2024

Horse Creek Watershed Plan

DEVELOPED FOR THE TOWN OF WAKE FOREST, NORTH CAROLINA

American Rescue Plan Act
ARPA
FUNDING

TOWN of WAKE FOREST

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Executive Summary

Falls Lake, in the Piedmont of North Carolina, is classified as a Nutrient-Sensitive Water (NSW) by the North Carolina Department of Environmental Quality (DEQ). The Upper Neuse River Basin Association (UNRBA) developed an Interim Alternative Implementation Approach (IAIA) to the NSW strategy so that communities with land draining to the lake may take actions to reduce nutrient loading. A portion of the land within the Horse Creek Watershed, which drains to Falls Lake, lies within the jurisdiction of the Town of Wake Forest (TOWF). As such, the Town has developed a watershed plan supported by an empirical water quality modeling framework that examines existing and future pollutant loading conditions within the watershed. The plan identifies and prioritizes projects that the TOWF may implement to comply with the IAIA and reduce nonpoint sources of nutrients to Falls Lake. The work conducted to produce this plan was funded through the American Rescue Plan Act (ARPA).

1.0 Introduction

1.1 Background, Purpose, and Need

As a member of the Upper Neuse Basin Association (UNRBA), it is in the interest of the Town of Wake Forest (TOWF) to have a watershed plan developed for the Horse Creek watershed, and to have that watershed plan supported by an empirical water quality modeling framework that will allow for examination of existing and future pollutant loading conditions, specifically nutrient loading, within the watershed. The watershed plan and supporting model framework will be used in tracking compliance with the Falls Lake Nutrient Sensitive Waters (NSW) requirements (discussed below), and in specifically with the UNRBA's Interim Alternative Implementation Approach (IAIA) to the NSW strategy. Rather than continuing to rely on hard numeric targets for nutrient load reduction to improve water quality in the lake, the IAIA stipulates that each member government meet a financial spending target annually toward the development and implementation of water quality improvement projects. The North Carolina Department of Environmental Quality (DEQ) approved the IAIA within a context of adaptive management, such that as long as water quality monitoring data showed improvement in the Lake, the IAIA would continue to stand in lieu of the numeric loading targets.

In this case, the watershed modeling framework developed to support this watershed plan relies on the well-established, Watershed Treatment Model (WTM), originally developed by the Center for Watershed Protection. The WTM and associated methods and results specific to the Horse Creek Watershed are described at length in Chapter 3 and Appendix A. This watershed plan and supporting model framework are intended to help guide the town by identifying a suite of project opportunities, such as implementation of new stormwater structural control measures (referred to in this document as BMP Retrofits) within existing, already developed landscapes, or stream restoration projects, and to illustrate the nutrient load reductions resulting from those projects The plan also seeks to prioritize projects by factors such as ease of implementation (feasibility) and cost-effectives in order to assist decision-makers in setting priorities and making meaningful investments in water quality improvement going forward.

The model will be developed for the closest approximation of the Wake County portion of the Horse Creek watershed that is consistent with the subwatersheds utilized for the UNRBA's Watershed Analysis Risk Management Framework (WARMF) watershed model in maintain consistency with that larger assessment and management effort. The Wake County portion of the Horse Creek Watershed was also selected as the study area because it represents a likely westward growth area for the TOWF.

1.1.1 Falls Lake Impairment

The Falls Lake Reservoir ("Lake") is a 12,400-acre impoundment that was created by the US Army Corps of Engineers to provide flood control and recreation on the Neuse River. Work began on the Falls Lake dam in 1978. It was completed in 1981 and impounds an average volume of 114,740 acre-feet. The Lake is also a major local water supply to surrounding communities. In Wake County, it supplies 41 million gallons per day in drinking water for approximately 500,000 people.

The Falls Lake contributing watershed (**Figure 1**) drains 770 square miles across six counties (Durham, Franklin, Granville, Orange, Person, and Wake counties) in the north-central portion of North Carolina. The watershed is currently 59% forested, 16% agriculture, and 15% developed, with approximately 90,000 residents. However, the area is rapidly developing, given its proximity to the cities of Raleigh, Durham, and Chapel Hill.

In recent years shallow upper portions of the Lake have experienced frequent violations of water quality standards for chlorophyll *a*, an indicator of algal productivity and blooms which is used to measure the impact of nutrient pollution. The Lake has exceeded the State's chlorophyll a standard since 2008 and continues to exceed standards. Although the Lake has recently experienced fewer violations since a peak during the 2005-2007 monitoring period, some segments are still on DEQ List of Impaired Waters.

