, Site Factors): \$40,000	Sediment (lbs/yr):		\$40	%
20-year O&M: \$482,000	Fecal Coliform (cfu*109/yr):			%
Total Cost: \$3,368,000	Copper (lbs/yr):			%
Proposed Implementation:	Zinc (lbs/yr):			%

Photos



PROPOSED PROJECT FACT SHEET

Subwatershed NH30

Project ID: LNHC1015

Project: **Stream Restoration**

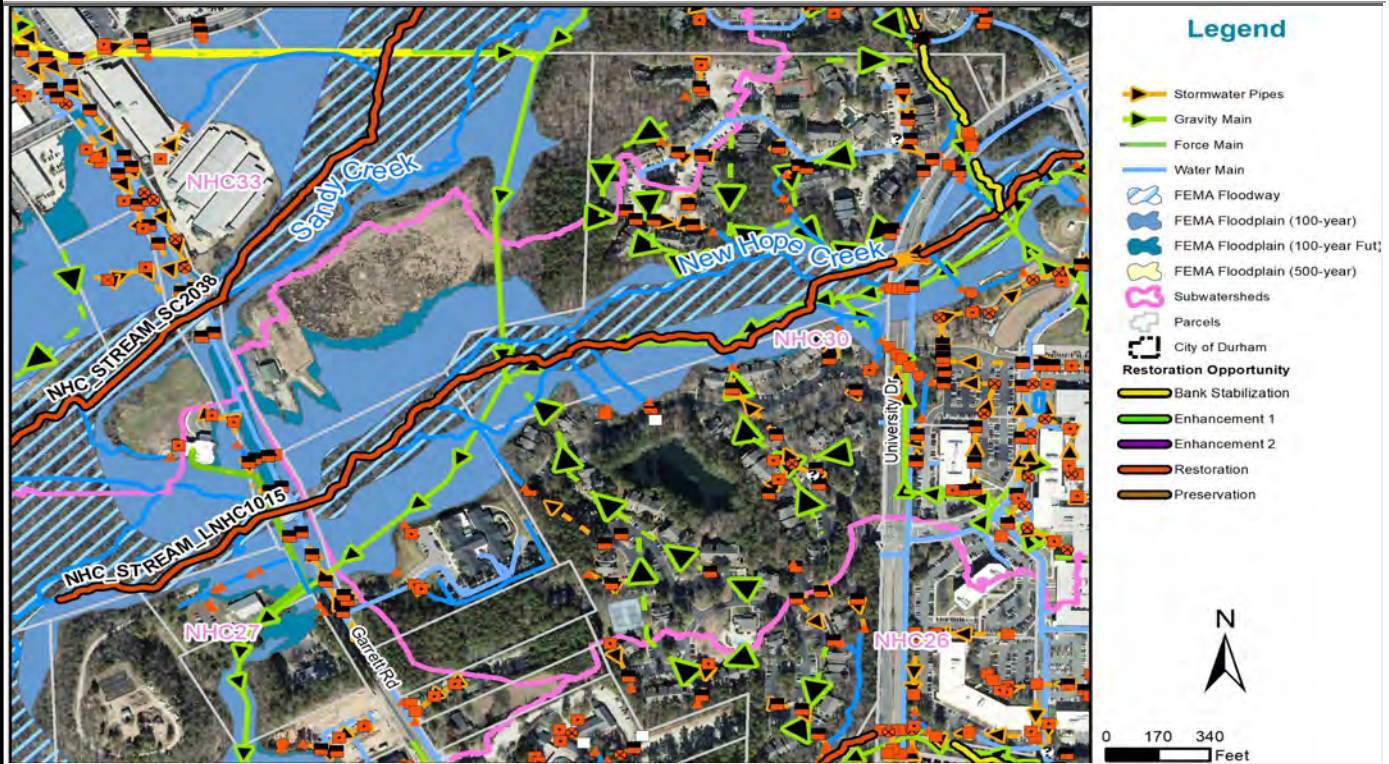


Figure 1 - Plan View of Stream Project

Prioritization Criteria Scores

Criteria	Score	Criteria	Score
<u>Water Quality Benefits</u>		<u>Community Enhancement</u>	
TN	10.0	Property Protection	5.0
TP	2.0	Property Protection Bonus	
Sediment	1.5	Property Owner/Acceptance	4.0
Fecal Coliform		Acceptance Bonus	
Copper		Public Education	3.0
Zinc		<u>Implementation Issue</u>	
Water Quality Bonus		Property Ownership	3.0
<u>Habitat and Biological Integrity</u>		Accessibility for Construction	2.0
Habitat/Biology	12.0	City Program Compatability	5.0
Habitat/Biology Bonus		Permitting/Adverse Env. Impacts	4.0
<u>Stream Bank Protection</u>		Permitting Bonus	
Stream Bank Protection		Total Project Score	
<u>Public Safety and Public Property</u>			
Public Safety and Property	0.0		
Safety Bonus			

Stream Restoration Crediting Protocol

Crediting Protocol	Sediment Reduction	TN Reduction	TP Reduction
Prevented Sediment Protocol:	35,374.4 lbs/yr	31.5 lbs/yr	8.1 lbs/yr
In-Stream Denitrification:	lbs/yr	377.1 lbs/yr	lbs/yr
Floodplain Reconnection:	lbs/yr	lbs/yr	lbs/yr

Notes

PIDs: 0800-04-82-4553, 0800-13-93-4668, 0800-04-72-8230, 0810-13-03-3457, 0800-72-35-4396, 0810-13-03-3457



**CITY OF DURHAM STORMWATER AND GIS SERVICES
PROPOSED PROJECT FACT SHEET**

Watershed: **Mud Creek**

Project ID: **MC1027**

Project: **Stream Restoration**

Project Type: **Enhancement 1**

Project Description

Proposed Enhancement 1 of a 2466 foot long degraded reach.

Watershed and Site Characteristics

Subwatershed: NH48

Location: Located in a wooded area southwest of Lochnora Pkwy beginning just south of the intersection of L	
Date of Field Evaluation: 2/17/2020	Number of Parcels Affected: 11
Projects Within Subwatershed: 4	Ownership: Public/Private
Contributing Drainage Area: 489.0 ac	Property Owner: KNIGHT RENAE MILLER,
Slope of the Drainage Area: %	Willingness to Cooperate: Not yet contacted
Impervious Cover: 30 %	Land Use of Site: New Development - Well Drai
Accessibility to Stream Site:	Receiving Water: Jordan Lake
Land Use in Contributing Drainage Area:	DWQ Class: WS-V;NSW
Residential: 41%	Use Support Rating: No data
Commercial: 0%	Sensitive Areas: NSW
Industrial: 0%	Project Length (ft): 2,466
Institutional: 4%	Project Setting: Semi-Urban
Agricultural: 31%	Bank Stability:
Parks and Open Space: 19%	Sediment Erosion Rate (lbs/yr):
Roads and Road Right-of-Way: 6%	1-Yr Storm Peak Discharge (cfs):
RTP: 0%	25-Yr Storm Peak Discharge (cfs):

Implementation Costs and Water Quality Benefits Provided by the Project

Estimated Costs (Includes 20 Years of O&M)	Water Quality Parameter	Pollutant Removal		
		Per Year	\$ Per Year	Efficiency
Construction: \$715,000	Total Nitrogen (lbs/yr):		\$38,660	%
Eng./ Admin/Permitting: \$214,500	Total Phosphorus (lbs/yr):		\$149,620	%
Other Costs (Land, Site Factors): \$110,000	Sediment (lbs/yr):		\$20	%
20-year O&M: \$151,000	Fecal Coliform (cfu*109/yr):			%
Total Cost: \$1,191,000	Copper (lbs/yr):			%
Proposed Implementation:	Zinc (lbs/yr):			%

Photos



PROPOSED PROJECT FACT SHEET

Subwatershed NH48

Project ID: MC1027

Project: Stream Restoration

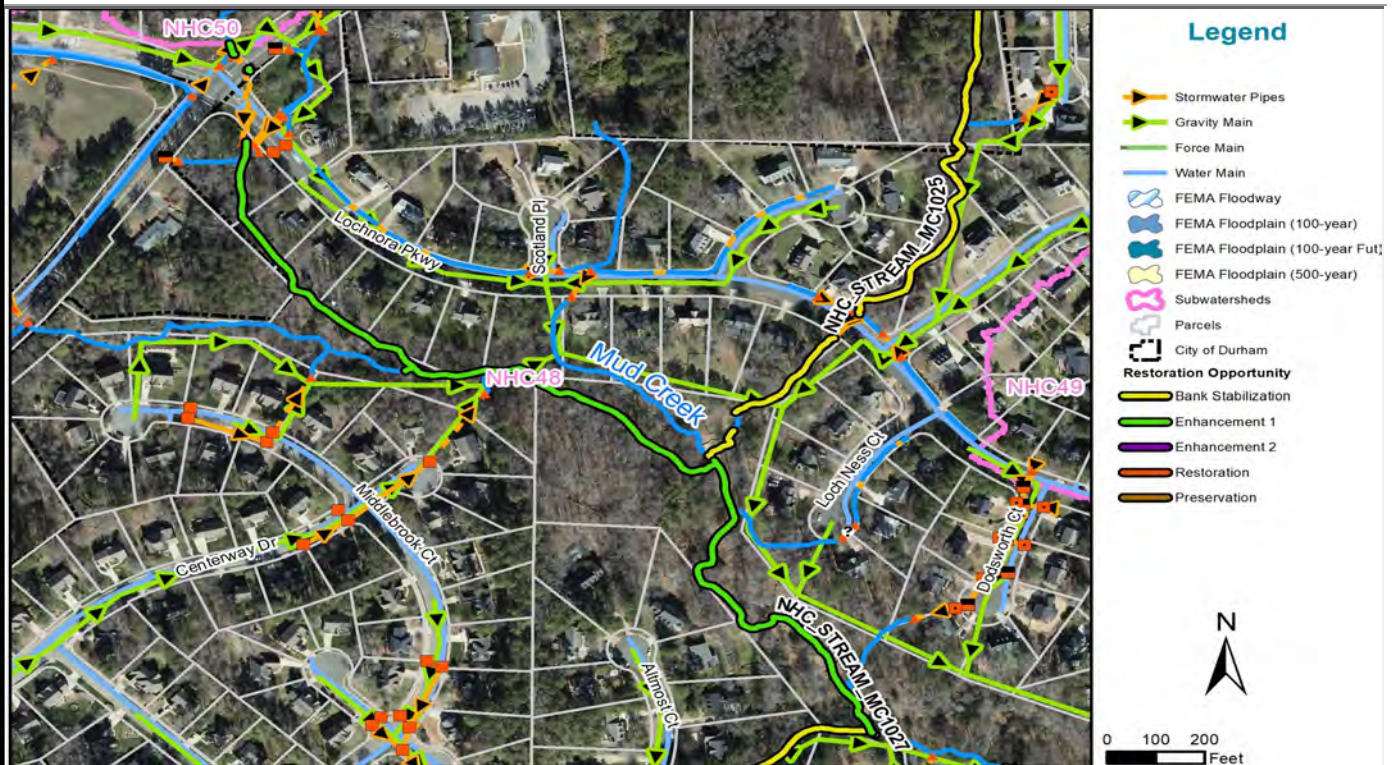


Figure 1 - Plan View of Stream Project

Prioritization Criteria Scores

Criteria	Score	Criteria	Score
<u>Water Quality Benefits</u>		<u>Community Enhancement</u>	
TN	6.0	Property Protection	0.7
TP	6.0	Property Protection Bonus	
Sediment	4.5	Property Owner/Acceptance	5.0
Fecal Coliform		Acceptance Bonus	
Copper		Public Education	5.0
Zinc		<u>Implementation Issue</u>	
Water Quality Bonus		Property Ownership	3.0
<u>Habitat and Biological Integrity</u>		Accessibility for Construction	2.0
Habitat/Biology	8.4	City Program Compatability	5.0
Habitat/Biology Bonus		Permitting/Adverse Env. Impacts	4.0
<u>Stream Bank Protection</u>		Permitting Bonus	
Stream Bank Protection		Total Project Score	
<u>Public Safety and Public Property</u>			
Public Safety and Property	0.0		
Safety Bonus			

Stream Restoration Crediting Protocol

Crediting Protocol	Sediment Reduction	TN Reduction	TP Reduction
Prevented Sediment Protocol:	32,112.7 lbs/yr	28.6 lbs/yr	7.4 lbs/yr
In-Stream Denitrification:	lbs/yr	196.0 lbs/yr	lbs/yr
Floodplain Reconnection:	lbs/yr	lbs/yr	lbs/yr

Notes

PIDs: 0801-03-43-3759, 0801-03-34-8416, 0801-03-34-6306, 0801-03-34-9413, 0801-03-34-4832, 0801-03-34-6620, 0801-03-34-3539, 0801-03-44-0442, 0801-03-34-5649, 0801-04-43-7668, 0801-01-36-5364



**CITY OF DURHAM STORMWATER AND GIS SERVICES
PROPOSED PROJECT FACT SHEET**

Watershed: **Lower NHC**

Project ID: **LNHC2017**

Project: **Stream Restoration**

Project Type: **Enhancement 1**

Project Description

Proposed Enhancement 1 of a 2222 foot long degraded reach.

Watershed and Site Characteristics

Subwatershed: NH11

Location: Located in a wooded area just north of the South Durham Water Reclamation Facility west of I-40	
Date of Field Evaluation: 2/4/2020 5:	Number of Parcels Affected: 2
Projects Within Subwatershed: 1	Ownership: Public
Contributing Drainage Area: ac	Property Owner: CITY OF DURHAM, UNITE
Slope of the Drainage Area: %	Willingness to Cooperate: Not yet contacted
Impervious Cover: %	Land Use of Site: Parks and Open Space - Poorly
Accessibility to Stream Site:	Receiving Water: Jordan Lake
Land Use in Contributing Drainage Area:	DWQ Class: WS-IV;NSW
Residential: 21%	Use Support Rating: No data
Commercial: 65%	Sensitive Areas: NSW
Industrial: 0%	Project Length (ft): 2,222
Institutional: 4%	Project Setting: Semi-Urban
Agricultural: 0%	Bank Stability:
Parks and Open Space: 3%	Sediment Erosion Rate (lbs/yr):
Roads and Road Right-of-Way: 7%	1-Yr Storm Peak Discharge (cfs):
RTP: 0%	25-Yr Storm Peak Discharge (cfs):

Implementation Costs and Water Quality Benefits Provided by the Project

Estimated Costs (Includes 20 Years of O&M)	Water Quality Parameter	Pollutant Removal		
		Per Year	\$ Per Year	Efficiency
Construction: \$644,200	Total Nitrogen (lbs/yr):		\$51,940	%
Eng./ Admin/Permitting: \$193,260	Total Phosphorus (lbs/yr):		\$201,010	%
Other Costs (Land, Site Factors): \$20,000	Sediment (lbs/yr):		\$20	%
20-year O&M: \$136,000	Fecal Coliform (cfu*109/yr):			%
Total Cost: \$993,000	Copper (lbs/yr):			%
Proposed Implementation:	Zinc (lbs/yr):			%

Photos



PROPOSED PROJECT FACT SHEET

Subwatershed NH11

Project ID: LNHC2017

Project: **Stream Restoration**

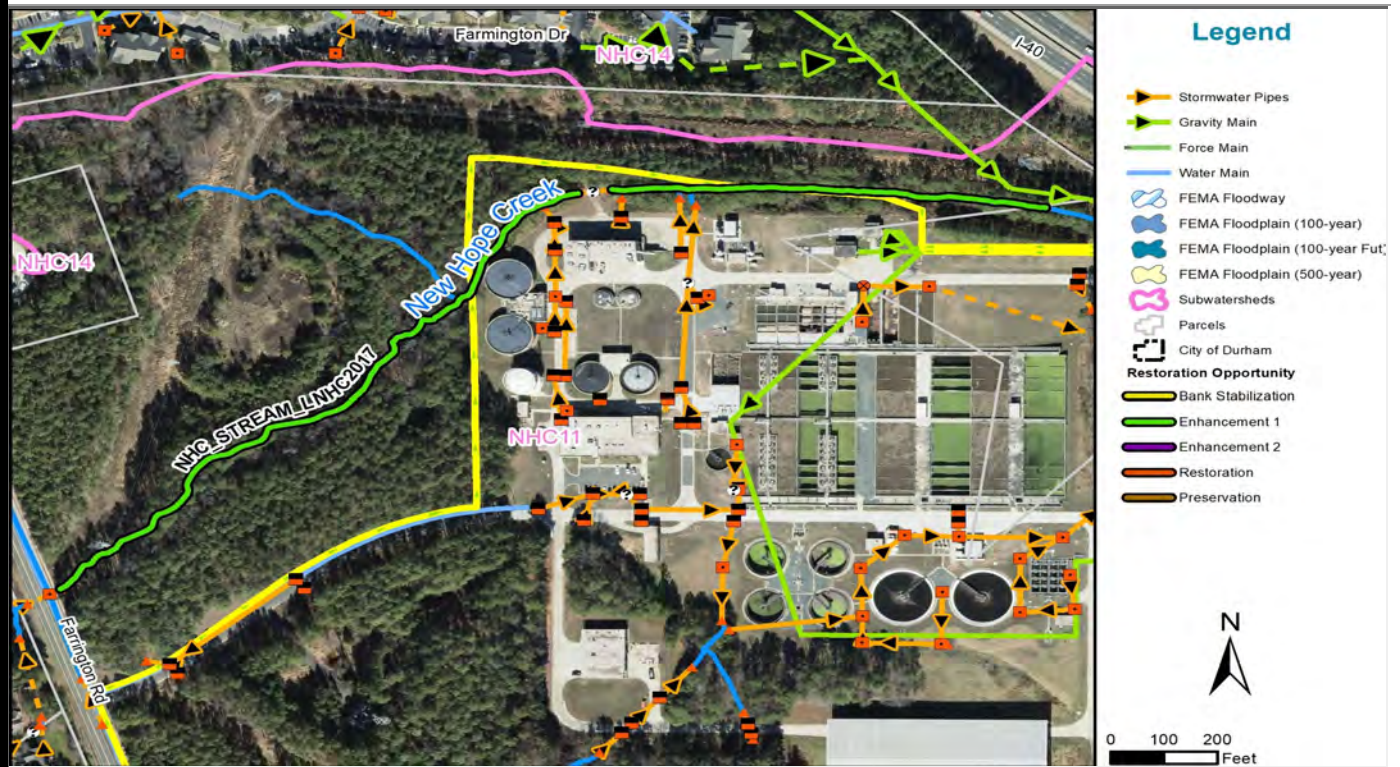


Figure 1 - Plan View of Stream Project

Prioritization Criteria Scores

Criteria	Score	Criteria	Score
<u>Water Quality Benefits</u>		<u>Community Enhancement</u>	
TN	2.0	Property Protection	2.1
TP	6.0	Property Protection Bonus	
Sediment	4.5	Property Owner/Acceptance	5.0
Fecal Coliform		Acceptance Bonus	
Copper		Public Education	5.0
Zinc		<u>Implementation Issue</u>	
Water Quality Bonus		Property Ownership	5.0
<u>Habitat and Biological Integrity</u>		Accessibility for Construction	2.0
Habitat/Biology	8.4	City Program Compatibility	5.0
Habitat/Biology Bonus		Permitting/Adverse Env. Impacts	4.0
<u>Stream Bank Protection</u>		Permitting Bonus	
Stream Bank Protection		Total Project Score	
<u>Public Safety and Public Property</u>			
Public Safety and Property	0.0		
Safety Bonus			

Stream Restoration Crediting Protocol

Crediting Protocol	Sediment Reduction	TN Reduction	TP Reduction
Prevented Sediment Protocol:	lbs/yr	lbs/yr	lbs/yr
In-Stream Denitrification:	lbs/yr	lbs/yr	lbs/yr
Floodplain Reconnection:	lbs/yr	lbs/yr	lbs/yr

Notes

PIDs: **0708-04-63-3956, 0708-04-83-0888**



**CITY OF DURHAM STORMWATER AND GIS SERVICES
PROPOSED PROJECT FACT SHEET**

Watershed: **Sandy Creek**

Project ID: **SC2034**

Project: **Stream Restoration**

Project Type: **Restoration**

Project Description

Proposed Restoration of a 952 foot long degraded reach.

Watershed and Site Characteristics **Subwatershed: NH35**

Location: Located in a wooded area south of Pickett Rd approximately a quarter of a mile southeast of the inter	
Date of Field Evaluation: 2/17/2020	5
Projects Within Subwatershed:	5
Contributing Drainage Area:	ac
Slope of the Drainage Area:	%
Impervious Cover:	%
Accessibility to Stream Site:	
Land Use in Contributing Drainage Area:	
Residential:	57%
Commercial:	8%
Industrial:	0%
Institutional:	7%
Agricultural:	0%
Parks and Open Space:	12%
Roads and Road Right-of-Way:	15%
RTP:	0%
Number of Parcels Affected:	5
Ownership:	Private
Property Owner:	WOODSTREAM GLEN TO
Willingness to Cooperate:	Not yet contacted
Land Use of Site:	Low Medium Density Resident
Receiving Water:	Jordan Lake
DWQ Class:	WS-V;NSW
Use Support Rating:	No data
Sensitive Areas:	NSW
Project Length (ft):	952
Project Setting:	Semi-Urban
Bank Stability:	
Sediment Erosion Rate (lbs/yr):	
1-Yr Storm Peak Discharge (cfs):	
25-Yr Storm Peak Discharge (cfs):	

Implementation Costs and Water Quality Benefits Provided by the Project

Estimated Costs (Includes 20 Years of O&M)	Water Quality Parameter	Pollutant Removal		
		Per Year	\$ Per Year	Efficiency
Construction:	Total Nitrogen (lbs/yr):		\$4,910	%
Eng./ Admin/Permitting:	Total Phosphorus (lbs/yr):		\$83,930	%
Other Costs (Land, Site Factors):	Sediment (lbs/yr):		\$10	%
20-year O&M:	Fecal Coliform (cfu*109/yr):			%
Total Cost:	Copper (lbs/yr):			%
Proposed Implementation:	Zinc (lbs/yr):			%

Photos



PROPOSED PROJECT FACT SHEET

Subwatershed NH35

Project ID: SC2034

Project: **Stream Restoration**



Figure 1 - Plan View of Stream Project

Prioritization Criteria Scores

Criteria	Score	Criteria	Score
<u>Water Quality Benefits</u>		<u>Community Enhancement</u>	
TN	10.0	Property Protection	1.0
TP	10.0	Property Protection Bonus	
Sediment	4.5	Property Owner/Acceptance	4.0
Fecal Coliform		Acceptance Bonus	
Copper		Public Education	3.0
Zinc		<u>Implementation Issue</u>	
Water Quality Bonus		Property Ownership	0.0
<u>Habitat and Biological Integrity</u>		Accessibility for Construction	2.0
Habitat/Biology	9.0	City Program Compatability	5.0
Habitat/Biology Bonus		Permitting/Adverse Env. Impacts	4.0
<u>Stream Bank Protection</u>		Permitting Bonus	
Stream Bank Protection		Total Project Score	
<u>Public Safety and Public Property</u>			
Public Safety and Property	0.0		
Safety Bonus			

Stream Restoration Crediting Protocol

Crediting Protocol	Sediment Reduction	TN Reduction	TP Reduction
Prevented Sediment Protocol:	lbs/yr	lbs/yr	lbs/yr
In-Stream Denitrification:	lbs/yr	lbs/yr	lbs/yr
Floodplain Reconnection:	lbs/yr	lbs/yr	lbs/yr

Notes

PIDs: 0810-01-09-0484, 0810-01-09-2620, 0810-01-09-3789, 0800-01-99-8104, 0800-01-99-6575,



**CITY OF DURHAM STORMWATER AND GIS SERVICES
PROPOSED PROJECT FACT SHEET**

Watershed: **Lower NHC**

Project ID: **LNHC2005**

Project: **Stream Restoration**

Project Type: **Restoration**

Project Description

Proposed Restoration of a 1180 foot long degraded reach.

Watershed and Site Characteristics

Subwatershed: NH22

Location: Located in a wooded area east of Farrington Rd just south of the intersection of Farrington Rd and B

Date of Field Evaluation: 2/5/2020 5:

Number of Parcels Affected: 5

Projects Within Subwatershed: 2

Ownership: Public/Private

Contributing Drainage Area: ac

Property Owner: CITY OF DURHAM, UNITE

Slope of the Drainage Area: %

Willingness to Cooperate: Not yet contacted

Impervious Cover: %

Land Use of Site: Low Density - Poorly Drained

Accessibility to Stream Site:

Receiving Water: Jordan Lake

Land Use in Contributing Drainage Area:

DWQ Class: WS-IV;NSW

Residential: 66%

Use Support Rating: No data

Commercial: 1%

Sensitive Areas: NSW

Industrial: 0%

Project Length (ft): 1,180

Institutional: 5%

Project Setting: Semi-Urban

Agricultural: 0%

Bank Stability:

Parks and Open Space: 10%

Sediment Erosion Rate (lbs/yr):

Roads and Road Right-of-Way: 19%

1-Yr Storm Peak Discharge (cfs):

RTP: 0%

25-Yr Storm Peak Discharge (cfs):

Implementation Costs and Water Quality Benefits Provided by the Project

Estimated Costs (Includes 20 Years of O&M)	Water Quality Parameter	Pollutant Removal		
		Per Year	\$ Per Year	Efficiency
Construction: \$456,100	Total Nitrogen (lbs/yr):		\$6,820	%
Eng./ Admin/Permitting: \$136,830	Total Phosphorus (lbs/yr):		\$128,030	%
Other Costs (Land, Site Factors): \$50,000	Sediment (lbs/yr):		\$10	%
20-year O&M: \$97,000	Fecal Coliform (cfu*109/yr):			%
Total Cost: \$740,000	Copper (lbs/yr):			%
Proposed Implementation:	Zinc (lbs/yr):			%

Photos



PROPOSED PROJECT FACT SHEET

Subwatershed NH22

Project ID: LNHC2005

Project: **Stream Restoration**



Figure 1 - Plan View of Stream Project

Prioritization Criteria Scores

Criteria	Score	Criteria	Score
<u>Water Quality Benefits</u>		<u>Community Enhancement</u>	
TN	10.0	Property Protection	3.0
TP	6.0	Property Protection Bonus	
Sediment	4.5	Property Owner/Acceptance	2.0
Fecal Coliform		Acceptance Bonus	
Copper		Public Education	0.0
Zinc		<u>Implementation Issue</u>	
Water Quality Bonus		Property Ownership	0.0
<u>Habitat and Biological Integrity</u>		Accessibility for Construction	2.0
Habitat/Biology	12.0	City Program Compatability	5.0
Habitat/Biology Bonus		Permitting/Adverse Env. Impacts	4.0
<u>Stream Bank Protection</u>		Permitting Bonus	
Stream Bank Protection		Total Project Score	
<u>Public Safety and Public Property</u>			
Public Safety and Property	0.0	54.5	
Safety Bonus			

Stream Restoration Crediting Protocol

Crediting Protocol	Sediment Reduction	TN Reduction	TP Reduction
Prevented Sediment Protocol:	lbs/yr	lbs/yr	lbs/yr
In-Stream Denitrification:	lbs/yr	lbs/yr	lbs/yr
Floodplain Reconnection:	lbs/yr	lbs/yr	lbs/yr

Notes

PIDs: 0709-02-57-6066, 0709-02-57-7566, 0709-01-46-7845, 0709-02-56-5630, 0709-02-56-0514



**CITY OF DURHAM STORMWATER AND GIS SERVICES
PROPOSED PROJECT FACT SHEET**

Watershed: **Lower NHC**

Project ID: **LNHC1008**

Project: **Stream Restoration**

Project Type: **Enhancement 2**

Project Description

Proposed Enhancement 2 of a 1066 foot long degraded reach.

Watershed and Site Characteristics

Subwatershed: NH28

Location: Located in a wooded area north of Durham-Chapel Hill Blvd approximately half of a mile west of th

Date of Field Evaluation: 2/4/2020 5:

Number of Parcels Affected: 4

Projects Within Subwatershed: 3

Ownership: Public/Private

Contributing Drainage Area: ac

Property Owner: DURHILL LLC, COUNTY O

Slope of the Drainage Area: %

Willingness to Cooperate: Not yet contacted

Impervious Cover: %

Land Use of Site: Parks and Open Space - Poorly

Accessibility to Stream Site:

Receiving Water: Jordan Lake

Land Use in Contributing Drainage Area:

DWQ Class: WS-V;NSW

Residential: 38%

Use Support Rating: No data

Commercial: 8%

Sensitive Areas: NSW

Industrial: 0%

Project Length (ft): 1,066

Institutional: 2%

Project Setting: Semi-Urban

Agricultural: 0%

Bank Stability:

Parks and Open Space: 42%

Sediment Erosion Rate (lbs/yr):

Roads and Road Right-of-Way: 10%

1-Yr Storm Peak Discharge (cfs):

RTP: 0%

25-Yr Storm Peak Discharge (cfs):

Implementation Costs and Water Quality Benefits Provided by the Project

Estimated Costs (Includes 20 Years of O&M)	Water Quality Parameter	Pollutant Removal		
		Per Year	\$ Per Year	Efficiency
Construction: \$206,100	Total Nitrogen (lbs/yr):		\$17,940	%
Eng./ Admin/Permitting: \$82,440	Total Phosphorus (lbs/yr):		\$69,410	%
Other Costs (Land, Site Factors): \$30,000	Sediment (lbs/yr):		\$8	%
20-year O&M: \$44,000	Fecal Coliform (cfu*109/yr):			%
Total Cost: \$363,000	Copper (lbs/yr):			%
Proposed Implementation:	Zinc (lbs/yr):			%

Photos



PROPOSED PROJECT FACT SHEET

Subwatershed NH28

Project ID: LNHC1008

Project: Stream Restoration



Figure 1 - Plan View of Stream Project

Prioritization Criteria Scores

Criteria	Score	Criteria	Score
<u>Water Quality Benefits</u>		<u>Community Enhancement</u>	
TN	6.0	Property Protection	0.4
TP	10.0	Property Protection Bonus	
Sediment	7.5	Property Owner/Acceptance	4.0
Fecal Coliform		Acceptance Bonus	
Copper		Public Education	3.0
Zinc		<u>Implementation Issue</u>	
Water Quality Bonus		Property Ownership	0.0
<u>Habitat and Biological Integrity</u>		Accessibility for Construction	2.0
Habitat/Biology	4.8	City Program Compatability	5.0
Habitat/Biology Bonus		Permitting/Adverse Env. Impacts	4.0
<u>Stream Bank Protection</u>		Permitting Bonus	
Stream Bank Protection		Total Project Score	
<u>Public Safety and Public Property</u>			
Public Safety and Property	0.0		
Safety Bonus			

Stream Restoration Crediting Protocol

Crediting Protocol	Sediment Reduction	TN Reduction	TP Reduction
Prevented Sediment Protocol:	lbs/yr	lbs/yr	lbs/yr
In-Stream Denitrification:	lbs/yr	lbs/yr	lbs/yr
Floodplain Reconnection:	lbs/yr	lbs/yr	lbs/yr

Notes

PIDs: 0800-04-44-8493, 0800-03-34-6437, 0800-04-54-4748, 0800-04-44-8493



**CITY OF DURHAM STORMWATER AND GIS SERVICES
PROPOSED PROJECT FACT SHEET**

Watershed: **Lower NHC**

Project ID: **LNHC1007**

Project: **Stream Restoration**

Project Type: **Restoration**

Project Description

Proposed Restoration of a 3278 foot long degraded reach.

Watershed and Site Characteristics **Subwatershed: NH28**

Location: Located in a wooded area east of Mt Moriah Rd just south of the intersection of Mt Moriah Rd with	
Date of Field Evaluation: 2/4/2020 5:	Number of Parcels Affected: 5
Projects Within Subwatershed: 3	Ownership: Public/Private
Contributing Drainage Area: ac	Property Owner: DURHILL LLC, COUNTY O
Slope of the Drainage Area: %	Willingness to Cooperate: Not yet contacted
Impervious Cover: %	Land Use of Site: Parks and Open Space - Poorly
Accessibility to Stream Site:	Receiving Water: Jordan Lake
Land Use in Contributing Drainage Area:	DWQ Class: WS-V;NSW
Residential: 14%	Use Support Rating: No data
Commercial: 31%	Sensitive Areas: NSW
Industrial: 0%	Project Length (ft): 3,278
Institutional: 0%	Project Setting: Semi-Urban
Agricultural: 0%	Bank Stability:
Parks and Open Space: 35%	Sediment Erosion Rate (lbs/yr):
Roads and Road Right-of-Way: 20%	1-Yr Storm Peak Discharge (cfs):
RTP: 0%	25-Yr Storm Peak Discharge (cfs):

Implementation Costs and Water Quality Benefits Provided by the Project

Estimated Costs (Includes 20 Years of O&M)	Water Quality Parameter	Pollutant Removal		
		Per Year	\$ Per Year	Efficiency
Construction: \$1,267,100	Total Nitrogen (lbs/yr):		\$11,560	%
Eng./Admin/Permitting: \$316,775	Total Phosphorus (lbs/yr):		\$1,509,520	%
Other Costs (Land, Site Factors): \$50,000	Sediment (lbs/yr):		\$170	%
20-year O&M: \$268,000	Fecal Coliform (cfu*109/yr):			%
Total Cost: \$1,902,000	Copper (lbs/yr):			%
Proposed Implementation:	Zinc (lbs/yr):			%

Photos



PROPOSED PROJECT FACT SHEET

Subwatershed NH28

Project ID: LNHC1007

Project: **Stream Restoration**

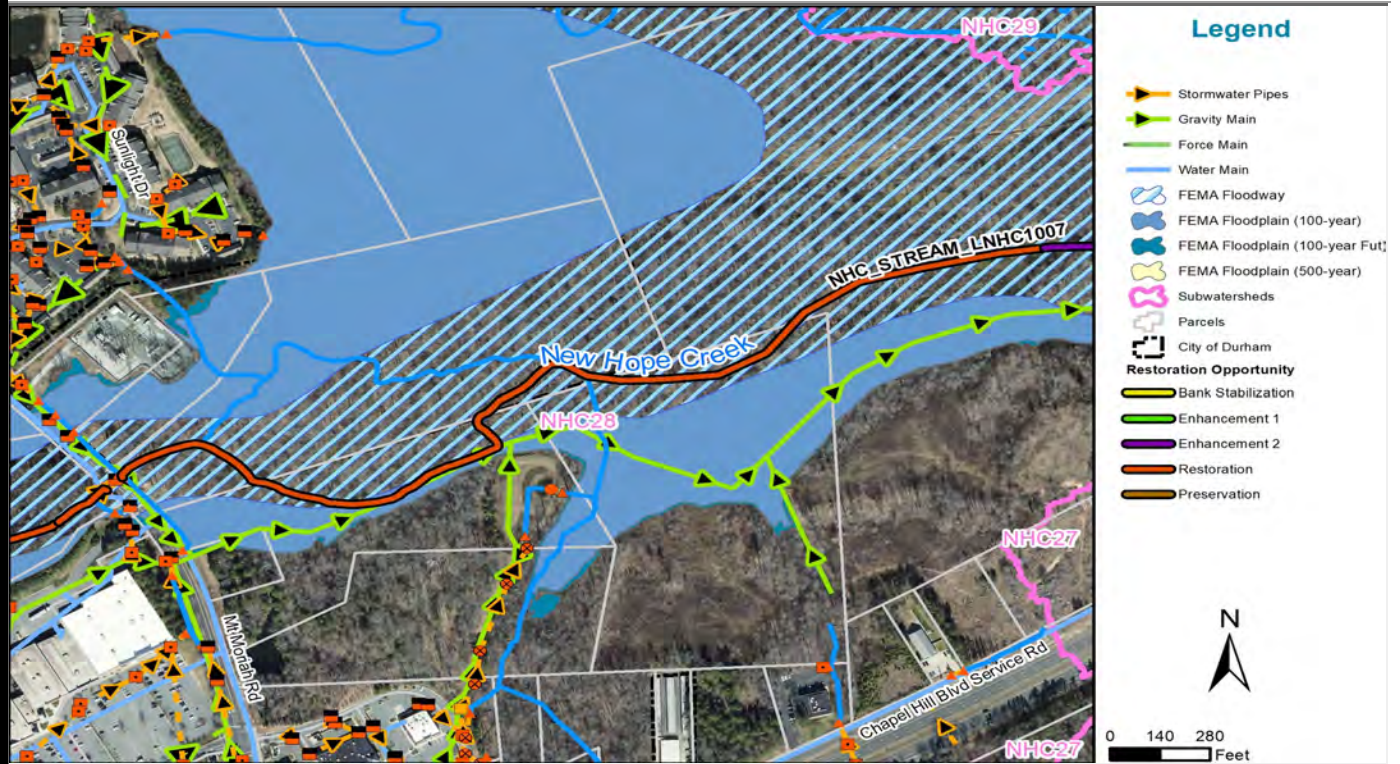


Figure 1 - Plan View of Stream Project

Prioritization Criteria Scores

Criteria	Score	Criteria	Score
<u>Water Quality Benefits</u>		<u>Community Enhancement</u>	
TN	6.0	Property Protection	4.0
TP	0.0	Property Protection Bonus	
Sediment	0.0	Property Owner/Acceptance	4.0
Fecal Coliform		Acceptance Bonus	
Copper		Public Education	3.0
Zinc		<u>Implementation Issue</u>	
Water Quality Bonus		Property Ownership	0.0
<u>Habitat and Biological Integrity</u>		Accessibility for Construction	2.0
Habitat/Biology	15.0	City Program Compatability	5.0
Habitat/Biology Bonus		Permitting/Adverse Env. Impacts	4.0
<u>Stream Bank Protection</u>		Permitting Bonus	
Stream Bank Protection		Total Project Score	
<u>Public Safety and Public Property</u>			
Public Safety and Property	0.0		
Safety Bonus			

Stream Restoration Crediting Protocol

Crediting Protocol	Sediment Reduction	TN Reduction	TP Reduction
Prevented Sediment Protocol:	lbs/yr	lbs/yr	lbs/yr
In-Stream Denitrification:	lbs/yr	lbs/yr	lbs/yr
Floodplain Reconnection:	lbs/yr	lbs/yr	lbs/yr

Notes

PIDs: 0800-03-34-6437, 0800-03-24-0096, 0800-03-23-0542, 0800-03-23-9545, 0800-03-21-1261.DO



Volume II Improvement Plan

August 2021

New Hope Creek and Little Creek Watershed Improvement Plan

Durham, North Carolina

PREPARED FOR:



City of Durham
Public Works Department
Stormwater & GIS Services Division
101 City Hall Plaza, Third Floor
Durham, North Carolina 27701

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New Hope Creek and Little Creek Watershed Improvement Plan



City of Durham
Stormwater & GIS Services Division
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Acronyms and Abbreviations

µg	Micrograms	NCDEQ	North Carolina Department of Environmental Quality
BEHI	Bank Erosion Hazard Index	NCDWR	North Carolina Division of Water Resources
BOD	Biochemical Oxygen Demand	NFIP	National Flood Insurance Program
CAPP	Critical Areas Protection Plan	NPDES	National Pollutant Discharge Elimination System
CCC	Criterion Continuous Concentration	NRCS	Natural Resources Conservation Service
cfu	Colony-Forming Unit	NSW	Nutrient Sensitive Water
City	City of Durham	NTU	Nephelometric Turbidity Units
CIP	Capital Improvement Plan	PAH	Polycyclic Aromatic Hydrocarbon
Cr	Chromium	PCB	Polychlorinated Biphenyl
Cu	Copper	PCSWMM	Personal Computer Storm Water Management Model
DO	Dissolved Oxygen	PSA	Pilot Study Area
EI	Enhancement I	RAMP	Riparian Area Management Plan
EII	Enhancement II	ReGIn	Residential Green Infrastructure
ELU	Existing Land Use	RSAT	Rapid Stream Assessment Technique
EMC	Event Mean Concentration	RSC	Regenerative Stormwater Conveyance
ESC	Erosion and Sediment Control	SESQA	Southeast Stream Quality Assessment
FEMA	Federal Emergency Management Agency	SCM	Stormwater Control Measure
FLU	Future Land Use	SR	State Route
ft ³ /s	Cubic Feet Per Second	SSO	Sanitary Sewer Overflow
GIS	Geographic Information Systems	SWAMP	Stream and Wetland Assessment Management Park
GSI	Green Stormwater Infrastructure	SWMM	Storm Water Management Model
HSG	Hydrologic Soil Group	TMDL	Total Maximum Daily Load
I&I	Infiltration and Inflow	TN	Total Nitrogen
JLOW	Jordan Lake One Water	TP	Total Phosphorus
L	Liter	TSS	Total Suspended Solids
LID	Low Impact Development	UCFRBA	Upper Cape Fear River Basin Association
lb	pound	UDO	Unified Development Ordinance
mg	Milligrams	UNRBA	Upper Neuse River Basin Association
ml	Milliliter	USACE	U.S. Army Corps of Engineers
MS4	Municipal Separate Storm Sewer System	USEPA	U.S. Environmental Protection Agency
NBS	Near Bank Stress		
NCIBI	North Carolina Index of Biotic Integrity		
NCWRC	North Carolina Wildlife Resources Commission		

Acronyms and Abbreviations (continued)

USGS	U.S. Geological Survey
WIP	Watershed Improvement Plan
WQI	Water Quality Index
WS	Water Supply
yr	year
Zn	Zinc

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1 Introduction

Healthy rivers and watersheds are essential to the well-being of the communities and ecosystems they support. They provide safe drinking water and food, maintain a healthy aquatic and terrestrial habitat for wildlife and plants, and promote sustainable economic growth. The City of Durham (City) develops watershed improvement plans to understand the condition of its waterbodies and watersheds and to identify effective ways of improving and maintaining water quality as well as other ecosystem services.

Watershed improvement plans help the City fulfill its mission to “make Durham a great place to live, work, and play” and its vision to be “a leading city in providing an excellent and sustainable quality of life” by providing strategies that serve to both protect the environment and achieve equitable and economic growth and development. The City’s 2019-2021 Strategic Plan serves as an action plan to achieve this vision. One of the 5 goals of the Strategic Plan is to “guide equitable, efficient, and environmentally sound investments in the City’s built and green stormwater infrastructure (GSI) assets.” This watershed improvement plan (WIP) aligns with this goal and the related objective to “create a more Sustainable Durham” with initiatives to improve water quality through best management practices of stormwater, land use, and stream restoration and protection. This WIP also helps in implementing and tracking the progress of the 2018 Sustainability Roadmap (City of Durham, 2018a), which is derived from the Strategic Plan (City of Durham, 2018b) and provides priority strategies to meet the City’s sustainability goals of protecting and restoring Durham’s natural systems and ensuring environmental equity and justice.

The City’s Stormwater & Geographic Information Systems (GIS) Services Division contributes to achieving the City’s vision by managing stormwater and implementing best management practices that will protect and restore the streams, rivers, and lakes in the City’s watersheds. The City’s Stormwater & GIS Services Division also helps achieve the City’s strategic goal, Sustainable Natural and Built Environment, through thoughtful planning and operations that ensure the long-term viability of the City’s infrastructure, facilities, and environment.

The City launched its watershed management program in 2007 to identify and prioritize projects that will improve water quality and watershed health. Since 2007, the City has developed WIPs for the following watersheds: Ellerbe Creek (City of Durham, 2010), Third Fork Creek (City of Durham, 2012a), Northeast and Crooked Creek (City of Durham, 2013a), Little Lick Creek (City of Durham, 2016a), and Eno River (City of Durham, 2018c).

This document, the New Hope Creek and Little Creek WIP, continues the City’s watershed program of protecting and restoring water quality.

1.1 Background

The New Hope Creek and Little Creek watersheds are located in the Cape Fear River Basin in central North Carolina. Located within Durham and Orange counties, the watersheds cover approximately 80 square miles (Exhibit 1). Approximately 45% (36 square miles) of these watersheds lie within city limits. The three major tributaries to New Hope Creek are Sandy Creek, Mud Creek, and Third Fork Creek. Little Creek forms at the confluence of Bolin Creek and Booker Creek northeast of Chapel Hill and flows southeast, joining New Hope Creek in the northern arm of Jordan Lake.

The study area for the WIP includes the portions of the New Hope Creek and Little Creek watersheds that are in Durham County and within the city boundary. Because the City already completed a WIP for Third Fork Creek in 2012 (City of Durham, 2012a), Third Fork Creek is not included in this project. The study area covers approximately

30.2 square miles (19,322 acres) and extends from the Durham/Orange County boundary to Stagecoach Road for New Hope Creek and Farrington Road for Little Creek. For the purposes of the WIP, the study area was divided into 56 subwatersheds.

Some sections of New Hope Creek, Little Creek, and their tributaries are on the 2018 North Carolina 303(d) list of impaired waters (NCDEQ, 2018a). New Hope Creek is listed as impaired for benthos (fair rating) along State Route (SR) 2220 (Old Chapel Hill Road) and from SR 2220 to Interstate 40 (assessment units 16-41-1-(11.5) a, b). A 5-mile portion of Little Creek (assessment unit 16-41-1-15-(0.5)), from its source at the confluence of Booker and Bolin Creeks to 0.7 miles downstream of SR 1110 (Farrington Rd), is listed due to poor benthos conditions. A 2-mile segment of Third Fork Creek (assessment unit 16-41-1-12-(1)) that discharges into New Hope Creek is also identified as impaired for copper upstream of NC Highway 54.

New Hope Creek flows into Jordan Lake, which is impaired for nutrients (total nitrogen [TN] and total phosphorus [TP]), pH, and turbidity. A total maximum daily load (TMDL) for Jordan Lake was approved for nutrients in 2007 and for pH and turbidity in 2014. In response to the impairments, the Jordan Lake Water Supply Nutrient Management Strategy (Jordan Lake Rules) was enacted by the State of North Carolina legislature in 2009 (15A NCAC 02B.0262). The rules require municipalities and other government entities in the watershed to implement programs that reduce nutrient loading to the lake. The Jordan Lake Rules cover a variety of topics such as agriculture, urban stormwater management, riparian buffer preservation and mitigation, wastewater discharges, fertilizer management, and other options for offsetting nutrient loads. Portions of the Jordan Lake Rules are in effect while other portions are delayed. The North Carolina Division of Water Resources (NCDWR) has partnered with the Triangle J Council of Governments and Jordan Lake One Water (JLOW) to develop a recommended One Water/Integrated Water Management framework for the Jordan Lake watershed as part of the Jordan Lake Nutrient Management Strategy Rules.

1.2 Goals

The primary goal of the New Hope Creek and Little Creek WIP is to provide a plan for enhancing the water quality and watershed health of the New Hope Creek and Little Creek watersheds. Other goals of the New Hope Creek and Little Creek WIP are as follows:

- Help the City address local water quality issues and federal and state requirements under the City's National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) permit (permit number NCS000249; effective October 10, 2018 – October 9, 2023).
- Present a prioritized list of new or retrofitted watershed improvement projects to reduce nutrient loading to Jordan Lake.
- Focus on ways to improve water quality and increase GSI on existing development so that the City may successfully achieve the goals set forth in their Strategic Plan and Sustainability Roadmap.
- Develop and implement strategies for engaging traditionally under-represented communities in the watershed planning process. This goal serves to achieve the equitable outreach initiatives set forth in the City's Equitable Engagement Blueprint, the Strategic Plan, and the Sustainability Roadmap.

Developing the WIP included the following tasks:

- Preparation of an Equitable Community Engagement Plan to encourage participation from historically underrepresented communities in the City's planning, policy, and decision-making and to provide a framework that guides the decision-making process of the WIP.

- Assessment of the existing water quality and health of the streams and aquatic habitats in the New Hope Creek and Little Creek watersheds through review of previous studies, watershed data, and field investigation.
- Identification of the major point and nonpoint pollution sources contributing to watershed degradation.
- Identification of potential projects that could improve watershed health such as stormwater control measures (SCMs), stream restoration projects, regulatory compliance, and stakeholder goals.
- Prioritization of the watershed improvement projects that were identified through field work.
- Identification and prioritization of high-quality riparian preservation projects on private property for conservation or protection to preserve water quality and watershed health and include this information in an update to the city-wide Critical Area Protection Plan (CAPP) (see Volume III, Appendix F, of the WIP).
- Identification of maintenance practices that will enhance or extend riparian buffers or improve existing maintenance practices on city-owned property near and along streams and include this information in an update the city-wide Riparian Area Management Plan (RAMP) (see Volume III, Appendix N, of the WIP).
- Development of partnerships between residents, local watershed organizations, and governmental agencies to increase public awareness of the issues surrounding watershed health with the aim of improving water quality and protecting aquatic habitats.

In accordance with Section 319 of the Clean Water Act, this WIP addresses nine key elements. They are described fully in the United States Environmental Protection Agency's (USEPA) *Handbook for Developing Watershed Plans to Restore and Protect Our Waters* (USEPA, 2008). Table 1- provides a brief description of the nine key elements and includes cross references to the sections of the WIP that most directly correspond. Refer to Volume III, Appendix M, of the WIP for the checklist.

The New Hope Creek and Little Creek WIP also meets the North Carolina Division of Mitigation Services requirements for local watershed plans and thereby facilitates the implementation of watershed improvement projects through mitigation funding.

Table 1-1. USEPA's nine key elements for watershed plans and corresponding section in the WIP

Element	Description	Section in WIP
1	Identify the causes and sources of pollution	Vol. II, Section 2, Watershed Assessment
2	Estimate pollutant loading into the watershed and expected management measures and load reductions	Vol. II, Section 5, Evaluation of Watershed Improvement Scenarios
3	Describe the management measures to achieve load reductions and identify the critical areas in which those measures will be implemented	Vol. II, Section 5, Evaluation of Watershed Improvement Scenarios and Vol. II, Section 6, Prioritization of Watershed Improvement Projects
4	Estimate the associated costs, amounts of technical and financial assistance needed, and the authorities needed to implement the plan	Vol. II, Section 6, Prioritization of Watershed Improvement Projects
5	Implement a public information and education component that will be used to enhance public understanding of the project	Vol. II, Section 7, Public Outreach and Involvement
6	Provide a schedule for implementing the nonpoint source management measures identified in the plan	Vol. II, Section 8, Watershed Improvement Plan

Table 1-1. USEPA's nine key elements for watershed plans and corresponding section in the WIP (continued)

Element	Description	Section in WIP
7	Describe interim, measurable milestones for verifying whether nonpoint source management measures or other control actions are being implemented effectively	Vol. II, Section 8, Watershed Improvement Plan
8	Describe a set of criteria that can be used to determine whether loading reductions are being achieved over time and substantial progress is being made toward attaining water quality standards	Vol. II, Section 8, Watershed Improvement Plan
9	Describe a monitoring plan to evaluate the effectiveness of the implementation efforts over time, measured against the criteria established under Element 8	Vol. II, Section 8, Watershed Improvement Plan

1.3 Organization

The New Hope Creek and Little Creek WIP is organized in a similar format to previous WIPs. The three volumes are:

- **Volume I: Executive Summary.** Description of project goals, watershed evaluation methods, results of the watershed improvement scenarios, recommended projects, high-priority project fact sheets, and next steps for evaluating progress.
- **Volume II: Improvement Plan.** Summary of the approach used to develop the WIP, including: data used to develop the watershed model, stream and SCM inventory and assessments, watershed improvement scenarios, watershed improvement project evaluation and prioritization, public outreach and involvement efforts, recommended strategies, implementation schedule, and measurable milestones.
- **Volume III: Technical Appendices.** Reports and memoranda which provide details describing the technical approach used in developing the WIP and the subtasks within it, including model development and field survey results.

2 Watershed Assessment

This section includes descriptions of the existing conditions of the watersheds, including an analysis of water quality concerns. An in-depth watershed assessment was conducted to inform the development of this WIP. Additional information beyond what is presented here can be found in the *New Hope Creek and Little Creek Watershed Assessment Report*, which is provided in Volume III, Appendix E, of this WIP.

Section 2 includes a summary of watershed characteristics (Section 2.1), water quality conditions (Section 2.2) and watershed impacts and sources of pollution (Section 2.3).

2.1 Watershed Characteristics

The New Hope Creek and Little Creek watersheds are located within the Central Piedmont Region of North Carolina in the Upper Cape Fear River Basin (Exhibit 1). The New Hope Creek watershed is approximately 80 square miles, 36 square miles or 45% of which are within the City of Durham limits. The Little Creek watershed is approximately 25.2 square miles, and approximately 5.6% or 1.4 square miles of the watershed is within the City of Durham limits.

New Hope Creek flows southeast from the south of Hillsborough in Orange County through Durham County until it discharges into Jordan Lake in Chatham County. Little Creek begins at the confluence of Bolin Creek and Booker Creek, within the Town of Chapel Hill limits, and flows through Durham County to its confluence with New Hope Creek north of Jordan Lake. New Hope Creek discharges to Jordan Lake and the Cape Fear River before ultimately reaching the Atlantic Ocean.

A study area was selected to help evaluate specific water quality problems and develop recommendations for the regions of New Hope Creek and Little Creek that lie within city limits (Exhibit 2). The study area includes the portion of the New Hope Creek watershed that extends from the Durham County boundary to Stagecoach Road (SR 1107) along New Hope Creek and the Little Creek watershed that extends from Durham County to Farrington Road (SR 1110). Third Fork Creek watershed is not included in the study area because the City completed a WIP for that watershed in 2012. The study area is 19,322 acres in total. Approximately 12,499 acres (65% of the study area) of the New Hope Creek Watershed and 900 acres (4.7% of the study area) of the Little Creek Watershed are within city limits.

The study area contains nine city parks (American Village Park, Sandy Creek Park, Leigh Farm Park, Morreene Road Park, Old Chapel Hill Road Park, Wrightwood Park, Maplewood Park, Crest Street Park, and Cornwallis Park). Duke Gardens, Duke Forest, and the Duke West Campus are also in the study area. Other public landmarks within the study area include Lakewood Elementary and Lakewood Middle, Sherwood Githens Middle, C E Jordan High, Creekside Elementary, Southwest Regional Library, and Duke University Hospital.

The study area was divided into 56 subwatersheds (NHC01 to NHC56) based on topography, existing stormwater infrastructure, and surface hydrology (Exhibit 3). The subwatersheds range in size from 0.24 to 1.08 square miles.

2.1.1 Data Inventory

Information from many sources, including local, state, federal government agencies, private companies, universities, non-profit, and public organizations, was used to assess watershed conditions, inform the project

team's understanding of water quality impacts, and determine the most effective methods to address watershed concerns.

A Data Control Plan and data catalog were developed to manage the large amount and variety of available information on the study watersheds. The Data Control Plan describes processes for managing GIS data, databases, spreadsheets, web applications, and other information to stay organized and maintain the quality of the data. The Data Control Plan is provided in Volume III, Appendix A, of this WIP.

The data catalog is an inventory of all available data used in this WIP and includes spatial and tabular data, academic research, and the previous watershed studies conducted within the study area. Section 2.1.2 summarizes a number of studies relevant to this WIP.

2.1.2 Summary of Previous Studies

The New Hope Creek and Little Creek watersheds have been the subject of numerous studies in recent decades. Multiple institutions and organizations have examined a range of water quality and watershed concerns and developed plans to protect or maintain aquatic health in the creeks and downstream Jordan Lake, including the City of Durham, Upper Cape Fear River Association, New Hope Creek Advisory Committee, research universities, and state and federal agencies. A list of recent key studies is summarized below:

- [Pollutant Source Tracking in Sandy Creek Tributary A and Warren Creek \(2020-2022\)](#). This project is being conducted by the City to determine causes of low dissolved oxygen in Sandy Creek Tributary A. Field work includes water and sediment sampling along the stream reach. This project is in progress at the time this WIP was written and is expected to be completed in the Spring of 2022.
- [State of Our Streams \(2004-2019\)](#) (City of Durham, 2019a). The City produces an annual State of Our Streams Report to inform and engage citizens on watershed health. The report includes a Water Quality Index (WQI) rating based on monitoring data on biochemical oxygen demand (BOD), bacteria, nutrients, turbidity, and metals. The 2019 report identified poor bacteria levels, fair nutrient levels, good turbidity levels and poor aquatic life in New Hope Creek.
- [Landscape Plan for Wildlife Habitat Connectivity](#) (Tuttle et al., 2019). The Partners for Green Growth Program of the North Carolina Wildlife Resources Commission (NCWRC) and Orange county funded this study to develop an action plan for maintaining wildlife habitat connectivity across the Eno River and New Hope Creek-Jordan Lake watersheds. The plan provides recommendations and strategies for minimizing the impacts of changing land use on wildlife habitat connectivity.
- [Jordan Lake Study](#) (UNC, 2019). The University of North Carolina completed this study on behalf of the North Carolina General Assembly in 2019. This report is a compilation of several studies related to Jordan Lake, performed by multiple agencies and researchers. Based on the research presented, management recommendations are provided in three categories: increasing revenue for Jordan Lake management and water quality improvement, increasing local government collaboration, and addressing nutrient loading to the lake.
- [Sandy Creek Special Study](#) (City of Durham, 2019b). The City conducted a special study in the Sandy Creek watershed to support the New Hope Creek WIP. Focusing on the mainstem and the two main tributaries, the study monitored twenty-one sites monitoring hydrology, channel morphology, sediment quality, ambient water quality, and other factors. The objectives were to characterize nutrient sources and loads, evaluate the impacts of stream physical and chemical conditions on aquatic life uses, and identify potential sources of pesticides within the Sandy Creek watershed.

- [Trends in Water Quality of Select Streams and Reservoirs used for Water Supply in the Triangle Area of North Carolina](#) (USGS, 2018). The United States Geological Survey (USGS), in partnership with the Triangle Area Water Supply Monitoring Project, studied temporal trends in water quality over a 25-year period (1989-2013) of 13 streams and 8 reservoirs in the triangle area of North Carolina, including USGS site 02097214 on New Hope Creek. The study documents considerable changes in population, land cover, streamflow, and water-quality characteristics in the study area over the 25-year period.
- [Duke Law Stream Litter Study](#) (Gerbode et al., 2018). The Duke Environmental Law and Policy Clinic conducted litter sampling and surveying in the Sandy Creek watershed. Three sampling locations were selected and sampled in both dry and post-rainfall periods to determine the influence of stormwater runoff in litter loads. Litter was observed in all stream segments during both periods and consisted primarily of soft plastic, followed by glass and hard plastic.
- [City of Durham Comprehensive Plan](#) (City of Durham, 2017a). The Durham Comprehensive Plan outlines the City's long-term vision for how the community would like to grow and develop. The New Hope Creek WIP support the goals of both Chapter 7 and Chapter 9 of the Comprehensive Plan. Chapter 7 addresses the protection and restoration of Durham green infrastructure by focusing on water quality, floodplain protection, low-impact development, wetland and stream restoration, and other habitat concerns. Chapter 9 focuses on the actions needed to ensure the City's water, wastewater, and stormwater facilities are adequate to support new development.
- [The Southeast Stream Quality Assessment](#) (SESQL; USGS, 2014a). The USGS studied stream quality at various sites across the Piedmont and southern Appalachian Mountains, including areas of Sandy Creek and New Hope Creek. The study aimed to relate water quality factors that stressed aquatic life, such as nutrients, sediment, and contaminants, to ecological conditions in the region.
- [Metformin and Other Pharmaceuticals Widespread in Wadeable Streams of the Southeastern United States](#) (USGS, 2014b). The USGS conducted a study to assess the concentrations of pharmaceutical contamination within wadeable headwater streams in the Piedmont ecoregion of the southeastern United States. The primary goals of the study were to address the lack of information about fluvial pharmaceutical contamination and assess the importance of non-wastewater treatment facility sources of pharmaceutical contamination in wadeable streams. The study included USGS site 0209722970 located within the New Hope Creek watershed.
- [Durham Parks and Recreation Master Plan](#) (City of Durham, 2013b). The three primary goals of the City's Parks and Recreation Master Plan are to make and maintain connections, improve sustainability and accessibility, and optimize current facilities. The New Hope Creek and Little Creek WIP will identify riparian restoration sites that may be helpful for addressing conservation plans, improving water quality, and improving the connectivity of wildlife habitat corridors.
- [Patterns of Watershed Urbanization and Impacts on Water Quality](#) (Carle et al., 2007). In this study, six urban watersheds in Durham, including New Hope Creek, were examined to determine how urbanization contributes to nonpoint source pollution. Factors like type and density of urbanization and access to municipal services were related to nutrients, sediment, and fecal coliforms via linear regression models. Results indicate that development density was correlated to decreased water quality. Indicators of urbanization type such as the house age, amount of contiguous impervious surface, access to city services, and stormwater connectivity were correlated with water quality as well.
- [U.S. Fish and Wildlife Service Wetland Study](#) (USFWS, 1992). The New Hope Creek corridor was designated as an "Important Regional Wetland" by the U.S. Fish and Wildlife Service in this study.

Approximately 1,500 acres between Chapel Hill and Durham were identified as Riverine (unconsolidated bottom) and Palustrine (forested and scrub-shrub) wetlands. The report describes the wetlands in the corridor as a rare area of Piedmont forest, which includes habitat for several species of special concern.

- [New Hope Creek Corridor Open Space Master Plan](#) (City of Durham et al., 1991). The master plan was developed to protect and preserve critical areas of environmental significance within the New Hope Creek corridor that links the Eno River State park, New Hope Creek, and U.S. Army Corps of Engineers (USACE) land to rapidly growing communities of Durham and Chapel Hill. It was developed by the City of Durham, Town of Chapel Hill, Durham County, and Orange County.

2.1.3 Hydrology

The New Hope Creek headwaters begin southwest of the Town of Hillsborough near Orange Grove Rd. The creek flows 31 miles from its origin until it reaches Jordan Lake. Approximately 19 miles of the creek flow through Orange County and 12 flow through Durham County. It has three major tributaries: Mud Creek, Sandy Creek, and Third Fork Creek.

Little Creek begins at the confluence of Bolin Creek and Booker Creek and continues 6.4 miles until its confluence with New Hope Creek north of Jordan Lake. The majority of the stream length (5.5 miles) is in Durham County. Bolin Creek and Booker Creek are its only major tributaries.

The U.S. Geological Survey (USGS) operates the following two gages within the study area. Both gages report daily stage and discharge.

- USGS gage 0209722970 is located on Sandy Creek at West Cornwallis Road (SR 1308).
- USGS gage 02097314 is located on New Hope Creek near Blands, North Carolina, at Stagecoach Road (SR 1107), south of the City of Durham. The station at Stagecoach Road has been in operation since 1982, and has a drainage area of 76 square miles, or about 95% of the total New Hope Creek drainage area.

USGS gage 02097280 is located in the Third Fork Creek watershed outside of the study area. The USGS does not maintain a gage on Little Creek.

Figure 2-1 presents the mean and median daily streamflow from 1982 to 2020 at Stagecoach Road on New Hope Creek and the mean monthly precipitation at Raleigh-Durham Airport from 1981 to 2010. The annual mean streamflow is 112 ft³/s, and the annual median flow is 37 ft³/s. However, the mean monthly flowrate ranges from a high of 195 ft³/s in March to a low of 57 ft³/s in August (Figure 2-1). Average streamflow varies greatly by season. Summer months have the lowest flow while winter and early spring have the highest flows. This discrepancy can be explained by higher evapotranspiration rates in the summer compared to winter as well as the soil composition in the Triassic Basin, in which Durham is located (see Section 2.1.5).

Median and mean streamflow statistics highlight the relative impact that infrequent flow events (high or low) have on the flow characteristics of a stream. The median value is more useful in describing “typical” flow conditions since it is less influenced by extreme events (e.g., very high flows). In contrast, the mean (or average) statistic is affected more by extreme events, which tend to skew the “typical” condition. Frequent high flow events, for example, would skew the mean daily flow value higher than the median value, which would indicate a tendency toward larger flow events within a stream, as is the case for New Hope Creek.

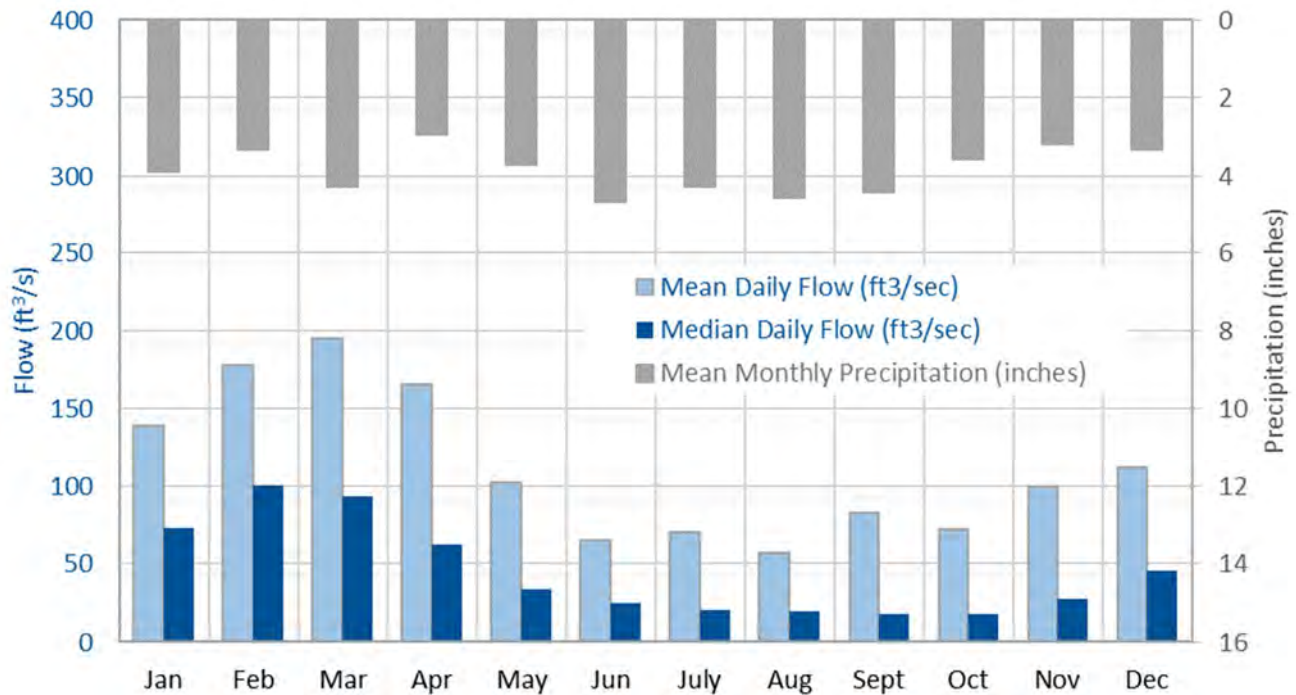


Figure 2-1. Daily flow (mean and median) at USGS gage 02097314 (New Hope Creek near Blands, NC; 1982-2020) located on Stagecoach Road and mean monthly precipitation (Raleigh-Durham Airport; 1981-2010)

Streamflow at the New Hope Creek near Blands, NC station (USGS gage 02097314) is affected by a NCWRC impoundment which is located directly upstream of the station. Throughout the project study area, the NCWRC manages five impoundments that were constructed to mitigate impacts to wetlands and streams caused by the construction of Jordan Lake. Each impoundment in the Jordan Game Lands is managed such that flooding occurs every other year. While rainfall and stream flow impact the scheduling of flooding events, in general, the impoundment management regime involves slowly raising the water level in an impoundment beginning in early fall to promote flooding during late fall or early winter. In early spring, water is released from the impoundment so that the stream and wetlands return to base levels.

2.1.4 Topography

The New Hope Creek and Little Creek watersheds are in the Piedmont physiographic province of North Carolina. The highest elevation in the watersheds is approximately 620 feet (NAD83) at the headwaters of the New Hope Creek, and the lowest elevation is 230 feet (NAD83) at Jordan Lake (USGS, 2021)). The watersheds are covered by two ecoregions: the Carolina Slate Belt and the Triassic Basin. The Carolina Slate Belt is typically distinguished by trellised drainage patterns. Groundwater is limited as streams tend to dry up, and water yields to wells in this region are typically low. In the Triassic Basin, elevations and local relief are typically lower than the surrounding area. Due to erodible rock in the Triassic ecoregion, stream valleys tend to widen (Griffith et al., 2002).

2.1.5 Geology and Soils

The study area is split between the geological regions of the Carolina Slate Belt in the northwest and the Triassic Basin (Exhibit 4). Inside the study area, approximately 8% of the New Hope Creek watershed lies within the Carolina Slate Belt, and 92% falls within the Triassic Basin. The Carolina Slate Belt is characterized by resistant metamorphic rock with moderate hydraulic conductivity and are shallow or thin. This leads to minimal water

storage in the surficial aquifer resulting in streams often not having baseflow during extended dry periods. The Triassic Basin, on the other hand, drains poorly due to soils with low hydraulic conductivity. It is composed of sedimentary deposits of conglomerates, sandstones, and mudstone. Over time, molten rock intruded into the deposits to form very hard igneous dikes. There is also a high shrink-swell potential because of the clay composition. Because of these properties, the Triassic Basin soils control both surface water and groundwater hydrology in the area. The low infiltration results in flashy streamflows and high peak flow rates during storms, but also lead to low baseflow since the groundwater recharge is minimal.

The Natural Resources Conservation Service (NRCS) classifies soils into hydrologic soil groups (HSGs) based on infiltration rate and water storage capacity (NRCS, 2007). The four major HSGs are described in Table 2-1. Some soils are assigned a dual hydrologic group (A/D, B/D, or C/D), where the first letter represents drained areas, and the second letter represents nondrained areas.

Table 2-1. Hydrologic soil groups

HSG	Description
Group A	High infiltration rates and low runoff potential; primarily well-drained sandy soils
Group B	Moderate infiltration rates and runoff potential; consist primarily of moderate to well-drained soils such as loams
Group C	Low infiltration rates and moderately high runoff potential; typically, sandy clays or clay loams
Group D	Low infiltration rates and high runoff potential. Most D soils are clays and contain a confining layer near the surface or consist of shallow soils over bedrock. Urban complex and gullied soils are also typically classified as Group D soils.

Source: NRCS (n.d.)
HSG = hydrologic soil group

The portion of the study area within the Carolina Slate Belt is dominated by well-drained, Group B soils, and the portion within the Triassic Basin is majority composed of poorly drained Group D soils. The hydrologic soil groups within the study area are presented in Table 2-2.

Additional information on soil types, soil texture HSG, and hydric soil indicators for the soils in the study area is presented in the *New Hope Creek and Little Creek Watershed Assessment Report* (see Volume III, Appendix E, of this WIP) and in Exhibit 5.

Table 2-2. Hydrologic soil groups within the study area by watershed

Hydrologic Soil Group	Mud Creek	Sandy Creek	Lower New Hope Creek	Little Creek	Study Area
A	<1%	0%	0%	1%	<1%
B	42%	19%	6%	3%	16%
C	1%	<1%	3%	1%	2%
D	35%	61%	60%	64%	55%
A/D	2%	3%	2%	2%	2%
B/D	5%	6%	22%	23%	15%
C/D	14%	3%	6%	4%	7%
Gullied Land (D soils)	<1%	<1%	1%	<1%	<1%
Urban Complex (D soils)	0%	7%	1%	0%	2%
Water	<1%	<1%	<1%	1%	<1%

2.1.6 Floodplains

Floodplains are the flat areas surrounding streams, composed of river sediments and subject to flooding. Typically, they are relatively large compared to the channel width. When a large storm event occurs, excess high-energy flow exits the channel and spills onto the floodplain. The energy dissipates as the flow spreads across the entire area, reducing the risk of stream erosion and damage to infrastructure. Natural floodplain systems offer many benefits other than energy-dissipation, including flood storage, enhanced water quality by filtering pollutants, reduced flow rates, reduced runoff through ponding and infiltration, groundwater recharge, and increased biological habitat.

The New Hope Creek watershed and Little Creek watershed floodplains (FEMA, 2019; Exhibit 6) have varying characteristics depending on the underlying geological regions described in Section 2.1.5 (Carolina Slate Belt and Triassic Basin). The New Hope Creek and tributaries northwest of Erwin Road are in the Carolina Slate Belt and are typically steep and fast moving. This topography, combined with the hard rock of the region, usually results in a narrow floodplain, though in the case New Hope Creek this region contains very little floodplain. The New Hope Creek and tributaries southeast of Erwin Road and the entire length of Little Creek are in the Triassic Basin. These streams have narrow channels and proportionally larger, wider, and flatter floodplains. The large intrusions of igneous rock cause the streams to make sharp turns into more erosive sandstone and siltstone, which form the wide floodplains.

Within the study area, the City manages a flood warning gage monitoring system on Sandy Creek at Cornwallis Road in coordination with USGS. USGS also manages a monitoring gage at Stagecoach Road on New Hope Creek that is a part of the North Carolina Inundation Mapping and Alert Network. Public Works Stormwater & GIS Services staff and Durham County Emergency Management receive alerts when certain gage depths are reached. Emergency Management then arranges for the closure of several sections of roads leading to impacted areas. Stormwater & GIS services also monitors flood warning systems for flooding in areas outside of the study area, such as central Durham and at the City's Public Works Operation Center.

The Federal Emergency Management Agency (FEMA), which is part of the Department of Homeland Security, produces maps which demarcate Special Flood Hazard Areas. The two primary hazard areas are the 1% Annual Chance Floodplain and the Floodway. The 1% Annual Chance Floodplain is the area in which there is a 1% chance

that flooding occurs in any given year, while the Floodway is the area within a floodplain where most of the flow and highest velocities occur during a flood. The FEMA maps inform the City for zoning and development decisions. Any properties within the 1% Annual Chance Floodplain are eligible for federally backed flood insurance through the National Flood Insurance Program (NFIP). Development within the FEMA Floodway is strongly discouraged by regulation and is usually limited to utility and street crossings. In addition, any development within the floodway generally requires flood studies by professional engineers to determine and map impacts of the development on floodplains.

The City and Durham County Emergency Management participate in and help maintain the Eno-Haw Regional Hazard Mitigation Plan. One of the benefits of maintaining a hazard mitigation plan and participating in the NFIP is eligibility for FEMA hazard mitigation grants. The City applies for hazard mitigation grants for mitigation actions that include acquisition, open space creation, and raising residential building elevation for high-risk structures within FEMA floodplains.

Additional information is presented in the *New Hope Creek and Little Creek Watershed Assessment Report* (see Volume III, Appendix E, of this WIP).

2.1.7 Land Use and Impervious Cover

Land use and land cover play a significant role in determining the hydrologic response of a watershed which can impact stream water quality and aquatic health. Changes in land use, such as new development and increased impervious surface, can greatly impact the receiving streams of a watershed. Generally, increases in development density negatively affect surface waters.

2.1.7.1 Land Use

Durham County and the City of Durham actively maintain land use data for areas within the county. Future land use data, based on projected build-out by 2025, are also available for Durham County. Table 2-3 and Exhibits 7 and 8 present the existing and projected land use in the study area. Most of the existing land use is Residential (37%) followed by Parks and Open Space (32%), consisting primarily of USACE and Duke Forest land.

Based on the 2025 land use projection the primary trend in land use within the study area will be the conversion of Agriculture, Parks and Open Space, and Very Low Density Residential to Low Density and High Density Residential land use. For example, in the Little Creek watershed (subwatersheds NHC01_LC to NHC07_LC), about 9% of the land is projected to become High Density Residential and 10% of the land is projected to become Low Density Residential. However, in the Mud Creek watershed (NHC47_MC to NHC56_MC), which has the least developed area, there is a projected 15% increase in Very Low Density Residential and a 5% increase in Low Density Residential, corresponding to a 20% decrease in Agriculture and Parks and Open Space. In the Lower New Hope Creek and Sandy Creek watersheds, which are already fairly developed, the percentage change is much smaller. Most of the change to residential land use is anticipated to occur in the region south of Highway NC 751 and northwest of Highway NC 15-501. Commercial, Institutional, and Industrial are all projected to increase as well, but the combined increased only comprises about 1% of the total study area. A detailed description of land use evaluations and changes projected to occur in each subwatershed is presented in the *New Hope Creek and Little Creek Watershed Assessment Report* (see Volume III, Appendix E, of this WIP).

Table 2-3. Projected land use change in the study area from existing to future conditions

Land Use Description	Existing Land Use		Future Land Use		Projected Change	
	Acres	Percent	Acres	Percent	Acres	Percent
Agriculture	717	4%	0	0%	-717	-100%
Very Low Density Residential	1,426	7%	1,334	7%	-92	-6%
Low Density Residential	2,537	13%	3,545	18%	1,008	40%
Medium Density Residential	1,941	10%	1,840	10%	-101	-5%
High Density Residential	1,291	7%	1,767	9%	476	37%
Commercial	1,522	8%	1,639	8%	117	8%
Institutional	1,469	8%	1,496	8%	27	2%
Industrial	26	<1%	153	1%	127	488%
Parks and Open Space	6,123	32%	5,279	27%	-844	-14%
Roadways ⁽¹⁾	2,261	12%	N/A	N/A	-	0%

(1) Information necessary to project roadway land use in 2025 was insufficient.

N/A = not available
Source: City of Durham (2016b)

2.1.7.2 Impervious Cover

Impervious area impacts the hydrologic response of a watershed and the water quality of surface waters. As impervious area increases, the amount of water infiltrating into soils decreases, resulting in higher volumes and peak flows and lower base flows in streams. Additionally, pollutants that get deposited on impervious areas, such as bacteria, nutrients, heavy metals, and hydrocarbons, are transported directly into streams via stormwater runoff, which results in diminished water quality. The higher peak flows also result in increased shear stress which accelerates bank erosion and stream scour, both of which are significant sources of sediment.

The impervious area within the entire study area is approximately 19%, and the impervious area in the city limits of the study area is 25%. Most of the impervious cover occurs in the Lower New Hope Creek watershed (1,699 acres; 20% impervious) while the greatest percent impervious coverage is in the Sandy Creek watershed (27%). Little Creek and Mud Creek have the lowest impervious coverage at only 10% impervious area. Table 2-4 provides a summary of impervious area and percent impervious area associated with each of the City's monitoring stations and the two Upper Cape Fear River Basin Association (UCFRBA) stations within the study area. See Exhibit 9 for a map displaying the impervious area in the study area. The *New Hope Creek and Little Creek Watershed Assessment Report* (see Volume III, Appendix E, of this WIP) provides a detailed description of impervious area within the study area and subwatersheds.

Table 2-4. Impervious cover and drainage area at water quality monitoring locations

Station	Watershed	Total Drainage Area (acres)	Drainage Area Within Study Area (acres)	Impervious Area Within Study Area (acres)	% Impervious Within Study Area
LCTC1.5LITC	Little Creek	15,232	2,221	227	10
B3020000	Lower New Hope Creek	35,915	13,422	2,704	20
B3040000	Lower New Hope Creek	48,759	15,657	2,936	19
NH0.0NHC	Lower New Hope Creek	33,442	11,045	2,312	21
NH3.0NHC	Lower New Hope Creek	20,035	0	0	NA
NH2.3MC	Mud Creek	3,388	3,388	323	10
NH1.0SC	Sandy Creek	4,321	4,321	1,148	27
NH1.6SC	Sandy Creek	4,196	4,196	1,104	26
NH1.7SCTA	Sandy Creek	893	893	414	46
NH1.8SCTA	Sandy Creek	706	706	320	45
NH3.3SC	Sandy Creek	2,979	2,979	865	29
NH3.4SC	Sandy Creek	1,271	1,271	441	35
NH3.4SCTD	Sandy Creek	1,674	1,674	418	25
NH4.3SC	Sandy Creek	942	942	411	44
NH4.4SCTD	Sandy Creek	999	999	297	30
NH4.7SC	Sandy Creek	546	546	251	46
NH4.8SCTDT	Sandy Creek	220	220	89	40
NH5.0SCTD	Sandy Creek	596	596	176	30

(1) With the exception of "Total Area (acres)", all columns refer to areas or percentage of area within the study area

(2) "NA" = not applicable

2.2 Water Quality Conditions

The New Hope Creek and Little Creek WIP aims to protect areas within the watersheds with healthy surface waters and improve areas in the watershed where there are water quality concerns. This section describes the applicable surface water classifications and characterizes the existing water quality conditions within the study area.

2.2.1 Surface Water Classifications

The NCDWR assigns surface water classifications to all surface waters within North Carolina based on the best uses of that waterbody, such as swimming, fishing, and drinking water supply. The classifications are used to protect and manage effectively the streams, rivers, lakes, and other surface waters (NCDEQ, 2020a). The New Hope Creek and Little Creek watershed study area contain three primary classifications and one supplemental classification. These are listed below and are presented in Exhibit 10.

- Class C (Primary): Waters protected for uses such as secondary recreation (wading, boating, and other activities that involve infrequent human contact with water), fishing, wildlife, fish consumption, and aquatic life propagation are designated as Class C. Class C standards are the most basic, and apply to all surface waters in North Carolina.

- Water Supply IV (WS-IV; Primary): Waters used as water supply for drinking, culinary, or food processing purposes that cannot feasibly meet the standards of WS-I through WS-III. In the study area, the waters that are classified as WS-IV include a portion of New Hope Creek from 0.3 miles upstream of Old Chapel Hill Road to Jordan Lake, Gum Creek, and Little Creek. The WS-IV classification includes a critical area within one-half mile of the Jordan Lake normal pool and a protected area within 5 miles of the Jordan Lake normal pool.
- Water Supply V (WS-V; Primary): Waters protected as water supplies that are upstream or drain into WS-IV waters, are used by industry to supply their employees with drinking water, or were formerly used as water supply. There are no density development restrictions for this classification. Sandy Creek, Mud Creek, and the portion New Hope Creek upstream of Old Chapel Hill Road are included in this classification.
- Nutrient Sensitive Waters (NSW; Supplemental): Waters which require additional nutrient management because of excessive aquatic vegetation (both microscopic and macroscopic). The entire Jordan Lake watershed is classified as NSW.

2.2.2 Water Quality Monitoring

The City, UCFRBA, and NCDWR maintain water quality and biological monitoring stations in the New Hope Creek and Little Creek watersheds study area (see Exhibit 11 and listed below). The frequency and type of data collected at each monitoring station varies; however, eleven of the water quality stations located within the study area of the New Hope Creek and Little Creek watersheds are monitored regularly by the City under the City's ambient monitoring program. Included in this list is one station located on the mainstem of New Hope Creek (NH0.0NHC) and 10 stations located on tributaries to New Hope Creek (LITC1.5LITC, NH1.0SC, NH1.7SCTA, NH2.3MC, NH3.0NHC, NH3.3SC, NH4.3SC, NH4.4SCTD, NH4.8SCTDT, and NH5.0SCTD). For each City of Durham monitoring station, the first two letters denote the watershed (NH = New Hope), the number denotes the upstream distance from New Hope Creek in river miles, and the last two to four letters denote the stream name (LITC = Little Creek, MC = Mud Creek, NHC = New Hope Creek, SC = Sandy Creek, SCTA = Sandy Creek Tributary A, SCTD = Sandy Creek Tributary D).

- LITC1.5LITC: City ambient station on Little Creek at Farrington Road with a drainage area of 23.8 square miles.
- NH0.0NHC: City ambient station on New Hope Creek at Chapel Hill Road; most downstream City station with a drainage area of 52.3 square miles.
- NH1.0SC: City ambient station on Sandy Creek at Garrett Road with a drainage area of 6.9 square miles.
- NH1.6SC: City station on Sandy Creek at Larchmont Road with a drainage area of 6.6 square miles.
- NH1.7SCTA: City ambient station on Sandy Creek Tributary A at Ivy Creek Boulevard with a drainage area of 1.4 square miles.
- NH1.8SCTA: City station on Sandy Creek Tributary A at MLK Parkway, just upstream of NH1.7SCTA, with a drainage area of 0.06 square miles.
- NH2.3MC: City ambient station on Mud Creek at Pickett Road with a drainage area of 5.4 square miles.
- NH3.0NHC: City ambient station on New Hope Creek at Erwin Road with a drainage area of 31.3 square miles. This station is located outside the study area.

- NH3.3SC: City ambient station on Sandy Creek at Cornwallis Road with a drainage area of 4.8 square miles.
- NH3.4SC: City station on Sandy Creek located upstream of the confluence with Sandy Creek Tributary D with a drainage area of 2.05 square miles.
- NH3.4SCTD: City station on Sandy Creek Tributary D located upstream of the confluence with Sandy Creek with a drainage area of 2.65 square miles.
- NH4.3SC: City ambient station on Sandy Creek at Erwin Road near Duke Center for Living with a drainage area of 1.39 square miles.
- NH4.4SCTD: City ambient station on Sandy Creek Tributary D at Academy Road with a drainage area of 1.59 square miles.
- NH4.7SC: City station on Sandy Creek at Morrene Road with a drainage area of 0.92 square miles.
- NH4.8SCTDT: City ambient station on Sandy Creek Tributary D at Duke University Road with a drainage area of 0.34 square miles.
- NH5.0SCTD: City ambient station on Sandy Creek Tributary D at Anderson Road with a drainage area of 0.96 square miles.
- B3040000: UCFRBA ambient station on New Hope Creek at Stagecoach Road near Blands with a drainage area of 74.4 square miles.
- B3020000: UCFRBA ambient station on New Hope Creek at NC-54 with a drainage area of 56.1 square miles.
- BB085: NCDWR station on New Hope Creek at I-40 with a drainage area of 57.9 square miles.
- BB238: NCDWR station near station B3040000.
- BB090, BF057: NCDWR stations located at the same site on New Hope Creek near station NH0.0NHC.

In addition, the City also conducted a comprehensive water quality study in the Sandy Creek watershed from 2018-2019 to support this WIP. The stations included in that study are presented on Exhibit 11 and are described below.

- SCSN 1: Located near Waterbury Street with a drainage area of 0.99 square miles.
- SCSN 3: Located at Welcome Drive and Tryon Road with a drainage area of 0.08 square miles.
- SCSN 4: Located at Evans Street with a drainage area of 0.09 square miles.
- SCSN 6: Located off Kangaroo Drive behind the post office with a drainage area of 0.06 square miles.
- SCSN 7: Located downstream of NC-147 in Duke Manor Apartments off LaSalle Street with a drainage area of 0.17 square miles.
- SCSN 10: Located at Circuit Drive with a drainage area of 0.08 square miles.
- SCSN 11: Located near parking lot of Faqua Drive with a drainage area of 0.07 square miles.
- SCSN 13: Located near Nasher Museum parking lot off Campus Drive with a drainage area of 0.08 square miles.
- SCSN 14: Located at the end of Hull Avenue with a drainage area of 0.04 square miles.