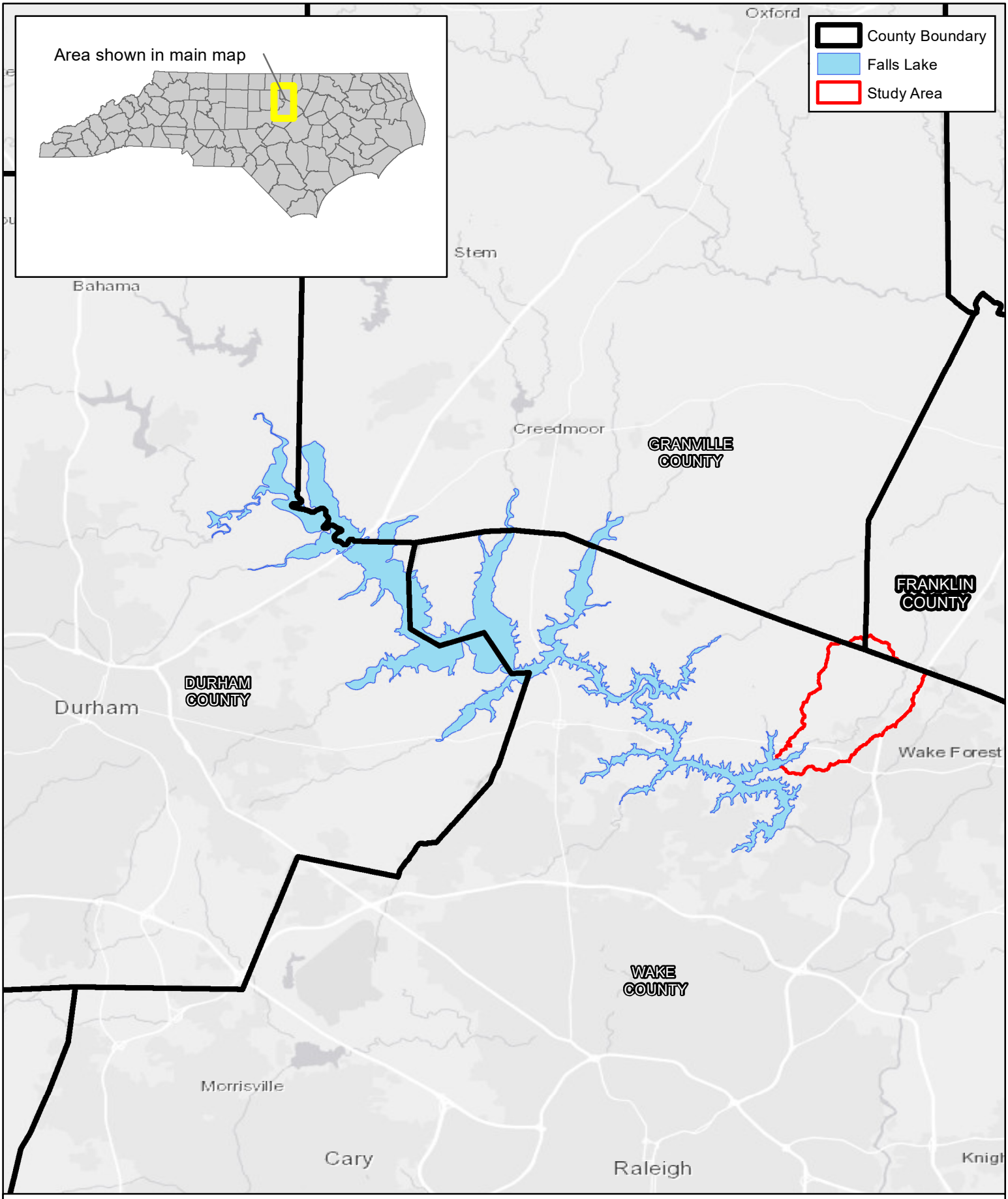
Primary Surface Water Classifications are designations applied to surface water bodies by the DEQ Division of Water Resources (DWR) to define the best uses to be protected within these waters, and as a tool that state and federal agencies can use to manage and protect all streams, rivers, lakes, and other surface waters. Supplemental classifications are sometimes added by DWR to the primary classifications to provide additional protection to waters with special uses or values. The waters within Falls Lake have been assigned a primary classification of Class C, WS-IV, and a supplementary classification of Nutrient Sensitive Waters (NSW), which is intended for waters needing additional nutrient management due to being subject to excessive growths of microscopic or macroscopic vegetation.

1.1.2 Falls Lake Nutrient Management Strategy

To address the NSW designation and improve the water quality of the Lake without discouraging development within the contributing watershed, the NC General Assembly implemented the Falls Lake Nutrient Management Strategy in 2011. Also known as the Falls Lake Rules ("Rules"), the Rules are a nutrient management strategy designed to restore water quality in the Lake by reducing the amount of pollution entering upstream.

The Rules require nutrient load reductions related to all potential sources within the watershed, including wastewater discharges, agriculture, and new and existing development. They establish nutrient loading levels from 2006 as the baseline year. Phase 1 of the Rules targets an overall 20% reduction in nitrogen and a 40% reduction in phosphorous from baseline. Phase 2 targets will eventually require a 40% reduction in nitrogen loading and a 77% reduction in phosphorous.

To help achieve these reductions, the Rules place strict requirements on new development within all areas of the watershed. The Rules also require DEQ to report on the lake's status every five years. The most recent report was completed in 2021. It indicated that both agriculture and wastewater segments have achieved reductions greater than those required in the rules. Successful reductions allowed DEQ to



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Horse Creek Watershed
Figure 1. Vicinity Map

N W E S

0 2.5 5 Miles

Map Created: February 2023
Image Source: NC Statewide Orthoimagery, 2015

consider alternative compliance/implementation strategies to address loading from existing development.

1.1.3 UNRBA and Interim Alternative Implementation Approach

The Upper Neuse Basin Association is an association of communities in the upper Neuse River Basin. In 2018, UNRBA started working on ideas for communities to comply with the Falls Lake Rules, which will be up for re-adoption in 2025. As a result of this work, member communities developed an Interim Alternative Implementation Approach (IAIA) strategy to address NSW. The IAIA is a voluntary approach for communities to take steps to reduce nutrient loads so that additional restrictions on existing land use and new development are not put into place. Through the IAIA, member communities can demonstrate commitment to addressing NSW by implementing water quality projects in their respective portions of the Falls Lake Watershed on an annual basis. Financial commitments for each community were determined by the relative percentage of contributing area to Falls Lake that lies within jurisdictional boundaries. **Table 1** shows the TOWF annual financial commitment to funding water quality projects under the IAIA, respective to funding levels of neighboring communities.

Table 1. Local Government Financial Commitment Levels for Members that Choose to Participate in the Stage I ED IAIA

Member	Annual Funding Level	Member	Annual Funding Level
Town of Butner	$23,393	Town of Hillsborough	$34,221
City of Creedmoor	$16,926	Orange County	$161,943
City of Durham	$337,587	Person County	$114,394
Durham County	$133,300	City of Raleigh	$466,081
Franklin County	$19,058	Wake County	$88,968
Granville County	$100,453	Town of Wake Forest	$13,692
Town of Stem	$11,605		

1.2 Watershed-Based Plan

Watershed planning is an effective method of documentation for community efforts to maintain, protect, or restore the natural resources within a watershed while also enhancing the quality of life for residents. It is in the best interest of the TOWF to have a localized water quality model that can be utilized to support a watershed plan for Horse Creek. A local model will help pinpoint potential sources of nutrients within the Horse Creek Watershed, both under current and projected future land use conditions. It can also be used to estimate the benefits of a variety of potential practices and structural control measures the TOWF could implement to reduce nutrient loads within the watershed.

The TOWF has elected to complete the Horse Creek Watershed Study (“Study”) to document existing conditions within the watershed via the results of the local watershed model, and to identify and prioritize potential activities that the Town can implement to track compliance with the Falls Lake NSW requirements, and specifically with the UNRBA’s IAIA to the NSW strategy. The results of the Study are documented within this watershed plan.

1.3 Study Goals and Objectives

The goals of the Horse Creek Watershed Study are to:

- Identify opportunities for new stormwater management practices or retrofits within the TOWF-managed portion of the Horse Creek Watershed that drains to Falls Lake.
- Identify degraded stream reaches and stream restoration opportunities within the Horse Creek Watershed.
- Provide a tool to help manage future change within the Watershed.

The Watershed Treatment Model (WTM), developed by the Center for Watershed Protection, is a relatively low-cost method that can be used to estimate pollutant loads from existing land uses. WTM requires basic land use information and calculates surface runoff loads. Pollutants modeled include total nitrogen (TN), total phosphorus (TP), total suspended solids (TSS) and fecal coliform.

The TOWF elected to use WTM for the Horse Creek Watershed Study due to the scale of the study watershed, available existing data for modeling, and the capabilities within the model to evaluate the benefits of a variety of activities to improve water quality, including implementation of Stormwater Control Measures (SCMs) and nature-based solutions such as stream restoration. The watershed and subwatershed boundaries of the individual WTMs established in the Horse Creek Watershed Study were established to coincide with the subwatershed and catchment boundaries utilized in the UNRBA WARMF model, to maintain consistency with that collaborative study sponsored by the UNRBA.

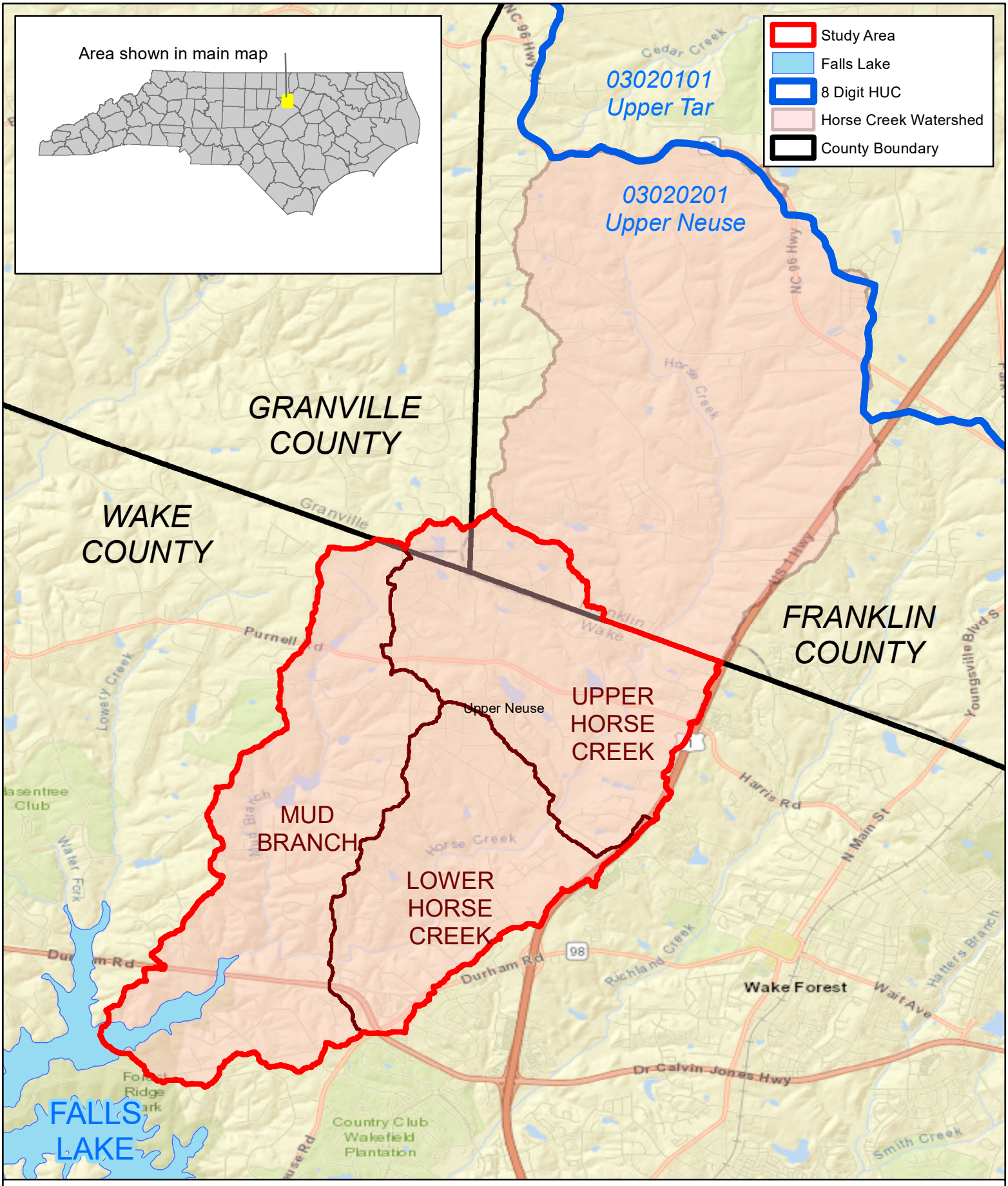
2.0 Analysis of Watershed Conditions

2.1 Location and Boundaries

The Horse Creek Watershed is located at the western edge of the TOWF, and spans the intersection of Wake County, Franklin County, and Granville County. The watershed is drained by two named tributaries, Horse Creek to the east, and Mud Branch to the west. The two tributaries join just upstream of Highway 98/Durham Road and flow south into the lower portion of Falls Lake near Forest Ridge Park.