- SCSN 15: Located at Campus Drive with a drainage area of 0.03 square miles.
- SCSN 17: Located near Morehead Drive with a drainage area of 0.09 square miles.
- SCSN 18: Located off Brooks-Pascal Drive below the stadium with a drainage area of 0.08 square miles.
- SCSN 21: Located near Pierce Street and Price Street with a drainage area of 0.13 square miles.

Table 2-5 provides water quality stations in the study area and the available monitoring data for the stations. The data is available for download from the City-maintained Water Quality Data Web Portal <http://www.durhamwaterquality.org/>

Details on water quality data for each station is presented in the *New Hope Creek and Little Creek Watershed Assessment Report* (see Volume III, Appendix E, of this WIP). All watersheds (New Hope Creek, Little Creek, Sandy Creek, and Mud Creek) showed BOD concentrations that exceeded the benchmark, while DO concentrations remained at acceptable values. Fecal coliforms were a problem for all watersheds, especially in Sandy Creek where 70% of samples exceeded the benchmark. Average annual TN values exceeded the City of Durham benchmark (0.8 mg/L TN) in Little, Sandy, and Mud Creeks in most of the years for which samples were collected. The potential water quality concerns in the study area and an assessment of them based on the monitoring data are listed in Table 2-6.

In an annual report titled *State of Our Streams*, the City of Durham publishes a summary of the results of the water quality monitoring stations in all watersheds (City of Durham, 2019a). These data are evaluated, and each station is given a Water Quality Index (WQI). The *State of Our Streams* report can be found at: <https://durhamnc.gov/708/State-of-Our-Streams>. The WQI is a grade from 0 (poor) to 100 (excellent) and indicates the health of the City's streams. In the 2019 report, the WQI was based on the levels of bacteria, nutrients, turbidity and aquatic life.

Table 2-7 lists the average WQI for each City station for which a WQI was computed. All WQIs within a watershed are combined to give that watershed an overall WQI. In the 2019 report, New Hope Creek was given a rating of 77, which is a "C" grade. The Sandy Creek station at Garrett Road was assigned a WQI of 71 ("C" grade) in 2019, also lower than the average value of 83 since 2004. Mud Creek had the highest 2019 WQI value, at 82 ("B" Grade), lower than the average value of 85 since 2004. Little Creek is not included in the report because very little land within the City limits drains into the watershed. The individual station scores show that the water quality of each subwatershed could be improved.

Table 2-5. Water quality sampling stations in the New Hope Creek and Little Creek watershed study area and dates of available monitoring data

Station ID	Agency	Watershed	Dates of Available Monitoring Data on Water Characteristics					
			Nitrogen	Phosphorus	Dissolved Oxygen	Turbidity	Fecal Coliform	Benthic Macroinvertebrates
LITC1.5LITC	City	LC	2015	2015	2013, 2015	2013, 2015	2013, 2015	
NH0.0NHC	City	NHC	2004–2011, 2013, 2015, 2017, 2019	2004–2011, 2013, 2015, 2017, 2019	2004–2011, 2013, 2015, 2017, 2019	2004–2011, 2013, 2015, 2017, 2019	2004–2011, 2013, 2015, 2017, 2019	
NH1.0SC	City	SC	2004–2011, 2013, 2015, 2017, 2019	2004–2011, 2013, 2015, 2017, 2019	2004–2011, 2013, 2015, 2017, 2019	2004–2011, 2013, 2015, 2017, 2019	2004–2011, 2013, 2015, 2017, 2019	2006–2007, 2009–2011, 2013, 2015, 2017, 2019
NH1.6SC ⁽¹⁾	City	SC	2018	2018	2018	2018	-	
NH1.7SCTA	City	SC	2009–2011, 2013, 2015, 2017, 2019	2009–2011, 2013, 2015, 2017, 2019	2009–2011, 2013, 2015, 2017–2019	2009–2011, 2013, 2015, 2017–2019	2009–2011, 2013, 2015, 2017, 2019	
NH1.8SCTA ⁽¹⁾	City	SC	2018	2018	2018	2018	-	
NH2.3MC	City	MC	2004–2011, 2013, 2015, 2017, 2019	2004–2011, 2013, 2015, 2017, 2019	2009–2011, 2013, 2015, 2017–2019	2009–2011, 2013, 2015, 2017–2019	2009–2011, 2013, 2015, 2017–2019	2009–2011, 2013, 2015, 2017, 2019
NH3.0NHC ⁽²⁾	City	NHC	2009–2011, 2013, 2015, 2017, 2019	2009–2011, 2013, 2015, 2017, 2019	2004–2011, 2013, 2015, 2017, 2019	2004–2011, 2013, 2015, 2017, 2019	2004–2011, 2013, 2015, 2017, 2019	
NH3.3SC	City	SC	2008–2020	2008–2020	2008–2020	2008–2020	2008–2020	
NH3.4SC ⁽³⁾	City	SC	-	-	2018	-	-	
NH3.4SCTD ⁽³⁾	City	SC	-	-	2018	-	-	
NH4.3SC	City	SC			2008	2008	2008	
NH4.4SCTD ^(1, 3)	City	SC	2018–2019	2018–2019	2004–2005, 2018–2019	2004–2005, 2018–2019	2004–2005, 2019	
NH4.7SC ^(1, 3)	City	SC	2018	2018	2018	2018	-	
NH4.8SCTDT	City	SC	2011, 2013, 2015, 2017	2011, 2013, 2015, 2017	2006–2011, 2013, 2015, 2017	2006–2011, 2013, 2015, 2017	2006–2011, 2013, 2015, 2017	

Table 2-5. Water quality sampling stations in the New Hope Creek and Little Creek watershed study area and dates of available monitoring data (continued)

Station ID	Agency	Watershed	Dates of Available Monitoring Data on Water Characteristics					
			Nitrogen	Phosphorus	Dissolved Oxygen	Turbidity	Fecal Coliform	Benthic Macroinvertebrates
NH5.0SCTD	City	SC	2011, 2013	2011, 2013	2006–2011, 2013	2006–2011, 2013	2006–2011, 2013	
SCSN 1 ⁽⁴⁾	City	SC	2018	2018	2018	2018		
SCSN 3 ⁽⁴⁾	City	SC	2018	2018	2018	2018		
SCSN 4 ⁽⁴⁾	City	SC	2018	2018	2018	2018		
SCSN 6 ⁽⁴⁾	City	SC	2018	2018	2018	2018		
SCSN 7 ⁽⁴⁾	City	SC	2018	2018	2018	2018		
SCSN 10 ⁽⁴⁾	City	SC	2018	2018	2018	2018		
SCSN 11 ⁽⁴⁾	City	SC	2018	2018	2018	2018		
SCSN 13 ⁽⁴⁾	City	SC	2018	2018	2018	2018		
SCSN 14 ⁽⁴⁾	City	SC	2018	2018	2018	2018		
SCSN 15 ⁽⁴⁾	City	SC	2018	2018	2018	2018		
SCSN 17 ⁽⁴⁾	City	SC	2018	2018	2018	2018		
SCSN 18 ⁽⁴⁾	City	SC	2018	2018	2018	2018		
SCSN 21 ⁽⁴⁾	City	SC	2018	2018	2018	2018		
B3040000, BB238	UCFRBA, NCDWR	LNHC	1980–2018	1980–2018	1980–2018	1980–2018	1980–2018	1985, 1998, 2003, 2008
B3020000	UCFRBA	LNHC	2000–2020	2000–2020	2000–2020	2000–2020	2000–2020	2000–2020
BB085	NCDWR	LNHC						1985
BB090, BF057	NCDWR	LNHC						1987, 1998, 2003

(1) Water quality data at stations NH1.6SC, NH1.8SCTA, NH4.4SCTD, and NH4.7SC are from the Sandy Creek Watershed Study conducted in 2018 (City of Durham, 2019b).

(2) Station is located outside of the project study area.

(3) Pesticide de data at stations NH3.4SCTD, NH3.4SC, NH4.4SCTD, and NH4.7SC were collected on a single day (6/6/2018) as part of the Sandy Creek Watershed Study. These data were collected to complement USGS sampling.

(4) Data at “SCSN” stations were collected on a single day (7/18/2018) as part of a synoptic nutrient study.

City = City of Durham

LC = Little Creek

NHC = New Hope Creek

UNRBA = Upper Neuse River Basin Association

SC = Sandy Creek

MC = Mud Creek

LNHC = Lower New Hope Creek

NCDEQ = North Carolina Department of Environmental Quality

Table 2-6. Water quality in the study area

Water Characteristic	Water Quality Standard ⁽¹⁾	Water Quality in Study Area
Dissolved oxygen (DO)	Daily average not less than 5 mg/L and an instantaneous value of not less than 4 mg/L	DO measurements collected during 2004-2020 indicate overall fair conditions at all monitoring locations. All stations averaged DO concentrations greater than 5.0 mg/L. Most stations reported at least one sample per year have an instantaneous value of less than 4 mg/L. NH _{0.0} NHC was less than 4.0 mg/L at least 15% of the time in 8 of 12 years during which monitoring occurred.
Fecal coliform bacteria	Geometric mean less than 200 cfu/100 ml based on five consecutive samples during a 30-day period and does not exceed 400 cfu/100 ml in more than 20% of the sample collected during the same period	Fecal coliform measurements collected during 2004-2020 indicate high bacteria concentrations are frequently present throughout the New Hope Creek and Little Creek watersheds. Only NH _{3.0} NHC did not average more than 200 cfu/100 ml over all years. In addition, all stations except NH _{3.0} NHC exceeded the 20% 400 cfu/100 ml threshold a vast majority of the time.
Turbidity	50 Nephelometric Turbidity Units (NTUs)	Turbidity measurements collected during 2004-2020 indicate low concentrations are generally present in New Hope Creek and its monitored tributaries and Little Creek. The average annual turbidity concentration was below 50 NTUs for all stations.
Dissolved copper	Water quality standard is defined using the Criterion Continuous Concentration (CCC), calculated to be 4.7 µg/L in New Hope Creek, 7.6 µg/L in Sandy Creek, 4.8 µg/L in Mud Creek, and 4.0 µg/L in Little Creek	Dissolved copper does not appear to be a problem pollutant in the New Hope Creek watershed. While elevated copper has been observed at all ambient stations, the occurrences have been infrequent. However, the only year that copper was tested in the Little Creek station, it was present 33% of the time. Additional data in Little Creek would help determine if this is a pollutant of concern.
Zinc	Water quality standard is defined using the CCC calculated to be 66 µg/L in New Hope Creek, 106 µg/L in Sandy Creek, 66 µg/L in Mud Creek, and 63 µg/L in Little Creek.	Zinc does not appear to be a problem pollutant in the New Hope Creek or Little Creek watersheds.
Nutrients	There are no numeric standards for total nitrogen (TN) or total phosphorus (TP) established or enforced by the State of North Carolina, however, the City applies a TN benchmark of 0.8 mg/L and a TP benchmark of 0.08 mg/L as part of its WQI.	The average TN and TP concentrations exceeded the Durham benchmarks for most years across all stations. Sandy Creek and Little Creek had elevated TN and TP concentrations for many of the years samples were taken. At the most downstream station of New Hope Creek, however, the TN benchmark was only exceeded for one year, and the average of all data over all years was below the benchmark.
Biochemical oxygen demand (BOD)	There are no numeric standards for BOD though the City applies a benchmark of greater than 2 mg/L but less than 4 mg/L as part of its WQI.	The average BOD concentration was between 2.0 mg/L and 4.0 mg/L for most years at every station. However, it was only greater than 4.0 mg/L for one year at NH _{4.8} SCTDT and one year at NH _{2.3} MC.
Chlorophyll <i>a</i>	The North Carolina water quality standard for chlorophyll <i>a</i> is not to exceed 40 µg/L.	Chlorophyll <i>a</i> is not monitored or regulated in flowing streams. In 2006, Jordan Lake was placed on the 303(d) list for elevated chlorophyll <i>a</i> concentrations. Because New Hope Creek and Little Creek drain to Jordan Lake, nutrient management measures within the Jordan watershed encompass the two watersheds.

(1) Source: NCDEQ (2020)
ml = milliliter

cfu = colony-forming unit
WQI = Water Quality Index

mg/L = milligrams per liter
µg/L = microgram per liter

Table 2-7. Average WQI for New Hope Creek and Little Creek watershed water quality monitoring stations

Station	Stream	Average WQI	Number of Years of Data WQI Based On
LITC1.5LITC	Little Creek	72	1 year
NH0.0NHC	New Hope Creek	82	12 years
NH3.0NHC	New Hope Creek	91	7 years
NH2.3MC	Mud Creek	85	12 years
NH1.0SC	Sandy Creek	83	12 years
NH1.7SCTA	Sandy Creek Tributary A	64	6 years
NH3.3SC	Sandy Creek	80	13 years
NH4.3SC	Sandy Creek	-	-
NH4.4SCTD	Sandy Creek Tributary D	77	1 year
NH4.8SCTDT	Sandy Creek Tributary D	78	4 years
NH5.0SCTD	Sandy Creek Tributary D	86	2 years

WQI = water quality index

2.2.3 Sediment Monitoring

Sediment sampling data is also available from the 2018 Sandy Creek Watershed Study for four sampling stations within the watershed (City of Durham, 2019b). In this study, sediment was tested for both physical (dry weight, particle size distribution) and chemical characteristics, including organic carbon, 10 metals, and 11 polycyclic aromatic hydrocarbons (PAHs). Physical results showed that upstream sediment tended to be fine-medium sand, while downstream was medium to coarse sand. In general, metals were below the historical means, except for cadmium, which could not be compared due to historical reporting limits, zinc at three stations, and lead at two stations. Comparisons of PAHs with historic observations could not be made due to reporting limits, but at one station most of the PAHs (7 of 10) exceeded historical means. From these results, the incidence of toxicity, which is the percent of samples that would cause toxicity for aquatic wildlife, ranged from 1.4% to 3.5%. This indicates that that there is a low likelihood that toxicity due to sediment chemistry would negatively impact benthic communities in Sandy Creek.

Additionally, the USGS sampled sediment at two stations: USGS-02097314 on New Hope Creek at Stagecoach Road (SR 1107) and 0209722970 on Sandy Creek at Cornwallis Road. This was part of the 2014 SESQA study referenced above. Results showed medium toxicity of benchmark quotient contaminants, such as PAHs, Polychlorinated Biphenyls (PCB), and metals, and medium toxicity of Pyrethroid pesticides at both locations.

2.3 Watershed Impacts and Sources of Pollution

Nonpoint source pollution is pollution that “results from land runoff, precipitation, atmospheric deposition, drainage, seepage or hydrologic modification” as defined by the USEPA (USEPA, 2017). Nonpoint source pollution is diffuse and is generated by a variety of natural and anthropogenic sources before being transported by stormwater runoff to streams. Point source pollution, on the other hand, originates from a single source such as a wastewater discharge pipe.

The New Hope Creek and Little Creek watersheds exhibit overall fair water quality (City of Durham, 2019a). Primary watershed concerns and sources of pollutants were identified through water quality data and field assessment. Occurrences of elevated turbidity and eroded banks are present throughout the study area. During field assessment, the most common water quality concerns observed were headcuts and exposed or threatened utilities. Headcuts can be significant sources of sediment within a stream, and exposed utilities have the potential to discharge into streams without being treated. The sampling data showed that in all watersheds fecal coliforms and nutrient concentrations were consistently elevated.

The *New Hope Creek and Little Creek Watershed Assessment Report* (see Volume III, Appendix E, of this WIP) describes the potential nonpoint sources identified during field investigations. Key source categories and watershed-specific concerns are presented in Table 2-8. A summary of potential nonpoint sources and impacts in the New Hope Creek and Little Creek watersheds is presented in Table 2-9.

Table 2-8. Summary of New Hope Creek and Little Creek Watershed pollution sources

Source	Description
Stormwater runoff from impervious surfaces	<ul style="list-style-type: none"> Increased impervious cover can result in increased stormwater runoff, higher peak flows, lower base flows, and reduced groundwater recharge. Impervious cover accounts for approximately 19% of the study area. The percentage of impervious cover in 27 of the 56 subwatersheds in the study area was found to be 15% or above. Eight of the 14 subwatersheds in the Sandy Creek watershed have relatively large amounts of impervious cover that account for between 25% and 45% of their respective subwatershed areas.
Animal waste	<ul style="list-style-type: none"> Animal waste deposits from both domestic house pets and wild animals such as deer and geese are potential sources of fecal coliform within urban areas. Additional information is needed to determine if pet waste is a contributor to fecal coliform exceedances in the New Hope Creek and Little Creek watersheds.
Headcuts	<ul style="list-style-type: none"> A headcut is an abrupt vertical drop in the stream bed that is an active erosional feature. Potentially major source of sedimentation in a stream. 55 headcuts were observed by field crews during stream assessments.
Illicit discharges	<ul style="list-style-type: none"> Examples of illicit discharges include petroleum spills, improper disposal of yard waste, public sanitary sewer overflows (SSO), and cooking related wastes like oil, grease, food that is discharged into storm drains or enter storm drains from overland runoff, and mobile car washing operations. Field biologists noted evidence of potential illicit discharges while performing stream assessments in the New Hope Creek and Little Creek watersheds (see Exhibit 12). These observations were reported to the Public Works Department staff who investigate and resolve any illicit discharges. Illicit discharges are documented in the City's State of Our Streams Reports (City of Durham, 2019a) and NPDES Annual Report (City of Durham, 2020b).
Elevated Levels of TN, TP, turbidity, and copper	<ul style="list-style-type: none"> Nutrients and fecal coliform associated with wastewater reduce water quality, contribute to growth of aquatic macrophytes, and reduce dissolved oxygen levels. Turbidity reduces light penetration and copper is toxic. These can affect the ecological productivity and habitat quality within streams. Average annual TN values exceeded the City of Durham benchmark (0.8 mg/L TN) in Little Creek, Sandy Creek, and Mud Creek for most of the sampling years. Little Creek and Sandy Creek exceeded TP most of the years, and New Hope Creek exceeded the threshold about 40% of the years. The CCC for copper was exceeded at least 1 month out of the year for all subwatersheds.

Table 2-8. Summary of New Hope Creek and Little Creek Watershed pollution sources (continued)

Source	Description
Degraded riparian buffer	<ul style="list-style-type: none"> • Degraded riparian buffers result in increased bank erosion and sediment inputs to surface waters. • In the study area, field investigations identified about 75,000 linear feet of stream in 39 reaches that would benefit from restoration and more than 90,000 linear feet that could undergo enhancement or stabilization.
Degraded habitat	<ul style="list-style-type: none"> • The abundance and diversity of fish and benthic macroinvertebrates are impacted by the physical characteristics, substrate composition, and riparian area features of a stream. • Healthy stream habitat in the Piedmont physiographic province of North Carolina is characterized by a diversity of riffles and pools as well as healthy, riparian buffers that stabilize banks, moderate temperatures, and filter pollutants from overland runoff. • Rapid Stream Assessment Technique (RSAT) assessments in the New Hope Creek and Little Creek Watershed revealed that, among the 35.8 stream miles assessed, 18% are rated "good", 70% are rated "fair", and 9% are rated "poor", and 3% were not rated due to the presence of a beaver impoundment or other environmental factor. Nearly all the assessed subwatersheds were either "good" and "fair" or "fair" and "poor," with the majority being "fair". See Exhibit 13 for the RSAT assessments within the study area. • Streams surveyed in the New Hope Creek and Little Creek watersheds are located mostly in the Triassic Basin. Streams in this area tend to score lower on biological assessments, which is a component of the RSAT, due, in part, to a relative lack of benthic macroinvertebrates.

Table 2-9. Summary of potential nonpoint sources and impacts in the New Hope Creek and Little Creek watershed

Impact	Potential Sources	Indicator	Supporting Documentation	Identified Management Recommendation
Bacteria	Leaking septic systems, sand filters, SSOs and other sewage discharges, animal waste, legacy sediment	Fecal coliform	Durham Water Quality Data Portal ⁽¹⁾	Behavioral changes, programmatic changes, sanitary sewer system upgrades
Sediment	Stream bank erosion, legacy sediment, improper ESC practices, degraded riparian buffer	TSS, turbidity, BEHI, aquatic habitat ratings	Durham Water Quality Portal, ⁽¹⁾ field assessments	Riparian buffer planting, improved ESC practices, behavioral changes
Increased peak flows	Increased impervious surfaces, degraded riparian buffer, vegetation removal	Incised streams, aquatic habitat ratings, increased frequency of high flow events	Discharge data ⁽²⁾	SCMs, riparian buffer plantings
Excess nutrients	Impervious runoff, poorly functioning septic systems, sand filters, SSOs and other sewage discharges, degraded riparian buffer, landscaping practices (fertilizer), animal waste, legacy sediment, soil, atmospheric deposition, yard waste	Total N and Total P concentrations, chlorophyll <i>a</i> , DO measurements, invasive aquatic macrophytes	Field assessments, Jordan Lake Rules ⁽³⁾ , Sandy Creek Special Study ⁽⁴⁾ , Southeast Stream Quality Assessment ⁽⁵⁾ , NC Invasive Plant Council	SCMs, environmental education, riparian buffer planting, sanitary sewer repairs and upgrades
Increased heavy metals	Impervious runoff, paint, roofing, brake pads, automobiles, metal workshops, geology, illicit discharges, pesticides, algaecides, cooling water, atmospheric deposition	Metals (Cu, Cr, Zn), NCIBI ratings	Durham Water Quality Portal, New Hope Creek and Little Creek Implementation Data Collection	SCMs (bioretention and wet ponds), behavior changes
Low DO	Sewage, excess nutrients, sediment, degraded riparian buffer, beaver dams, low-head dams, illicit discharges, leaves, roadway culverts	DO measurements, NCIBI ratings	Durham Water Quality Portal	SCMs, riparian buffer planting, beaver management, reconfiguring problematic culverts, stream restoration, baseflow augmentation, sanitary sewer repairs and upgrades
Pesticides	Agriculture, lawns, gardens, parks, roadways	Predicted Pesticide Toxicity to Invertebrates	Southeast Stream Quality Assessment ⁽⁵⁾	Behavioral changes, programmatic changes, SCMs, riparian buffers, integrated pest management

(1) <http://www.durhamwaterquality.org>

(2) USGS (n.d.)

(3) NCDEQ (2009)

(4) City of Durham (2019b)

(5) USGS (2014a)

BEHI = Bank Erosion Hazard Index

Cu = copper

Cr = chromium

DO = dissolved oxygen

ESC = erosion and sediment control

N = nitrogen

NCIBI = North Carolina Index of Biotic Integrity

P = phosphorus

SCM = stormwater control measure

SSO = sanitary sewer overflow

TSS = total suspended sediment

Zn = zinc

3 Stream Inventory and Assessment and Project Opportunities

Stream health is integral to overall watershed health and water quality. The physical condition and morphology of a stream impacts ecological health and aquatic habitats. Therefore, an assessment of the streams in the New Hope Creek and Little Creek watersheds was necessary for development of this WIP.

3.1 Stream Field Inventory and Assessment

Based on the City's stream hydrography GIS data, there are 63 miles of stream length in the study area. With support from City staff, field teams examined streams and riparian buffers to assess channel conditions and identify any water quality problems. They also identified potential stream and water quality improvement projects. Prior to field visits, GIS data was used to determine which streams would be assessed and whether they would have Level 1 (rapid) or Level 2 (comprehensive) assessment performed.

The stream inventory included six tasks:

1. Collect data on the physical condition of the streams and riparian buffers within the watershed
2. Identify stream reaches and riparian buffers in need of restoration, enhancement, or preservation
3. Identify potential sources of pollution along the stream corridors within the watershed
4. Identify issues with public utilities that cross or are adjacent to the streams
5. Collect information needed for the watershed modeling efforts
6. Collect more detailed information such as streambank erosion rates on Level 2 stream reaches that can help to prioritize restoration and enhancement projects

This field inventory and assessment was conducted in February 2020 on 35.8 miles of stream, split into 115 individual reaches. Reaches were partitioned at points when there was a change in either stream or riparian buffer conditions, such as cross-sectional dimensions, degree of erosion, width and density of buffers, or an obvious change in stream type.

Two levels of field assessment were performed. Level 1 assessment fulfilled tasks #1-#5 and consisted of a rapid, high-level survey intended to capture general data about as many streams as possible. Level 2 assessment addressed task #6 with a more detailed analysis on a small subset of Level 1 streams. The complete methodology for both Level 1 and Level 2 assessments is described in the *Stream Assessment Field Plan* (see Volume III, Appendix B, of this WIP).

3.2 Results of Stream Field Assessments

Section 3.2 summarizes the results from the field assessments. A more detailed description of the results can be found in the *New Hope Creek and Little Creek Watershed Assessment Report* (see Volume III, Appendix E, of this WIP).

Of the overall stream miles assessed, none were rated Excellent, 18% were rated Good, 70% were rated Fair, 9% were rated Poor, and 3% were not rated due to the presence of a beaver impoundment or other environmental

factor which prevented the field teams from gathering the required data. Figure 3-1 presents an example of a stream that is in Good condition (left photo) and a stream that is in Poor condition (right photo).



Figure 3-1. An example of a stream reach with an overall Good RSAT score: Reach MC1008 located in Duke Forest in NHC54_MC (left photo) and a stream reach with an overall Poor RSAT score: Reach SC 2015 located parallel to Chapel Tower in NHC46_SC (right photo)

Streams in thirty-five of the 56 total subwatersheds were assessed. While 10 subwatersheds had reaches rated as Poor, only two subwatersheds had greater than half of their assessed stream length rated as Poor. Thirteen subwatersheds had some stream length that was rated Good, and one of them (NHC15_LNHC) had all stream reaches rated as Good. Additionally, only two subwatersheds had scores in all three categories. The majority of subwatersheds were comprised entirely of Good or Fair reaches (Exhibit 13).

The primary water quality concerns identified during the stream field work were headcuts, exposed or threatened utilities, and litter. The field teams identified 55 headcuts, 56 exposed or threatened utilities, and 51 reaches that had litter (Exhibit 12).

During Level 2 assessments, the yearly bank erosion rates were determined for 28 stream reaches, totaling approximately 10.7 miles. Results of the Bank Erosion Hazard Index (BEHI) and Near Bank Stress (NBS) analysis showed that 11 reaches (6.7 stream miles) yielded more than 20 tons/year of sediment from the banks and the remaining 17 reaches had yields of less than 20 tons/year, with a median sediment yield of 12.3 tons/year. The locations of the 28 stream reaches are presented in Exhibit 14.

3.3 Potential Stream Project Opportunities

Along with evaluating the physical characteristics of the streams and determining erosion rates, field crews identified opportunities to improve stream health in each of the assessed reaches. This section provides a summary of stream project types; however, a more comprehensive description can be found in the *Stream Assessment Field Plan* (Volume III, Appendix B, of this WIP).

All 115 reaches that were assessed by field teams were assigned to a potential project type, as shown in Table 3-1. Defined by the USACE (USACE, 2003), these projects are Restoration, Enhancement I, Enhancement II, Bank Stabilization, and Preservation and are described below:

- **Stream Restoration:** Converts an unstable, altered, or degraded stream corridor, including adjacent riparian buffers and floodplain, to its natural, stable condition. Includes restoring a naturally stable channel planform pattern, longitudinal profile (riffle/pool sequence), and channel cross-section dimensions as well as improving biological and water quality functions.
- **Enhancement I (EI):** Improvements to the stream channel and riparian zone that restore channel stability, water quality, and stream ecology. Re-establishes channel cross-section dimensions and longitudinal profile, but restoration of channel pattern is not feasible or warranted. The project may also include other practices that provide improved water quality and ecological benefits.
- **Enhancement II (EII):** Activities that improve channel stability, water quality, and stream ecology but do not include re-establishing the channel profile or pattern. The type of project may include re-establishment of the channel cross-section as well as practices to improve water quality and ecological benefits.
- **Bank Stabilization:** Involves in-place stabilization of an eroding streambank. Techniques include sloping streambanks to a less vertical and more stable angles, installing streambank revetments with natural materials such as root wads or brush toe, and revegetating banks and riparian buffers without restoring cross-section dimensions.
- **Preservation:** Establishes protection of ecologically important or high-quality streams in perpetuity through the implementation of protective mechanisms. Preservation may include the protection of upland buffer areas adjacent to the stream necessary to ensure protection or enhancement of the overall stream.

Table 3-1 and Exhibit 15 present the number of reaches and the total stream length assigned to each project type.

Table 3-1. Potential stream project opportunities

Project Type	Number of Reaches	Project Length	
		Linear feet	Miles
Restoration	39	75,446	14.3
Enhancement I	16	22,366	4.2
Enhancement II	17	19,483	3.7
Bank Stabilization	37	52,467	9.9
Preservation	6	12,102	2.3
Total	115	181,864	34.4

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4 Stormwater Control Measure Inventory, Assessment, and Project Opportunities

Similar to the stream assessment, a SCM inventory and field assessment was conducted between December 2019 and January 2020. The key components of this field effort included assessing the surrounding area of existing SCMs, evaluating retrofit opportunities, and identifying SCMs with impaired functionality due to design or maintenance issues. Developed areas which do not receive treatment currently but are suitable for new SCMs were also evaluated. These assessments were used to identify potential new SCMs and retrofits to existing SCMs.

The field crews did not evaluate areas that were undeveloped as any future development is be subject to the Jordan Lake Rules (NCDEQ, 2009) and the Unified Development Ordinance (UDO) (Durham City-County Planning Department, 2021) administered by both the City and Durham County. These standards require on-site stormwater controls.

Out of the total 130 sites visited, 71 were existing SCMs and 59 were potential sites for new SCMs. Initially, the City provided a database containing 264 SCMs within the New Hope Creek and Little Creek watersheds. Of these, 59 were recommended to be evaluated following a GIS-based desktop prescreening analysis (Exhibit 16).

Existing SCMs were inspected during the field assessments to evaluate retrofit opportunities and determine if any performance problems exist due to design or maintenance issues. In addition, the field crews inventoried and evaluated 12 features (6 wet ponds, 4 dry ponds, and 2 water retention features) which were not included in the City's database. These 12 features are not included in the City's database of SCMs, and most appeared to have been constructed for purposes other than stormwater benefits. Therefore, they are not referred to as SCMs. Finally, field teams visited 59 potential sites for new SCMs, which had been identified during the GIS prescreening analysis.

A more detailed discussion of the GIS-based desktop analysis, selection criteria and the field assessment methodology for both existing and potential SCMs is presented in the *Stormwater Control Measure Inventory and Assessment Field Plan* (see Volume III, Appendix C, of this WIP).

4.1 SCM Field Assessment Methodology

Using tablets and forms that were developed in Survey 123 for ArcGIS software (Esri, n.d.) and following the procedures and protocols as outlined in the *Stormwater Control Measure Inventory and Assessment Field Plan* (see Volume III, Appendix C, of this WIP), field crews collected the following information for each of the 71 existing SCMs and features:

- SCM ID, subwatershed code, date, surrounding land use, HSG, receiving waterbody, and confirmation of SCM type
- Photographs of the overall site conditions and individual SCM components
- Physical measurements and information on SCM components, such as inlets, outlets, riser structures, and emergency spillways
- Potential retrofits or modifications to improve water quality treatment performance

- Site constraints which were not identified during prescreening that would prevent or hinder required maintenance or potential retrofits, such as known utilities and infrastructure, proximity to jurisdictional wetland or streams, insufficient access for construction and maintenance, encroachment on adjacent properties, and environmental impacts or permitting requirements
- Evaluation of the current SCM condition and degree of performance and any maintenance that is required or recommended

When field crews visited the 59 potential sites for new SCMs, they recorded and assessed the following information:

- Site constraints which were not identified during prescreening that would prevent or hinder required maintenance or potential retrofits, such as known utilities and infrastructure, proximity to jurisdictional wetland or streams, insufficient access for construction and maintenance, encroachment on adjacent properties, and environmental impacts or permitting requirements
- Potential new SCM type, length, and width of the available area and a completed sketch of a preliminary layout
- Type of receiving waterway or waterbody
- Site photographs including conditions at potential inlets and outlets and the receiving waterbody at a possible discharge point

The results of the SCM inventory and assessment were compiled in two GIS geodatabases: one for existing SCMs and one for potential new SCMs. The results from the field work, along with descriptions of retrofit opportunities and potential SCM implementation are summarized below.

4.2 Retrofit Opportunities to Existing SCMs

The 59 existing SCMs in the New Hope Creek and Little Creek watersheds that were evaluated during this study included 36 wet ponds, 19 dry ponds, 2 bioretention cells, 1 sand filter, and 1 stormwater wetland. Table 4-1 shows which SCMs were in each watershed. Thirty-eight SCMs were located in residential areas, 12 were in commercial areas, 8 were in institutional areas (e.g. schools, churches, libraries, etc.), and 1 was in a park (Exhibit 17). Table 4-2 presents a summary of adjacent land use for SCMs by watershed.

Table 4-1. Existing SCMs visited in the field

Subwatershed	Existing SCM Type					Total
	Dry Pond	Wet Pond	Bioretention	Sand Filter	Stormwater Wetland	
Little Creek (NHC01_LC-NHC07_LC)	5	5	-	-	-	10
Lower New Hope (NHC09_LNHC-NHC32_LNHC)	5	30	1	1	-	37
Sandy Creek (NHC33_SC-NHC46_SC)	7	1	1	-	1	10
Mud Creek (NHC47_MC-NHC56_MC)	2	-	-	-	-	2
Total	19	36	2	1	1	59

Table 4-2. Existing SCMs visited by surrounding land use and watershed

Surrounding Land Use	Number of SCMs			
	Little Creek ⁽¹⁾	Sandy Creek ⁽²⁾	Mud Creek ⁽³⁾	Lower New Hope Creek ⁽⁴⁾
Residential	9	4	1	24
Commercial	1	1	-	10
Institutional (schools, churches, etc.)	-	4	1	3
Parks & Open Space	-	1	-	-
Total (59)	10	10	2	37

(1) Subwatersheds NHC01-NHC07

(2) Subwatersheds NHC33-NHC46

(3) Subwatersheds NHC47-NHC56

(4) Subwatersheds NHC09-NHC32

When field crews evaluated SCMs for retrofits, they selected structural, volume, or add-on retrofits. Structural retrofits focus on modifications to a SCM's outlet structure. These can be simple, such as modifying the control structure to hold more runoff volume or change the peak flow, or can involve a more thorough redesign, completely changing the SCM type.

Volume retrofits involve increasing the storage volume of a SCM so that it can capture more volume or provide a longer retention time. These retrofits typically require the expansion of a SCM's footprint.

Add-on retrofits can be implemented without changing the storage volume or SCM footprint. They focus on enhancing the current water quality treatment capabilities by adding features, such as a forebay, level spreader, or floating wetlands to the SCM.

Of the 71 existing features visited, 29 were determined to be candidates for retrofits and recommended for further evaluation. Six of these were from the 12 additional features not included in the City's database. The most common recommendations were to redesign the existing SCM into a constructed or pocket wetland or a wet pond. In most cases, this would involve a relatively minor redesign of the outlet structure, along with the planting of suitable vegetation for increased water quality credit. The following discussion highlights specific recommendations for each watershed.

Little Creek

Three dry ponds in the Little Creek watershed were identified as candidates to be redesigned into constructed wetlands. Recommended add-on retrofits were building sediment forebays and adding level spreaders with filter strips.

Lower New Hope Creek

Thirteen total features were selected in the Lower New Hope Creek watershed, including 8 wet ponds, 4 dry ponds, and 1 bioretention cell. The common retrofit recommendations involved redesigning the SCMs to wetlands and increasing storage volume either by lowering permanent pool or increasing the footprint. Add-on retrofits include building a littoral shelf, adding floating wetlands, or implementing a sediment forebay. Figure 4-1 shows one of the retrofit opportunities to a wet pond.

Sandy Creek

SCM retrofits were recommended for 8 features—6 dry ponds, 1 wet pond, and 1 bioretention cell. Along with redesigning certain SCMs into a wetland or wet pond, simple control structure modifications were suggested as well as implementing a rainwater harvesting system at one site. Figure 4-2 shows one of the retrofit opportunities for a dry pond.

Mud Creek

In the Mud Creek watershed, 5 features were recommended for further evaluation. These were 3 dry ponds, 1 wet pond, and 1 unlisted water retention feature. The dry ponds and wet pond retrofits involved redesigning the SCMs into constructed wetlands, wet ponds, or a simple control structure modification. Internal berms or baffles were recommended for one dry pond to reduce short circuiting of flow, and a riparian buffer restoration was proposed for the water retention feature.

SCM performance can be hindered if the SCM design is older and less efficient, if the construction was poor, or maintenance is neglected. Eleven of the 59 existing SCMs were identified as requiring maintenance in order to ensure proper functioning. The main concern for most of the SCMs was overgrown vegetation, which can obstruct flow, reduce performance, and lower the storage capacity. These SCMs were reported to City staff for follow-up.

4.3 Potential New SCMs

Based on field visits, 36 of the 59 potential new SCM sites were determined to be suitable for further evaluation as a new SCM (Exhibit 18). Table 4-3 lists the new SCM opportunities by watershed. Twenty of the thirty-six recommended new SCMs are bioretention devices. Bioretention devices are generally smaller devices but can provide efficient stormwater treatment and nutrient reduction. Bioretention basins can accommodate various installation configurations as they do not require a high groundwater table to maintain a wetted footprint; however, they require 2-3 feet of depth for engineered soil media, which can be a limiting factor.

Table 4-3. Potential new SCMs by watershed

Subwatershed	Bioretention	Constructed Wetland	Regenerative Stormwater Conveyance	Treatment Swale (Dry)	Treatment Swale (Wet)	Other	Total
Little Creek (NHC01-NHC07)	-	-	-	-	-	-	-
Lower New Hope (NHC09-NHC32)	4	2	1	3	3	-	13
Sandy Creek (NHC33-NHC46) ⁽¹⁾	10	3	1	-	-	2	16
Mud Creek (NHC47-NHC56)	6	1	-	-	-	-	7
Total	20	6	2	3	3	2	36

(1) Two "Other" potential new SCMs include stream restoration and proprietary

Of the sites identified for new SCMs, none were located in the Little Creek watershed. During desktop exercises, engineers determined that most of the high-density development in the Little Creek watershed is being treated by existing SCMs but that field evaluations would be needed to assess opportunities at other residential and commercial development in the watershed. During field evaluations, the field teams determined these sites to be

infeasible for new SCM construction. For this reason, SCM opportunities in the Little Creek watershed are predominately green stormwater infrastructure practices, devices that would treat smaller-scale drainage areas, or future developments that could provide increased treatment. The limited potential for new stormwater control measures outside of existing residential and commercial areas is largely a result of land use and development patterns in the Little Creek watershed.

Treatment swales are vegetated conveyances designed to promote biofiltration, settling, and infiltration. The vegetation both reduces peak flows by slowing runoff and filtering pollutants from the flow. Wet swales further treat stormwater by incorporating some wetland function in the permanent pool, leading to greater nutrient reduction (referred to as “credit”). Figure 4-4 shows a site that is a potential candidate for a wet swale. Regenerative stormwater conveyance (RSC) is a relatively new type of control measure, involving a series of shallow pools connected by grade control structures and underlain by a sand layer to promote infiltration (Koryto et al., 2018). The RSC has similarities to a bioretention cell but allows for surface flow once the pools have filled. Figure 4-3 shows a site that is a potential candidate for an RSC.



Figure 4-1. Example of retrofit opportunity at a wet pond (SCM Site 00316 located along SW Durham Drive in the Lower New Hope Creek watershed). The temporary storage volume of this wet pond is relatively small and could be increased. The proposed retrofit at this location, a wet pond with increased storage, would involve lowering the water level to gain storage.



Figure 4-2. Example of a retrofit opportunity in an existing dry pond (SCM Site 00267 located along Keohane Drive in the Mud Creek watershed). The site is likely too small to accommodate a full-sized wetland but water quality could be improved with the proposed retrofit, a pocket wetland.



Figure 4-3. Potential new SCM site in which a regenerative stormwater conveyance was recommended (SCM Site NHCSC0040 located along McQueen Dr. in the Sandy Creek watershed).



Figure 4-4. Potential new SCM site in which a wet swale was recommended (SCM Site NHC0014 located along Garrett Rd. within the Lower New Hope Creek watershed). A proposed 650-foot-long treatment swale would collect runoff from an adjacent commercial parking lot and roof.

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5 Evaluation of Watershed Improvement Scenarios

The recommendations presented in this WIP are based on a watershed-scale evaluation of pollution control opportunities within the New Hope Creek and Little Creek watersheds that are found to provide the most cost-effective benefits to the city. This evaluation involves identification and prioritization of improvement projects, such as SCM construction or retrofits and stream restoration opportunities, that will help protect and restore water quality in the New Hope Creek, Little Creek, their tributaries, and Jordan Lake.

As mentioned previously, some sections of these streams are impaired for benthos, according to the 2018 North Carolina 303(d) list of impaired waterbodies. In addition, Jordan Lake is impaired for chlorophyll a, turbidity, and pH. As a contributor of nutrient load into Jordan Lake, the City is required to adhere to the Jordan Lake Rules, which establishes a nutrient management strategy for the watershed, for the purpose of improving the lake's water quality. The Jordan Lake Rules are currently being revised and the City is participating in the groups looking at how to revise the rules (Triangle J Council of Governments, 2021).

Watershed improvement scenarios were developed and evaluated to assess the potential water quality benefits offered by the SCMs and stream projects described in the previous sections. The selected scenarios include practices that have demonstrated nutrient reduction and are considered feasible in the New Hope Creek and Little Creek watersheds.

5.1 Pilot Study Areas

The 56 subwatersheds within the New Hope Creek and Little Creek watersheds were categorized into seven groups based on similar characteristics, including land use, imperviousness, soil type, projected development trends, location relative to city limits, and presence of existing SCMs, shown in Exhibit 19. Seven Pilot Study Areas (PSAs) were selected from the 56 subwatersheds, representing 6 of the 7 groupings. Detailed data was collected within each PSA to support model development and application in watershed management scenarios. Additional information on the PSA selection process is presented in the *New Hope Creek and Little Creek Watershed Assessment Report*, which is provided in Volume III, Appendix E, of this WIP and the *Pilot Study Area Fact Sheets* which is provided in Volume III, Appendix D, of this WIP.

5.2 Stormwater Management Modeling

The data collected during the watershed field assessment was used to develop and calibrate a Personal Computer Storm Water Management Model (PCSWMM). The ultimate goal of this computer modeling was to determine the projects that offer the greatest water quality benefits in order to form a priority list for implementation. The model results are presented in Section 5.3.2.

The PCSWMM framework is a commercially-available software system which runs the USEPA Storm Water Management Model (SWMM). PCSWMM was selected, as opposed to other watershed modeling software, for its ability to simulate urbanized watersheds, which have expansive stormwater drainage systems, and to estimate pollutant loadings and the transport of water quality constituents through the drainage system.