The entire Horse Creek Watershed is 15.6 square miles (9,984 acres). This study will focus on the 8.9 square mile portion of the lower watershed that is mostly located within Wake County, referred to as the Study Area, and shown in **Figure 2**. The upper portion of the Study Area includes small areas within Franklin and Granville counties. Information and analysis in subsequent sections of this report apply to the Study Area portion of the greater Horse Creek Watershed. As such, model results will not reflect actual in-stream nutrient loading, but rather, the fraction of in-stream nutrients contributed by the portions of the watershed within the Study Area. Appendix B contains additional information on how the Study Area was determined.

To facilitate WTM analysis, the Study Area was further subdivided into three sections. The portion of Horse Creek upstream of the confluence with Mud Branch was divided into two subwatersheds, Upper Horse Creek and Lower Horse Creek. The Upper Horse Creek subwatershed begins at the northern boundary of the Study Area and extends downstream to where Horse Creek crosses Jenkins Road. The Lower Horse Creek subwatershed extends from this point downstream to the confluence with Mud Branch. A third subwatershed includes the Mud Creek drainage to the west and the portion of the Horse Creek drainage downstream of the confluence with Mud Branch. These Study Area subwatersheds are shown in **Figure 2**.



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Horse Creek Watershed
Figure 2. Watershed Map

N W E S

0 0.5 1 Miles

Map Created: February 2023
Image Source: NC Statewide Orthoimagery, 2015

2.2 Climate

Climate influences soil formation and erosion processes, stream flow patterns, vegetation coverage, and a significant part of the geomorphology of a watershed. Precipitation not only provides water to streams and vegetation, but the intensity, frequency, and amount of rainfall can greatly influence watershed characteristics. Wake County, where the Horse Creek Watershed is located, is in the southeastern climatic region of the U.S. and has a temperate climate with a mean annual temperature of 61.5°F and a mean annual rainfall of 47.3 inches (NCEI.NOAA.gov), as summarized in **Table 2**. The mean annual rainfall is the precipitation value utilized by the WTM for the water quality analysis.

***Table 2**. Monthly mean climate data for Wake County, NC (Source: NOAA NOWData)*

Month	Mean Temperature (F)	Mean Maximum Temperature (F)	Mean Minimum Temperature (F)	Mean Precipitation (inches)
January	41.6	51.7	31.6	3.7
February	45.2	56	34.4	3.4
March	52.3	63.8	40.9	4.3
April	61	73	49.1	3.2
May	69	80.1	58	4
June	77	87.9	66.2	4.3
July	80.4	90.7	70.1	4.6
August	79.2	89.1	69.3	4.6
September	72.8	82.8	62.9	4.6
October	62.1	73.3	51	3.8
November	51.6	63.3	39.9	3.2
December	44.9	55.1	34.7	3.6
Annual	***61.5***	***72.3***	***50.7***	***47.3***

2.3 Physiography and Land Use

The Horse Creek Watershed and the TOWF are in the Piedmont physiographic province, an area in the geographic center of North Carolina that is characterized by gently rolling, well-rounded hills and long, low ridges with a few hundred feet of elevation difference between the hills and the valleys. Specifically, the watershed lies in the Northern Outer Piedmont level IV ecoregion, an area of dissected irregular plains with low rounded hills. Within the Northern Outer Piedmont, potential natural vegetation includes mixed oak forest or oak-hickory-pine forest, comprised mainly of white oak (*Quercus alba*), southern red oak (*Quercus falcata*), black oak (*Quercus velutina*), mockernut and pignut hickories (*Carya tomentosa and Carya glabra*), with some shortleaf pine (*Pinus echinata*) and loblolly pine (*Pinus taeda*) (Griffith et al). The average elevation within the Horse Creek watershed is 416 feet, with a range from 251 feet at the average water surface level of Falls Lake, to 555 feet. The higher areas are generally located along the eastern and western watershed boundaries in the northern area of the watershed.

Land use within the Study Area may be characterized as low-to-medium density development within the eastern half of the watershed, with areas of mixed forest dispersed with more rural development in the

western half of the watershed (**Figure 3**). Most of the land within the Study Area is privately owned. There are no large areas of agricultural or livestock production. **Table 3** details land use classes within each subwatershed.

Table 3. Study Area Land Cover Data

Category	Upper Horse Creek	Lower Horse Creek	Mud Branch
Residential - LDR (<1 du/acre)	14%	13%	8%
Residential - MDR (1-4 du/acre)	2%	4%	1%
Residential - HDR (>4 du/acre)	<1%	1%	<1%
Commercial	34%	25%	16%
Roadway	0%	<1%	<1%
Forest	45%	50%	61%
Rural	4%	6%	10%
Open Water	1%	<1%	4%

2.4 Surface Water Resources

Northern Outer Piedmont streams tend to have low to moderate gradient, with beds comprised mostly of cobble, gravel, and sandy substrates (Griffith et al).

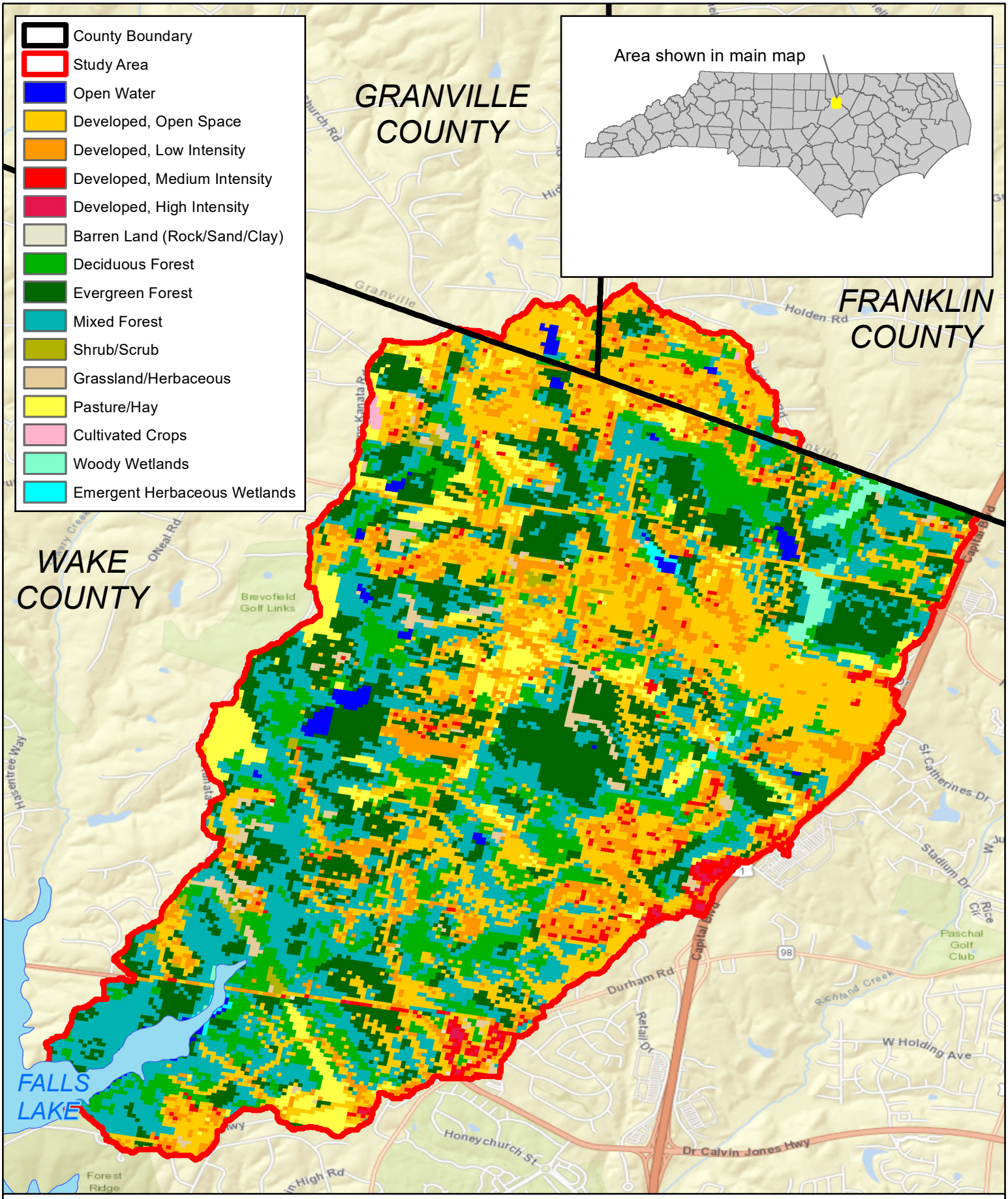
NCDOT ATLAS stream and waterbody data were used to spatially represent surface water features within the Study Area (**Figure 4**). This dataset was developed by the North Carolina Department of Transportation and is described in **Appendix A**. Horse Creek, the largest stream within the Study Area, is an 5th order stream where it flows into Falls Lake. One other named stream, Mud Branch, drains the western portion of the Study Area and flows into Horse Creek just upstream of where it enters Falls Lake. **Table 4** details the miles of stream within the Study Area.

The largest waterbody in the Study Area is Falls Lake. There are several other small impoundments within the study area, which can generally be classified as either small farm ponds, flood control ponds, or amenity/water quality ponds (for stormwater management) within subdivisions. Most occur along upper first- and second-order unnamed tributaries; however, several ponds are also located on the main stem of Mud Branch. The two largest ponds occur just upstream of Purnell Road, on an unnamed Tributary to Horse Creek, and south of Purnell Road, along Fairlake Drive on a separate unnamed tributary to Horse Creek.

Table 4. Study Area Streams

Stream Name	Length (miles)
Horse Creek and Tributaries	30.02
Mud Branch and Tributaries	10.73
Unnamed Tributaries to Falls Lake	2.58

There are few areas of intact and contiguous wetlands within the Study Area. The largest areas are within the floodplain of Horse Creek, particularly upstream of Purnell Road. These areas can be seen on **Figure 3**.