The primary tasks while using PCSWMM for the New Hope Creek and Little Creek watersheds were to:

- Simulate the hydrology, hydraulics, and water quality conditions throughout the watersheds, while being more detailed in the portion of the watersheds within Durham County and less detailed in the portion that is in Orange County.
- Apply the simulation model to estimate changes in pollutant loadings as a result of the various water quality improvement scenarios.

Additional information on the PCSWMM development and calibration is provided in *New Hope Creek and Little Creek PCSWMM Model Development and Calibration* (see Volume III, Appendix H, of this WIP).

5.3 Scenarios

The watershed improvement scenarios evaluated during previous City of Durham WIPs provided valuable insights into the feasibility and cost-effectiveness of various practices that could be used for improving the water quality in the New Hope Creek and Little Creek watershed. The modeling results from previous WIPs (see Volume III, Appendix K, of this WIP), the unique conditions of the New Hope Creek and Little Creek watershed, and the current nutrient crediting in North Carolina were all considered in formulating the watershed improvement scenarios for this WIP.

The following watershed improvement scenarios were selected for the New Hope Creek and Little Creek watersheds:

1. Baseline for current conditions (existing land use with existing SCMs)
2. Baseline for future conditions (future land use with existing SCMs)
3. Stormwater Performance Standards for New Development and Redevelopment Parcels
4. Recommended SCM retrofits and new SCM projects
5. Recommended stream restoration projects
6. Green Stormwater Infrastructure/Low Impact Development (GSI-LID)
7. Additional on-site treatment for pre-1980 development and commercial land uses
8. Oversize new SCMs and SCM retrofits
9. Enhanced street sweeping
10. The combination of all practices listed above

Additional information on the methods used to develop the individual scenarios are presented in Section 5.3.1. The PCSWMM model was used to evaluate all watershed improvement scenarios except for stream restoration projects which were modeled in Microsoft Excel. The modeling results for all scenarios are discussed in Section 5.3.2. Additional information on scenario selection is available in the memorandum titled *Summary of Watershed Improvement Scenarios Used to Support the City of Durham Watershed Improvement Plans* (see Volume III, Appendix K, of this WIP)

5.3.1 Scenario Methodology

Ten watershed improvement scenarios were considered for their impact on nutrient and total suspended sediment (TSS) loading rates throughout the watershed. Scenarios 1 and 2 establish a baseline for current and future conditions assuming no additional SCMs are constructed, while scenarios 3-10 simulate changes due to watershed improvements. Scenarios 3 and 10 build upon Scenario 2, Scenarios 4 and 5 build on Scenario 3, and

Scenarios 6-9 build upon Scenario 4. Additional information on scenario methods and results is available in *Technical Memorandum – New Hope Creek and Little Creek SWMM Scenario Analysis* (See Volume III, Appendix I, of this WIP).

5.3.1.1 Scenario 1: Existing Land Use with Existing SCMs (Baseline Condition)

Scenario 1 models the existing conditions in the watersheds, without any modification to the current land use or SCM performance. Within the project study area, the existing land use scenario uses an AECOM-modified existing land use layer that was originally provided by the City of Durham (see Volume III, Appendix A, of this WIP). Outside the project study area, the existing land use was defined using the NLCD 2016 land coverages (USGS, 2016). The land use classifications within these datasets were reclassified to correspond with the City's system. The reclassification method is described in *Technical Memorandum – New Hope Creek and Little Creek SWMM Model Development* (see Volume III, Appendix H, of this WIP). Two land use categories, forest and wetlands, were not accounted for in the City data and so were not reclassified. During reclassification, various hydrology parameters, such as Manning's n and depression storage, and water quality parameters, like event mean concentrations (EMCs), were assigned to the land uses. This manual parameterization is important for successful characterization of the watersheds because of varying runoff rates and water quality effects associated with land use types. For example, large forests have much smaller runoff rates and higher nutrient and sediment retention rates than residential green spaces.

To determine SCM performance within the watersheds, 253 existing SCMs were included in the model. These included 31 dry ponds, 73 wet ponds, 30 wetlands, three permeable pavements, five rainwater harvesting systems, 35 sand filters, seven swales, 27 underground storages, and 42 bioretention cells, as presented in Table 5-1. Pollutant removals for each type of SCM were specified using the North Carolina Stormwater Control Measure Credit Document (NCDEQ, 2018b), provided in Table 5-1. The Stormwater Control Measure Credit Document does not provide suspended sediment removal efficiencies, so an 85% sediment removal efficiency was applied to all SCMs except Underground Storage (0%) and Dry Pond (50%). Of the 71 existing SCMs field crews surveyed within the New Hope Creek and Little Creek watersheds, it was determined that 11 were not functioning properly. For these 11 SCMs, the removal efficiencies were halved to reflect their impaired status in the "existing condition" scenario. For future condition scenarios these SCMs were assumed to be fully functioning.

Table 5-1. Summary of existing SCM counts and pollutant removal efficiencies

SCM Type	SWMM Method	Count	Removal Efficiency		
			TN	TP	TSS
Bioretention with internal water storage	LID	13	40%	45%	85%
Bioretention without internal water storage	LID	16	35%	45%	85%
Bioretention: StormFilter by Contech	LID	4	50%	70%	85%
Bioretention: Filterra by Contech	LID	9	35%	45%	86%
Dry Pond	Storage	31	10%	10%	50%
Permeable Pavement	LID	3	84%	84%	85%
Rainwater harvesting system	LID	5	10%	10%	85%
Sand Filter	LID	35	35%	45%	85%
Swale/level spreader	LID	7	30%	35%	85%

Table 5 1. Summary of existing SCM counts and pollutant removal efficiencies (continued)

SCM Type	SWMM Method	Count	Removal Efficiency		
			TN	TP	TSS
Underground Storage	Storage	27	0%	0%	0%
Wet pond	Storage	73	30%	30%	85%
Wetland	Storage	30	44%	40%	85%

Source: NCDEQ, 2018b

SCM = stormwater control measure

TN = total nitrogen

TP = total phosphorus

5.3.1.2 Scenario 2: Future Land Use Conditions and Existing SCM Repairs

Scenario 2 represents the future development conditions in the study area if no additional watershed improvement projects or pollution control measures are added. This scenario assigns land uses to the study area based on the 2025 land use projection provided by the City (City of Durham, 2016b) and includes only the existing SCMs described in Scenario 1. The portions of the watersheds outside of the study area were unchanged from Scenario 1 to evaluate the degree that land use changes impact the study area. Scenario 2 serves as the baseline for the rest of the New Hope Creek and Little Creek Watershed scenarios.

When the land use distribution was updated from existing land use to future use, the impervious area for each PCSWMM subcatchment in the study area required updating as well. The impervious area of existing land use types informed the impervious percentage used for future land use distributions, as summarized in Table 5-2. In addition, Scenario 2 assumed that all the existing SCMs from Scenario 1 would be maintained and repaired in order to ensure full performance. Therefore, the full removal efficiency values were used for the 11 non-functioning SCMs identified in Scenario 1.

Table 5-2. Summary of characteristic impervious percent by existing land use

Land Use	Characteristic Impervious (%)
Agricultural	0.4%
Commercial	55.1%
Forest	--
Industrial	50.3%
Institutional	31.1%
Public open space	0.9%
Residential, high-density	39.6%
Residential, medium-density	13.0%
Residential, low-density	17.5%
Residential, very low-density	7.1%
Road	100.0%
Wetland	--

5.3.1.3 Scenario 3: Future Land Use with Stormwater Performance Standards for New Development

Scenario 3 was developed to evaluate the benefit of implementing the City of Durham’s Stormwater Performance Standards on new development and redeveloped parcels within the project study area (City of Durham, 2012b). New development and redeveloped parcels were identified within the project study area by comparing existing and future land use data from the City of Durham. The following criteria were used to identify new development and redevelopment parcels:

- New development parcels were identified as areas > 1 acre that were changed from a low development land use (agriculture, wetland, public open space, very low density residential) to a higher development land use. “New Development” parcels accounted for 8.5% of the project study area.
- Redeveloped parcels were identified as areas >1 acre and changed from one developed land use to another. “Re-development” parcels accounted for 1.9% of the project study area.

The Stormwater Performance Standards were implemented on all new development and redevelopment parcels that experienced an increase in impervious surface area greater than 24%. Exceedance of the criteria in individual parcels is determined from land use export rates. For parcels that exceeded the Stormwater Performance Standards criterion, the TSS load was reduced by 85%, TN load was reduced by 30%, and TP load reduced by 40%.

As previously described, portions of the Jordan Lake Rules, including rules affecting New Development, are not currently in effect. The City adopted their Performance Standards for New Development Ordinance on April 19, 2005. Recent revisions to that City ordinance included the removal of the Jordan Lake Stormwater Management for New Development regulations which were replaced with NPDES Phase II regulations. This change was adopted on May 20, 2019.

5.3.1.4 Scenario 4: Stormwater Performance Standards for New Development with Recommended SCM Retrofits and New SCM Projects

Scenario 4 determines how the proposed new and retrofit SCM projects within the study area would affect the annual pollutant loads in the entire watershed. During the SCM inventory and assessment portion of this WIP development process (see Section 4), 35 new and 29 retrofit SCM opportunities were identified. The field-determined retrofit projects are listed in Table 5-3. Retrofits were modeled in PCSWMM by updating the existing SCM characteristics from Scenario 3, which include stage-storage curves, stage-discharge curves, and pollutant removal efficiencies.

Table 5-3. Recommended retrofits to existing SCMs

SCM ID	SCM Type - Existing	SCM Type - Retrofit
00054	Dry pond	Wetland
00072	Dry pond	Wetland
00100	Wet pond	Wetland
00103	Wet pond	Wetland
00111	Wet pond	Wetland
00255	Dry pond	Wetland
00267	Dry pond	Wetland
00276	Wet pond	Wetland

Table 5-3. Recommended retrofits to existing SCMs (continued)

SCM ID	SCM Type - Existing	SCM Type - Retrofit
00287	Wet pond	Wetland
00289	Bioretention without internal water storage	Bioretention with internal water storage
00303	Dry pond	Wetland
00316	Wet pond	Wet pond with increased storage
00325	Dry pond	Wetland
00359	Dry pond	Wetland
00360	Dry pond	Wetland
00439	Dry pond	Wetland
00446	Dry pond	Wetland
00447	Dry pond	Wetland
00464	Wet pond	Wetland
00497	Dry pond	Wetland
00503	Dry pond	Wetland
00511	Dry pond	Wetland
00674	Bioretention without internal water storage	Bioretention with internal water storage
NHC0024	Aesthetic pond	Wet pond
NHCMC0067	Aesthetic pond	Wet pond
NHCMC0068	Aesthetic pond	Wet pond
NHCMC0069	Aesthetic pond	Wet pond
NHCMC0070	Dry pond	Wetland
NHCMC0071	Dry pond	Wetland

Scenario 4 also evaluates the implementation of new SCMs in the watershed. During the field work, 36 potential new SCM sites were identified. Follow-up desktop assessments resulted in the removal of one potential new SCM (NHSC0026) which was a recommendation to restore a stream. For this reason, 35 of the 36 potential new SCMs originally identified in the field were evaluated using PCSWMM under scenario 4. For all existing, new and retrofit SCMs simulated, a water quality treatment volume was calculated using the Simple Method as recommended by the NCDEQ Stormwater Design Manual (NCDEQ, 2017a). SCMs were sized to accommodate the calculated water quality treatment volume and, when possible, represented using the minimum design criteria provided by NCDEQ (NCDEQ, 2017b). Because Regenerative Stormwater Conveyance (RSC) was not included in the North Carolina Control Measure Credit Document (NCDEQ, 2018b), RSCs were given the same removal efficiencies as bioretention with internal water storage. A summary of the new SCMs included in the model is provided in Table 5-4.

Table 5-4. Summary of new SCM counts and pollutant removal efficiencies

SCM Type	SWMM Method	Count	Removal Efficiency		
			TN	TP	TSS
Bioretention Basin with Internal Water Storage	LID	20	40%	45%	85%
Bioretention Basin – Regenerative Stormwater Conveyance	LID	2	40%	45%	85%
Treatment Swale – Wet	Storage	3	30%	30%	85%
Treatment Swale – Dry	LID	3	10%	10%	85%
Wetland	Storage	7	44%	40%	85%

5.3.1.5 Scenario 5: Stormwater Performance Standards for New Development with Recommended Stream Restoration Projects

Scenario 5 was developed to quantify the pollutant load reduction that could be achieved through implementing the proposed 28 projects (10.7 miles of stream length) identified during the Stream Inventory and Assessment (see Section 3). At each location, field crews collected measurements for bank heights, bankfull widths, and calculated near bank stress (NBS) values and bank erosion hazard index (BEHI) values. While urban stream restoration is recognized as an eligible practice for nutrient crediting under the Chesapeake Bay Nutrient TMDL framework, this practice is not currently recognized by NCDEQ for crediting in North Carolina. For this reason, the annual pollutant load reductions for TN, TP, and sediment were determined using a methodology developed by the Chesapeake Bay Program (2014) and later applied by Doll (2018) to case study projects in North Carolina. Because PCSWMM is not well-suited for modeling stream processes, a Microsoft Excel model was used instead. To evaluate performance, projects were grouped into the protocols outlined by the Chesapeake Bay Program (2014). The projects were categorized as follows:

- Stream reaches proposed for restoration could achieve the pollutant reductions for Protocol 1: Credit for Prevented Sediment and Protocol 2: In-stream Denitrification.
- Stream projects which were proposed for Enhancement I, Enhancement II, or Bank Stabilization (USACE, 2003) could achieve the pollutant reductions for Protocol 1: Prevented Sediment only.
- No stream projects were credited for Protocol 3: Credit for Floodplain Reconnection Volumes during Storm Flow because it would require detailed design information for each potential stream project.

Credits for Protocol 1 were estimated by calculating the expected sediment erosion volume for each of the stream restoration sites. Sediment volumes were calculated using stream length, bank height, and Durham-specific sediment erosion rates (City of Durham, 2021a). A project efficiency of 50% was assumed for the three pollutants, which is based on the Chesapeake Bay Program's assumption that stream projects are not 100% effective and that sediment transport occurs naturally in stable streams (Chesapeake Bay Program, 2014). Protocol 2 only credits nitrogen reduction by estimating denitrification within a hyporheic box, which is the volume of soil around the stream bed where groundwater and stream flow mixes. For this project, the method used to calculate Protocol 2 credit varied slightly from the Chesapeake Bay Program approach to account for recent research published by Doll et al. (2018). Where the soil type indicated a depth of five feet, the hyporheic depth was modified to two feet based on research by NC State University to account for the shallower confining layers found in Piedmont soils (Doll et al., 2018). The hyporheic depth was then used to calculate the volume of the hyporheic box. The net nitrogen reduction via denitrification was then calculated using the recommended sediment density,

denitrification rate, and the volume of the hyporheic box. For additional information, see Technical Memorandum – New Hope Creek and Little Creek SWMM Scenario Analysis in Volume III, Appendix I, of this WIP.

5.3.1.6 Scenario 6: Stormwater Performance Standards for New Development with Green Infrastructure and Low Impact Development

Scenario 6 is used to assess potential GSI-LID distributed throughout the study area. Residential (low-, medium-, and high-intensity) and commercial land use were targeted for GSI-LID implementation. Eligible portions of the project study area were identified using the results of the City of Durham's Residential Green Infrastructure (ReGIn) analysis, the future land use layer, and parcels (City of Durham, 2017b; see Volume III, Appendix A, of this WIP). In the City's ReGIn analysis, sections of the city identified as Tier 1 are considered priority areas for GSI-LID practices that target water quality and flooding concerns while considering environmental justice. After identifying eligible areas, portions that were treated in previous scenarios were removed. In total, 3.5% of the project study area was eligible for treatment in this scenario.

After identifying areas eligible for treatment, adjustments were made to the land use, coverage, and wash-off blocks within the PCSWMM model to account for all runoff that is generated on areas eligible for GSI-LID treatment. This method is used to compensate for the limitations within the PCSWMM modeling framework where PCSWMM LID objects only treat pollutants associated with underdrain outflows and don't account for overland flows.

5.3.1.7 Scenario 7: Additional On-site Treatment for Pre-1980s Development and Commercial Land Uses

Scenario 7 was intended to evaluate the impact of treating portions of the project study area that were developed pre-1980 or have commercial land use. This scenario was developed in response to the modeling effort of Miller et al. (2019), where areas of pre-1980 development in the Jordan Lake watershed were found to have pollutant export rates substantially higher than areas of post-1980 development.

Eligible portions of the project areas were identified using City of Durham average year of residential construction data (filtered for areas developed pre-1980), the future land use layer, and parcels (City of Durham, 2016b). After identifying eligible areas, portions that were treated in Scenarios 3 and 4 were removed to avoid double counting treatment areas. SCMs implemented in treated areas were assumed to achieve 40% reductions in TN and TP, and 85% reductions in TSS. The approach to implementing treatment in scenario 7 is the same wash-off block method used in Scenario 6, in which an SCM treats wash-off from its entire drainage area.

5.3.1.8 Scenario 8: Stormwater Performance Standards for New Development using Oversized SCMs

Scenario 8 was developed to quantify the benefit associated with oversizing new SCMs and SCM retrofits to 150% of their design volume. Oversizing new and retrofit SCMs to 150% was selected for two reasons. First, sizing the SCM to 150% would allow treatment of the 1.5-inch design storm, which satisfies the requirement that SCMs treat the 1-inch design storm within the City of Durham limits. Second oversizing the SCM past 150% has diminishing returns on the percent of annual runoff treated (NCDEQ, 2018b).

All SCMs were eligible for oversizing except for wet and dry treatment swales, which are not permitted to be oversized per guidance from the NC SCM Credit Document (NCDEQ, 2018b). The incremental benefits and associated removal efficiencies of oversizing each SCM were estimated and incorporated in the PCSWMM model. It was not possible to estimate the added benefit that oversizing SCMs would have on TSS because Part C of the

NC SCM Credit Document does not provide effluent event mean concentrations for TSS, a necessary parameter to complete the calculations outlined above. A summary of the oversized new and retrofitted SCMs with associated removal efficiencies is presented in Table 5-5.

Table 5-5. Summary of pollutant removal enhancements based on oversizing SCMs

SCM Type	New	Retrofit	Removal Efficiency Benefit	
			TN	TP
Bioretention with internal water storage	20	2	5-6%	6-7%
Bioretention – regenerative stormwater conveyance	2	0	5-6%	6-7%
Treatment – Wet	3	0	--	--
Swale – Dry	3	0	--	--
Wet pond	0	5	4%	4%
Wetland	7	22	6%	5%

5.3.1.9 Scenario 9: Stormwater Performance Standards for New Development with Street Sweeping

Scenario 9 was developed to evaluate the impact of increasing street sweeping practices within the project study area. The enhanced street sweeping practices are in addition to current practices, which are assumed to already be captured in the calibrated baseline model. The pollutant reduction benefits associated with enhanced street sweeper were calculated using the City of Durham roads layer and street sweeping credit document (Culpepper, 2019) and the following assumptions:

- Additional street sweeping activities will remove 0.12 lbs of debris/mile swept. This number was calculated using 2015-2017 street sweeping data provided by the City of Durham.
- Street sweeping activities were limited to roads constructed of asphalt or concrete and maintained by the City of Durham. Using City of Durham road data, approximately 105 miles of roads were identified as eligible for sweeping.
- Twelve additional sweeping events would be performed during the course of the year. Each event would involve sweeping all 105 miles of road within the New Hope Creek and Little Creek watersheds within the City of Durham.
- The Design Specifications and Nutrient Accounting for Street Sweeping (NCDEQ, 2019) credit document provides reduction credits for total nitrogen (0.023 lbs/lbs of debris) and total phosphorus (0.002 lbs/lbs of debris), but it does not provide credits for TSS. It was assumed that enhanced street sweeping would provide some reduction to TSS. Existing milage and debris information were evaluated in an attempt to estimate TSS reduction credit. Unfortunately, this evaluation resulted in a determination that inadequate information was available to calculate a TSS credit. For this reason, TN and TP reductions (on a percentage basis) were used to define the TSS reduction credit.

5.3.1.10 Scenario 10: Combined Nonpoint Source Pollution Projects

Scenario 10 is a combination of Scenarios 4-9. The goal is to assess the combined benefit of all the potential pollutant reduction strategies. This Scenario includes the Stormwater Performance Standards for New Development (City of Durham, 2012b) but with oversized SCMs, retrofits to existing SCMs and the construction of

new SCMs, stream projects, GSI-LID controls, updated stormwater systems for aging developments, and street sweeping. The approaches described for Scenarios 4-9 were used to generate the results for Scenario 10.

5.3.2 Scenario Results

Results from the watershed improvement scenarios suggest that TN, TP, and TSS loadings will increase under changes in future land use, but that significant reductions can be achieved through implementing management practices, as shown in Table 5-6. Under future land use conditions with existing SCM repairs, TN loads increase 6.1%, TP loads increase 4.2% and TSS loads increase 4.2%. The new development standards, when applied to future land use conditions, provide a 2.5% reduction in TN, 2.9% reduction in TP, and 5.0% reduction in TSS compared to loads under future conditions. Implementing all watershed improvements (Scenario 10), provides a 26.7% reduction in TN, 20.2% reduction in TP, and 66.0% reduction in TSS compared to loads under future conditions.

Estimated nutrient and sediment load reductions for the different watershed improvement scenarios (Scenarios 4-9; see Section 5.3.1) is presented in Table 5-7 and discussed below:

Total Nitrogen. Treating pre-1980 developed land produced the largest reduction in TN exported from the study area under the future land use condition (8.2%), with stream projects producing the second highest reduction (7.6%), and enhanced street sweeping the third (6.8%). GSI-LID resulted in a 2.6% reduction in TN, SCM projects resulted in 0.9% reduction in TN, and oversizing SCMs resulted in 0.2% reduction in TN.

Total Phosphorus. Similar to Total Nitrogen, treating pre-1980 developed land produced the largest reduction in TP exported from the study area under the future land use condition (7.9%). For TP, however, the second highest reduction resulted from enhanced street sweeping (6.5%) rather than stream projects (1.3%). GSI-LID resulted in a 2.6% reduction in TP, SCMs provided a 0.7% reduction in TP, and oversizing SCMs resulted in 0.1% reduction in TP.

Total Suspended Solids. Stream projects are projected to provide the largest reduction in TSS (29.4%) while treating pre-1980 developed land producing the second largest reduction at 23.5%. Enhanced street sweeping resulted in 7.8% reduction in TSS, GSI-LID resulted in 6.6% reduction in TSS, and SCMs resulted in 0.3% reduction in TSS. As earlier noted, changes in TSS loading were not estimate for oversizing SCMs scenario.

Treating pre-1980 developed land produced the largest benefit for both TN and TP and the second largest for TSS. These results complement the findings of Miller et al. (2019) where areas of the Jordan Lake watershed that were developed before 1980 were found to have much higher TN and TP loading rates than those developed after 1980. Though not the largest reducer, treating pre-1980 developed resulted in high reductions for TSS as well. These results suggest that targeting areas with older development with various stormwater improvement strategies could result in higher reductions and may be a more cost-effective approach to reducing nutrients and sediment pollution compared to other management measures evaluated. Since most lands developed prior to 1980 were not subject to onsite water quality requirements, these lands may contribute a larger amount of nutrient and sediment loads into the watershed than those developed more recently.

Stream projects produced the largest reduction in TSS and the second highest reductions for TN but produced much smaller reductions for TP. Enhanced street sweeping also resulted in substantial reductions in TN and TP and comparatively modest reductions in TSS. GSI-LID, oversizing SCMs and SCM projects resulting in much smaller TN, TP, and TSS reductions. The planning level costs for implementing the stream restoration projects are \$26,809,000, while the planning level costs for the SCM projects are \$14,124,000 (City of Durham, 2021a and City of Durham, 2021b). While the cost for implementing the stream projects is nearly double that of SCMs, the stream projects provide substantially greater TN and TSS reductions; over 8 times the reduction in TN and 88 times the

reduction in TSS when compared to SCMs, indicating that stream projects represent a better value and should be prioritized over SCM projects. Costs associated with stream projects and SCMs are based on gross assumptions and should be used for high-level planning only. Since DEQ has not yet finalized the TP and TP reduction values for stream restoration projects, the projected pollutant load reductions associated with stream projects may be subject to change.

Enhanced street sweeping also resulted in substantial reductions in TN and TP and comparatively modest reductions in TSS. GSI-LID, oversized SCMs and SCM projects resulted in much smaller TN, TP, and TSS reductions.

Table 5-6. Estimated change in TN, TP, and sediment annual loads and reductions for watershed improvement scenarios evaluated in the New Hope Creek and Little Creek watershed study area

Watershed Management Scenario	Total Nitrogen			Total Phosphorus			Total Suspended Sediment		
	Annual Load (lb/yr)	Reduction from FLU ⁽¹⁾ (lb/yr)	Relative Reduction from FLU ⁽¹⁾ (%)	Annual Load (lb/yr)	Reduction from FLU ⁽¹⁾ (lb/yr)	Relative Reduction from FLU ⁽¹⁾ (%)	Annual Load (tons/yr)	Reduction from FLU ⁽¹⁾ (tons/yr)	Relative Reduction from FLU ⁽¹⁾ (%)
1 ELU	92,195	—	—	8,829	—	—	867	—	—
2 FLU and existing SCM repairs	97,863	—	—	9,196	—	—	904	—	—
3 FLU and NewDStds	95,444	-2,419	-2.5%	8,933	-263	-2.9%	859	-45	-5.0%
4 FLU, NewDStds, and SCM Projects	94,556	-3,307	-3.4%	8,871	-325	-3.5%	856	-48	-5.3%
5 FLU, NewDStds, and Stream Projects	87,100	-10,763	-11.0%	8,749	-447	-4.9%	591	-313	-34.7%
6 FLU, NewDStds, and GSI-LID	92,136	-5,727	-5.9%	8,640	-556	-6.0%	800	-104	-11.5%
7 FLU, NewDStds, and treatment of pre-1980 developed land	86,805	-11,058	-11.3%	8,167	-1,029	-11.2%	655	-249	-27.5%
8 FLU, NewDStds, and oversized SCMs ⁽²⁾	94,377	-3,486	-3.6%	8,858	-338	-3.7%	856	-48	-5.3%
9 FLU, NewDStds, and enhanced street sweeping	88,293	-9,570	-9.8%	8,310	-886	-9.6%	794	-110	-12.2%
10 FLU, NewDStds, and combination of nonpoint source pollution projects	71,739	-26,124	-26.7%	7,340	-1,856	-20.2%	308	-596	-66.0%

(1) Annual load reduction percentages are based on a comparison to Scenario 2, which represents the future land use condition with repairs to existing SCMs and without stormwater performance standards for new development.

(2) It was not possible to estimate the added benefit that oversizing SCMs would have on TSS because Part C of the NC SCM Credit Document does not provide effluent event mean concentrations for TSS, a necessary parameter to complete the calculations for this scenario.

“—” = not applicable

ELU = existing land use

FLU = future land use

lb/yr = pounds per year

GSI-LID = green infrastructure – low impact development

NewDStds = Stormwater Performance Standards for New Development

SCM = stormwater control measure

Table 5-7. Estimated TN, TP, and sediment annual load reductions for each practice evaluated in the New Hope Creek and Little Creek watershed study area

Scenario and Watershed Management Practice	Annual Load Reduction					
	Total Nitrogen		Total Phosphorus		Total Suspended Sediment	
	lb/yr	Percent	lb/yr	Percent	tons/yr	Percent
3 Stormwater Performance Standards for New Development ⁽¹⁾	2,419	2.5%	263	2.9%	45	5.0%
4 Recommended SCM Retrofits and New SCM Projects ⁽²⁾	888	0.9%	62	0.7%	3	0.3%
5 Recommended stream restoration projects ⁽³⁾	7,456	7.8%	122	1.4%	266	31.0%
6 Green Infrastructure/Low Impact Development ⁽⁴⁾	2,420	2.5%	231	2.5%	56	6.5%
7 Additional On-site Treatment for Pre-1980 Development and Commercial Land Uses ⁽⁴⁾	7,751	8.1%	704	7.9%	201	23.4%
8 Oversize new SCMs and SCM retrofits ⁽⁴⁾⁽⁵⁾	179	0.2%	13	0.1%	0	0.0%
9 Enhanced street sweeping ⁽⁴⁾	6,263	6.6%	561	6.3%	62	7.2%
10 Combination of nonpoint source pollution projects ⁽²⁾	23,705	24.8%	1,593	17.8%	551	64.1%

(1) Annual load reduction percentages are based on a comparison to Scenario 2, which represents the future land use condition without stormwater performance standards for new development.

(2) Annual load reduction percentages are based on a comparison to Scenario 3, which represents the future land use condition with stormwater performance standards for new development.

(3) Scenario 5 load reductions were calculated in Microsoft Excel. Reductions shown represent the change in load compared to Scenario 3, which represents the future land use condition with stormwater performance standards for new development.

(4) Annual load reduction percentages are based on a comparison to Scenario 4, which represents the future land use condition with stormwater performance standards for new development and recommended SCM retrofit and new SCM projects. The models used to evaluate these scenarios included recommended SCM retrofits and new SCM projects so comparing loads to Scenario 4 loads removes the reductions gained from those practices.

(5) It was not possible to estimate the added benefit that oversizing SCMs would have on TSS because Part C of the NC SCM Credit Document does not provide effluent event mean concentrations for TSS, a necessary parameter to complete the calculations for this scenario.

“—” = not applicable
 ELU = existing land use
 FLU = future land use
 lb/yr = pounds per year

GSI-LID = green infrastructure – low impact development
 NewDStds = Stormwater Performance Standards for New Development
 SCM = stormwater control measure

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6 Prioritization of Watershed Improvement Projects

Using field assessments, hydrologic and hydraulic modeling, and water quality modeling, 179 potential watershed improvement projects were identified as feasible, including 115 stream projects (34.4 miles of stream), 29 retrofits to existing SCMs, and 35 new SCMs. While all of these projects would benefit the watershed, the type and degree of benefit and the cost vary widely. Of the 115 stream projects, 39 (14.3 mi) are proposed for Restoration, 16 (4.2 mi) are proposed for Enhancement 1, 17 (3.7 mi) are proposed for Enhancement 2, 37 (9.9 mi) are proposed for Stabilization, and six (2.3 mi) are proposed for Preservation.

Section 6 explains the evaluation and prioritization process of the watershed improvement projects. This process determines which projects would be most cost-effective for the City. It is similar to the processes used in other WIPs so that the City can use a systematic and transparent method for allocating funds to various projects both in the New Hope Creek and Little Creek watersheds and throughout City limits.

6.1 Prioritization Criteria

Comparing and prioritizing projects required developing criteria which could be used to evaluate the benefits gained from implementing the projects. The benefits were then weighed against the number of dollars invested. Selecting the criteria for the New Hope Creek and Little Creek WIP began by considering the following:

- Water quality problems observed in the watersheds
- Jordan Lake nutrient strategy and JLOW water quality concerns
- Criteria used in the City's previous WIPs
- The USEPA's watershed planning process (USEPA, 2008)

The project team determined that the criteria used in previous WIPs were appropriate for this WIP, with a few minor changes relating to public acceptance and environmental equity. Updates to the prioritization criteria were informed by the Residential Green Infrastructure (ReGIn) Analysis, the Equitable Community Engagement Plan (Volume III, Appendix G), City of Durham FY 2019-2021 Strategic Plan (City of Durham, 2018c) and Sustainability Roadmap (City of Durham, 2018b). By using similar criteria, projects identified in different WIPs can be directly compared. In addition, the use of a standard scoring criteria allows for comparison between streams, new SCMs, and retrofit SCMs. The 14 criteria were divided into the following six categories:

- **Water Quality Treatment:** Amount of pollutant(s) removed and the associated cost-effectiveness.
- **Habitat and Biological Integrity:** Benefit to the ecological function of the stream and the stream's ability to support aquatic life.
- **Stream Bank Protection:** The ability of a project to reduce erosion of stream banks during high flow events.
- **Community Enhancement:** Benefit to the surrounding community such as property protection and environmental equity, landowner acceptance, opportunities for public education through proximity to schools, parks, libraries, and other public locations.

- **Implementation Issues:** Difficulty and cost of implementing a project, such as property ownership, accessibility, permitting requirements, and environmental impacts.
- **Public Safety and Public Property Considerations:** Amount of flood reduction or protection for streets, infrastructure, or property.

Each criterion was scored from 0 to 5, with 0 indicating no benefit and 5 indicating a significant benefit. The raw scores are weighted to make certain criteria more important than others. Ultimately, each project would have a final score between 0 and 100 (see Table 6-1).

Table 6-1. Prioritization criteria with scoring ranges and weighting factors

Category	Criteria	Score Range	Weighting Factor	Results of Score x Weighting Factor
Water Quality Treatment	Nitrogen	0 – 5	2	0 – 10
	Phosphorus	0 – 5	2	0 – 10
	Sediment	0 – 5	1.5	0 – 7.5
	Fecal Coliform	0 – 5	1.5	0 – 7.5
Habitat and Biological Integrity	Habitat/Biology	0 – 5	3	0 – 15
Stream Bank Protection	Stream Bank Protection	0 – 5	2	0 – 10
Community Enhancement ⁽¹⁾	Property Protection and Environmental Equity	0 – 5	1	0 – 5
	Landowner Acceptance	0 – 5	1	0 – 5
	Public Education Potential	0 – 5	1	0 – 5
Implementation Issues	Property Ownership	0 – 5	1	0 – 5
	Accessibility for Construction and Operations and Maintenance	0 – 5	1	0 – 5
	City program compatibility	0 – 5	1	0 – 5
	Permitting/Adverse Environmental Impacts	0 – 5	1	0 – 5
Public Safety and Public Property Considerations	Public Safety and Public Property	0 – 5	1	0 – 5
Total Possible Score				0 – 100

(1) Updates were made to the *Community Enhancement* category to ensure these criteria reflect current City strategies of environmental equity-based decision-making while remaining comparable across previous WIPs. Specifically, the former criterion of *Property Protection* was revised to *Property Protection and Environmental Equity* in order to better serve the flood-prone residential areas located in previously identified priority (Tier 1) areas. *Property Owner and Neighborhood Acceptance* was revised to *Landowner Acceptance* to better define and prioritize projects on public and private lands. *Public Education* was revised to *Public Education Potential* to capture the potential of projects to increase public awareness due to their strategic location in highly visible and accessible areas. Specific details about each criteria are provided in the *Community Enhancement* section.

The weighing factors remain the same for all projects, though the raw scores are variable. For a more comprehensive explanation of the scoring methodology and how raw scores were determined, see *Technical Memorandum – Prioritization of Proposed Watershed Improvement Projects* in Volume III, Appendix J, of this WIP.

Water Quality Treatment was the most heavily weighed category. Stream project prioritization evaluated nitrogen, phosphorus, and sediment benefits based on the methodology of the Chesapeake Bay Program (2014) with modifications for the North Carolina Piedmont region based on the protocol outlined in the *North Carolina Piedmont Nutrient Loading Measures Technical Report* (Tetra Tech, 2013). For SCM projects, water quality modeling

in PCSWMM determined a pollutant removal rate which was then combined with project costs to compare opportunities.

A Microsoft Excel-based tool was used to estimate the costs associated with each project. Originally developed by the City for the Ellerbe Creek WIP (City of Durham, 2010), the tool has been maintained and updated with current market prices for use in this WIP. The total capital cost for each SCM and stream project was based on the costs associated with surveying, land acquisition, permitting, construction, engineering, administrative costs, and annual maintenance.

6.2 High-Priority Watershed Improvement Projects

The watershed improvement projects were evaluated using the prioritization criteria outlined in Section 6.1, resulting in a final selection of 30 high-priority SCM projects and 15 high-priority stream improvement projects.

The high-priority SCM projects consist of 15 retrofits and 15 new SCM projects. The high-priority stream improvement projects consist of 11 Restoration projects, two Enhancement I projects, one Enhancement II project, and one Bank Stabilization project. Five additional high-scoring stream restoration projects located on parcels owned by Duke University are recommended but require further investigation and coordination with Duke University to assess feasibility.

The high-priority SCM projects are described in Section 6.2.1, and the high-priority stream projects are described in Section 6.2.2.

6.2.1 High-Priority SCM Projects

The 15 high-priority SCM projects are described below and in Table 6-2. The locations of these SCM projects are presented in Exhibit 20.

- **00497**: Convert a dry pond to a constructed wetland. The existing SCM appears to have been designed under earlier SCM standards. There is some room on the site to accommodate an appropriately sized constructed wetland.
- **NHCMC0068**: Simple control structure modification at an existing wet pond. This wet pond appears to have been designed to previous SCM standards. An updated design could be implemented to improve water quality treatment.
- **NHCMC0054**: Proposed 15,000 square foot constructed wetland located in a city park that also collects runoff from an apartment complex
- **00111**: Convert a wet pond to a constructed wetland. The site has room to expand the footprint of the SCM to accommodate an appropriately sized constructed wetland.
- **NHCSC0039**: Proposed 3,600 square foot constructed wetland collecting parking lot and roof runoff at a high-density residential area.
- **NHCSC0027**: Proposed 6,600 square foot constructed wetland converted from an existing drainage ditch at the sports fields of a private school.
- **00103**: Convert a wet pond to a constructed wetland. There appears to be room to expand the footprint of the SCM if necessary, and a constructed wetland would be safer (because the water would not be as deep) and more appealing than the existing wet pond (because of the vegetation).

- **00276:** Convert a dry pond to a constructed wetland. The site has room to expand the footprint of the SCM to accommodate an appropriately sized constructed wetland. The existing dry pond has standing water and wetland vegetation growing in it which indicates it may support a wetland.
- **00267:** Convert dry pond to a pocket wetland. The site is likely too small to accommodate a full-sized wetland, but water quality could be improved with a pocket wetland and the site appears to be able to support a wetland since the existing dry pond has standing water.
- **NHCMC0069:** Convert an existing water retention feature to a wet pond. This existing water feature/pond could be redesigned as a water quality treatment device by adding forebays and modifying the outlet structure.
- **NHCMC0070:** Convert dry pond to a wet pond. The existing SCM appears it may pre-date the SCM standards and has many deficiencies and maintenance issues. It could be redesigned to a wet pond to improve water quantity treatment and add water quality treatment.
- **00511:** Convert a dry pond to a constructed wetland. The site has room to expand the footprint of the SCM to accommodate an appropriately sized constructed wetland. The existing dry pond has standing water and wetland vegetation growing in it which indicates it may support a wetland.
- **NHCMC0071:** Convert a dry pond to a constructed wetland. The site has room to expand the footprint of the SCM to accommodate an appropriately-sized constructed wetland.
- **00316:** Lower the water level of the wet pond to gain storage. Based on as-builts, the temporary storage volume of this wet pond is relatively small and could be increased.
- **NHC0014:** Proposed 9,750 square foot, 650-foot-long, treatment swale to collect runoff from a parking lot and roof on commercial property.

6.2.2 High-Priority Stream Improvement Projects

The 15 high-priority stream improvement projects are described below and presented in Table 6-3. The locations of these projects are shown in Exhibit 21.

- **LNHC1006:** Restoration is proposed on 1,446 LF of UT to New Hope Creek located on one parcel owned by the City of Durham. The project stream has poor instream habitat and biological indicators and has been impounded due to beaver activity downstream. Historic channelization and runoff from nearby commercial development have left this stream unstable and degraded.
- **LNHC1002:** Restoration is proposed on 7,219 LF of New Hope Creek located on several parcels owned by Durham County. The project stream has poor instream habitat and severely eroding banks with little to no riparian vegetation.
- **SC2038:** Restoration is proposed on 5,185 LF of Sandy Creek located on several parcels owned by commercial and residential entities. The project stream has a wide, forested buffer but has been negatively impacted by runoff from surrounding urban development resulting in highly eroded banks and heavy sediment deposits.
- **LNHC1014:** Restoration is proposed on 1,395 LF of New Hope Creek located on several commercial parcels and DOT right-of-way. Runoff from residential areas and adjacent major roadways on either side of the project stream have resulted in severe channel erosion.

- **MC1015:** Restoration is proposed on 6,313 LF of Mud Creek located on several private residential and two County of Durham parcels. Runoff from nearby residential communities has created unstable and degraded channel conditions.
- **LNHC1024:** Restoration is proposed on 949 LF of UT to New Hope Creek located on two privately-owned residential parcels. Runoff from Garrett Road and Old Chapel Hill Road along with the development of two residential neighborhoods on either side of the project stream have caused severe bank erosion and channel instability.
- **MC1026:** Restoration is proposed on 2,523 LF of UT to Mud Creek located on City of Durham and private residential parcels. Residential neighborhood developments adjacent to the project stream have caused severe channel incision and bank erosion.
- **LNHC1003:** Bank stabilization is proposed on 2,251 LF of New Hope Creek located mostly on County of Durham parcels. Runoff from Durham-Chapel Hill Boulevard along with commercial and residential developments nearby have caused localized areas of bank erosion.
- **LNHC1015:** Restoration is proposed on 3,926 LF of Sandy Creek Tributary A located on several commercial and residential parcels. The project stream has a wide forested buffer, but extensive development beyond the buffer has increased surface runoff and caused bank erosion and moderate channel incision.
- **MC1027:** Enhancement 1 is proposed on 2,466 LF of UT to Mud Creek located on City of Durham and private residential parcels. Residential neighborhoods adjacent to the project stream have caused bank erosion and moderate channel incision.
- **LNHC2017:** Enhancement 1 is proposed on 2,222 LF of UT to New Hope Creek located on one parcel owned by the City of Durham. The project stream flows adjacent to the South Durham Water Reclamation Facility. Runoff from the facility has caused moderate incision and localized areas of bank erosion.
- **SC2034:** Restoration is proposed on 952 LF of UT to Sandy Creek located on several residential parcels. Channel conditions have been negatively impacted by runoff from Pickett Road and the development of a large residential neighborhood east of the project stream.
- **LNHC2005:** Restoration is proposed on 1,180 LF of UT to New Hope Creek located on one City of Durham parcel and two residential parcels. The project stream has a wide, forested riparian buffer but has been impacted by runoff from residential communities nearby, causing moderate incision and bank erosion.
- **LNHC1008:** Enhancement 2 is proposed on 1,066 LF of UT to New Hope Creek located on two vacant commercial parcels. The project stream has been impacted by a beaver impoundment downstream, causing areas of the stream to braid. Upstream commercial developments have caused localized areas of bank erosion and incision.
- **LNHC1007:** Restoration is proposed on 3,278 LF of UT to New Hope Creek located on two parcels owned by the County of Durham and New Hope Creek, LLC. The project stream has been impounded due to beaver activity downstream. Runoff from commercial developments upstream has left the project stream unstable and degraded.

In addition to the above-mentioned high priority projects, there are five projects located on parcels owned by Duke University that scored high. All five projects are proposed for restoration and total 10,483 LF. These projects have mostly been impacted by development in the watershed along with clearing of riparian buffers. These projects are described below and presented in Table 6-4. The locations of these projects are shown in Exhibit 21.

- [SC2005](#): Restoration is proposed on 2,268 LF of New Hope Creek located on two parcels owned by the City of Durham and Duke University. Clearing of the riparian buffer for development of the Maplewood cemetery along with runoff from residential and commercial development in the watershed have caused severe channel incision and degradation.
- [SC2025 and SC2026](#): Restoration is proposed on two reaches of Sandy Creek, totaling 5,898 LF. Both reaches are located on one parcel owned by Duke University, which is currently used as the Duke University Golf Club. Channel conditions have been impacted by runoff from large residential developments in the watershed causing bank erosion and channel incision.
- [MC1023](#): Restoration is proposed on 1,342 LF of UT to Mud Creek located on one forested parcel owned by Duke University. Clearing the parcel upstream of the project stream has caused channel instability and degradation.
- [SC2024](#): Restoration is proposed on 2,269 LF of UT to Sandy Creek located on one parcel owned by Duke University, which is currently used as the Duke University Golf Club. Clearing of the riparian buffer for the golf course and large developments in the watershed have caused channel incision and degradation.

Table 6-2. High-priority SCM projects in the New Hope Creek and Little Creek watersheds

Project ID	Project Description	Sub-watershed	SCM Drainage Area (ac)	Annual Load Reduction (lbs/yr)			Total Capital Costs (2018 Dollars) ⁽¹⁾	Total Project Prioritization Score (100 Max)
				TN	TP	Sediment		
00497	Convert Existing Dry Pond to Constructed Wetland	NHC32	23	26	2	5,591	\$202,000	68.5
NHCMC0068	Water Quality Improvements to an Existing Wet Pond	NHC47	24	36	3	1,604	\$240,000	64.0
NHCMC0054	New Constructed Wetland	NHC51	4	12	1	403	\$310,000	58.5
00111	Convert Existing Wet Pond to Constructed Wetland	NHC09	10.1	31	3	1,782	\$230,000	56.5
NHCSC0039	New Constructed Wetland	NHC46	3.3	15	1	302	\$265,000	54.5
NHCSC0027	New Constructed Wetland	NHC35	10.6	46	3	1,752	\$218,000	53.5
00103	Convert Existing Wet Pond to Constructed Wetland	NHC12	7.8	26	2	1,218	\$201,000	53.5
00276	Convert Existing Wet Pond to Constructed Wetland	NHC09	7.9	28	3	1,060	\$223,000	53.5
00267	Convert Existing Dry Pond to a Pocket Wetland	NHC47	32.8	26	2	4,001	\$216,000	52.5
NHCMC0069	Convert Existing Water Retention Feature to a Wet Pond	NHC56	16.9	31	4	2,154	\$172,000	52.0
NHCMC0070	Convert Existing Dry Pond to a Wet Pond	NHC56	14.1	7	1	1,390	\$201,000	51.0
00511	Convert Existing Dry Pond to Constructed Wetland	NHC31	2.6	2	0	452	\$193,000	50.0
NHCMC0071	Convert Existing Dry Pond to Constructed Wetland	NHC56	10.2	5	1	1,039	\$223,000	48.5
00316	Lower Water Level in Wet Pond to Gain Storage	NHC25	9.4	24	2	1,466	\$211,000	48.0
NHC0014	New Treatment Swale - Wet	NHC27	0.28	1	0	61	\$39,000	46.5
Totals			176.98	316	28	24,275	\$3,144,000	

(1) Total capital costs consist of administrative, engineering, surveying, permitting, land acquisition, construction, and construction administration costs and 20 years of annual maintenance. Costs presented in this table are not adjusted to present day. Given that the United States economy, and the construction industry in particular, is experiencing major supply-chain disruptions, staffing difficulties, and exceptionally steep and fast-rising costs for a variety of materials (Associated General Contractors of America, 2021), the capital costs presented in this table may be low. As such, the information provided in this table should be used with caution and additional investigations or evaluations may be required to develop more accurate cost assessments.

Table 6-3. High priority stream improvement projects in the New Hope Creek and Little Creek watersheds

Project ID	Project Description	Sub-watershed ⁽¹⁾	Watershed	Stream Reach Length (ft)	Annual Load Reduction (lbs/yr)			Total Capital Costs (2018 Dollars) ⁽²⁾	Total Project Prioritization Score (100 Max)
					TN	TP	Sediment		
LNHC1006	Restoration	NH28	Lower NHC	1,446	137	7	61,663	\$118,000	74.5
LNHC1002	Restoration	NH29	Lower NHC	7,219	1,304	35	307,750	\$591,000	73.5
SC2038	Restoration	NH33	Sandy Creek	5,186	857	19	165,878	\$319,000	65.5
LNHC1014	Restoration	NH30	Lower NHC	1,395	195	11	91,977	\$171,000	65.5
MC1015	Restoration	NH47	Mud Creek	6,313	717	16	138,363	\$517,000	64.5
LNHC1024	Restoration	NH26	Lower NHC	949	100	7	62,558	\$78,000	63.5
MC1026	Restoration	NH48	Mud Creek	2,523	241	6	49,914	\$207,000	61.5
LNHC1003	Stabilization	NH27	Lower NHC	2,251	66	17	148,410	\$115,000	61.5
LNHC1015	Restoration	NH30	Lower NHC	3,926	334	9	76,278	\$482,000	59.5
MC1027	Enhancement 1	NH48	Mud Creek	2,466	31	8	69,245	\$151,000	57.6
LNHC2017	Enhancement 1	NH11	Lower NHC	2,222	19	5	42,964	\$136,000	57.0
SC2034	Restoration	NH35	Sandy Creek	952	123	7	62,757	\$78,000	56.5
LNHC2005	Restoration	NH22	Lower NHC	1,180	109	6	50,292	\$97,000	54.5
LNHC1008	Enhancement 2	NH28	Lower NHC	1,066	20	5	45,459	\$44,000	52.7
LNHC1007	Restoration	NH28	Lower NHC	3,278	165	1	10,921	\$268,000	51.0
Totals				42,372	4,418	159	1,384,429	\$3,372,000	

(1) NH28 (3 projects) and NH48 (2 projects) are located within the same subwatershed, could be combined into a single project. This would reduce cost relative to the cost of implementing individual projects

(2) Total capital costs consist of administrative, engineering, surveying, permitting, land acquisition, construction, and construction administration costs and 20 years of annual maintenance. Costs presented in this table are not adjusted to present day. Given that the United States economy, and the construction industry in particular, is experiencing major supply-chain disruptions, staffing difficulties, and exceptionally steep and fast-rising costs for a variety of materials (Associated General Contractors of America, 2021), the capital costs presented in this table may be low. As such, the information provided in this table should be used with caution and additional investigations or evaluations may be required to develop more accurate cost assessments.

Table 6-4. High priority stream improvement projects located on parcels owned by Duke University in the New Hope Creek and Little Creek watersheds

Project ID	Project Description	Sub-watershed	Watershed	Stream Reach Length (ft)	Annual Load Reduction (lbs/yr)			Total Capital Costs (2018 Dollars) ⁽¹⁾	Total Project Prioritization Score (100 Max)
					TN	TP	Sediment		
SC2025	Restoration	NH40	Sandy Creek	3,693	509	28	243,441	\$302,000	73.5
SC2026	Restoration	NH40	Sandy Creek	2,205	268	17	145,337	\$181,000	73.5
MC1023	Restoration	NH51	Mud Creek	1,342	46	7	57,213	\$110,000	67.5
SC2024	Restoration	NH40	Sandy Creek	974	69	5	41,532	\$80,000	66.5
SC2005	Restoration	NH45	Sandy Creek	2,269	234	9	76,596	\$279,000	64.5
Totals				10,483	1,126	66	564,119	\$952,000	

(1) Total capital costs consist of administrative, engineering, surveying, permitting, land acquisition, construction, and construction administration costs and 20 years of annual maintenance. Costs presented in this table are not adjusted to present day. Given that the United States economy, and the construction industry in particular, is experiencing major supply-chain disruptions, staffing difficulties, and exceptionally steep and fast-rising costs for a variety of materials (Associated General Contractors of America, 2021), the capital costs presented in this table may be low. As such, the information provided in this table should be used with caution and additional investigations or evaluations may be required to develop more accurate cost assessments.

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7 Public Outreach and Involvement

Public involvement is a critical component of the watershed improvement planning process. Public outreach is important as a means to inform the public, gain support for the process, and gather valuable local knowledge from residents. This information is invaluable for developing an improvement plan which accurately captures local concerns.

The following sections describe the City's public outreach process to inform and engage the public, key stakeholders, staff from various City departments, and elected officials. Components of this outreach and involvement process included a City-hosted project webpage, an Equitable Community Engagement Plan, three virtual public information sessions, three project factsheets that provide progress updates and address watershed topics, and social media engagement to communicate and solicit public feedback. Two educational videos were also developed to inform the public about key stormwater principles. Materials prepared to support the public education and outreach efforts for the City are provided in Volume III, Appendix L, of this WIP.

A significant Spanish-speaking population lives within the New Hope Creek and Little Creek watersheds. Spanish-language materials included a stormwater-focused radio message that was broadcast on a Spanish radio channel, a project factsheet, captions for two videos, meeting announcements, and social media posts.

7.1 Equitable Community Engagement Plan

An Equitable Community Engagement Plan ("Plan") was prepared early in the New Hope Creek and Little Creek WIP project to develop strategies that would encourage participation from historically underrepresented communities and provide a framework for inclusive decision-making throughout the project. The Plan aligns with several planning documents developed by the City, including the City of Durham FY 2019-2021 Strategic Plan, Equitable Community Engagement Blueprint, Sustainability Roadmap (City of Durham, 2018b), and Language Access Plan.

The Plan provides a description of the community who work and live in the watershed, potential community partner organizations, and recommendations for engagement events and other public participation. Additional information is available in the *Equitable Community Engagement Plan* provided in Volume III, Appendix G, of this WIP.

7.2 Public Information Sessions

Three public information sessions were hosted by the City between 2020 and 2021. The public information sessions were held to educate the public on the impact stormwater can have on watershed health within New Hope Creek and Little Creek watersheds, solicit feedback from the public, and update them on the progress of the WIP. Attendees included residents, representatives from local nonprofit and environmental organizations, City staff, members of the consulting team, and middle school students. Because of the COVID-19 pandemic all public information sessions were held online, with power point presentations and time allowed for comments and questions.

7.2.1 First Public Information Session: September 23, 2020

An interactive, visual aid (StoryMap) developed in ESRI ArcGIS platform was launched prior to the first information session for the public to view and become familiar with the watershed. At the first public information session the

City presented an overview of the New Hope Creek and Little Creek WIP. The presentation began by describing the reasons why watershed health is valuable and how stormwater affects it. Presenters explained the City's watershed planning program, which includes considerations for federal and state regulations as well as water quality challenges in the region. Presenters then stated the goals of the New Hope Creek and Little Creek WIP and explained the process for completing the WIP, such as field analysis of streams and SCMs, computer modeling, and project evaluation and prioritization. They discussed the results from the field studies regarding the condition of select streams and SCMs, and they described the next steps for the project. A key focus of the presentation was to solicit feedback from the attendees. Two pop-up live survey questions were asked about attendee interaction with the New Hope Creek and Little Creek watersheds. Presenters also explained how the field results would inform the project evaluation and prioritization process, and that resident information could enhance this process. Finally, the presenters addressed questions and comments from the attendees regarding project methodology, future public engagement, and suggestions to improve the StoryMap and other visual aids. Overall, 57 people participated in the meeting, including 17 from the City and consultant team.

An online survey was conducted in conjunction with the September 23, 2020 virtual public meeting for the New Hope Creek and Little Creek Watershed Improvement Plan (WIP). The survey and virtual meeting were advertised via a news release, the City of Durham's social media channels, and the Public Works Department project webpage.

The purpose of the survey was to obtain input from the community and other stakeholders about priorities for the watershed that will be used to help refine the WIP. Some of the survey questions were intended to be used to develop future targeted outreach and assist with efforts to employ equitable engagement strategies. The survey contained eight questions related to the watersheds and/or the WIP, and 13 questions related to public outreach and demographics. A total of 48 responses were provided through the survey and are summarized as follows:

- Most of the respondents (88%) either live or work in New Hope Creek, Sandy Creek, Mud Creek or Little Creek watersheds.
- Most respondents spend a lot of time in these watersheds (69% once a week or more, 13% about once a month). Hiking/walking/jogging was by far the most popular activity as referenced by respondents.
- When asked to describe the creeks, lakes, and open lands in New Hope Creek, Sandy Creek, Mud Creek, and Little Creek watersheds, the largest number of respondents (46%) said the open land and waterbodies are part of nature to be left alone. Three people (6%) said the area is a place for fishing and recreation, three people (6%) said they don't really think about these areas, and one person (2%) described the areas as polluted ditches.
- Respondents ranked the criteria that were proposed for watershed improvement projects as follows (in order of importance):
 - Better water quality in the creeks and ponds throughout the watershed
 - Restore habitat for fish and wildlife
 - Protect Jordan Lake as a drinking water supply
 - Improve the creeks and ponds throughout the watershed as community assets
 - Improve flood protection
 - Provide recreational opportunities along the creeks and ponds throughout the watershed
 - Increased community knowledge about the creeks and ponds throughout the watershed

- Respondents identified the following general categories of problems (with number of mentions shown in parenthesis) either in or along creeks, lakes and open lands in the New Hope Creek watershed:
 - Erosion, including undercut stream banks and storm-induced, and along New Hope Creek (10 respondents)
 - Pollution, including litter on trails and lake shore, trash in streams from storm drains, and nutrients (8 respondents)
 - Turbidity and sedimentation (6 respondents)
 - Excessive stormwater runoff into creeks from existing development (4 respondents) and construction (1 respondent)
 - Invasive species (2 respondents)
 - Too many people/too much new development (2 respondents)
 - Ineffective sediment and erosion control (1 respondent)
 - Not enough land protected (1 respondent)
 - Need more wetlands. Beavers will help (1 respondent)
 - Flooding (3 respondents)
- Eleven respondents identified specific places in the watershed that should be considered for protection or as a location that could treat stormwater, as follows:
 - New Hope Creek headwaters
 - Along the 15-501 Durham Chapel Hill Boulevard area
 - New Hope Creek/Mud Creek near the 15-501 crossing
 - Upstream in New Hope Creek
 - Confluence of Mud Creek, Sandy Creek and New Hope Creek
 - Large tracts of preserved open space
 - Duke Forest
 - Areas with rare species habitat (aquatic or terrestrial species), natural heritage areas, riparian zones, and places especially important for protecting wildlife corridors and core areas
 - Low spots in the aqueduct behind 121 Celeste and around 153 (and 157) Celeste
 - Degraded streams within the urban areas
 - Along New Hope Creek to protect plants uncommon in NC Piedmont
- The City used several outlets to advertise the project. Survey responses suggested that most people heard about the project through the following outlets, from highest to lowest based on the frequency cited in survey responses:
 - Word of mouth
 - Durham website
 - Sierra Club meet-up
 - Online search
 - Zoom presentation

7.2.2 Second Public Information Session: March 16, 2021 and March 18, 2021

Pandemic-related restrictions on public gatherings required the project team to alter plans for conducting in-person meetings. In lieu of the in-person, in-the-field, 'eco-tour' meeting format originally planned for Meeting #2, the project team reached out to Durham Public School science teachers for an opportunity to directly engage with Durham youth in the watershed. Rogers-Herr Middle School was chosen as the year-round magnet middle school in the Durham Public Schools system that serves south Durham. It draws students from neighborhoods throughout south and central Durham County, resulting in a racially, ethnic, and economically diverse student body.

A 30-minute PowerPoint Presentation was developed to provide a review of basic watershed characteristics and introduce students to microbial source tracking as a method for identifying sources of fecal coliform bacteria in Northeast Creek and to help develop strategies for control. The presentation finished with "What Can I Do to Help" actions such as identifying items that should not be flushed in toilets, proper disposal of oil and grease, and picking up pet waste.

The presentations consisted of live, virtual, and interactive presentations via the Zoom online meeting platform for four separate 7th grade Core science classes. The presentations were led by the City and Three Oaks Engineering. In total, 113 students participated in the live events. The individual classroom presentations were not recorded due to student privacy concerns; however, a recorded version of the presentation with voice-over narration was produced and is available for other science classes or interested individuals.

7.2.3 Third Public Information Session: June 29, 2021

The third and final public information session was hosted on June 29, 2021. The goal of the final session was to present stream and SCM inventory prioritization results, watershed modeling and scenario analysis, and overall project recommendations from the WIP.

This session was held in the evening via Zoom online meeting platform. A live, evening meeting was selected to provide residents with an opportunity to attend in-person if they were not able to attend meeting #1, which was held at noon. Spanish-proficient staff from the Public Works Department were in attendance to provide Spanish-language support. Thirty-three attendees participated in the meeting, including 13 City staff and four members of the consultant team.

A PowerPoint presentation was used by the City and consultant team to provide an overview of the City's watershed improvement planning program, project goals, project prioritization and public outreach survey results, SCM and stream inventory prioritization results, watershed modeling and scenario analysis, and project recommendations from the WIP.

Attendees were encouraged to interact and submit questions during the session. Two live, survey questions were asked during the presentation and nine questions were asked in the meeting chat. In response to the survey questions, approximately 39% of the attendees responded that had attended a previous meeting about the New Hope Creek and Little Creek WIP. Thirty-three percent of attendees had not attended a previous meeting but had attended a meeting for other watershed plans while 28% of attendees had not ever attended a previous watershed plan meeting. Approximately 83% of attendees responded that they either live, work, or play in the New Hope Creek or Little Creek watershed while 27% of attendees responded that they did not. After the presentation, the City answered questions submitted in the chat. The meeting was recorded and posted to the project webpage (<https://durhamnc.gov/3766>).

Several forms of outreach were used to inform and invite the public to participate in advance of the session. The City reached out to eight organizations identified in the Equitable Community Engagement Plan, posted a notice

on the City of Durham's Community Calendar, issued a press release on June 14, 2021, posted information on City's Facebook and Twitter social media accounts in English and Spanish, and sent a digital postcard notification to 28 stakeholders who attended previous public information sessions.

7.3 New Hope Creek and Little Creek Watershed Improvement Plan Webpage

As part of the effort to inform the public about the progress of the project, the City provided a dedicated webpage for the New Hope Creek and Little Creek WIP (<https://durhamnc.gov/3766>). Throughout the project, from 2018 to 2021, the webpage was updated regularly with important schedule updates, field activities, project milestones, and various literature. The webpage contains links to project factsheets, recordings of public information sessions, and key project reports.

7.4 Project StoryMap

The City prepared an ArcGIS StoryMap which provides a high-level description of watersheds and stormwater, the Jordan Lake nutrient management strategy, New Hope Creek and Little Creek watershed, and WIP progress updates, including an interactive SCM and stream map. The StoryMap is available online at: <https://storymaps.arcgis.com/stories/98876c442ac842e5b8bb07444bfa24eb>.

7.5 Social Media Updates

Along with the webpage, the City used social media platforms such as Facebook (<https://www.facebook.com/durhamncstormwater/>) and Twitter ([@DurhamStormH2O](https://twitter.com/DurhamStormH2O)) to publish key updates on the project, stormwater management and volunteer events, and videos. Twenty-five social media posts were prepared over the course of the project, including 20 in English and five in Spanish.

7.6 Project Fact Sheets

Four project factsheets were developed for New Hope Creek and Little Creek watershed improvement project to communicate project progress and key findings to the public. One project status report was also developed in both English and Spanish to be inclusive of diverse populations within Durham. The Spanish factsheet provides a summary of the watershed, stream and SCM field work, scenario modeling results, and overview of public involvement. The two-page factsheets were developed in conjunction with each public information session and were made available on the project webpage.

7.7 Educational Radio Spots

A radio spot was developed in Spanish and broadcasted on the channel La Ley 101.1FM to reach the Spanish-speaking population. The radio message was focused on recycling motor oil and keeping the watershed clean. A recording of the radio message can be found at <https://durhamnc.gov/DocumentCenter/View/38562> and a link can be found on the webpage for the New Hope Creek and Little Creek WIP (<https://durhamnc.gov/3766>).

7.8 Educational Videos

Two videos were developed for the public outreach and education effort:

1. "Durham Doody" addresses pet waste wash-off within the watershed. The video touches on the importance of picking up pet waste and provides information on the harmful impacts of pet waste on receiving streams. It emphasizes the danger of fecal coliform contamination in streams to people and animals alike. The video ends with a pledge drive that encourages people to take a selfie picking up their

pet waste with the hash tag #DurhamDoodyPledge. Captions in English and Spanish were developed for the video to support digital accessibility and are available through the media player. The video can be found online at https://youtu.be/XwBw3_TnLlc.

2. "What's That Pond?" educates on the purpose and function of wet detention basins in collecting stormwater runoff and mitigating downstream water quality issues. The video starts with explaining the structures of the wet detention basin and their function in retaining and cleaning stormwater. The importance of keeping the watershed clean, particularly in reference to cleaning up dog waste and not feeding wild birds that may pollute the pond with feces is also explained. Captions in English and Spanish were developed for the video to support digital accessibility and are available through the media player. The video can be found online at: <https://youtu.be/leiRzHpg7Z0>.

8 Watershed Improvement Plan

Achieving and maintaining water quality goals and watershed health in the New Hope Creek and Little Creek watersheds will be assisted by the implementation of protective measures such as pollution controls and management practices. Such measures are designed to mitigate the bacteria, sediment, nutrient, metals, low DO, and flow impacts described in Section 2.2. Restoration and maintenance of physical, chemical, biological integrity of receiving waterbodies will be achieved by:

- Reducing or avoiding pollutant inputs to receiving waters
- Controlling discharges that could alter natural hydrology
- Mitigating other stressors that may contribute to impairment

The strategies described in each WIP are tailored to address the unique challenges and concerns that are present in each watershed. As described in this section and in NPDES annual reports, the City already implements multiple practices and programs throughout the New Hope Creek and Little Creek watersheds and other city watersheds. WIP recommendations are prioritized across all city watersheds based on current and anticipated City initiatives and regulatory obligations.

8.1 Recommended Strategies

The City is currently implementing a number of projects and programs that will protect and enhance the New Hope Creek and Little Creek. The recommendations presented in this section build on these initiatives and highlight additional opportunities for future consideration. The City recognizes that watershed protection requires creative water quality improvement projects and effective partnerships and, as a result, actively partners with state and local agencies (including other City departments), watershed associations, and stakeholder groups in working to protect the New Hope Creek and Little Creek watershed.

Future WIP planning, development, and implementation should consider recent changes to the Clean Water Act (CWA) achieved through the Water Infrastructure Improvement Act (WIIA) of 2019 (USEPA, 2019). The WIIA amendments includes programs designed to support communities and states on integrated planning and green infrastructure. The voluntary program may be incorporated in the NPDES permit thereby allowing a compliance schedule that can be implemented over more than a single permit cycle. USEPA may provide technical assistance to develop the integrated plans. Incorporating the integrated planning approach in future WIPs may promote partnership with USEPA and result in other benefits such as outreach, training, and technical support for green infrastructure implementation.

At this time, the City's authority to implement watershed-specific or local stormwater requirements is limited. North Carolina General Statute 143-214.7 (NC Session Law 2014-90) restricts local government stormwater programs from imposing increased stormwater controls beyond what is required by the state or federal government.

8.1.1 Stormwater Runoff Treatment from Older Urban Areas

During urbanization, pervious surfaces are converted to land uses that usually have increased areas of impervious surface, resulting in increased runoff volumes and pollutant loading which change the physical, chemical, and biological characteristics of a watershed. Studies in the Jordan Lake watershed have revealed there to be a strong

relationship between poor water quality and the age of development, density of development, and connectedness of impervious surfaces (Carle et al., 2007 and Miller et al., 2019). Recent modeling suggests that older urban lands (developed prior to 1980) in the Jordan Lake watershed contribute the largest amount of nutrients (normalized by area) in the watershed (Miller et al., 2019). Given that these pre-1980 developed lands have been found to contribute relatively greater pollutant loads, it is recommended that these areas be prioritized for stormwater retrofits to treat runoff generated from these impervious surfaces. These areas should also be prioritized for investigating illicit discharges and inspections of the sanitary sewer infrastructure for integrity. In areas where site constraints limit retrofit opportunities, nonstructural controls such as expanded street sweeping may reduce pollutant loads.

8.1.2 High-Priority Stream Improvement Projects

Stream degradation may be a result of channelization, higher peak flow rates due to increased impervious cover, lack of riparian buffer, or upstream pollution. Degraded streams typically lack diversity in aquatic habitat and fauna and increased levels of streambank erosion contribute to higher sediment loading and transport downstream.

Stream restoration is the process of re-establishing general structure, function, and self-sustaining behavior of the stream. Many restoration projects feature aspects of the natural channel design method such as modification of channel dimension, pattern, and profile. Stream enhancement focuses on improving the floodplain and stream stabilization focuses on streambank areas.

Through field assessments, hydrologic and hydraulic modeling, and water quality modeling, 115 stream projects were identified as feasible watershed improvement projects. Total nitrogen and TSS annual load reductions obtained through the implementation of stream restoration projects (Scenario 5) were found to be relatively high compared to other watershed improvement projects (Table 5-7). The top 15 stream projects are presented in Section 6.2.2.

8.1.3 High-Priority SCM Projects

Stormwater controls and retrofits reduce the pollutants from stormwater and can mitigate the hydraulic impacts of runoff from impervious surfaces. These controls help reduce the impacts of increased peak flows, excess nutrients, metals, and low DO described in Section 2.3. Through field assessments, hydrologic and hydraulic modeling, and water quality modeling, 35 retrofits to existing SCMs and 29 new SCM projects were identified as feasible watershed improvement projects. The top 15 SCM projects are presented in Section 6.2.1.

Based on model results assessing the benefit of treating areas with pre-1980 construction (Scenario 7), when possible, implementation of high-ranking SCMs in those pre-1980 areas should be prioritized.

8.1.4 Green Stormwater Infrastructure and Low Impact Development Opportunities

GSI combines elements of the natural environment and traditional stormwater drainage systems to improve water quality and restore ecosystems. Examples of GSI include rain gardens and disconnecting downspouts. The City implements GSI practices by incorporating them into larger City projects through research projects and grants, partnerships with local organizations, and by working with other City departments.

In 2018 the City published the Sustainability Roadmap (City of Durham, 2018a) which identified implementing GSI practices as a strategy to protect and restore Durham's natural resources and ecosystem. Low Impact Development (LID) is implemented through the Stormwater Performance Standards for Development (City of Durham, 2012b) and the Durham City-County UDO (Durham City-County Planning Department, 2021).

GSI practices are not appropriate in all areas of the watershed due to the presence of soils with low hydraulic conductivity in some areas (Table 2-2 and Exhibit 5). The evaluation of GSI opportunities in the New Hope Creek and Little Creek watersheds involved field evaluation of a GIS-based ReGIn analysis that was conducted in 2017 (City of Durham, 2017b). The field assessment area included 1,544 parcels in the watershed that were selected from census blocks that scored highest in the ReGIn analysis and could be potential sites for GSI and low impact development opportunities. However, because many of these potential sites are located on private property, GSI and LID treatment practices will likely not be implemented on all sites.

Watershed improvement scenario results show that using GSI and LID practices reduces TN by 3.5%, TP by 3.3%, and TSS by 6.9% (Table 5-7).

KEYSTONE properties are the highest-priority parcels identified for protection in each watershed that can expand high-quality riparian areas that are already protected, such as existing parks, or that could serve as parcels around which larger protected areas might be built.

URBAN GEMS are properties that contain high-quality riparian areas in heavily urbanized portions of each watershed which are isolated or lack connectivity to other protected open spaces. Although Urban Gems would not qualify as a keystone property, they still hold specific individual characteristics that are deemed particularly worthy of protection.

8.1.5 Protection and Preservation of High-Quality Riparian Areas

Stream buffers hold the stream banks in place, preventing erosion and providing biological and hydrologic benefits by diffusing and treating stormwater runoff. While a significant portion of the riparian buffers along the mainstem and tributaries of New Hope Creek and Little Creek are already protected through public ownership or development restrictions, additional opportunities for protection exist.

The Riparian Area Management Plan (RAMP) identifies maintenance practice opportunities to enhance or extend riparian buffers or to improve existing maintenance practices on city-owned property near and along streams. The RAMP document is reassessed and updated as part of each WIP to reflect the City's goals of supporting an equitable implementation of maintenance practices along riparian areas to support biodiversity and water quality. Updates to the RAMP that were a part of the New Hope Creek and Little Creek WIP included field data collection to determine the width of three existing no mow buffer zones and the identification of four new clusters of potential no mow sites. The latest RAMP update also incorporates the City's environmental equity and sustainability goals described in other planning documents including the City's Sustainability Roadmap (City of Durham, 2018b) and Strategic Plan (City of Durham, 2018c). The updated RAMP also includes "tool kits" such as native seed mixes and invasive plant lists and descriptions that can be used by City departments to improve riparian areas. Additional information is provided in the *Riparian Area Management Plan* provided in Volume III, Appendix N, of this WIP.

Riparian land conservation practices do not currently have an established nutrient credit in North Carolina. NCDEQ is in the process of developing an accounting and crediting mechanism for riparian buffer improvements. Upon completion, it is anticipated that opportunities to partner on riparian buffer improvement projects may be incentivized.

The City's Critical Areas Protection Plan (CAPP) identifies privately-owned parcels with high-quality riparian buffers that could be prioritized for conservation or protection to preserve benefits to water quality and watershed health. The CAPP addresses watersheds within City jurisdiction and is updated with each WIP to include a list of priority parcels and areas marked for protection. For the New Hope Creek and Little Creek watershed study area, a total of 103 keystone parcels and 14 urban gems were identified. Twenty-three of the keystone parcels were identified outside the City's jurisdictional limits but are within Durham County's jurisdiction. These properties were included

as keystone parcels because they are immediately adjacent to the city limits. Parcels associated with Duke University West Campus and Duke Forest comprise a substantial area within the study area (~4 square miles); however, these parcels were not considered eligible to be selected as keystone parcels or urban gems because they are operated by a separate institution and authority under an existing comprehensive management plan. Additionally, a large portion of riparian buffers along the main stem of New Hope Creek and its tributaries are already protected through public ownership by the United States Army Corps of Engineers.

Twenty of the 93 keystone parcels and one of the 14 urban gems were located within the Mud Creek subwatershed. Eight parcels have riparian buffers along the main stem of Mud Creek which could link the Duke Forest parcels in the north with the publicly protected open space in the south that are located adjacent to New Hope Creek.

Twenty-two keystone parcels and one urban gem were located within the Sandy Creek subwatershed. Three parcels bordering four schools (Cresset Christian Academy, Durham Academy Lower School, Durham Academy Upper School, and the Hill Center) could provide a habitat connection between Duke Forest and the Sandy Creek Park. South of Sandy Creek Park, three keystone parcels would help connect Sandy Creek Park to publicly protected open space along New Hope Creek.

Fifty-one keystone parcels and 12 urban gems were located within the New Hope Creek subwatershed. Most of the high scoring parcels in this subwatershed are located to the north, near the confluence of Mud Creek and Sandy Creek into New Hope Creek and contain several existing trails. Protection of the riparian buffers of these parcels would help link to other protected open spaces in the Mud and Sandy Creek subwatersheds. Most of the urban gem properties are vacant parcels adjacent to keystone parcels or protected open space.

Ten keystone parcels were located within the Little Creek watershed. The two highest scoring keystone parcels border each other and have the same owner. Both parcels are large (54 acres and 20 acres), mostly forested, and contain a stream that flows into Little Creek approximately 1,700 feet downstream. The largest and the highest rated vacant keystone parcel is 64 acres. This parcel also contains the only segment of stream that was rated as a high-quality stream. The CAPP analysis and subsequent engagement with various stakeholders did not identify any urban gems within the Little Creek Watershed. Within this watershed, there were very few parcels within the City Limits that contained a stream segment that were not already identified as either a keystone property or as protected open space.

A complete list of keystone parcels and urban gems identified in the New Hope Creek and Little Creek watersheds is provided in Volume III, Appendix F, of this WIP.

8.1.6 Continuation of Existing City Programs and Practices

The City's Stormwater & GIS Services Division is actively engaged in a number of activities that improve and protect watershed and water quality conditions in the New Hope Creek and Little Creek watershed. As part of the City's MS4 permit requirements, the City reports annually on how it is implementing the following permit requirements: public education and outreach; public participation and involvement; illicit discharge, detection, and elimination; post-construction runoff; municipal pollution prevention and good housekeeping; industrial inspection; and water quality monitoring and assessment (City of Durham, 2019c). Together, these activities help the City manage stormwater and reduce pollutants of concern in the watershed.

Examples of ongoing City initiatives in the New Hope Creek and Little Creek watersheds include:

- [Jordan Lake One Water \(JLOW\) Partnership](#). The City is engaged in the JLOW effort, an ongoing partnership to facilitate increased collaboration and integrated watershed management partnership in the Jordan Lake watershed. This group is composed of local governments, conservation groups, universities,

water utilities, agriculture, state agencies, and private industry stakeholders. JLOW is in the process of developing an integrated watershed management approach for the Jordan Lake watershed, including the New Hope Creek and Little Creek watersheds (Triangle J Council of Governments, 2021).

- **Street Sweeping.** The City regularly sweeps the streets within city limits to remove trash, sediment, and debris. Street sediments and debris can contain pollutants such as nutrients, fecal bacteria, trace metals, hydrocarbons, and pesticides. Collecting and disposing such pollutants before they enter the storm drain can significantly enhance the water quality of streams within the New Hope Creek and Little Creek watersheds and Jordan Lake.
- **Environmental Equity & Inclusion.** Equity and resident engagement are key components of the City's FY2019-2021 Strategic Plan, which includes *Advance a More Inclusive and Equitable Durham*, *Shared Economic Prosperity*, and the *Language Access Plan*. The City has also created an Equitable Community Engagement Blueprint which is a guide to address systemic barriers related to public engagement. This document describes how the City should intentionally seek input from communities most adversely impacted by its projects, including those projects implemented by the Public Works Department.
- **Upper Cape Fear River Basin Association (UCFRBA).** The primary objectives of the UCFRBA is to conduct water quality monitoring and lead projects to improve water use and water quality management of the Deep River, Haw River, and New Hope Creek subbasins of the Upper Cape Fear River Basin. As an active UCFRBA member, the City supports these objectives and ongoing efforts to collaborate with other similar organizations (for example, Triangle J Council of Governments) on citywide water resources planning, management and protection issues.
- **Illicit discharge detection and elimination.** An illicit discharge is a discharge that conveys unauthorized substances to the stormwater drainage system. The City identifies and mitigates non-stormwater discharges and illegal dumping of materials through routine inspections and monitoring as well as investigation following observations or complaints, reliance on regulatory measures for abatement and enforcement, and remedial construction of illicit connections where necessary.
- **Post-construction runoff control.** Post-construction controls are designed to reduce potential pollutant and hydrological impacts associated with development and increased impervious surface. Post-construction controls include SCMs that treat runoff or through site design that employs LID or GSI principles to reduce the volume of runoff. The Stormwater and GIS Services Division of the Public Works Department reviews development plans and administers standards for post-construction SCMs in accordance with the City's stormwater performance standards for development. As required under Section F of their NPDES stormwater permit (permit number NCS000249, effective October 10, 2018 – October 9, 2023), the City manages an SCM inspection program that requires annual inspection reports of permitted structural SCMs, performed by a qualified professional.
- **Watershed protection ordinances.** The City's UDO includes natural resource protections (City of Durham, 2021c). City Articles 8 and 12 of the UDO address environmental protection and outline standards to protect and conserve natural resources, minimize future flooding, and minimize impacts to natural resources by future development. Part of New Hope Creek is in the Jordan Lake Water Supply Watershed and therefore has more stringent buffer protections than waters that are not designated for drinking supply. Riparian buffer protection zones are 150 feet on perennial streams and 100 feet on intermittent streams located in Falls/Jordan Critical Area (F/J-A). Falls/Jordan Protected Area (F/J-B) require 100 feet on perennial and 50 feet (100 feet high density) for intermittent streams.

- **Pollutant source tracking.** The City is performing water and sediment monitoring and evaluation of Sandy Creek Tributary A in the New Hope Creek watershed and Warren Creek in the Eno River watershed. This project is being conducted to determine causes of low dissolved oxygen in Sandy Creek Tributary A and elevated concentrations of metals and polycyclic aromatic hydrocarbons in sediments in Warren Creek. This project is expected to be completed in 2022.
- **Water quality and biological monitoring.** The City performs water quality and biological monitoring at 11 ambient water quality stations in the New Hope Creek and Little Creek watershed study area and has collected data from additional stations as part of watershed studies. The City also collects benthic macroinvertebrate data at two ambient water quality stations within the watershed.

The City maintains a Water Quality Web Portal (<http://www.durhamwaterquality.org>) where the public can access existing water quality data. Results of water quality and biological monitoring are also presented in the City's Annual State of Streams Report, and characterization of the water through the WQI is presented for each monitoring station.

- **Wastewater treatment improvements.** Both centralized and decentralized wastewater treatment systems require regular maintenance to ensure proper functioning and protection of the water quality of receiving streams. Older sanitary sewer lines may have high rates of infiltration and inflow (I&I) (water entering the sewer line) and exfiltration (untreated sewage leaching into the soil and groundwater). Excessive I&I can cause the volume of the sewage transported to exceed the design capacity of the system which can result in sewer overflows. Failing septic systems and sand filters can also be a source of fecal coliform bacteria, nutrients, and BOD in receiving streams. The City will continue scheduled I&I inspections, rehabilitation, and other collection system improvements.
- **Stormwater research.** Local universities conduct stormwater research that provides insight into the quantity and type of pollutants in stormwater and controls that can be used to mitigate the impacts of pollutants. Research on SCMs such as regenerative stormwater conveyance, permeable pavement, and others, helps the City better understand the pollutant removal effectiveness of these SCMs within City boundaries. Stormwater research is also used to support recommendations for site selection, design, installation, and maintenance activities.
- **Flood prevention and mitigation.** The City manages a flood warning gage monitoring system within the New Hope Creek and Little Creek watershed, on Sandy Creek at Cornwallis Road in coordination with USGS. USGS also manages a monitoring gage at Stagecoach Road on New Hope Creek that is a part of the North Carolina Inundation Mapping and Alert Network. Public Works Stormwater & GIS Services staff and Durham County Emergency Management receive alerts when certain gage depths are reached. Emergency Management then arranges for the closure of several sections of roads leading to impacted areas. Stormwater & GIS services also monitors flood warning systems for flooding in areas outside of the study area, such as central Durham and at the City's Public Works Operation Center.
- **Environmental education programs.** City staff routinely educate the public on stormwater-related topics. This education helps to inform the public about the importance of stormwater quality, reduce pollution at its source by changing attitudes and behaviors, and create a body of support for local stormwater initiatives. Encouraging the proper application of lawn fertilizer, landscape practices, pet waste disposal, and septic system maintenance can also lead to behavior changes that reduce bacteria, sediment, nutrient, and heavy metal impacts in the New Hope Creek and Little Creek watershed. City staff are regularly engaged in direct and indirect education that includes engagement of select audiences,

provision of educational materials, demonstration of best practices, and solicitation of feedback and involvement.

- **Collaboration among City departments.** The City coordinates several projects within various departments (e.g., Water Management, Parks and Recreation) that have the potential to affect water quality in the New Hope Creek and Little Creek watershed. Project examples include trail stabilization and stream restoration. Ongoing collaboration between departments should continue in effort to implement projects while potentially minimizing impacts to residents and businesses.

8.2 Evaluating Progress

Progress toward protecting water quality in New Hope Creek and its tributaries is achieved through an adaptive management framework, in which actions intended to protect and restore water quality are informed by up-to-date information. The adaptive management process begins with tracking the existing controls, programs, and practices that improve water quality, discussed in Section 8.1. The City assesses the effectiveness of these controls by continuously monitoring the conditions within the watershed. This information is then used to adjust project implementation as needed.

Current monitoring and assessment tools used to protect the New Hope Creek and Little Creek watersheds and implement nutrient management strategies for Jordan Lake are presented in Table 8-1.

Table 8-1. Information used to track the effectiveness of controls in the New Hope Creek and Little Creek watershed

Category	Collected or Reported Information	Implementation Schedule
Water quality	Ambient water chemistry is collected at 11 locations in the New Hope Creek and Little Creek watershed, and WQI and water quality analyses are reported annually in the City's State of Our Streams Report (City of Durham, 2019a). Water quality data are available through the City's web portal (http://www.durhamwaterquality.org). Chemical water quality monitoring is also performed by NCDEQ and UCFRBA throughout the watershed.	Ongoing with annual reporting
Benthic community and freshwater mussels	Biological data including benthic macroinvertebrate data have been collected by the City, NCDEQ, and UCFRBA. The City has collected benthic macroinvertebrate data at two stations within the watershed, one on Mud Creek and other on Sandy Creek.	Every other year
Nutrient loading	Jordan Lake undergoes continual water quality monitoring as required by the Jordan Lake Nutrient Management Strategy. A three-year study of Jordan Lake nutrient loading (Jordan Lake Study) was conducted by researchers at multiple universities within North Carolina and submitted in 2020. The study sought to provide actionable information for decision-makers regarding sustaining water quality in Jordan Lake.	2020 and future updates
Sediment chemistry	The City conducted a comprehensive water quality study for Sandy Creek watershed between February 2018 and January 2019 that included sediment sampling (City of Durham, 2019b). This information will serve as a reference and baseline for future sediment sampling.	2018-2019
Streamflow and flooding	Streamflow and stage are recorded at two USGS gages located on Sandy Creek and New Hope Creek. The City manages a flood warning gage monitoring system for portions of the New Hope Creek watershed.	Ongoing

Table 8-1. Information used to track the effectiveness of controls in the New Hope Creek and Little Creek watershed (continued)

Category	Collected or Reported Information	Implementation Schedule
SCM retrofits	The City maintains a database of all SCMs installed by the City or others within the city under the Stormwater Performance Standards for Development Ordinance (City of Durham, 2012b) as well as completed retrofit SCMs that were not installed under these requirements.	Ongoing with frequent updates
SCM retrofits (potential)	The City tracks potential or proposed SCM retrofits and new SCMs identified through watershed planning studies and, on an annual basis, selects projects for CIP funding.	Ongoing with frequent updates
SCM maintenance	The City tracks SCM inspection and maintenance actions for all SCMs.	Ongoing with frequent updates
GSI-LID Implementation	The City tracks the implementation of GSI-LID practices throughout the city.	Ongoing with frequent updates

CIP = capital improvement plan

GSI-LID = green stormwater infrastructure – low impact development

SCM = stormwater control measure

WQI = Water Quality Index

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


Exhibits

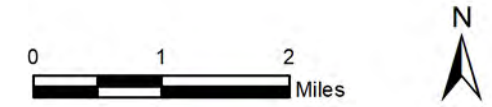
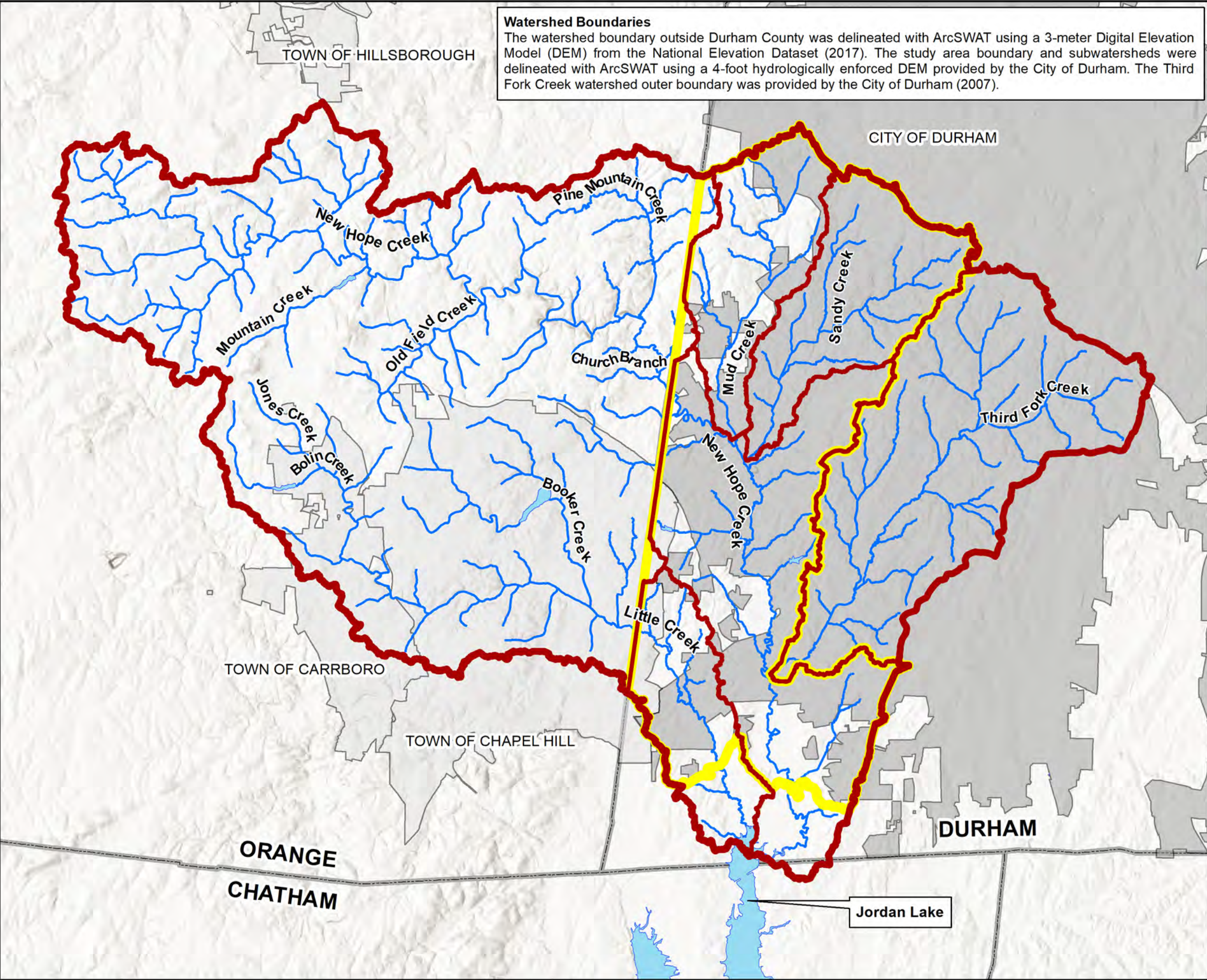
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Watershed Boundaries
 The watershed boundary outside Durham County was delineated with ArcSWAT using a 3-meter Digital Elevation Model (DEM) from the National Elevation Dataset (2017). The study area boundary and subwatersheds were delineated with ArcSWAT using a 4-foot hydrologically enforced DEM provided by the City of Durham. The Third Fork Creek watershed outer boundary was provided by the City of Durham (2007).