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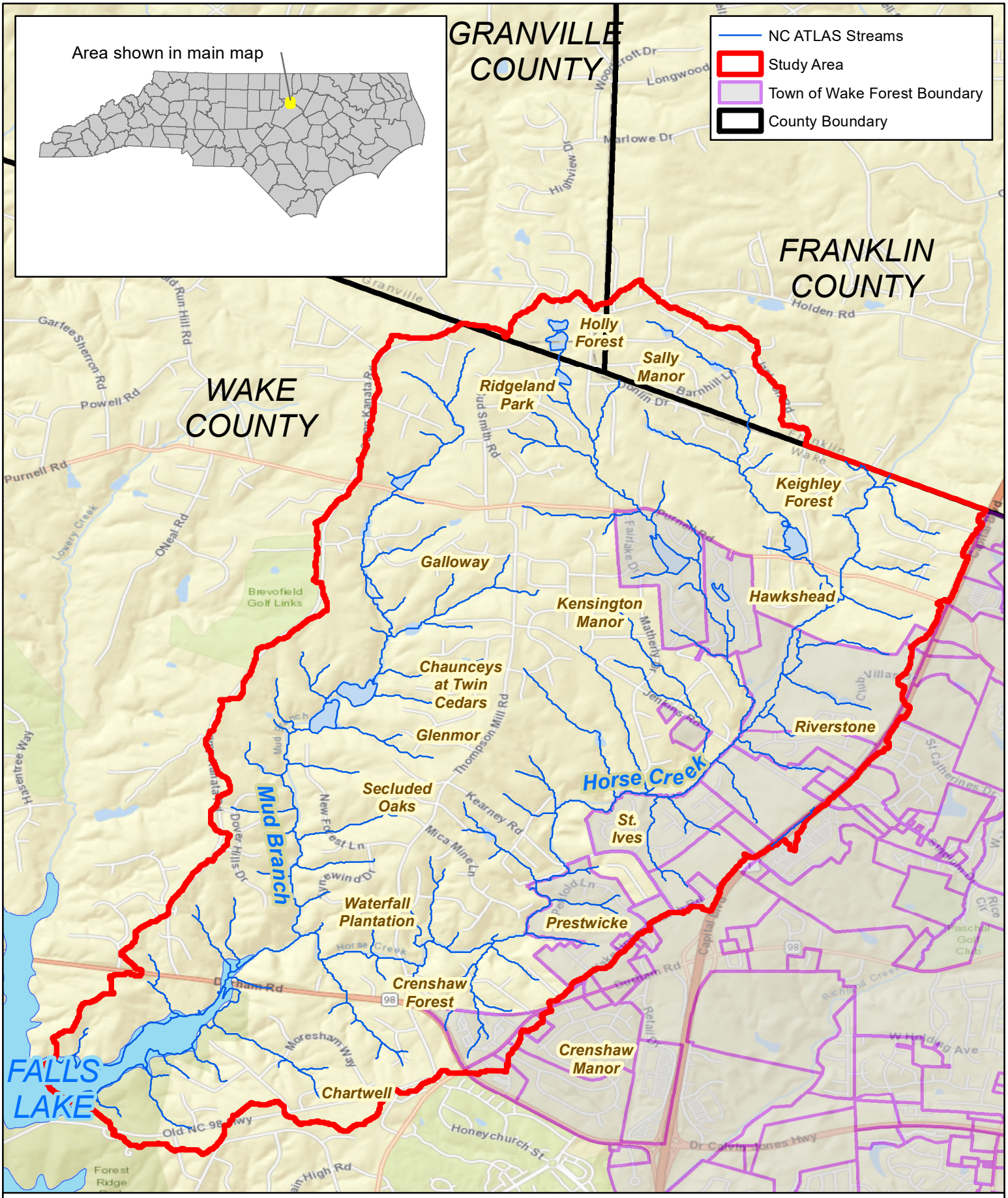
Horse Creek Watershed Study
Figure 3. Land Cover Map

N W E S

0 0.5 1 Miles

Map Created: Decemeber 2023
Image Source: NC Statewide Orthoimagery, 2015



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Horse Creek Watershed Study
Figure 4. Surface Waters Map

Map Created: Decemeber 2023
Image Source: NC Statewide Orthoimagery, 2015

2.5 Geology and Soils

Wake County lies within the Raleigh belt, a geologic region primarily composed of granite, gneiss, and schist. The eastern portion of the Horse Creek falls within the Crabtree terrane, and the western portion lies within the Falls Lake terrane. Terranes are crust fragments formed on a tectonic plate and accreted or "sutured" to crust lying on another plate. The crustal block or fragment preserves its distinctive geologic history, which is different from the surrounding areas. In general, the Crabtree terrane contains more foliated metamorphosed rocks such as gneiss, and the Falls Lake terrain contains more schist. Both geologic formations erode to form soils with sandy clay interspersed with sandy saprolite and rock outcrops.

Soils within the Study Area are predominantly Chewacla and Wehadkee loam within the Upper and Lower Horse Creek subwatersheds, and Pacolet Sandy Loam in the Mud Branch subwatershed. Chewacla and Wehadkee loams are somewhat poorly to poorly drained soils typically found within alluvial floodplains of the Piedmont. Pacolet soils tend to be well drained and are more typical of forested pine and mixed hardwood hillslopes.

WTM utilizes the Hydrologic Group soil classification to assign infiltration potential and runoff properties in its calculations. Soils within the Study Area are distributed by hydrologic group as shown in **Table 5**.

Table 5. Soil Hydrologic Groups within Study Area subwatersheds

Hydrologic Soil Group	Upper Horse Creek	Lower Horse Creek	Mud Branch
Group A: Soils having a high infiltration rate (or low runoff potential) when thoroughly wet. These consist mainly of deep, well-drained sands or gravelly sands. These soils have a high rate of water transmission.	46%	50%	40%
Group B: Soils having a moderate infiltration rate when thoroughly wet	36%	35%	48%
Group C: Soils having a slow infiltration rate when thoroughly wet. These soils typically have a layer that impedes the downward movement of water.	1%	<1%	1%
Group D: Soils that have a very slow infiltration rate (or high runoff potential) when thoroughly wet. Generally, these are soils that have a clay layer at or near the surface; soils that have a high water table; and/or soils that are shallow over nearly impervious material.	14%	11%	7%

2.6 Political Jurisdictions / Relevant Authorities

The Study Area contains land within the limits of the TOWF, as well as land in unincorporated areas of Wake, Franklin, and Granville Counties.

Several areas within the Study Area that are surrounded by areas of incorporated Wake Forest, but which are technically outside the current jurisdictional town limits, are governed by the Town through the establishment of an Extra-Territorial Jurisdiction (ETJ) agreement between the TOWF and Wake County.

These ETJ areas enable the Town to better ensure that development patterns and associated infrastructure will allow the efficient provision of urban services as the Town grows into that area.

2.7 Growth and Development Patterns

Land cover indicates the physical land type, such as forest or open water. Land use describes how people are managing the landscape, such as for development or conservation. Different types of land cover can be managed or used differently, such as rural versus residential areas. For the purposes of the Horse Creek Watershed Study, the project team evaluated both current and future land use.

All properties located within the Wake Forest Town Limits or ETJ are subject to the requirements of a specified zoning district and associated zoning and building regulations. Wake County also has a Unified Development Ordinance (UDO) to guide development in areas outside of the jurisdiction of municipalities. The County is in the process of implementing a new intentional growth framework called PLANWake, which was adopted in 2021, and is intended to guide growth for the next 10 years. PLANWake specifies minimum standards for development within unincorporated areas and may outline a plan to transition county jurisdiction to municipal jurisdiction in the future within areas experiencing rapid growth. Granville and Franklin Counties also have their own development guidance.