**Exhibit 1
 Watershed Overview Map**

CITY OF DURHAM
 NEW HOPE CREEK AND LITTLE CREEK
 WATERSHED IMPROVEMENT PLAN

-  Streams
-  Lakes and Reservoirs
-  New Hope and Little Creek Watersheds
-  Subwatersheds
-  Study Area
-  Durham City Limits - 2019
-  Other Municipal Limits
-  County Boundary

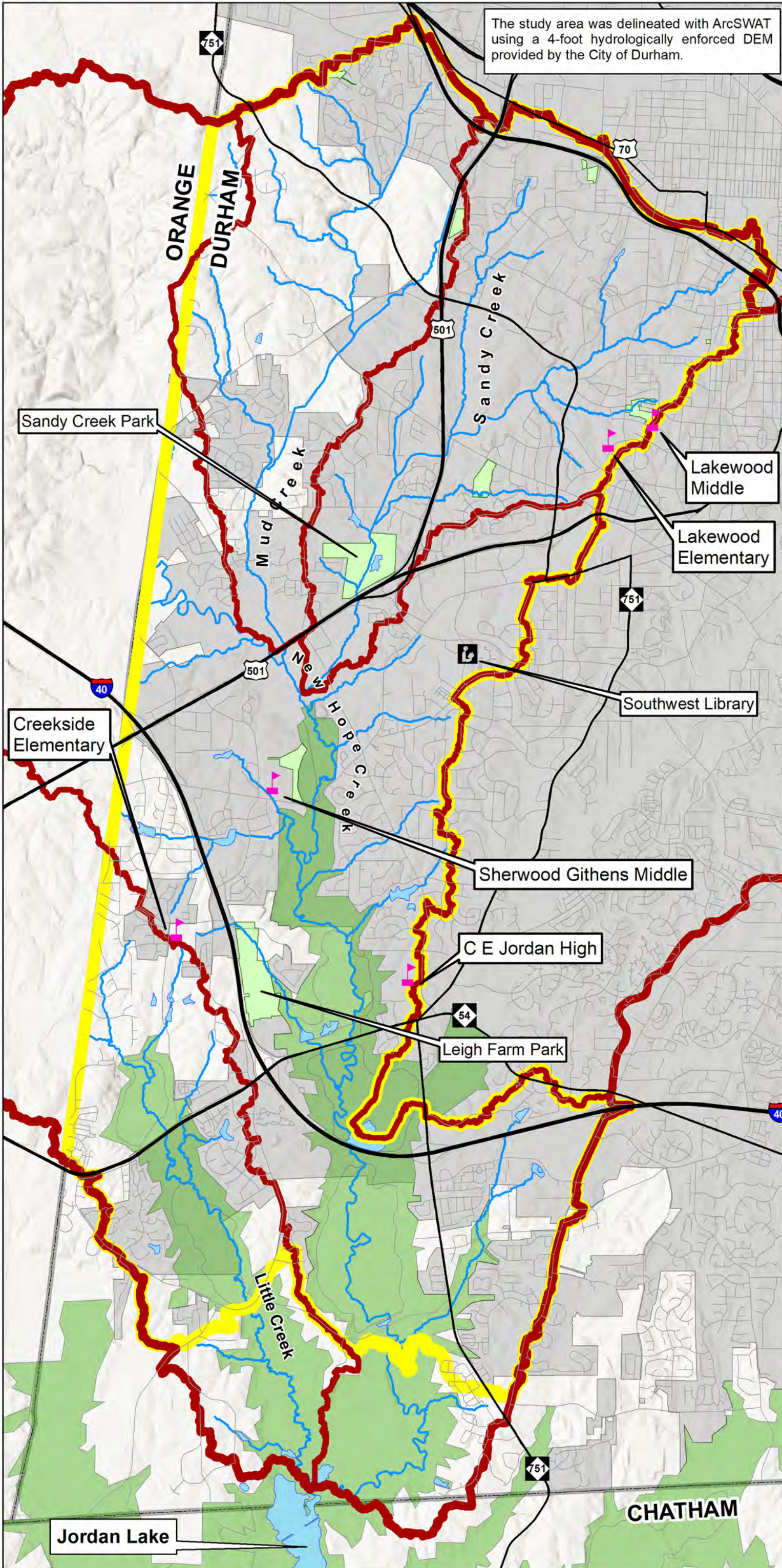


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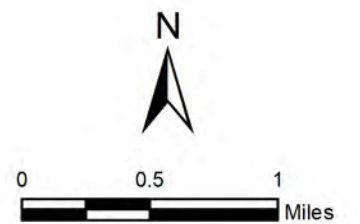
Exhibit 2 Study Area

CITY OF DURHAM
NEW HOPE CREEK AND LITTLE CREEK
WATERSHED IMPROVEMENT PLAN

The study area was delineated with ArcSWAT using a 4-foot hydrologically enforced DEM provided by the City of Durham.



- Durham Public Libraries
- Durham Public Schools
- Major Roads
- Roads
- Streams
- Ponds and Lakes
- Parks
- Jordan Game Lands
- Study Area
- New Hope and Little Creek Watersheds
- Subwatersheds
- Durham City Limits - 2019
- County Boundary



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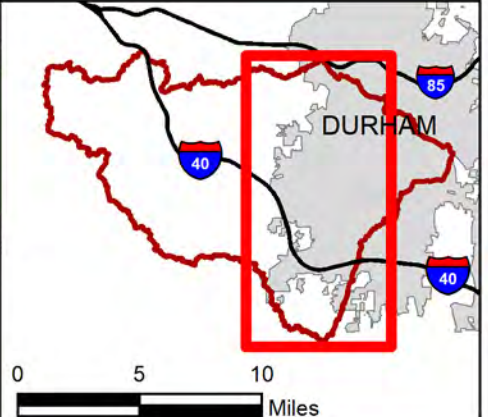








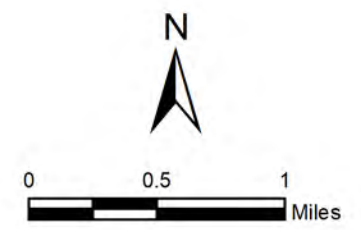
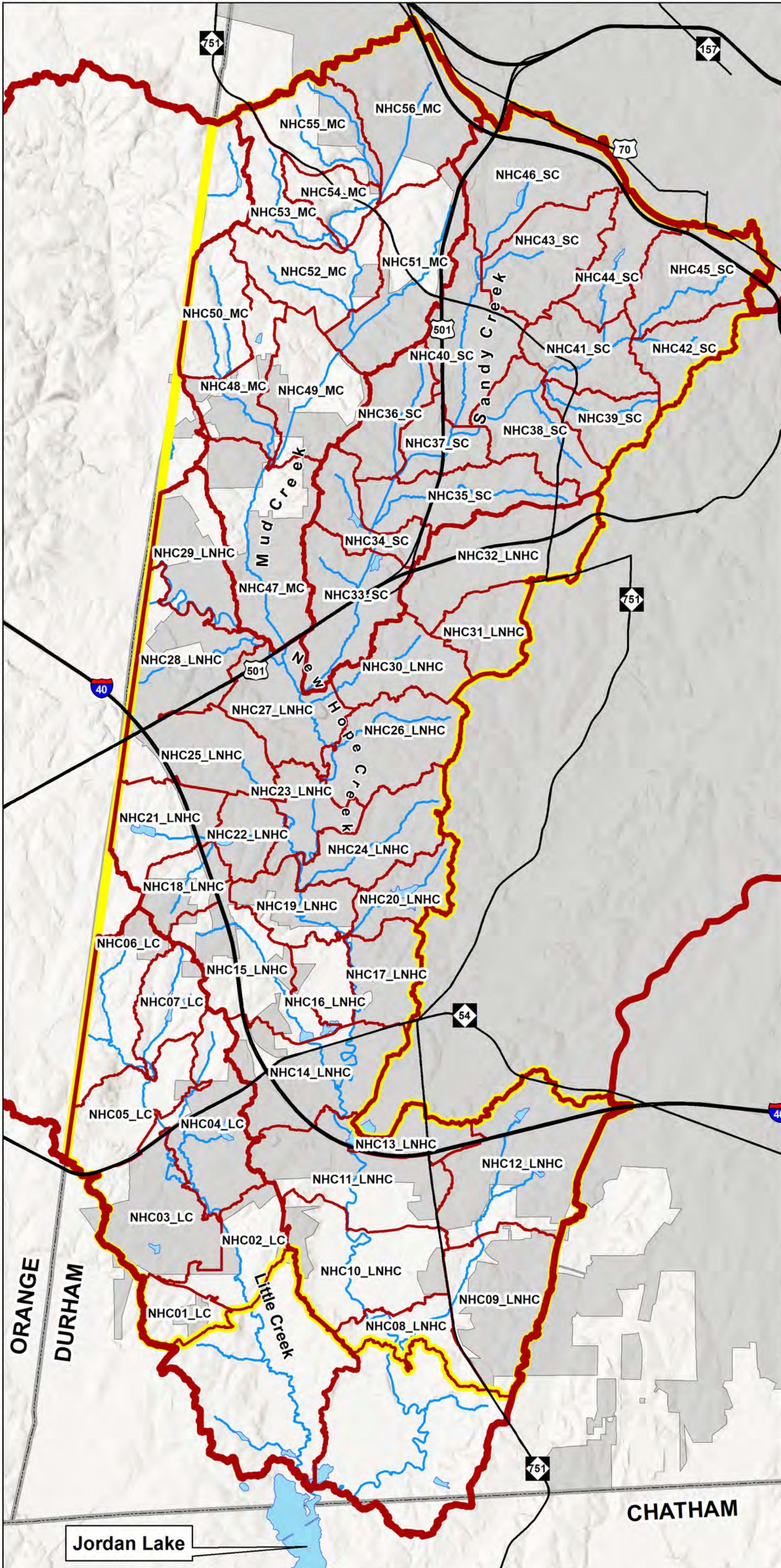


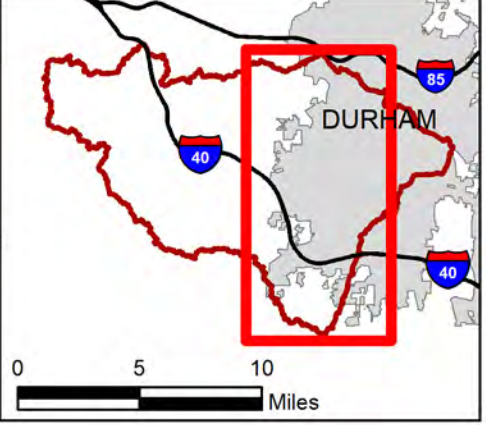
Exhibit 3 Subwatersheds

CITY OF DURHAM
NEW HOPE CREEK AND LITTLE CREEK
WATERSHED IMPROVEMENT PLAN

-  Major Roads
-  Streams
-  Ponds and Lakes
-  Study Area
-  New Hope and Little Creek Watersheds
-  Major Subwatersheds
-  Subwatersheds
-  Durham City Limits - 2019
-  County Boundary



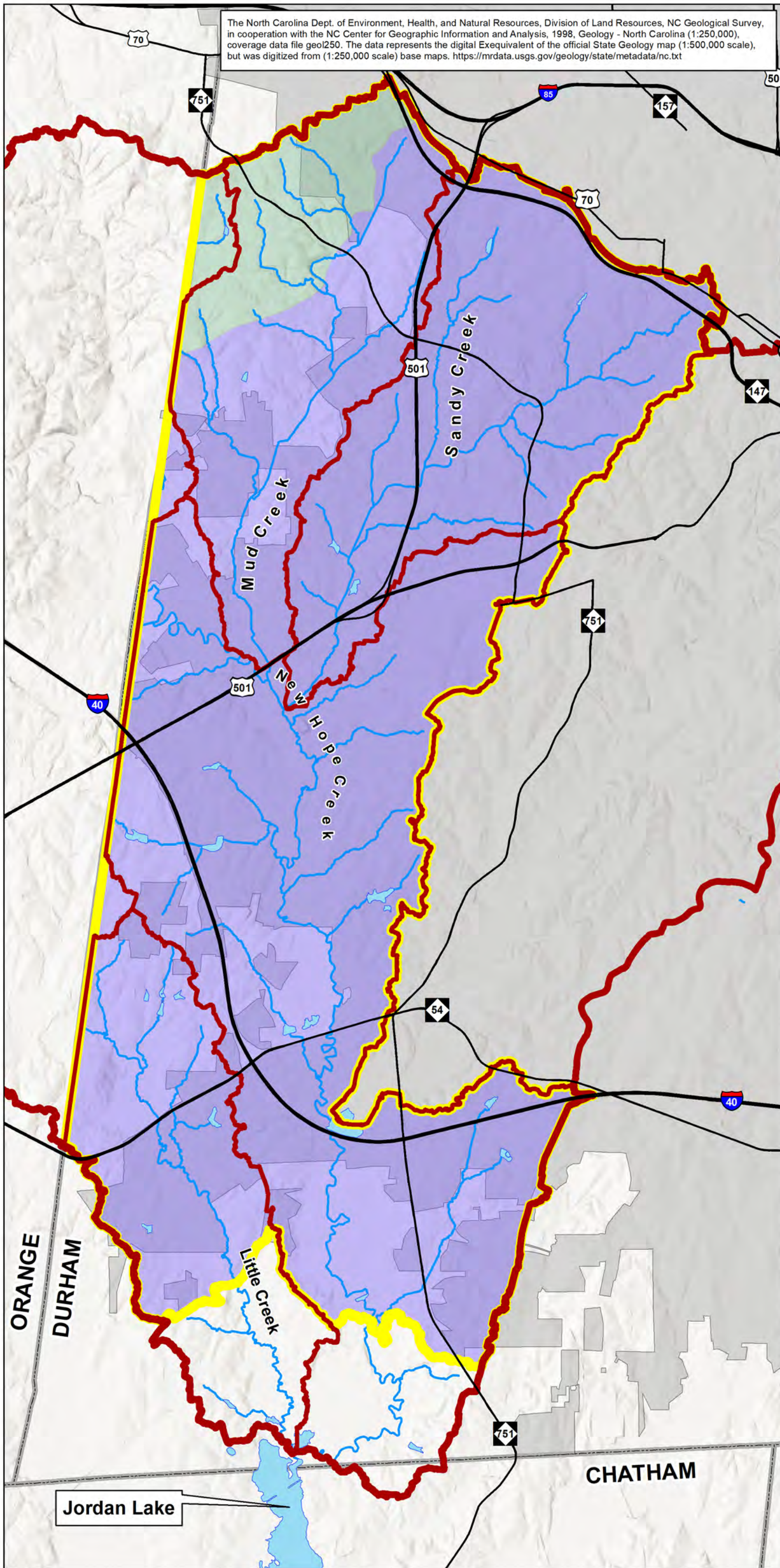
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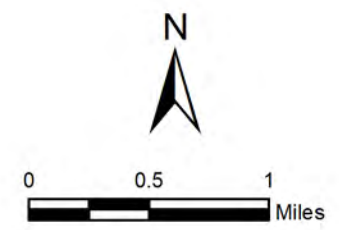
The North Carolina Dept. of Environment, Health, and Natural Resources, Division of Land Resources, NC Geological Survey, in cooperation with the NC Center for Geographic Information and Analysis, 1998, Geology - North Carolina (1:250,000), coverage data file geol250. The data represents the digital Equeivalent of the official State Geology map (1:500,000 scale), but was digitized from (1:250,000 scale) base maps. <https://mrdata.usgs.gov/geology/state/metadata/nc.txt>

Exhibit 4 Geology

CITY OF DURHAM NEW HOPE CREEK AND LITTLE CREEK WATERSHED IMPROVEMENT PLAN



- Major Roads
- Streams
- Ponds and Lakes
- ▭ Study Area
- ▭ New Hope and Little Creek Watersheds
- ▭ Subwatersheds
- ▭ Durham City Limits - 2019
- ▭ County Boundary
- Geology**
- ▭ Carolina Slate Belt
- ▭ Triassic Basins



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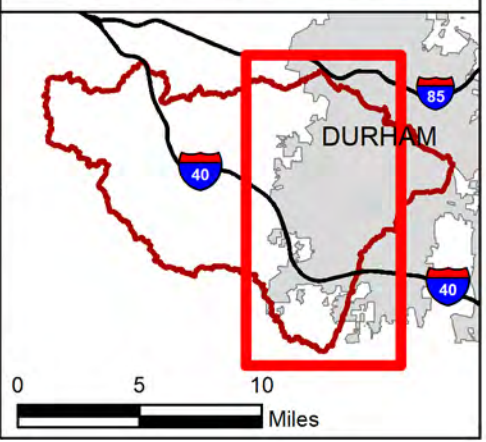
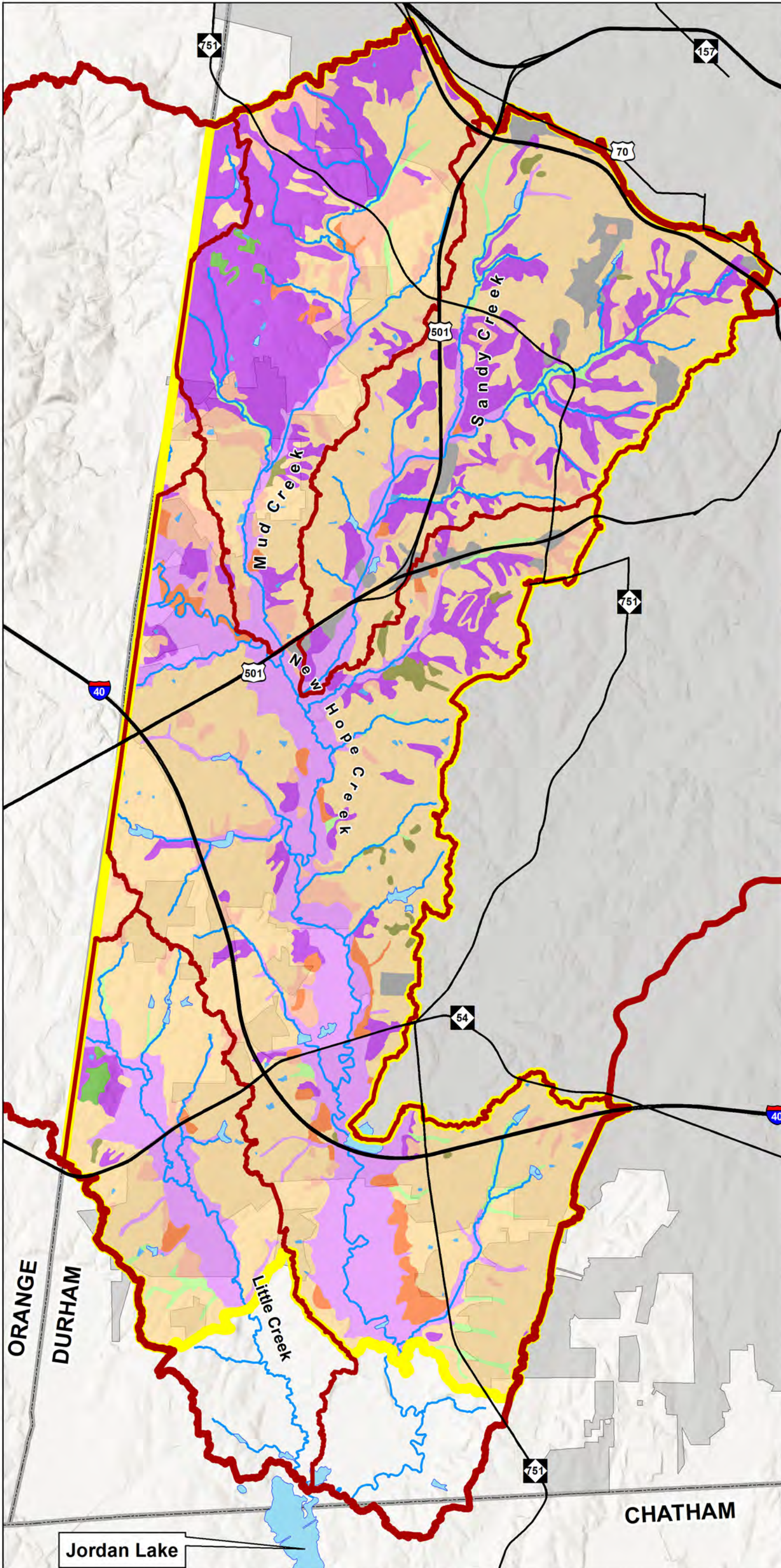
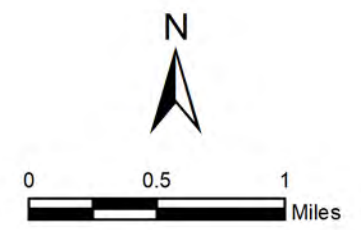


Exhibit 5 Hydrologic Soil Groups

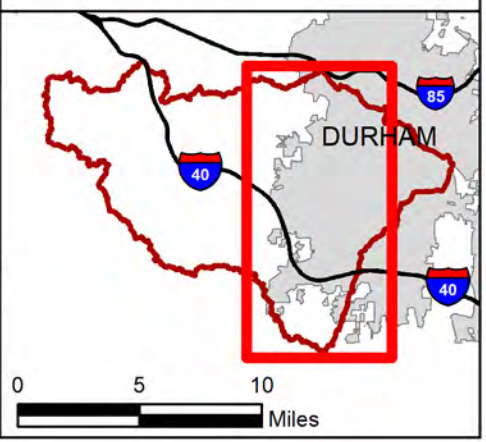
CITY OF DURHAM
NEW HOPE CREEK AND LITTLE CREEK
WATERSHED IMPROVEMENT PLAN



- Major Roads
 - Streams
 - Ponds and Lakes
 - Study Area
 - New Hope and Little Creek Watersheds
 - Subwatersheds
 - Durham City Limits - 2019
 - County Boundary
- Hydrologic Soil Group**
- A - Rapid Infiltration (<1%)
 - A/D - (Drained/Undrained Areas) (2%)
 - B - Medium Infiltration (16%)
 - B/D - (Drained/Undrained Areas) (15%)
 - C - Slow Infiltration (2%)
 - C/D - (Drained/Undrained Areas) (7%)
 - D - Very Slow Infiltration (55%)
 - Gullied Land (<1%)
 - Urban Land (2%)
 - Water (<1%)



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








Jordan Lake

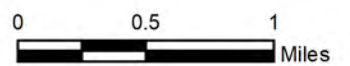
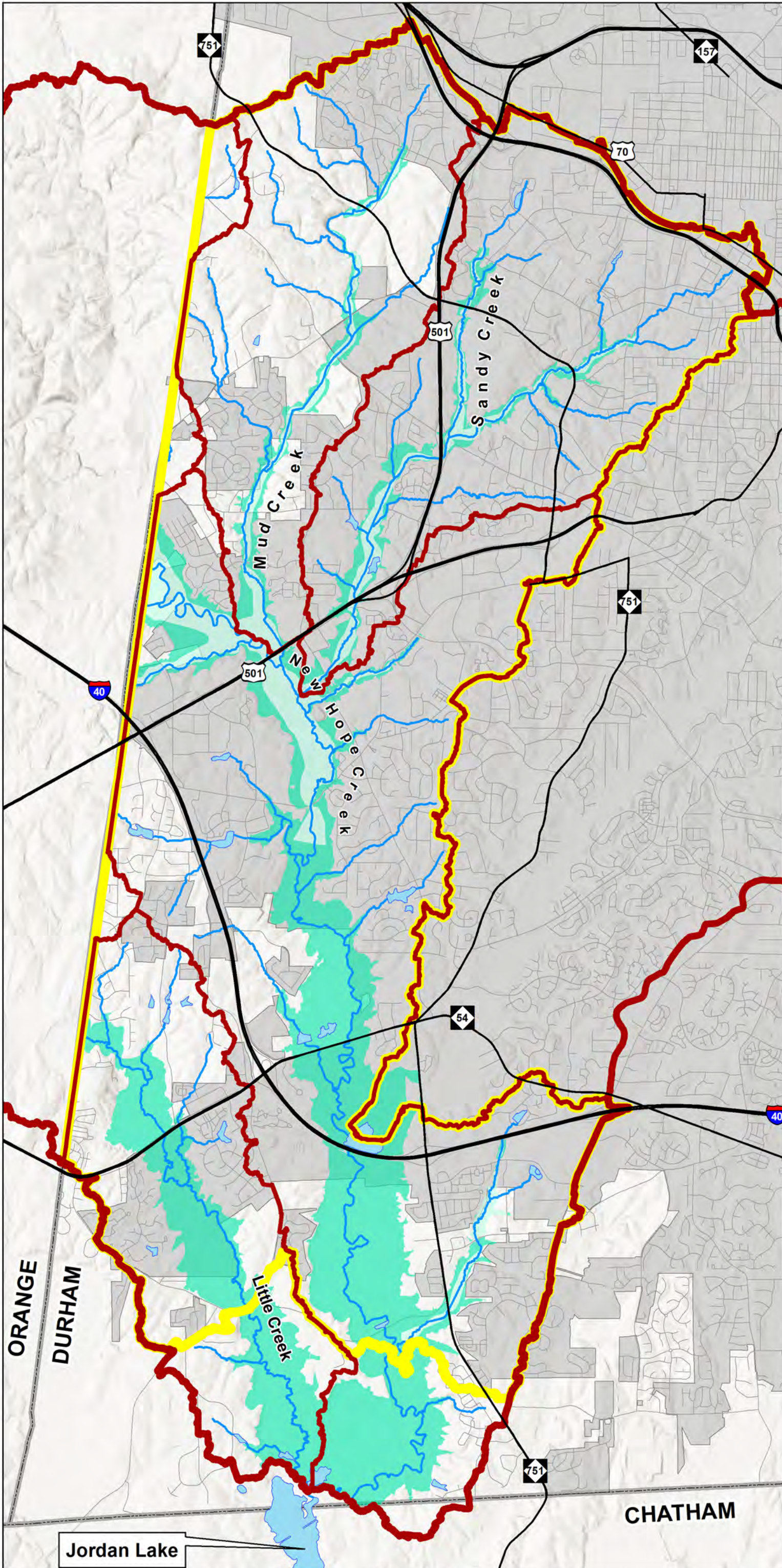
ORANGE
DURHAM

CHATHAM

Exhibit 6 FEMA Floodplains

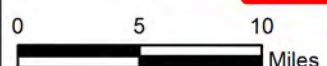
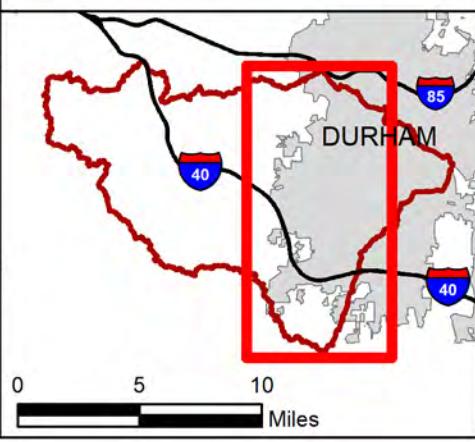
CITY OF DURHAM
NEW HOPE CREEK AND LITTLE CREEK
WATERSHED IMPROVEMENT PLAN

-  Major Roads
 -  Roads
 -  Streams
 -  Ponds and Lakes
 -  Study Area
 -  New Hope and Little Creek Watersheds
 -  Subwatersheds
 -  Durham City Limits - 2019
 -  County Boundary
- Flood Zones**
-  FEMA 100-yr Floodplain (effective 2019)
 -  FEMA Floodway (effective 2019)



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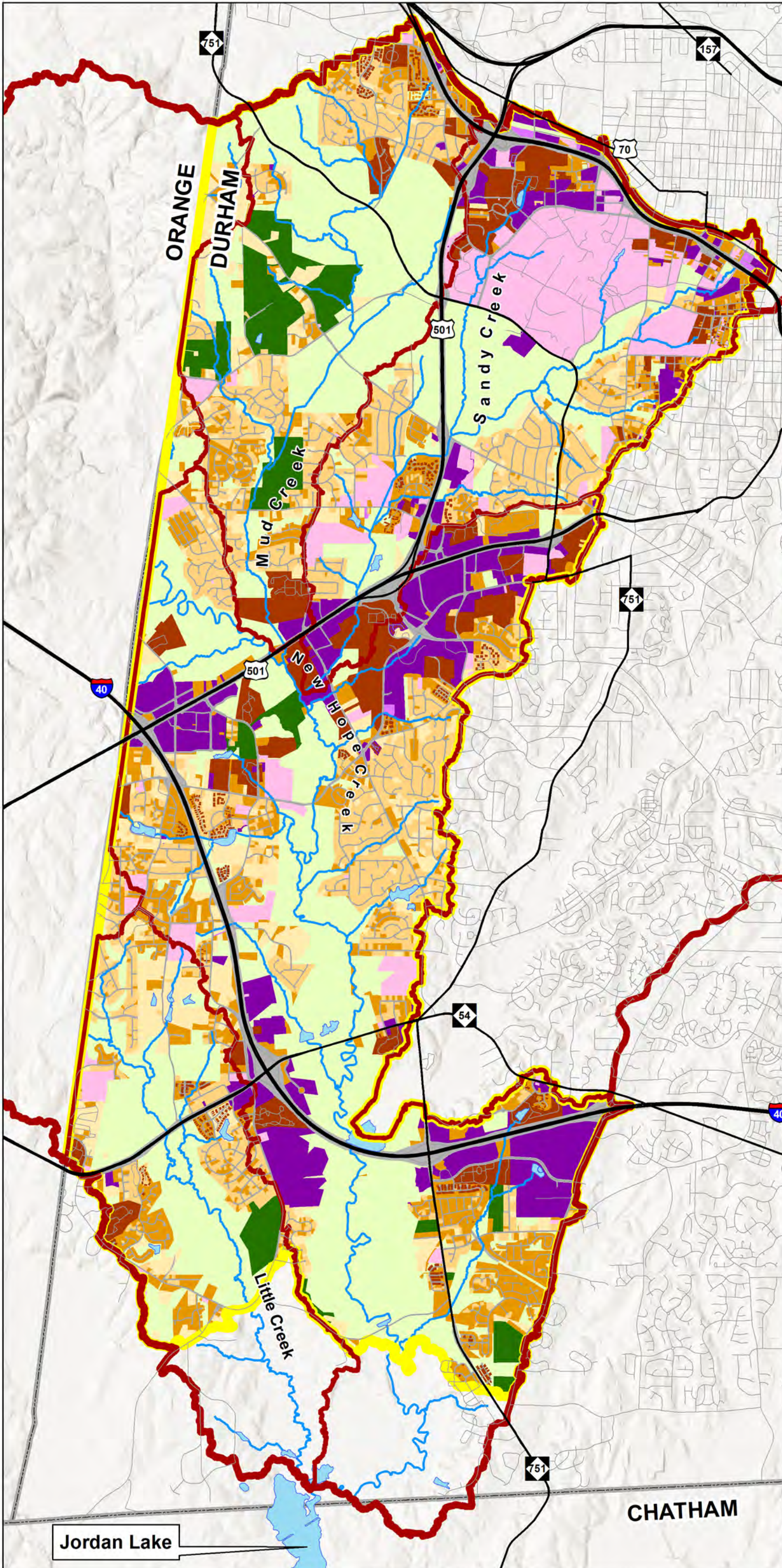
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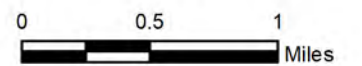
Jordan Lake

Exhibit 7 Existing Land Use

CITY OF DURHAM
NEW HOPE CREEK AND LITTLE CREEK
WATERSHED IMPROVEMENT PLAN

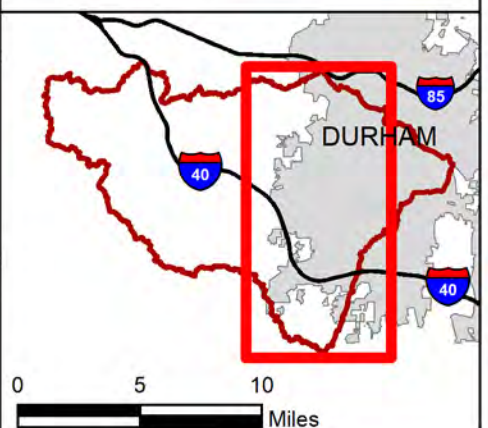


- Major Roads
 - Roads
 - Streams
 - Ponds and Lakes
 - Study Area
 - New Hope and Little Creek Watersheds
 - Subwatersheds
 - County Boundary
- Existing Land Use**
- Very Low Density Residential
 - Low Density Residential
 - Medium Density Residential
 - High Density Residential
 - Institutional
 - Industrial
 - Commercial
 - Parks and Open Space
 - Agriculture
 - Roadways



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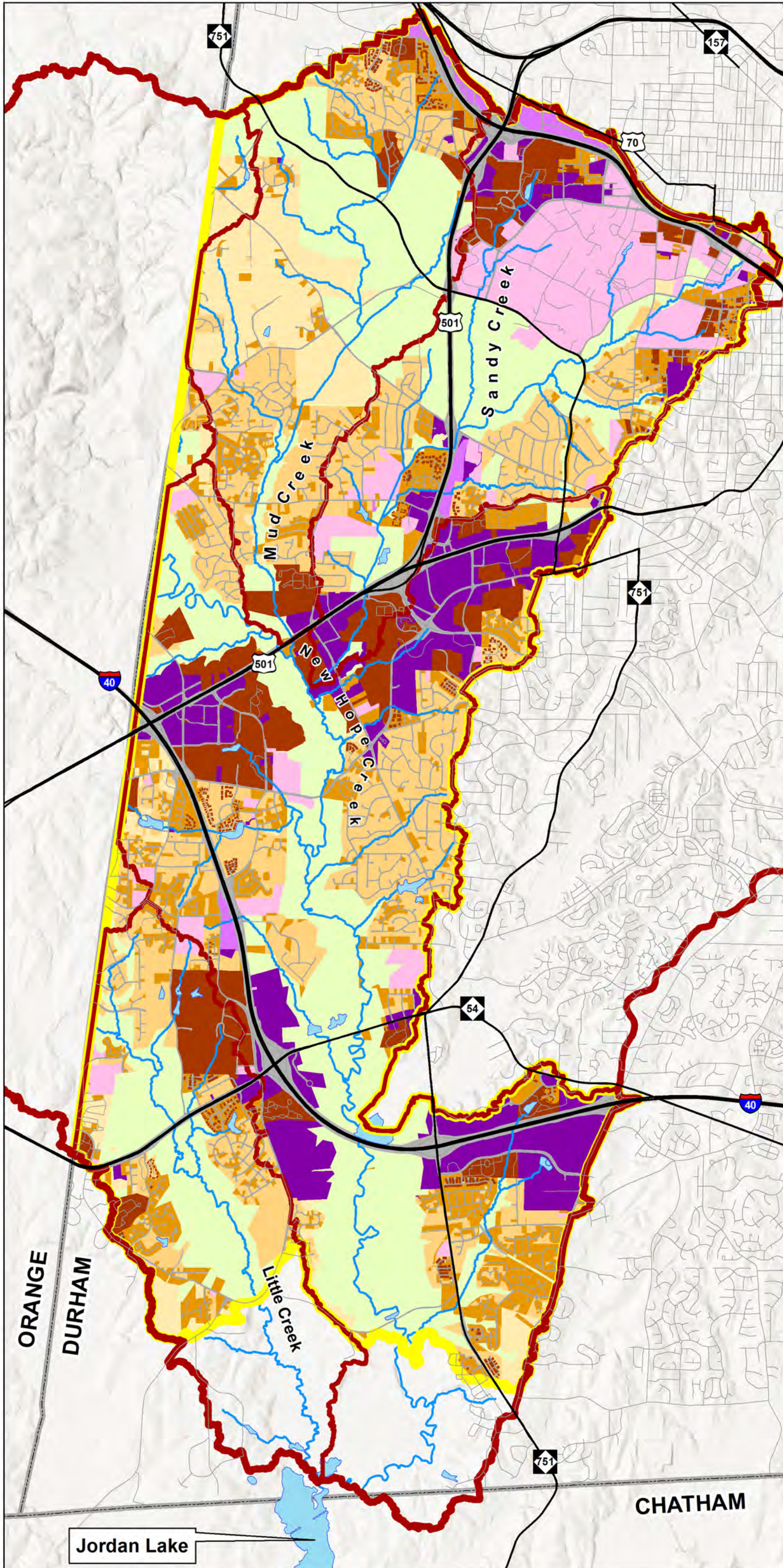


Jordan Lake

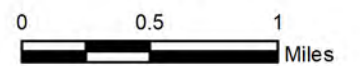
CHATHAM

Exhibit 8 Future Land Use

CITY OF DURHAM
NEW HOPE CREEK AND LITTLE CREEK
WATERSHED IMPROVEMENT PLAN

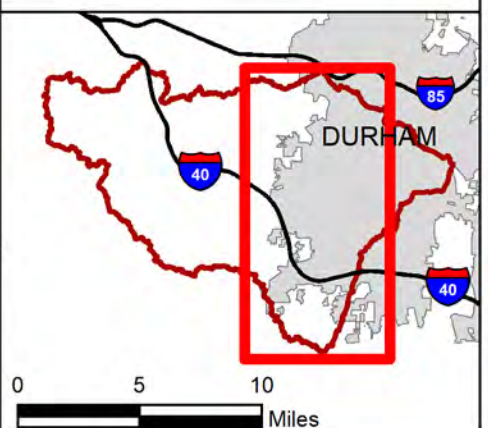


- Major Roads
 - Roads
 - Streams
 - Ponds and Lakes
 - ▭ Study Area
 - ▭ New Hope and Little Creek Watersheds
 - ▭ Subwatersheds
 - ▭ County Boundary
- Land Use**
- ▭ Very Low Density Residential
 - ▭ Low Density Residential
 - ▭ Medium Density Residential
 - ▭ High Density Residential
 - ▭ Institutional
 - ▭ Industrial
 - ▭ Commercial
 - ▭ Parks and Open Space
 - ▭ Agriculture
 - ▭ Roadway



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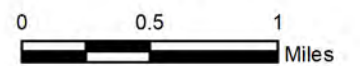
Jordan Lake

Exhibit 9 Impervious Cover

CITY OF DURHAM
NEW HOPE CREEK AND LITTLE CREEK
WATERSHED IMPROVEMENT PLAN

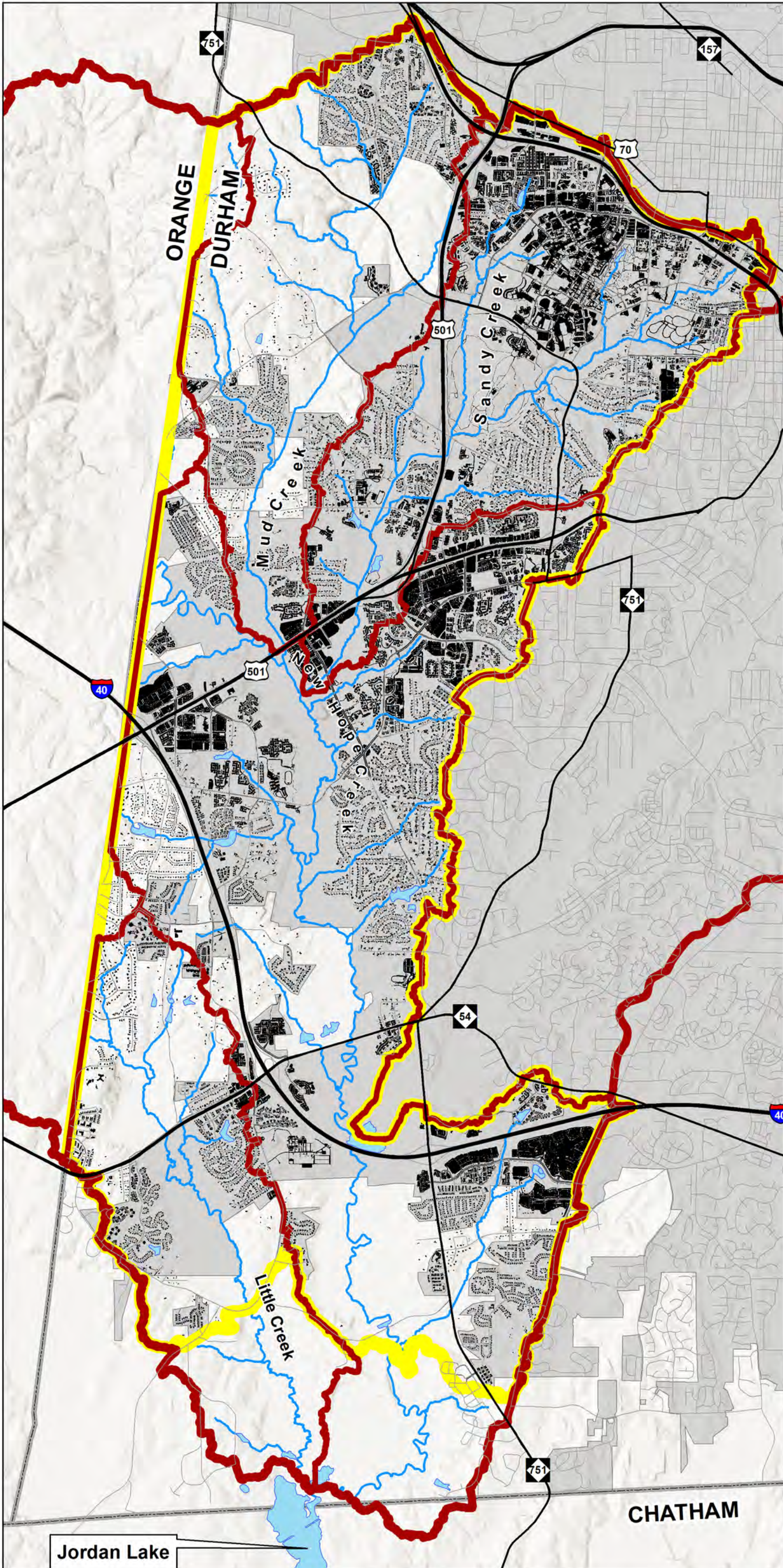
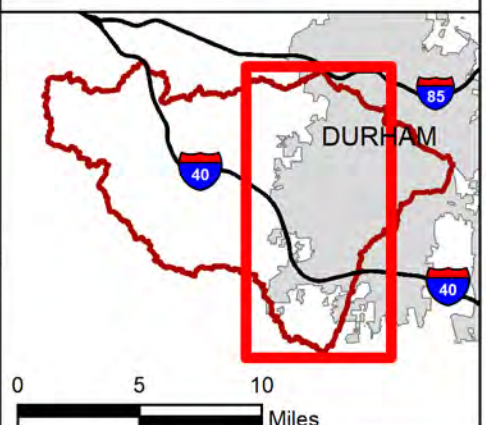
-  Major Roads
-  Roads
-  Streams
-  Ponds and Lakes
-  Study Area
-  New Hope and Little Creek Watersheds
-  Subwatersheds
-  Durham City Limits - 2019
-  County Boundary
-  Impervious Area

Impervious area within study area: 19%
Impervious area within city limits: 25%



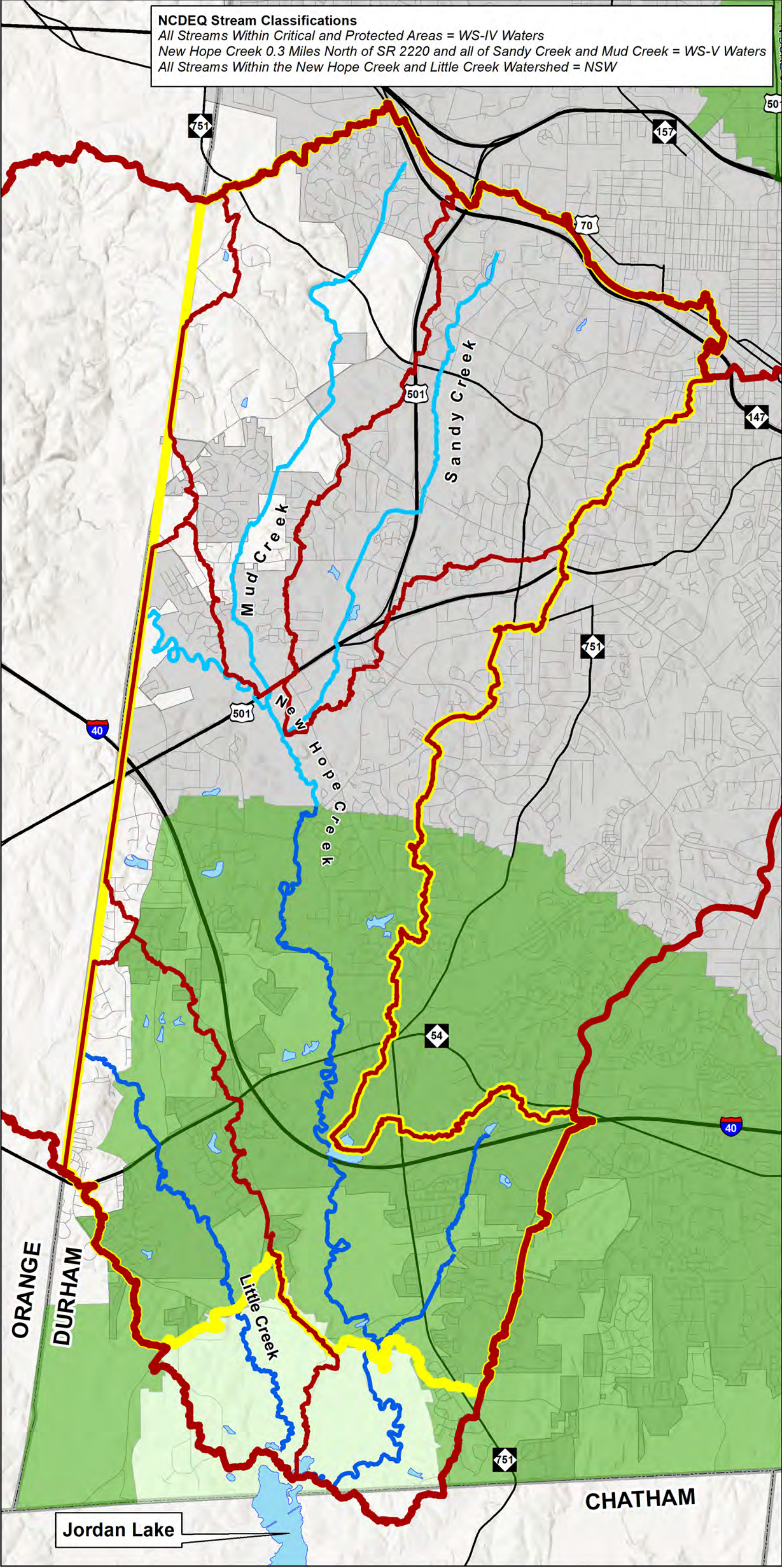
**CITY OF
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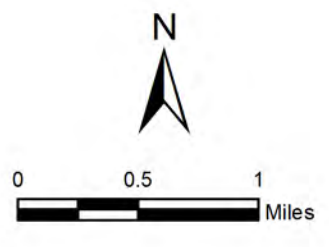


NCDEQ Stream Classifications
 All Streams Within Critical and Protected Areas = WS-IV Waters
 New Hope Creek 0.3 Miles North of SR 2220 and all of Sandy Creek and Mud Creek = WS-V Waters
 All Streams Within the New Hope Creek and Little Creek Watershed = NSW

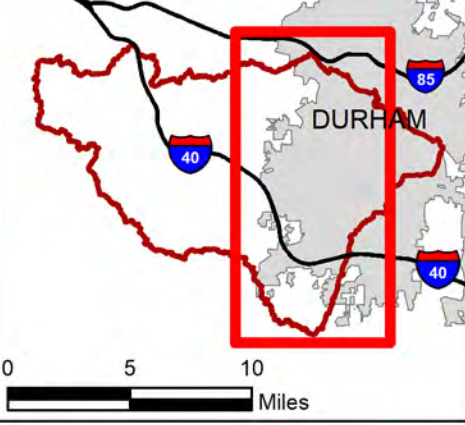
Exhibit 10
NCDEQ
Stream Classifications
 CITY OF DURHAM
 NEW HOPE CREEK AND LITTLE CREEK
 WATERSHED IMPROVEMENT PLAN



- Major Roads
- Roads
- Streams - WS-V, NSW
- Streams - WS-IV, NSW
- Ponds and Lakes
- Study Area
- Subwatersheds
- New Hope and Little Creek Watersheds
- Durham City Limits - 2019
- County Boundary
- Falls/Jordan District A Critical Area
- Falls/Jordan District B Protected Area



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Jordan Lake

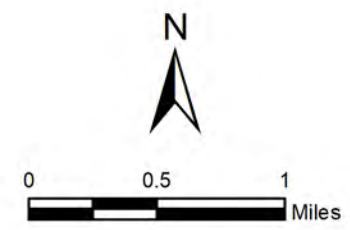
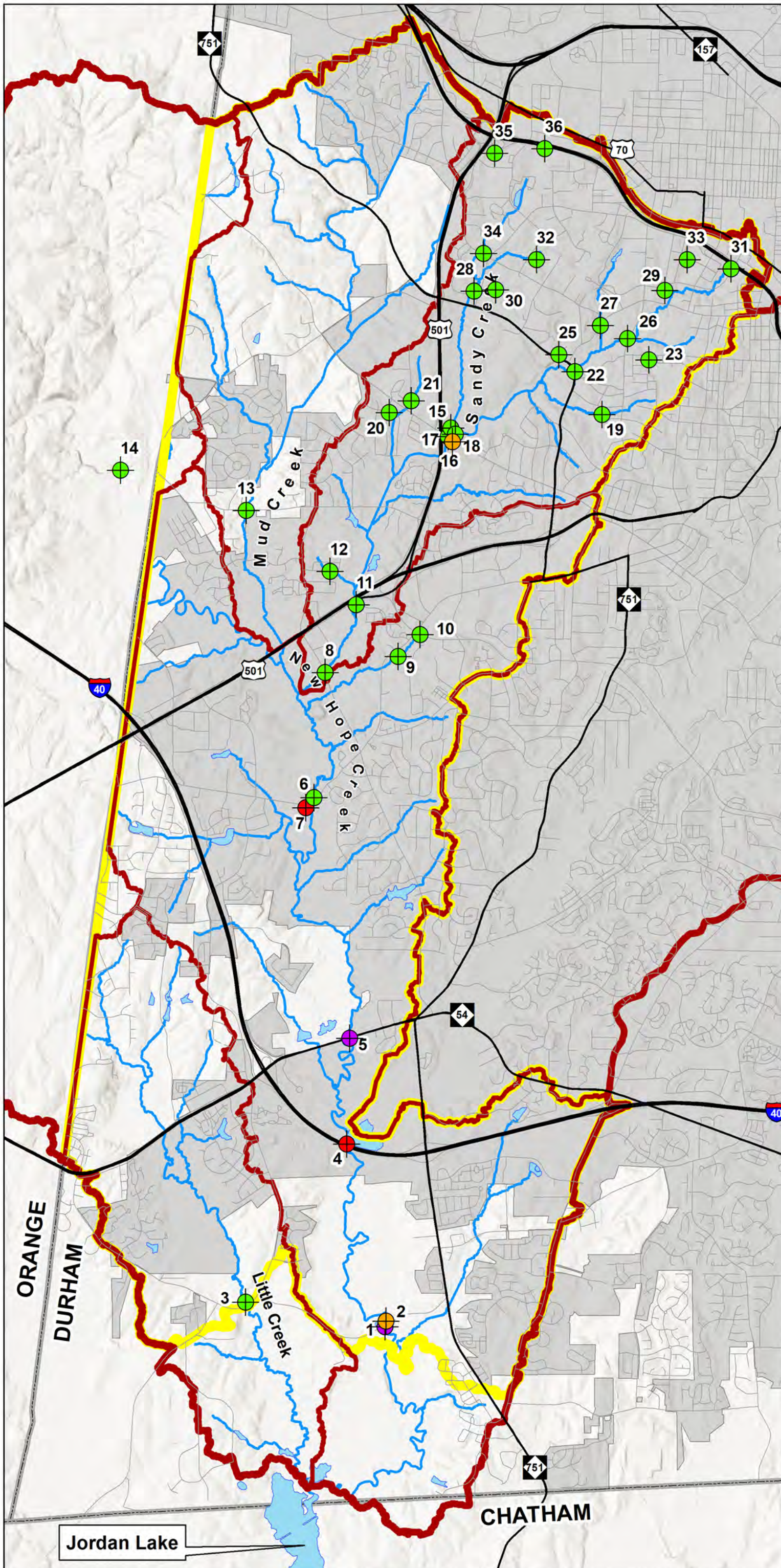
ORANGE
 DURHAM

CHATHAM

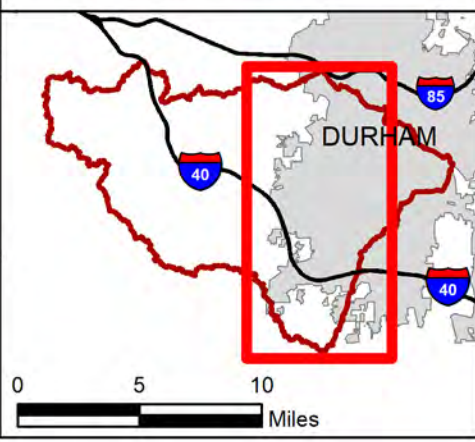
Exhibit 11 Monitoring Stations

CITY OF DURHAM
NEW HOPE CREEK AND LITTLE CREEK
WATERSHED IMPROVEMENT PLAN

- Major Roads
 - Roads
 - Streams
 - ▭ Ponds and Lakes
 - ▭ Study Area
 - ▭ Subwatersheds
 - ▭ New Hope and Little Creek Watersheds
 - ▭ Durham City Limits - 2019
 - ▭ County Boundary
- Stations**
- City of Durham
 - North Carolina Department of Water Resources
 - Upper Cape Fear River Basin Association
 - USGS



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Jordan Lake

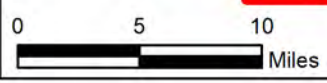
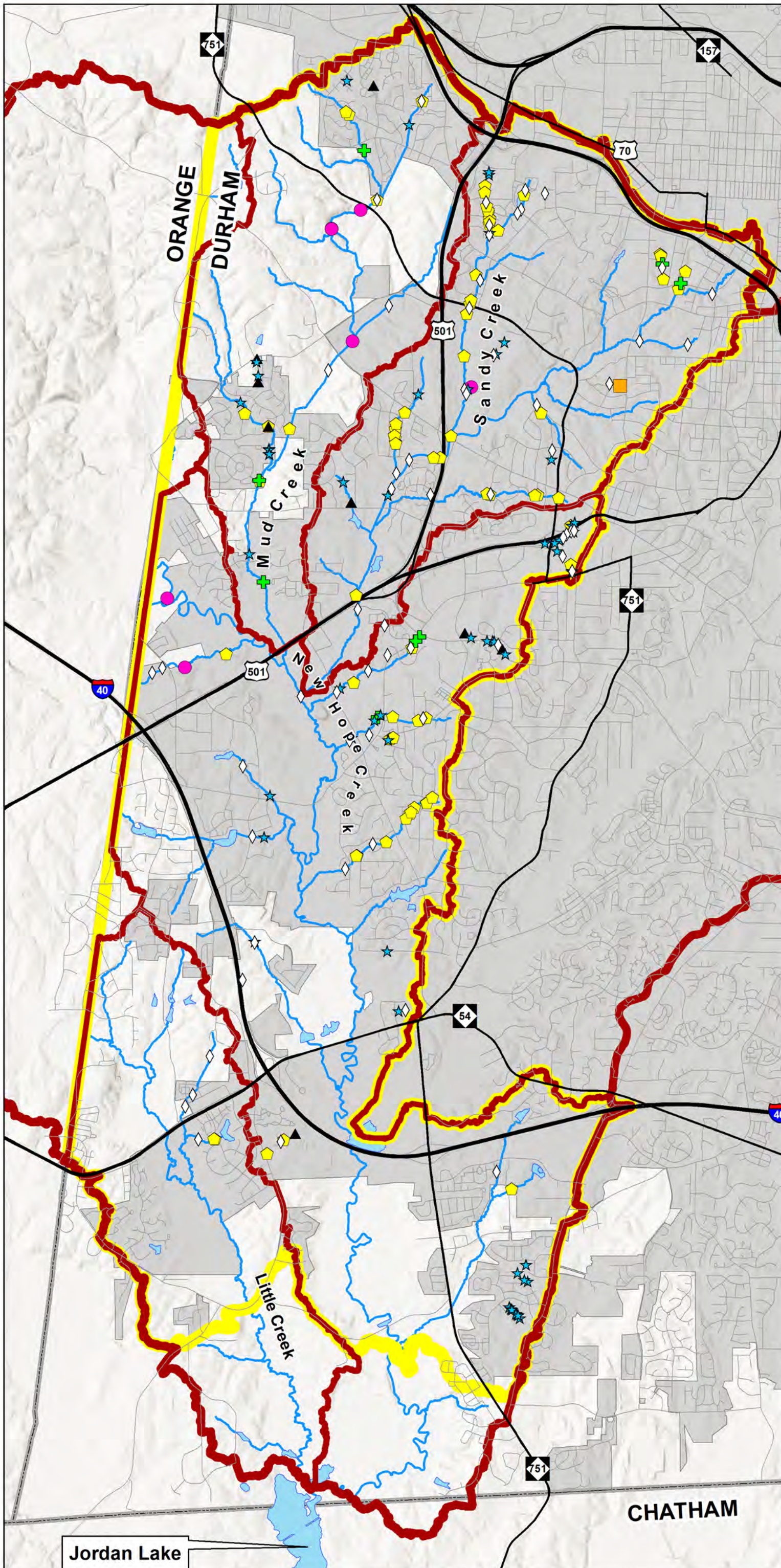
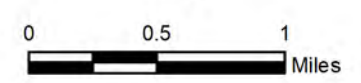


Exhibit 12 Observed Water Quality Concerns

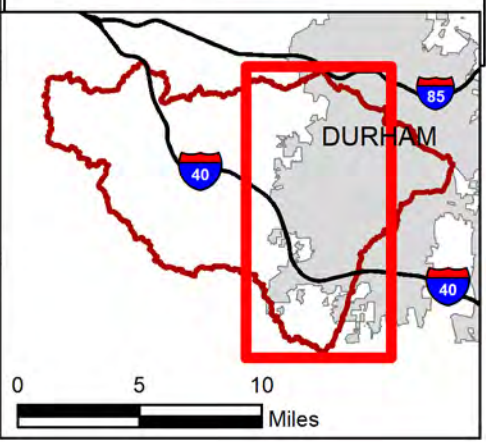
CITY OF DURHAM
NEW HOPE CREEK AND LITTLE CREEK
WATERSHED IMPROVEMENT PLAN



- Major Roads
 - Roads
 - Streams
 - Ponds and Lakes
 - Study Area
 - Subwatersheds
 - New Hope and Little Creek Watersheds
 - Durham City Limits - 2019
 - County Boundary
 - +
 - ▲
 -
 -
 - ◆
 - ★
 - ◇
- Potential sources of excess sediment
- Suspect water appearance
- Suspect Odor
- Low-head dam
- Exposed or threatened utility
- Headcut
- Litter Observed



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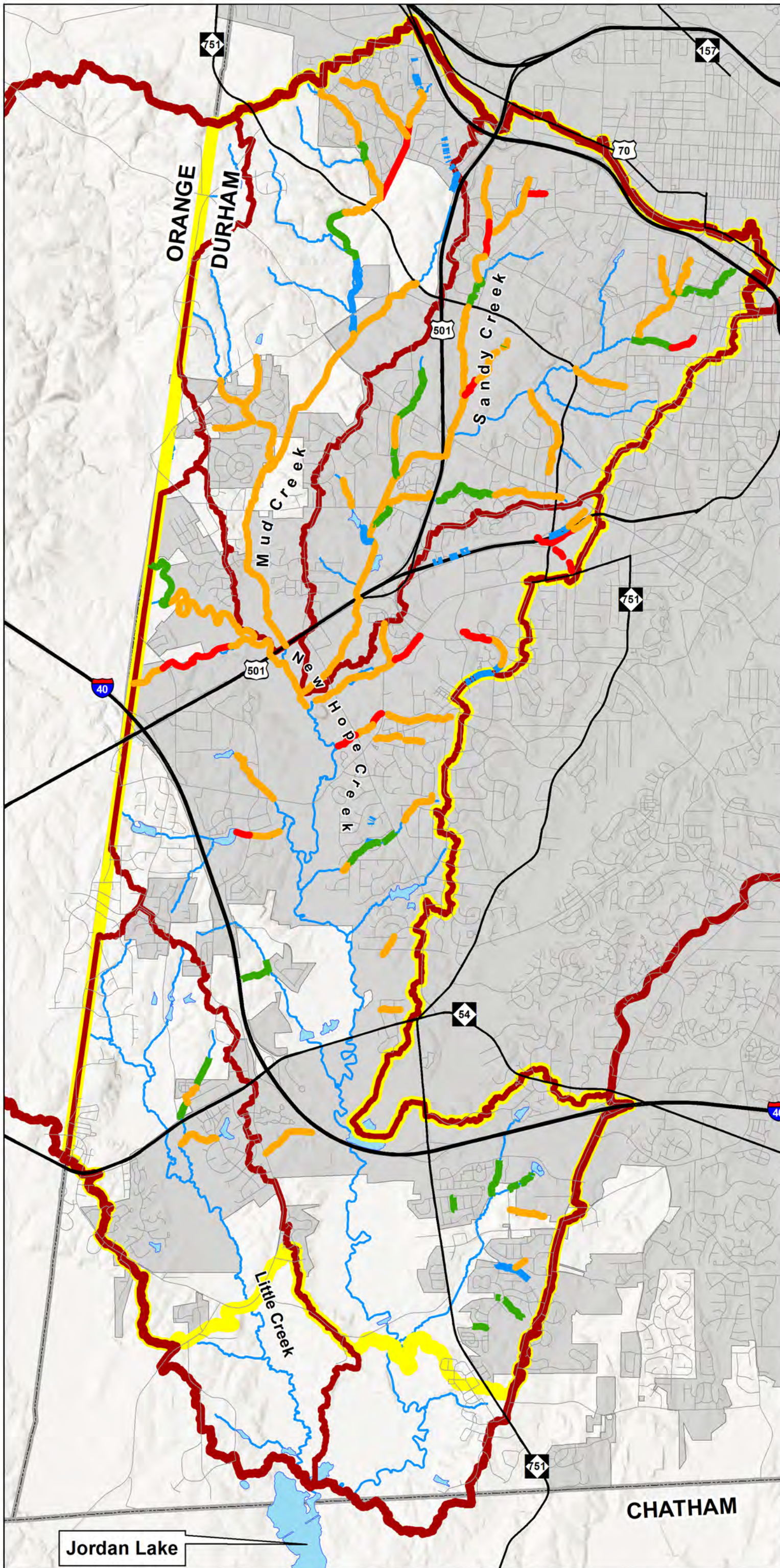


Jordan Lake

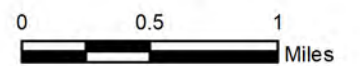
CHATHAM

Exhibit 13 Stream Quality Rating (RSAT)

CITY OF DURHAM
NEW HOPE CREEK AND LITTLE CREEK
WATERSHED IMPROVEMENT PLAN



- Major Roads
 - Roads
 - Streams
 - ▭ Ponds and Lakes
 - ▭ Study Area
 - ▭ Subwatersheds
 - ▭ New Hope and Little Creek Watersheds
 - ▭ Durham City Limits - 2019
 - ▭ County Boundary
- RSAT Rating**
- ▬ Good Condition (30-41)
 - ▬ Fair Condition (16-29)
 - ▬ Poor Condition (< 16)
 - ▬ Streams (Assessed but no RSAT)

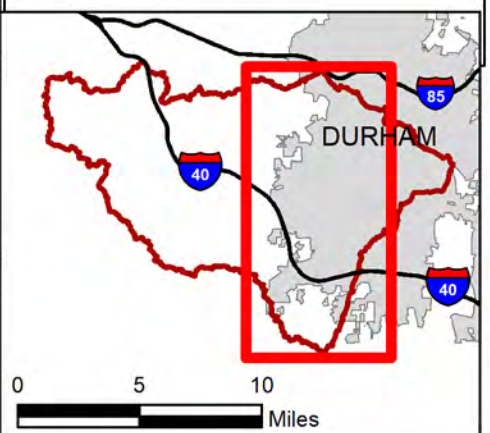


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DURHAM

AECOM

Kimley»Horn

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Jordan Lake

CHATHAM

ORANGE
DURHAM

Mud Creek

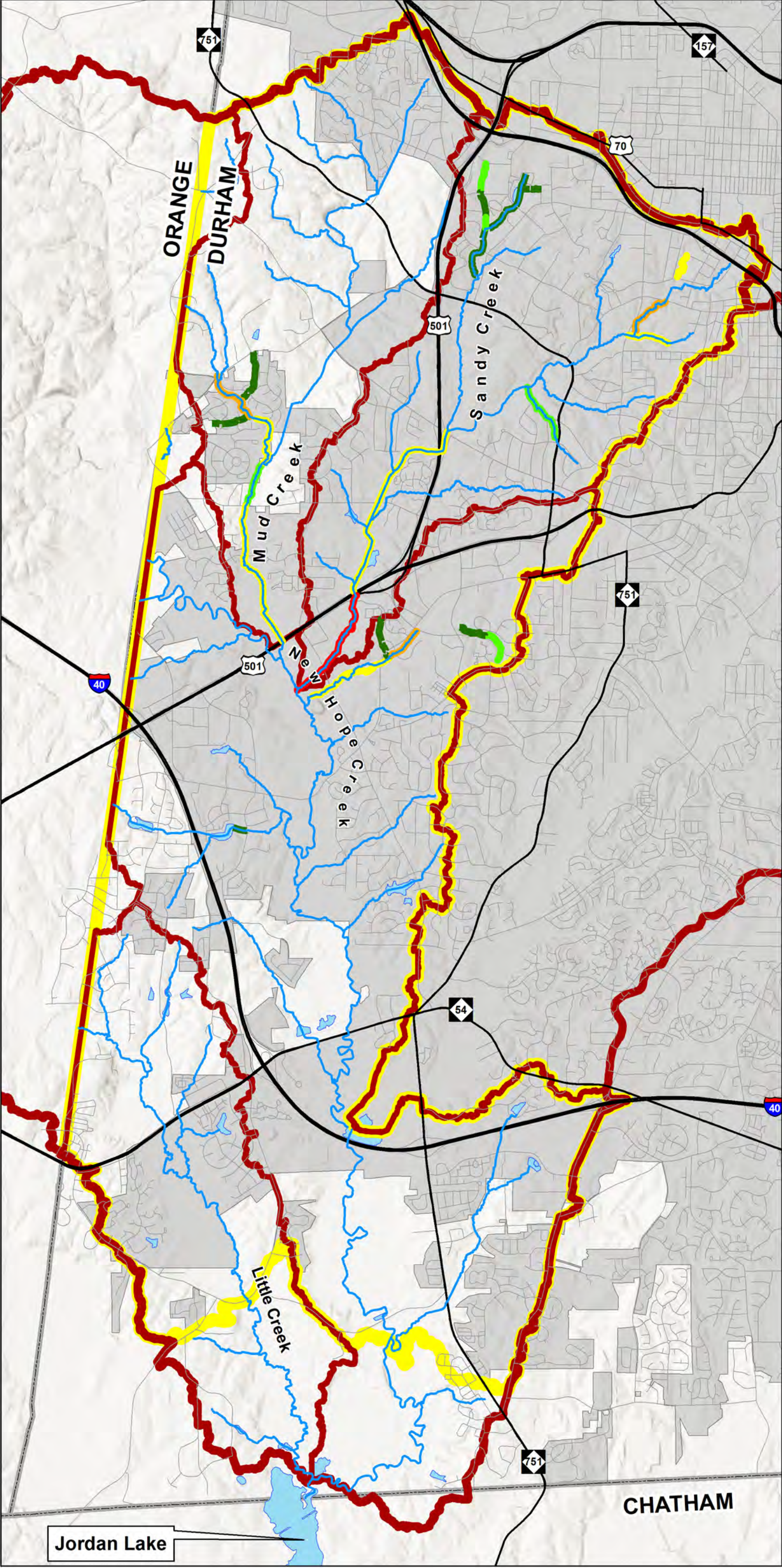
Sandy Creek

New Hope Creek

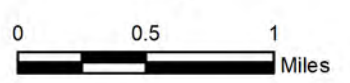
Little Creek

Exhibit 14 Stream Bank Erosion

CITY OF DURHAM
NEW HOPE CREEK AND LITTLE CREEK
WATERSHED IMPROVEMENT PLAN

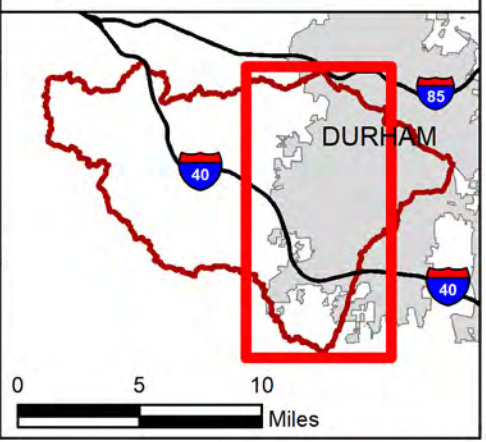


- Major Roads
 - Roads
 - Streams (Not Assessed for Bank Erosion)
 - Ponds and Lakes
 - Study Area
 - New Hope and Little Creek Watersheds
 - Subwatersheds
 - Durham City Limits - 2019
 - County Boundary
- Sediment Yield (tons/year)**
- 1-10 (tons/year)
 - 10-20 (tons/year)
 - 20-100 (tons/year)
 - 100-300 (tons/year)
 - >300 (tons/year)



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Jordan Lake

CHATHAM

ORANGE
DURHAM

Sandy Creek

Mud Creek

New Hope Creek

Little Creek

751

157

70

501

501

751

54

751

40

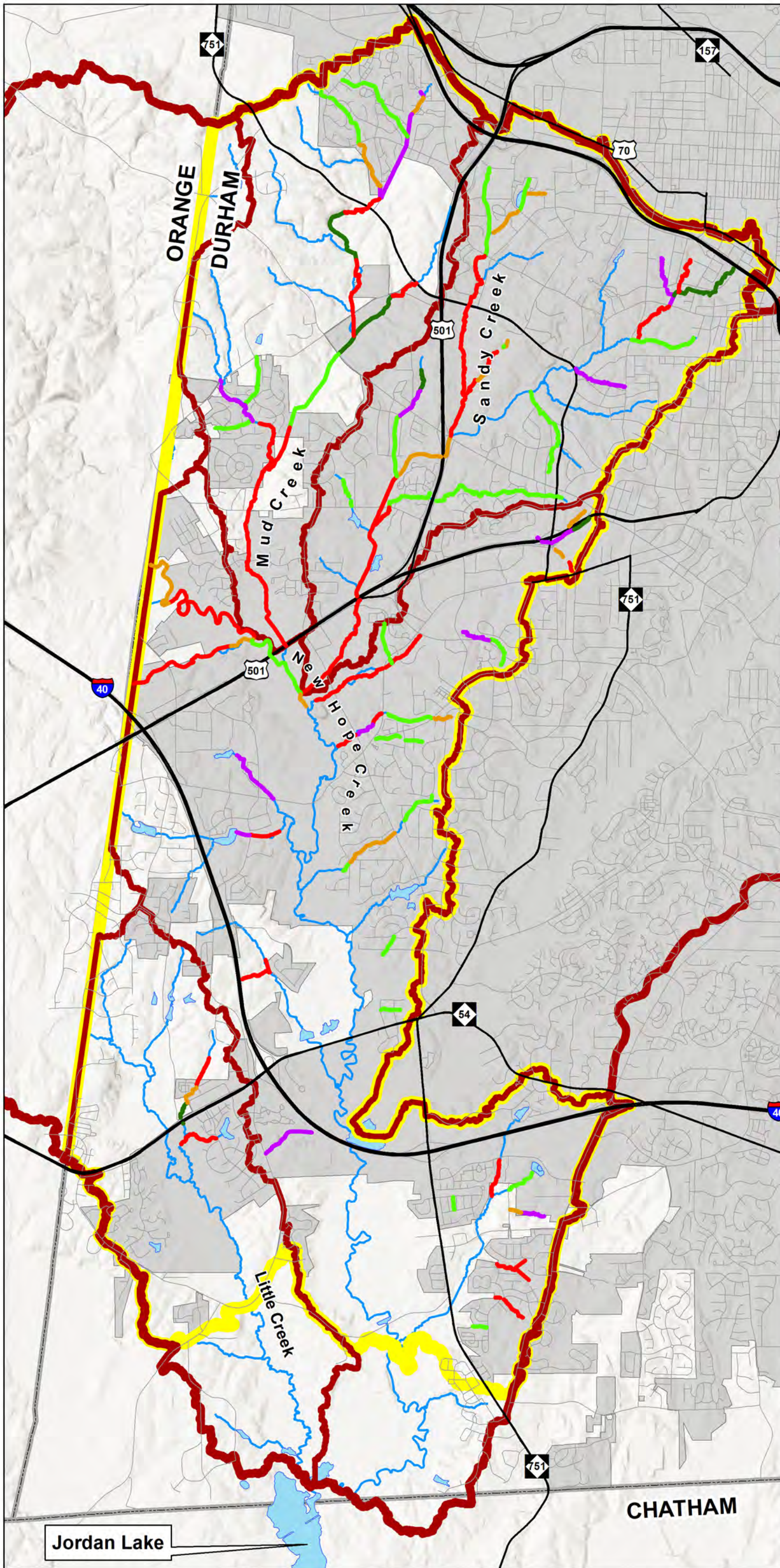
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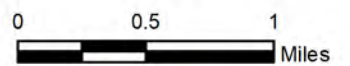
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Exhibit 15 Potential Stream Projects

CITY OF DURHAM
NEW HOPE CREEK AND LITTLE CREEK
WATERSHED IMPROVEMENT PLAN

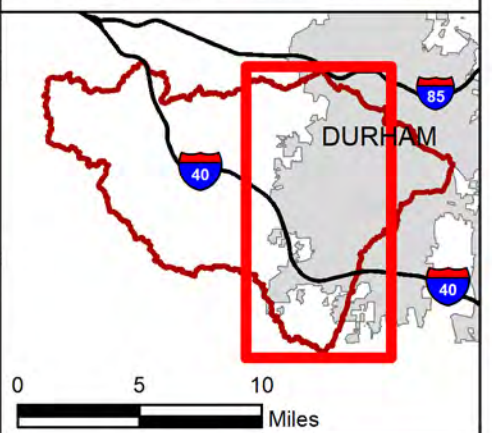


- Major Roads
 - Roads
 - Ponds and Lakes
 - Study Area
 - New Hope and Little Creek Watersheds
 - Subwatersheds
 - Durham City Limits - 2019
 - County Boundary
- Stream Project Potential (Number of Reaches)**
- Restoration
 - Stream Enhancement I
 - Stream Enhancement II
 - Bank Stabilization
 - Preservation
 - Other Streams not Prioritized for Projects



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AECOM
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Jordan Lake

CHATHAM

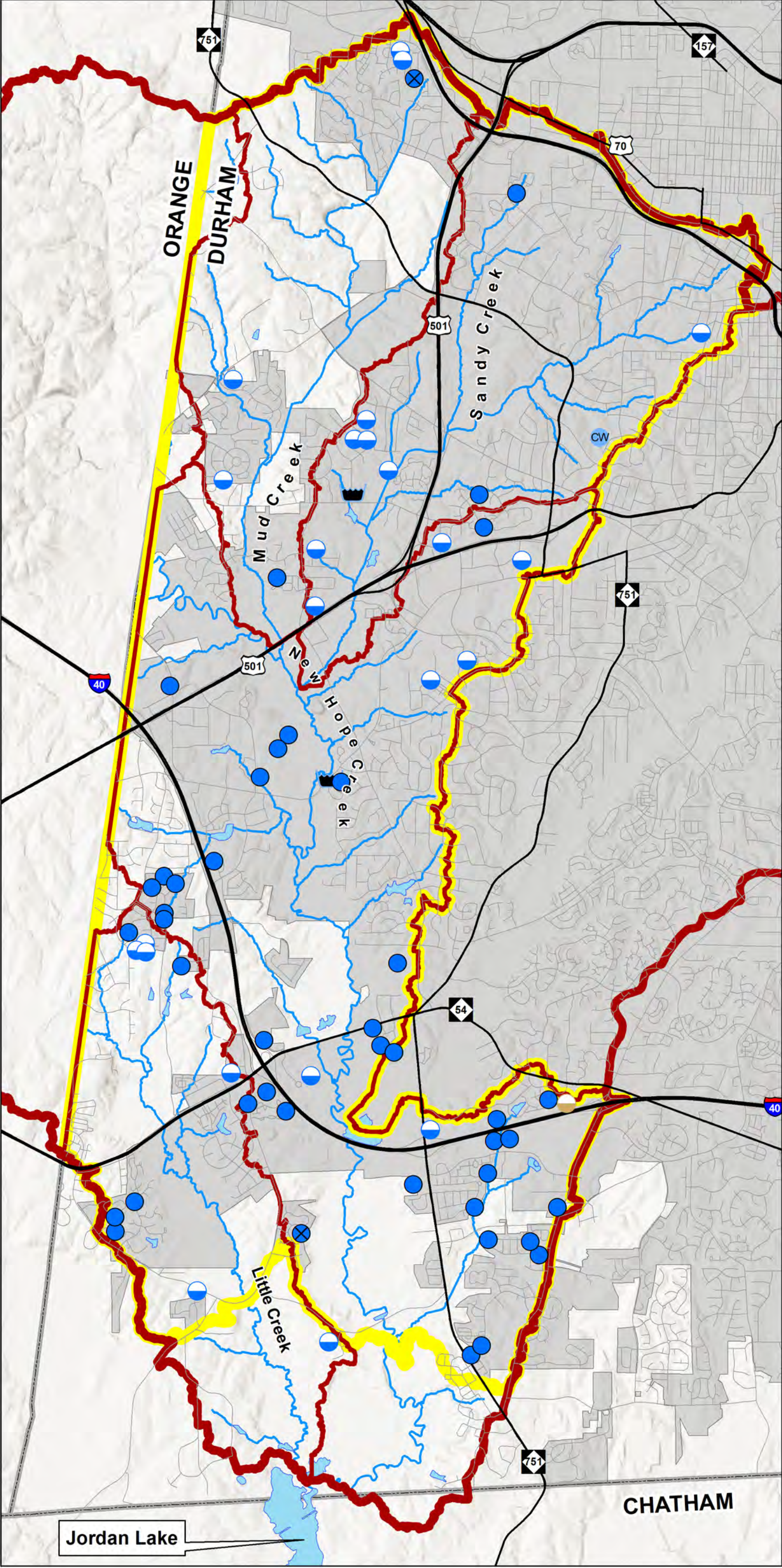
ORANGE
DURHAM

Mud Creek
New Hope Creek

Sandy Creek

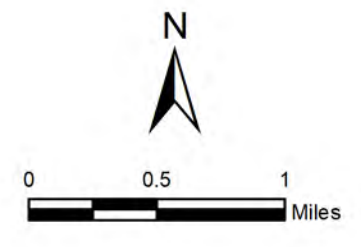
Little Creek

Exhibit 16
Existing Stormwater
Control Measures
Evaluated
 CITY OF DURHAM
 NEW HOPE CREEK AND LITTLE CREEK
 WATERSHED IMPROVEMENT PLAN

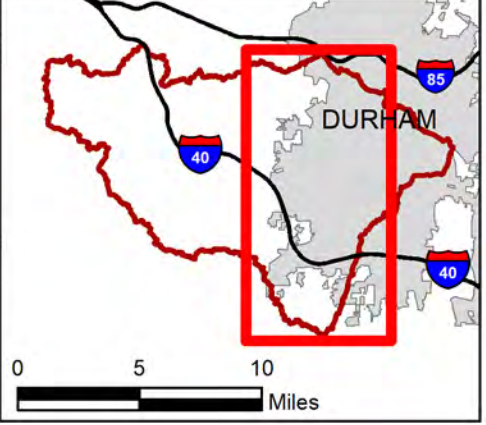


- Major Roads
- Roads
- Streams
- Ponds and Lakes
- Study Area
- New Hope and Little Creek Watersheds
- Subwatersheds
- Durham City Limits - 2019
- County Boundary

- Existing SCM Type**
- Bioretention w/o IWS
 - CW Constructed Wetland
 - Dry Pond
 - Sand Filter
 - Wet Pond
 - Existing Water Retention Feature (i.e. farm pond)



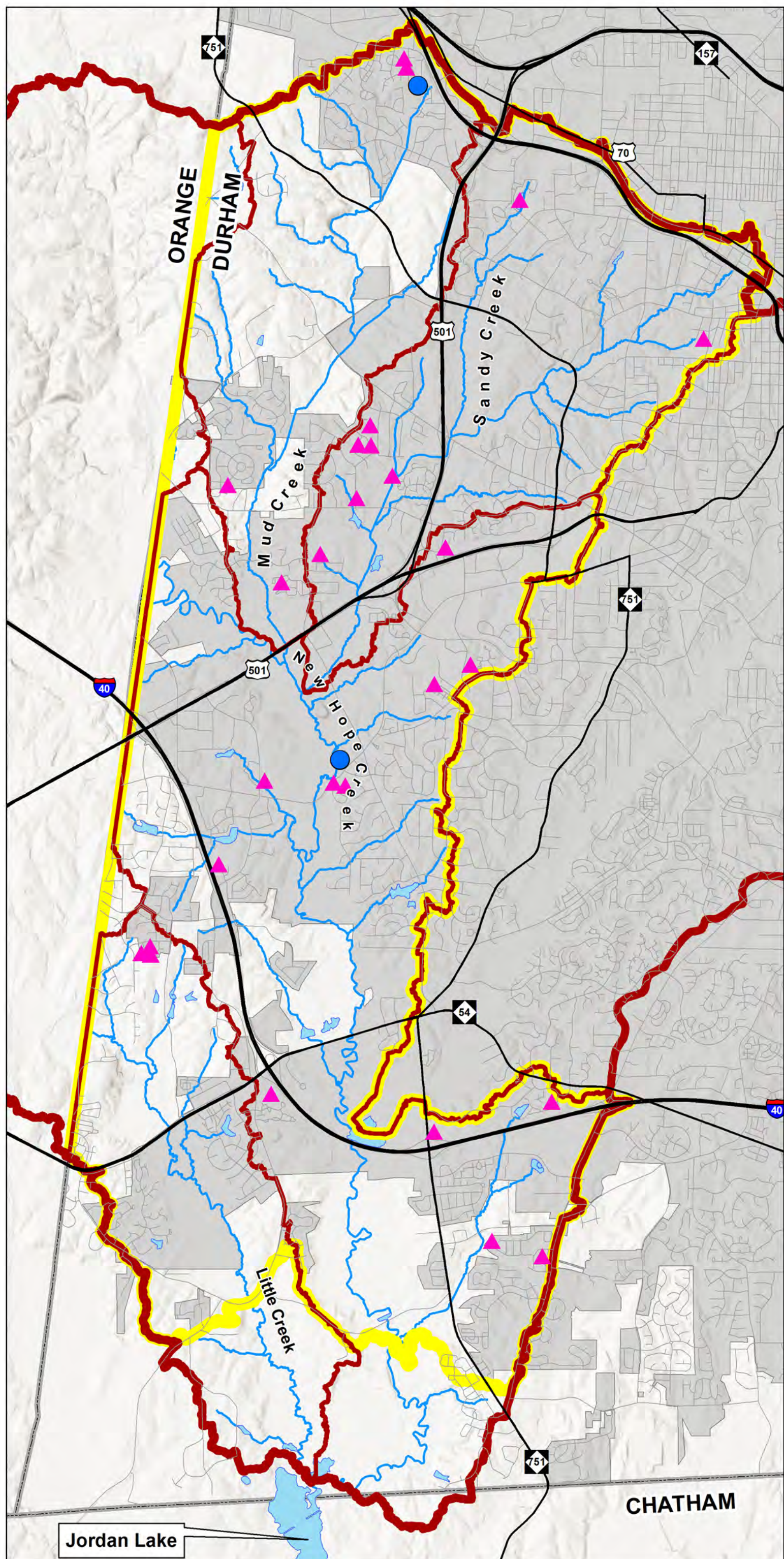
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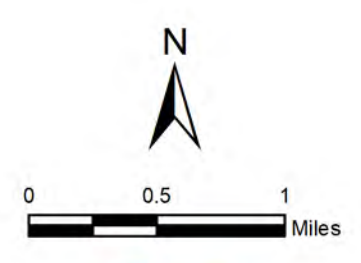
Jordan Lake