Zoning and development guidelines from the four governmental units within the study area were used to determine the area of land eligible for development under maximum buildout conditions within each subwatershed, as documented in **Appendix A**. **Table 6** documents the acres of land in each subwatershed that were found to be eligible to be developed and modeled as such under the Future Conditions modeling scenario. By virtue of this process, parcels of land that were not currently developed to the maximum built-upon density were simulated at the maximum developed density under Future Conditions.

Table 6. Acres of Land for Future Development

Category	Upper Horse Creek	Lower Horse Creek	Mud Branch
	Additional Development (acres)		
Residential - LDR (<1 du/acre)	-	22.94	55.53
Residential - MDR (1-4 du/acre)	238.00	113.81	573.04
Residential - HDR (>4 du/acre)	198.19	65.56	-
Multifamily	4.88	-	-
Commercial	-	74.12	2.00

2.8 MS4 and Stormwater

The National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) Program is mandated under the federal Clean Water Act. In North Carolina, the EPA has delegated MS4 Program oversight to DEQ. The TOWF is a 2000 census designee. As such, the US Environmental Protection Agency designated the Town for inclusion in the Phase II stormwater program because its municipal boundary intersects a US Census-defined Urbanized Area. As a NPDES community, the Town is required to follow the six minimum control measures (MCM's) established by the EPA:

1) Public Education and Outreach;
2) Public Participation/Involvement;

3) Illicit Discharge Detection and Elimination;
4) Construction Site Runoff Control;
5) Post Construction Runoff Control; and
6) Pollution Prevention/Good Housekeeping.

The Town of Wake Forest utilizes the NCDEQ Stormwater Design Manual for design criteria regarding Phase II stormwater regulations. The Town's Unified Development Ordinance (Chapter 12) and Manual Specifications, Standards & Design (Chapter 2) detail stormwater design requirements for new development within the municipal boundaries and ETJs.

The NPDES Phase II requirements ensure that all SCMs have an associated Operations and Maintenance Agreement. This agreement requires the SCMs to be inspected annually to make sure they are functioning properly to prevent flooding and keep our waterways clean. The Town requires owners of SCMs to submit their annual inspection reports completed by a qualified inspector to the Stormwater Engineer and should have a record for the past 5 years of inspection, maintenance, and repairs available for the Town.

2.9 Sanitary Sewer Providers

The City of Raleigh provides sanitary sewer service to a portion of the Study Area, including the Kensington Manor, Prestwicke, Riverstone, and St. Ives neighborhoods along Jenkins Road. Most parcels in the Study Area, including those outside areas with existing sewer service, were assumed to be on septic systems. Appendix A details the methodology used to determine the waste disposal service associated with each parcel.

2.10 Recreational Uses

As mentioned in Section 2.3, much of the land within the Study Area is privately owned. Access to Falls Lake provides the dominant recreational uses within the Study Area. A portion of Forest Ridge Park, owned by Wake County, falls within the lower portion of the Study Area, adjacent to the Lake. A former golf course, located adjacent to Horse Creek off Club Villas Drive, ceased operation in the early 2000s. While the site is privately owned and has not been redeveloped, there is a conservation easement associated with a compensatory mitigation stream site, which is administered by NCDEQ, along Horse Creek within the former golf course property. YMCA Camp Kanata, which serves as a regional destination for YMCA youth activities and summer camps, is also located along the western edge of the Study Area.

Erosion at dam in the Fairlake neighborhood, identified as a stakeholder concern.

2.11 Stakeholder Input

To better capture the full spectrum of watershed issues, and to tailor solutions to address those issues, the TOWF conducted several community outreach efforts in conjunction with the Horse Creek Watershed Study. The Town created a public-facing website that detailed the purpose and goals of the Study. The website featured a link to an online survey, where community members could provide the location and details of potential

water quality and quantity issues, such as flooding, erosion, and potential sources of nutrients and contaminants. The survey also collected information on stakeholder preferences and priorities.

The Town also held an online community meeting, where stakeholders could ask questions about the purpose and goals of the study, contribute ideas for water quality needs and improvements, and make comments about other watershed issues. A detailed summary of priorities that were identified for the watershed by stakeholders, as well as potential sources of nutrient and sediment inputs identified by stakeholders, are included in **Appendix C**.

3.0 Watershed Treatment Model Results

This section contains a summary of the modeling results for the Horse Creek Watershed Study. For a full description of data sources and methods, see **Appendix A**.

3.1 Existing Conditions

WTM models were produced to simulate loading estimates (total nitrogen, total phosphorous, Total Suspended Solids (TSS, a proxy for sediment), and Fecal Coliform bacteria (FC) for each of the three subwatersheds of the Study Area under the current land use and BMP conditions. **Table 7** details the existing loads and loads per acre computed by WTM for the three subwatersheds, as well as the total loads delivered to Falls Lake from the Study Area portion of the Horse Creek watershed. While it is recognized by the study team that nutrient loading is the primary focus of this watershed plan, the loading numbers for TSS and FC are provided for the benefit of readers and decision makers because WTM provides those load estimates with no additional effort once all the model inputs are in place.