CHATHAM

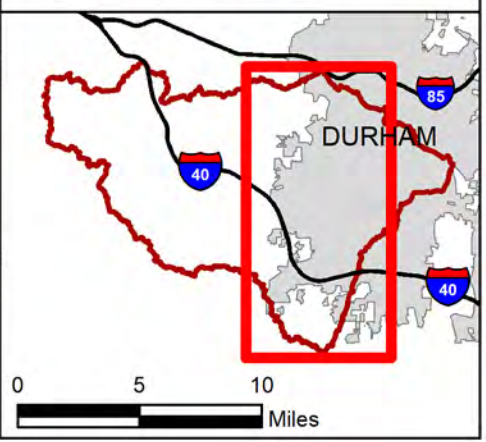
Exhibit 17
Potential Retrofits to Existing Stormwater Control Measures
 CITY OF DURHAM
 NEW HOPE CREEK AND LITTLE CREEK WATERSHED IMPROVEMENT PLAN



- Major Roads
 - Roads
 - Streams
 - Ponds and Lakes
 - Study Area
 - New Hope and Little Creek Watersheds
 - Durham City Limits - 2019
 - County Boundary
- Existing SCM Type**
- Existing Water Retention Features
 - ▲ Existing SCMs (SCM ID)



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Jordan Lake

CHATHAM

ORANGE
DURHAM

Sandy Creek

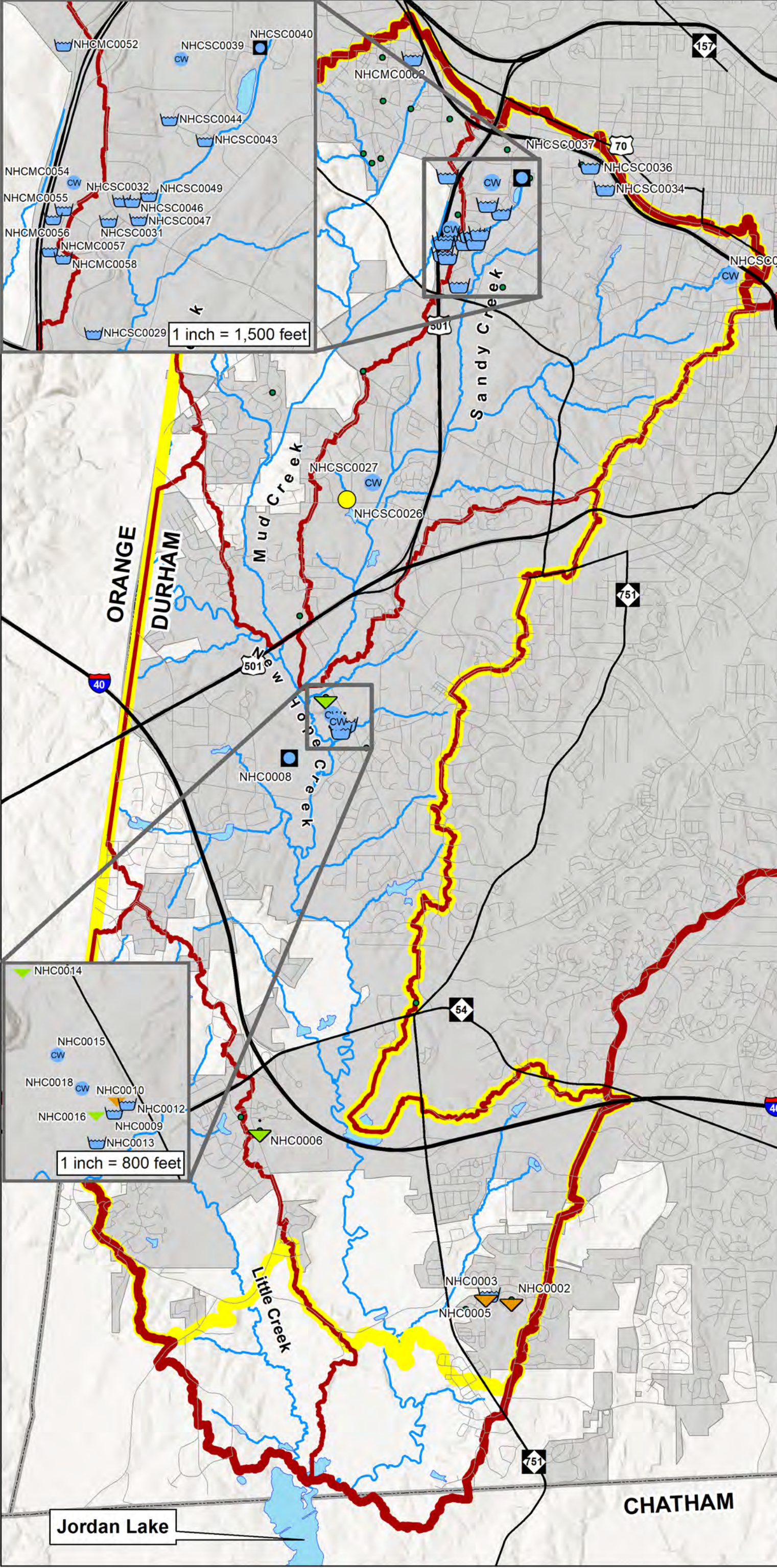
Mud Creek

New Hope Creek

Little Creek

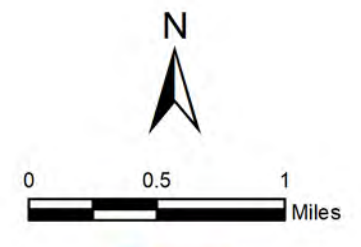
Exhibit 18 Potential New Stormwater Control Measures

CITY OF DURHAM
NEW HOPE CREEK AND LITTLE CREEK
WATERSHED IMPROVEMENT PLAN



- Major Roads
- Roads
- Streams
- Ponds and Lakes
- Study Area
- New Hope and Little Creek Watersheds
- Subwatersheds
- Durham City Limits - 2019
- County Boundary

- Potential New SCM Type**
- Bioretention
 - Constructed Wetland
 - Regenerative Stormwater Conveyance
 - Treatment Swale - Dry
 - Treatment Swale - Wet
 - Wet Pond
 - Other



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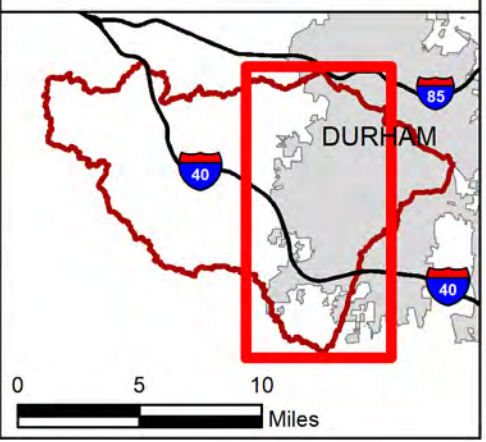
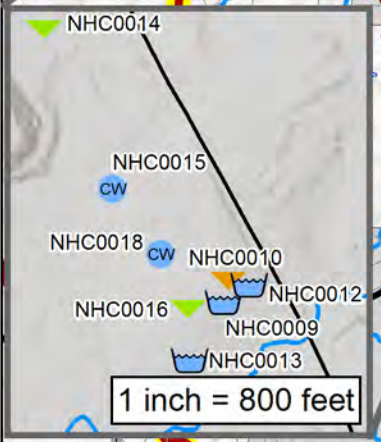
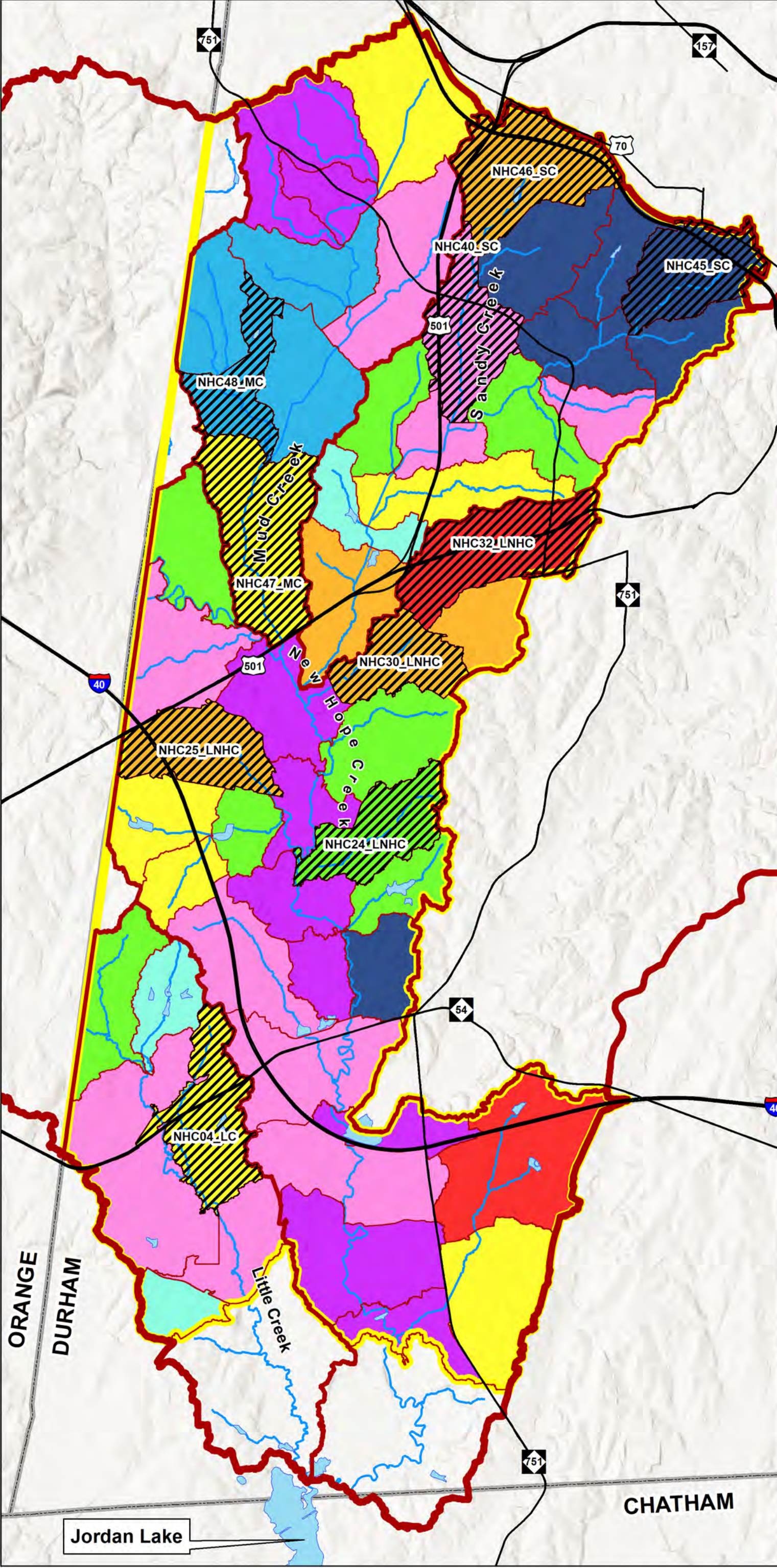
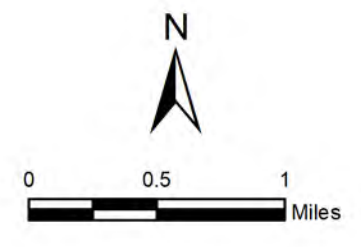


Exhibit 19 Pilot Study Areas

CITY OF DURHAM
NEW HOPE CREEK AND LITTLE CREEK
WATERSHED IMPROVEMENT PLAN



- Major Roads
 - Streams
 - Ponds and Lakes
 - Study Area
 - New Hope and Little Creek Watersheds
 - Major Subwatersheds
 - Subwatersheds
 - Candidate PSAs
 - County Boundary
 - Durham City Limits - 2019
- Subwatershed Groups**
- Parks and Open Space - Poorly Drained
 - Parks and Open Space - Well Drained
 - Low Density - Poorly Drained
 - Low and Medium Density Residential - Poorly Drained
 - High Density Residential and Commercial
 - Commercial
 - New Development - Poorly Drained
 - New Development - Well Drained
 - Institutional



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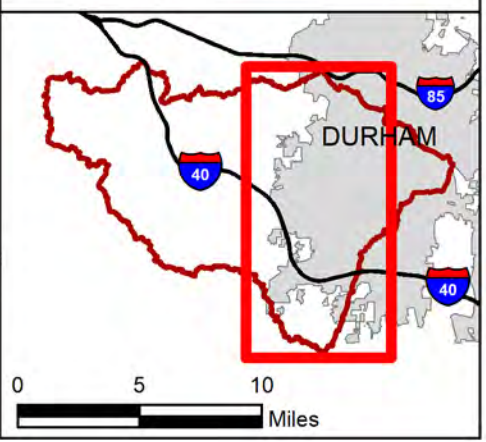
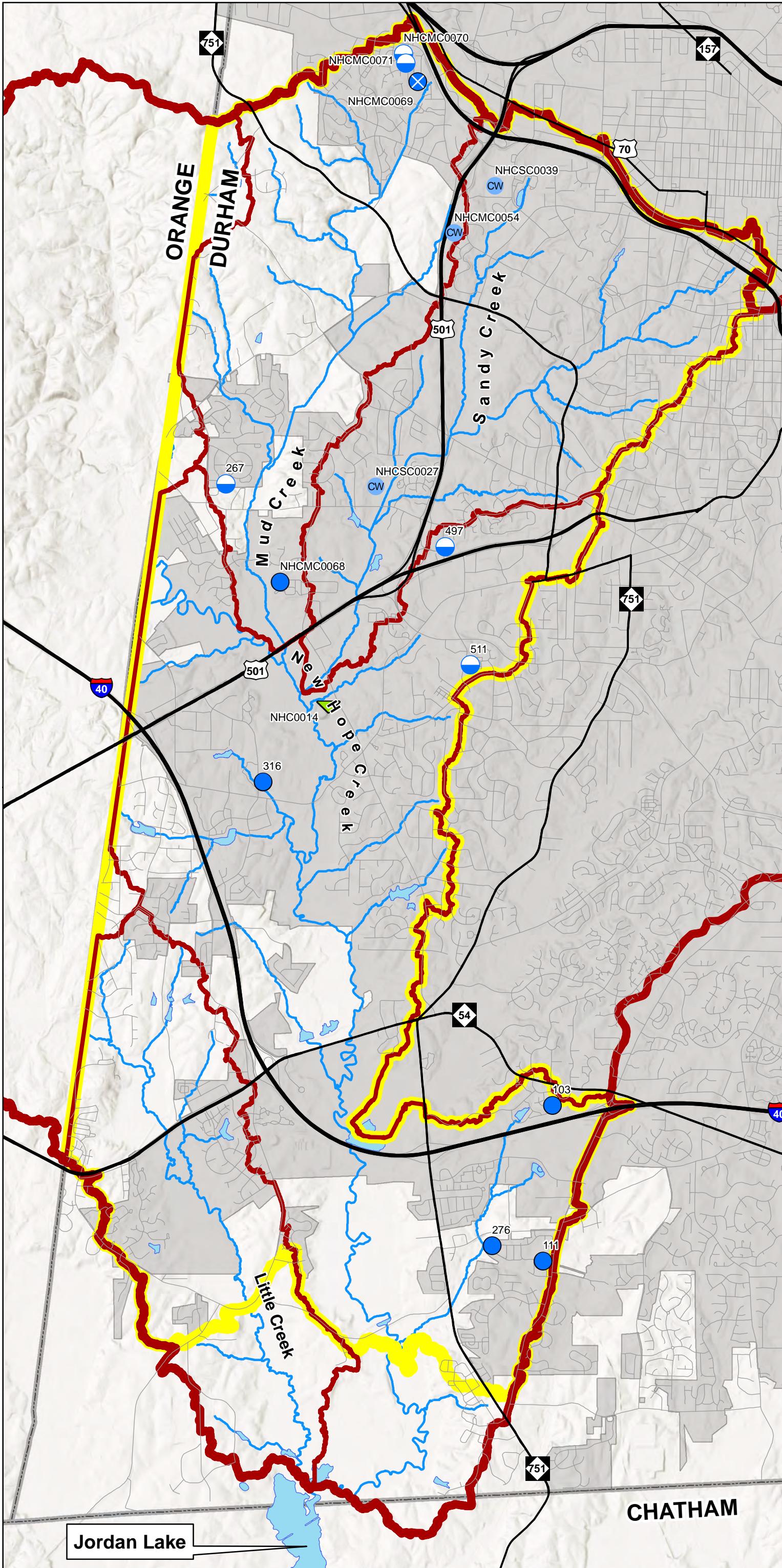


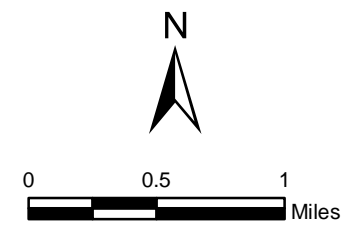
Exhibit 20 High Priority Stormwater Control Measures

CITY OF DURHAM
NEW HOPE CREEK AND LITTLE CREEK
WATERSHED IMPROVEMENT PLAN



- Major Roads
- Roads
- Streams
- Ponds and Lakes
- Study Area
- New Hope and Little Creek Watersheds
- Subwatersheds
- Durham City Limits - 2019
- County Boundary

- SCM Type**
- Constructed Wetland
 - Treatment Swale - Wet
 - Wet Pond
 - Dry Pond
 - Existing Water Retention Feature



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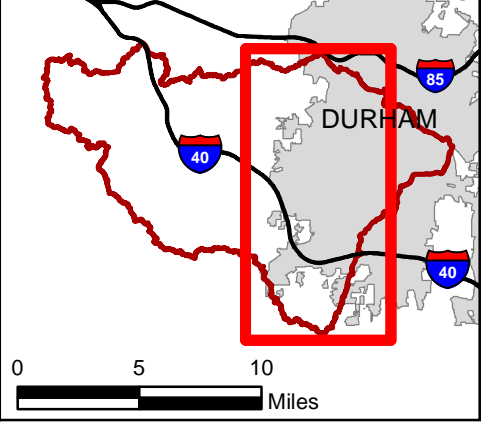
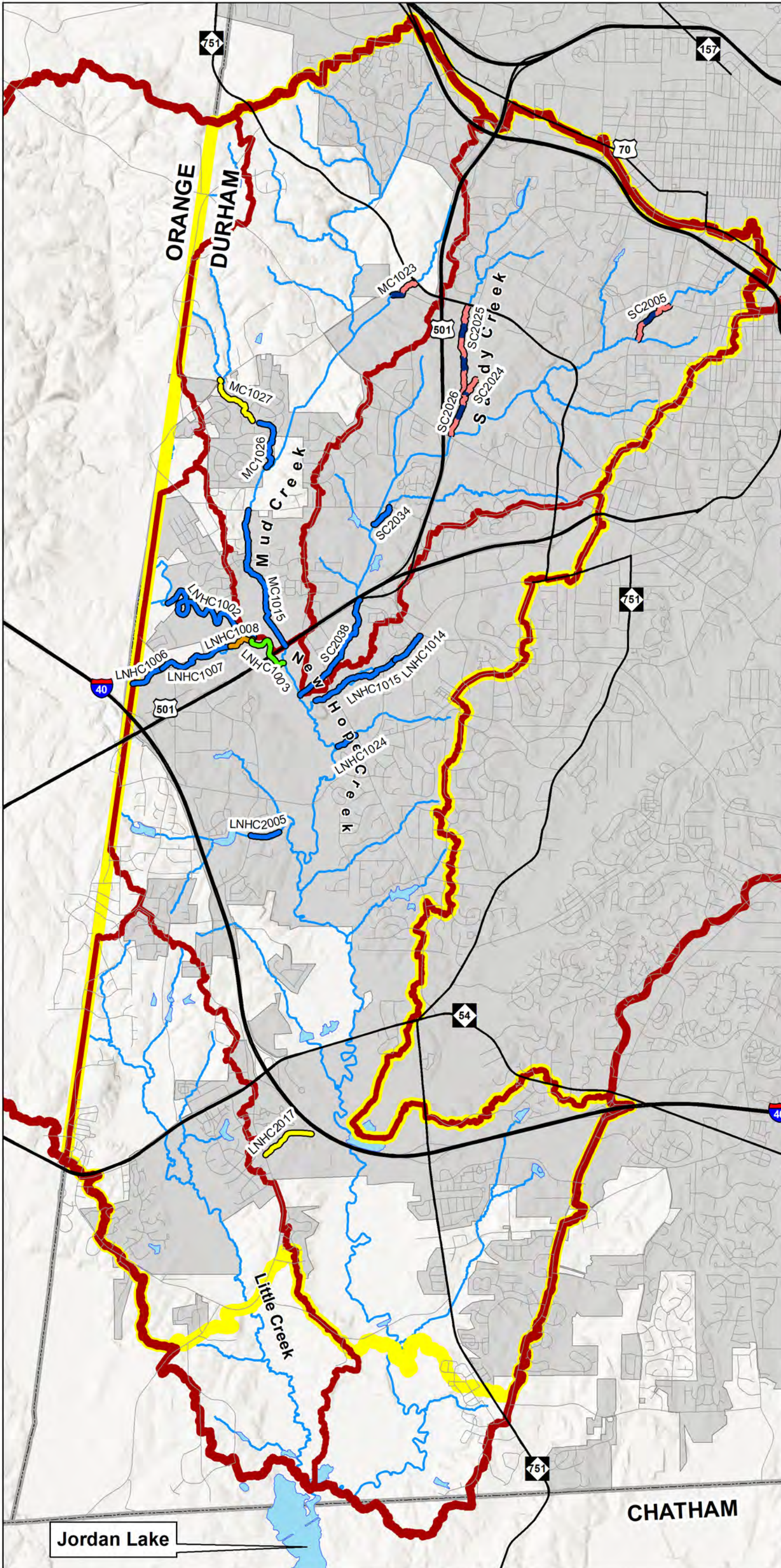
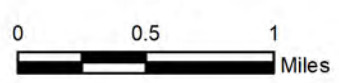


Exhibit 21 High Priority Stream Projects

CITY OF DURHAM
NEW HOPE CREEK AND LITTLE CREEK
WATERSHED IMPROVEMENT PLAN

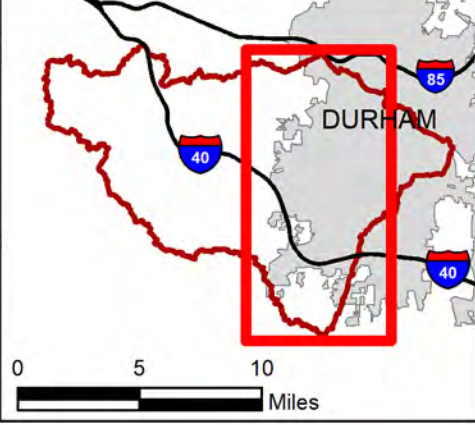


- Major Roads
 - Roads
 - Streams
 - Ponds and Lakes
 - Study Area
 - New Hope and Little Creek Watersheds
 - Subwatersheds
 - Durham City Limits - 2019
 - County Boundary
- High Priority Stream Projects (Number of Reaches)**
- Restoration (11)
 - Stream Enhancement I (2)
 - Stream Enhancement II (1)
 - Bank Stabilization (1)
- High Priority Stream Projects on Duke Property (Number of Reaches)**
- Restoration (5)



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DURHAM
AECOM

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Jordan Lake

CHATHAM

ORANGE
DURHAM

Mud Creek
Sandy Creek
New Hope Creek
Little Creek

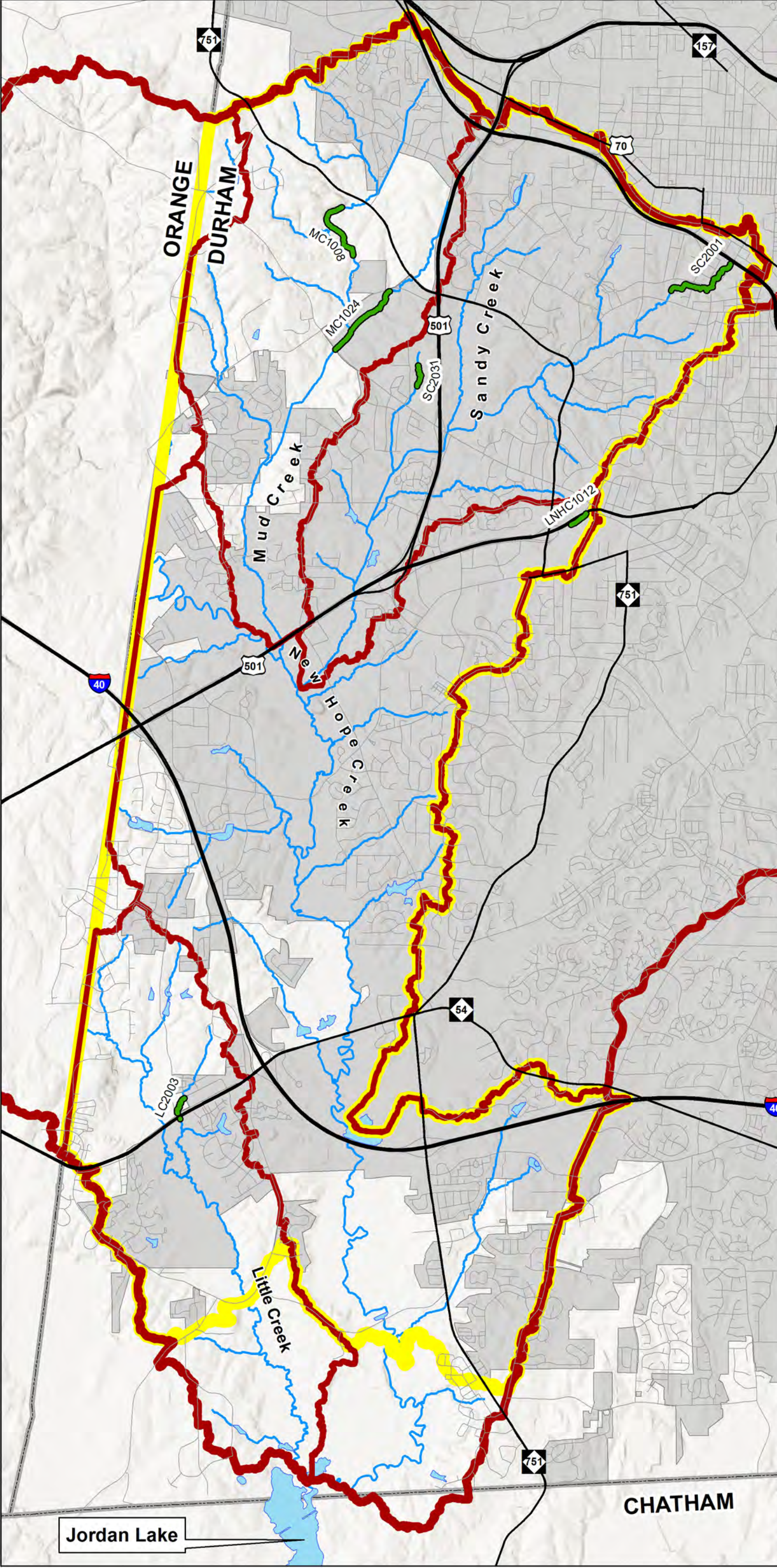
MC1023
MC1027
MC1026
MC1015
MC1024
SC2025
SC2024
SC2026
SC2005
SC2038
SC2034
LNHC1002
LNHC1008
LNHC1006
LNHC1007
LNHC1003
LNHC1015
LNHC1014
LNHC1024
LNHC2005
LNHC2017



Exhibit 22 Stream Reaches Identified for Preservation

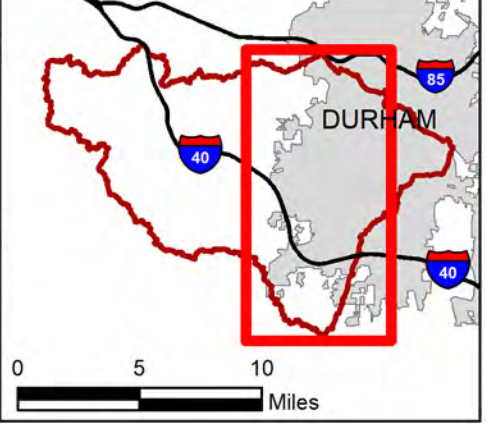
CITY OF DURHAM
NEW HOPE CREEK AND LITTLE CREEK
WATERSHED IMPROVEMENT PLAN

- Major Roads
- Roads
- Streams
- Ponds and Lakes
- Study Area
- New Hope and Little Creek Watersheds
- Subwatersheds
- Durham City Limits - 2019
- County Boundary
- Preservation Stream Reaches



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DURHAM
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Jordan Lake

CHATHAM

ORANGE
DURHAM

Mud Creek
New Hope Creek

Sandy Creek

Little Creek

MC108

MC1024

SC2031

70

501

751

LNHC1012

501

54

LC2003

40

751

85

40

40



Volume III Technical Appendices

August 2021

New Hope Creek and Little Creek Watershed Improvement Plan

Durham, North Carolina

PREPARED FOR:



City of Durham
Public Works Department
Stormwater & GIS Services Division
101 City Hall Plaza, Third Floor
Durham, North Carolina 27701

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New Hope Creek and Little Creek Watershed Improvement Plan



City of Durham
Stormwater & GIS Services Division
Public Works Department
101 City Hall Plaza, Third Floor
Durham, North Carolina 27701

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Acknowledgments

The AECOM Team received assistance from many individuals while completing the Watershed Improvement Plan for the New Hope Creek and Little Creek Watershed Improvement Plan, including the following:

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Jeff Lecky	Travis Marion
Erin Harrison	Cory Caddell
Antwon Williams	Sean McKnight

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Beth Reed
Jennifer Murphy
Andrew Jones
Jared Hodes
Brian Spiro

LimnoTech

Scott Bell
Julie Padilla
Peter Klaver

Three Oaks Engineering

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Tom Dickinson
Diana Young-Paiva
Meghan Makoid
Kate Monteith Sevick
Lizzy Stokes-Cawley
Lillian Lovingood

Davenport

Matt Michel
Ryenne Murphy

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Appendix B Stream Assessment Field Plan

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Appendix D Pilot Study Area Fact Sheets

Appendix E New Hope and Little Creek Watershed Assessment Report

Appendix F Critical Area Protection Plan

Appendix G Equitable Community Engagement Plan

Appendix H Technical Memorandum – New Hope Creek and Little Creek SWMM Model Development

Appendix I Technical Memorandum – New Hope Creek and Little Creek SWMM Scenario Analysis

Appendix J Technical Memorandum – Prioritization of Proposed Watershed Improvement Projects

Appendix K Technical Memorandum – Summary of Watershed Improvement Scenarios Used to Support the City of Durham Watershed Improvement Plans

Appendix L Public Education and Outreach Materials

Appendix M North Carolina Nine Element Plan Checklist

Appendix N Riparian Area Management Plan

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Introduction

The New Hope Creek and Little Creek Watershed Improvement Plan (WIP) is divided into three volumes, similar to previous City of Durham (City) watershed studies. The three volumes and supporting reports are:

- [Volume I: Executive Summary](#). Project goals, watershed evaluation methods, results of the watershed improvement scenarios, recommended projects, high-priority project fact sheets, and next steps in evaluating progress.
- [Volume II: Improvement Plan](#). Summary of the approach used to develop the WIP, data used to develop watershed models, stream and SCM inventory and assessments, watershed improvement scenarios, watershed improvement project evaluation and prioritization, public outreach and involvement efforts, recommendations, implementation schedule, and measurable milestones.
- [Volume III: Technical Appendices](#). Reports and memoranda with more detailed information on the technical approach used in the development of the WIP than in Volume II, including field surveys and the development of modeling.
- [Watershed Assessment Report](#). The New Hope Creek and Little Creek Watershed Assessment Report presents an analysis of the City of Durham's water quality monitoring data, existing and future land use, results of field assessments for streams and SCMs, and identification of impacts and sources to watershed functions. Pilot Study Areas and preliminary project opportunities are also identified.
- [Critical Area Protection Plan \(CAPP\)](#). The Critical Area Protection Plan (CAPP) identifies and prioritizes high-quality riparian preservation projects on private property throughout Durham. Properties were evaluated based on criteria that would enhance water quality and watershed health. The CAPP covers the entire city and provides an evaluation and summary of high-quality privately owned riparian buffer areas in Ellerbe Creek, Third Fork Creek, Northeast Creek, Crooked Creek, Little Lick Creek, Eno River, New Hope Creek, and Little Creek.
- [Riparian Area Management Plan \(RAMP\)](#). The purpose of the Riparian Area Management Plan (RAMP) is to identify, describe, and encourage maintenance practices that protect or enhance these areas to improve water quality and watershed health. The RAMP focuses on property that is either owned by the city or maintained by the city, such as utility easements, greenways, parks, trails, and facilities. The recommendations contained in the RAMP are intended for City maintenance staff who routinely operate in or maintain these areas; however, the recommendations may be useful to other, non-city groups who own or maintain land along streams or other riparian areas.

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Appendix A:

Data Control Plan

The purpose of the Data Control Plan is to describe the plan for managing the collection and use of the extensive amount of data required to support the development of the New Hope Creek and Little Creek WIP. The plan addresses the management and use of Geographic Information Systems (GIS), databases, spreadsheets, and web applications that were used to prepare the WIP and other project deliverables.

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Appendix B: Stream Assessment Field Plan

The Stream Inventory and Assessment Plan is a detailed work plan developed to guide field-based stream reach assessments that were used to support the development of the New Hope Creek and Little Creek WIP. The plan describes the methods for Level 1 and 2 stream assessments, data management, and quality control.

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Appendix C: Stormwater Control Measure Inventory and Assessment Field Plan

The Stormwater Control Measure Inventory and Assessment Field Plan is a detailed work plan developed to guide field-based stormwater control measure (SCM) evaluations that were used to support the development of the New Hope Creek and Little Creek WIP. The plan focuses on acquiring data to meet the New Hope Creek and Little Creek WIP goals, including the acquisition of pertinent SCM data to develop a watershed model, the identification of retrofits to existing SCMs to improve stormwater treatment, and the evaluation of potential new SCM locations to treat areas that are not currently served by an SCM.

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Appendix D:

Pilot Study Area Fact Sheets

Pilot Study Area (PSA) fact sheets are two-page descriptions of areas in the New Hope Creek and Little Creek watersheds that were selected for detailed field investigations and modeling to support the development of the New Hope Creek and Little Creek WIP. The PSAs represent typical subwatershed conditions (e.g., land use, imperviousness, soil type, future development plans, presence of existing SCMs). The PSAs are evaluated to determine water quality benefits associated with the implementation of SCMs, stream restoration, and other water quality improvement strategies.

The following five final PSAs were recommended for detailed field evaluation and modeling:

- Parks and Open Space – Poorly Drained: NHC40_SC
- Low Density – Poorly Drained: NHC24_LNHC
- Low Medium Density Residential – Poorly Drained: NHC04_LC, NHC47_MC
- High Density Residential and Commercial: NHC30_LNHC
- Commercial: NHC32_LNHC
- Institutional: NHC45_SC

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Appendix E:

New Hope Creek and Little Creek Watershed Assessment Report

The New Hope Creek and Little Creek Watershed Assessment Report presents an analysis of water quality monitoring data, existing and future land use, results of field assessments for streams and SCMs, and identification of impacts and water quality concerns. Pilot Study Areas and preliminary project opportunities are also identified.

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Appendix F:

Critical Area Protection Plan

The Critical Area Protection Plan (CAPP) identifies and prioritizes high-quality riparian preservation projects on private property throughout the City of Durham (City) that could be prioritized for conservation or protection to preserve water quality and watershed health. The CAPP covers the entire City and provides an evaluation and summary of high-quality privately owned riparian buffer areas in Ellerbe Creek, Third Fork Creek, Northeast Creek, Crooked Creek, Little Lick Creek, Eno River, New Hope Creek, and Little Creek.

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Appendix G:

Equitable Community Engagement Plan

The Equitable Community Engagement Plan provides a framework to guide the decision-making process of the New Hope Creek and Little Creek Watershed Improvement Plan (WIP) so all residents of Durham have equitable access to the information from, and opportunities to provide input on, the project. The memo discusses the various strategies and aspects of community engagement relating to this WIP, including: the demographics of the New Hope Creek and Little Creek watershed, potential partnerships with community groups who can assist in outreaching to historically underrepresented groups, suggested events for public engagement and participation.

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Appendix H: Technical Memorandum – New Hope Creek and Little Creek SWMM Model Development

The New Hope Creek and Little Creek SWMM Model Development technical memorandum describes the development and calibration of a Stormwater Management Model (SWMM) watershed model to support development of a WIP for the New Hope Creek and Little Creek watersheds.

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Appendix I:

Technical Memorandum – New Hope Creek and Little Creek SWMM Scenario Analysis

The New Hope Creek and Little Creek SWMM Scenario Analysis memorandum describes the application of the SWMM model to assess potential reductions in total nitrogen, total phosphorus, and total suspended solids that could be gained through implementation of improvement measures in the New Hope Creek and Little Creek watersheds. The following ten scenarios were assessed as part of this modeling:

1. Existing land use
2. Future land use and existing stormwater control measure repairs
3. Future land use with stormwater performance standards for new development and redeveloped parcels
4. New SCMs and retrofits
5. Stream restoration
6. Green infrastructure and low impact design
7. Additional treatment for pre-1980 development and commercial land uses
8. Oversizing new SCMs and SCM retrofits
9. Enhanced Street Sweeping
10. Combined nonpoint source pollution projects (combining Scenarios 2-9)

This technical memorandum summarizes the methods and results for those scenarios.

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Appendix J:

Technical Memorandum – Prioritization of Proposed Watershed Improvement Projects

The Prioritization of Proposed Watershed Improvement Projects Technical Memorandum presents the evaluation, prioritization, and ranking process for the proposed SCM retrofit and stream restoration projects in the New Hope Creek and Little Creek watershed. As with previous Watershed Improvement Plans, project prioritization criteria were updated to reflect watershed-specific concerns in the New Hope and Little Creek watershed and incorporate current city strategies and priorities of environmental-equity based decision-making. The updates to the prioritization criteria were informed by the Residential Green Infrastructure (ReGI) Analysis, Equitable Community Engagement Plan, City of Durham FY 2019-2021 Strategic Plan, and Sustainability Roadmap. Overall, criteria remain directly comparable to the scores assigned to potential projects in other Durham watersheds (Ellerbe Creek, Third Fork Creek, Northeast Creek, Crooked Creek, Little Lick Creek, and Eno River).

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Appendix K: Technical Memorandum – Summary of Watershed Improvement Scenarios Used to Support the City of Durham Watershed Improvement Plans

The Summary of Watershed Improvement Scenarios Used to Support the City of Durham Watershed Improvement Plans Technical Memorandum provides a summary of the watershed scenarios that were evaluated during watershed planning studies conducted by the City of Durham in the Ellerbe Creek, Third Fork Creek, Northeast Creek, Crooked Creek, Little Lick Creek, and Eno River watersheds. The scenarios have been used to evaluate the effectiveness of water quality improvement practices, including stormwater control measure retrofits, stream restoration projects, sanitary sewer system rehabilitation, stormwater performance standards for new development and redevelopment, land conservation, and green infrastructure/low impact development (techniques to improve watershed-wide water quality). The memorandum also discusses the scenarios that were selected for evaluation in the New Hope Creek and Litter Creek watersheds, the methodology, and the results.

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Appendix L:

Public Education and Outreach Materials

Appendix L presents the materials that were prepared to support the public education and outreach efforts by the City for the New Hope Creek and Little Creek WIP. The materials include:

- Meeting summaries of the three Public Information Sessions held on September 23, 2020, March 16-18, 2021, and June 29, 2021
- Three Project Fact Sheets prepared for each Public Information Session
- Two videos were prepared during this project and are available at:
 - https://youtu.be/XwBw3_TnLlc
 - <https://youtu.be/leiRzHpg7Z0>
- A radio spot was developed in Spanish and broadcasted on the channel La Ley 101.1FM to reach the Spanish-speaking population. The radio message was focused on recycling motor oil and keeping the watershed clean. The recorded message is available at: <https://durhamnc.gov/3766>.

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Appendix M: North Carolina Nine Element Plan Checklist

Appendix M is a checklist that shows how the New Hope Creek and Little Creek WIP meets the nine elements that are required in watershed plans by Section 319 of the Clean Water Act. The checklist is required if the City applies for grant funding to implement any future projects identified under the plan.

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Appendix N: Riparian Area Management Plan

The Riparian Area Management Plan (RAMP) identifies maintenance practice opportunities to enhance or extend riparian buffers or to improve existing maintenance practices on city-owned property near and along streams. The RAMP document is reassessed and updated as part of each WIP to reflect the City's goals of supporting an equitable implementation of maintenance practices along riparian areas to support biodiversity and water quality. Updates to the RAMP that were a part of the New Hope Creek and Little Creek WIP included field data collection to determine the width of three existing no mow buffer zones and the identification of four areas of potential new no mow sites. The latest RAMP update also incorporates the City's environmental equity and sustainability goals described in other planning documents including the City's Sustainability Roadmap and Strategic Plan. The RAMP update includes "tool kits" that can be used by City departments to improve riparian areas such as native seed mixes, native tree lists, and planting strategies for buffer areas.

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