Table 7. Existing Conditions Nutrient, Sediment, and Bacteria Loads

Subwatershed	Upper Horse Creek	Lower Horse Creek	Mud Branch	Total Study Area
TN (lb/year)	10,950	7,189	9,125	27,264
TN (lb/yr/acre)	6.0	4.9	3.8	4.8
TP (lb/yr)	1,496	1,010	1,020	3,525
TP (lb/yr/acre)	0.8	0.7	0.4	0.6
TSS (lb/yr)	530,858	372,992	533,535	1,437,385
TSS (lb/yr/acre)	290.8	253.6	223.0	252.7
FC (bil/yr)	366,642	236,286	150,093	753,020
FC (bil/yr/acre)	200.8	160.6	62.8	132.4

Upper Horse Creek contributes the largest portion of existing nutrient loads from the Study Area and contributes the largest load per acre of TSS. All three subwatersheds currently contribute loads that exceed the Falls Lake nutrient load limits for new development, which are 2.2 lb/acre/year of total nitrogen, and 0.33 lb/acre/year of total phosphorous. However, these numbers need to be viewed within the context of the capabilities of the WTM modeling framework. WTM results have errors associated with them and should not be taken as a prediction of the quantified actual pollutant loads from the watershed. Reliable predictions of actual pollutant loads would require a calibrated watershed model, which would be a much more expensive and time-consuming endeavor. WTM is an un-calibrated steady-state model

that allows the user(s) to compare the relative benefits of various management options and pollutant control measures to optimize management strategies going forward. These results should be taken merely as a statement that opportunities for pollutant load reductions exist in this watershed.

3.2 Future Conditions

Future development conditions, assuming buildout according to current zoning with adherence to existing load limits for new development, were also modeled in WTM. More specifically, when areas of new development were implemented within WTM, the appropriate stormwater SCMs were also input in conjunction with those new developed lands according to the requirements of the jurisdiction in which they were located. A detailed description of the WTM methodology associated with the future conditions scenario for the three study subwatersheds is detailed in Appendix B. Results of the future conditions model are detailed in **Table 8**.

Table 8. Predicted Loading under Future Conditions

Subwatershed	Upper Horse Creek	Lower Horse Creek	Mud Branch	Total Study Area
TN (lb/year)	13,628	9,012	13,077	27,544
TN (lb/yr/acre)	7.5	6.1	5.5	4.8
TP (lb/yr)	2,070	1,300	1,863	3,122
TP (lb/yr/acre)	1.1	1	1	1
TSS (lb/yr)	629,009	455,409	639,515	1,719,318
TSS (lb/yr/acre)	344.6	309.6	267.4	302.2
Fecal Coliform (bil/yr)	450,987	301,103	265,544	1,017,634
FC (bil/yr/acre)	247.0	204.7	111.0	178.9

Notably, the future conditions model predicts that all three subwatersheds will continue to produce nutrient loads that exceed NSW loading limits, even with the implementation of BMPs associated with new development under the Falls Lake Rules. Additionally, sediment and bacteria loading are predicted to increase for all three subwatersheds.

3.3 Retrofit Scenarios

Methods for locating potential new and retrofit structural stormwater, stream restoration, and riparian buffer restoration opportunities within the Study Area are described in **Appendix A**.

The retrofit modeling scenario applies all the new structural stormwater measures, improvements to existing BMPs, and stream/buffer projects that were identified within the Study Area to the Existing Conditions scenario, to predict the potential loading reductions achieved from within existing developed areas.

Table 9. Existing Conditions with Proposed New Projects

Subwatershed	Upper Horse Creek	Lower Horse Creek	Mud Branch	Total Study Area
TN (lb/year)	9,832	6,715	9,109	26,631
TN (lb/yr/acre)	5.4	4.6	3.8	4.7
TP (lb/yr)	1,222	936	1,017	3,427
TP (lb/yr/acre)	0.7	0.6	0.4	0.6
TSS (lb/yr)	527,450	364,947	533,240	1,426,185
TSS (lb/yr/acre)	288.9	248.1	222.9	250.7
Fecal Coliform (bil/yr)	361,776	219,772	149,485	731,033
FC (bil/yr/acre)	198.2	149.4	62.5	128.5

Only one proposed project is in the Mud Branch subwatershed. As such, the Existing Conditions with retrofits model reflects limited change in loading values for Mud Branch. Minimal reductions in nutrient, sediment, and bacteria loading were achievable through implementation of multiple projects identified in the Upper and Lower Horse Creek subwatersheds. These potential projects are detailed in Section 4.

4.0 Implementation Plan

4.1 Strategies to Address Nonpoint Sources of Nutrient Pollution

Opportunities for the retrofit (improvement) of existing structural stormwater best management practices (BMPs) within the watershed were evaluated using methodologies detailed in **Appendix A**. In addition, suitable opportunities to implement new BMPs and potential stream and buffer restoration projects were also identified through a combination of desktop and field evaluations. Due to the relatively small size of the study area watershed, it was necessary to identify project opportunities both within and beyond the Town's limits. **Figure 5** shows the locations of the 19 BMPs identified within the Study Area. **Table 10** lists the number and types of strategies identified within each Study Area subwatershed. Two tables in **Appendix B** present all the proposed projects along with key details regarding their projected performance and potential implementation. Project opportunities located within the Town's jurisdiction are presented in Table 2a and project opportunities located beyond the Town's jurisdiction are presented in Table 2b. Two potential improvements to existing stormwater structures were identified; the remaining strategies are new opportunities for BMPs or stream restoration projects.

While some projects are located outside the Town's jurisdiction, it should be noted that the IAIA includes detailed provisions for implementation of projects in partnership with other jurisdictions (such as surrounding counties, other municipalities, and soil & water conservation districts) as well as provisions for implementation in partnership with other third-party entities. At the most basic level, to receive credit toward a participating jurisdiction's spending commitment, the project need only be located, and result in water quality improvement, specifically nutrient pollutant load reduction, in the Falls Lake Watershed.

In support of this watershed plan, the UNRBA provided numerous successful examples of implementation of collaborative projects which have been approved for compliance with the IAIA Strategy (personal communication, Alix Matos), and those examples are shown in the large table in **Appendix D**. The table provides details on the 24 collaborative projects that were submitted and approved for IAIA compliance

in just the second year of the program (FY2023). The examples demonstrate a wide array of project types, including those that were developed and implemented though partnerships between two or more UNRBA member governments, and between UNRBA member governments and third-party collaborators, as well as some examples of projects with numerous partners representing member governments and third parties. The projects also include examples where member governments were funding and implementing projects both within and beyond their jurisdictional boundaries.

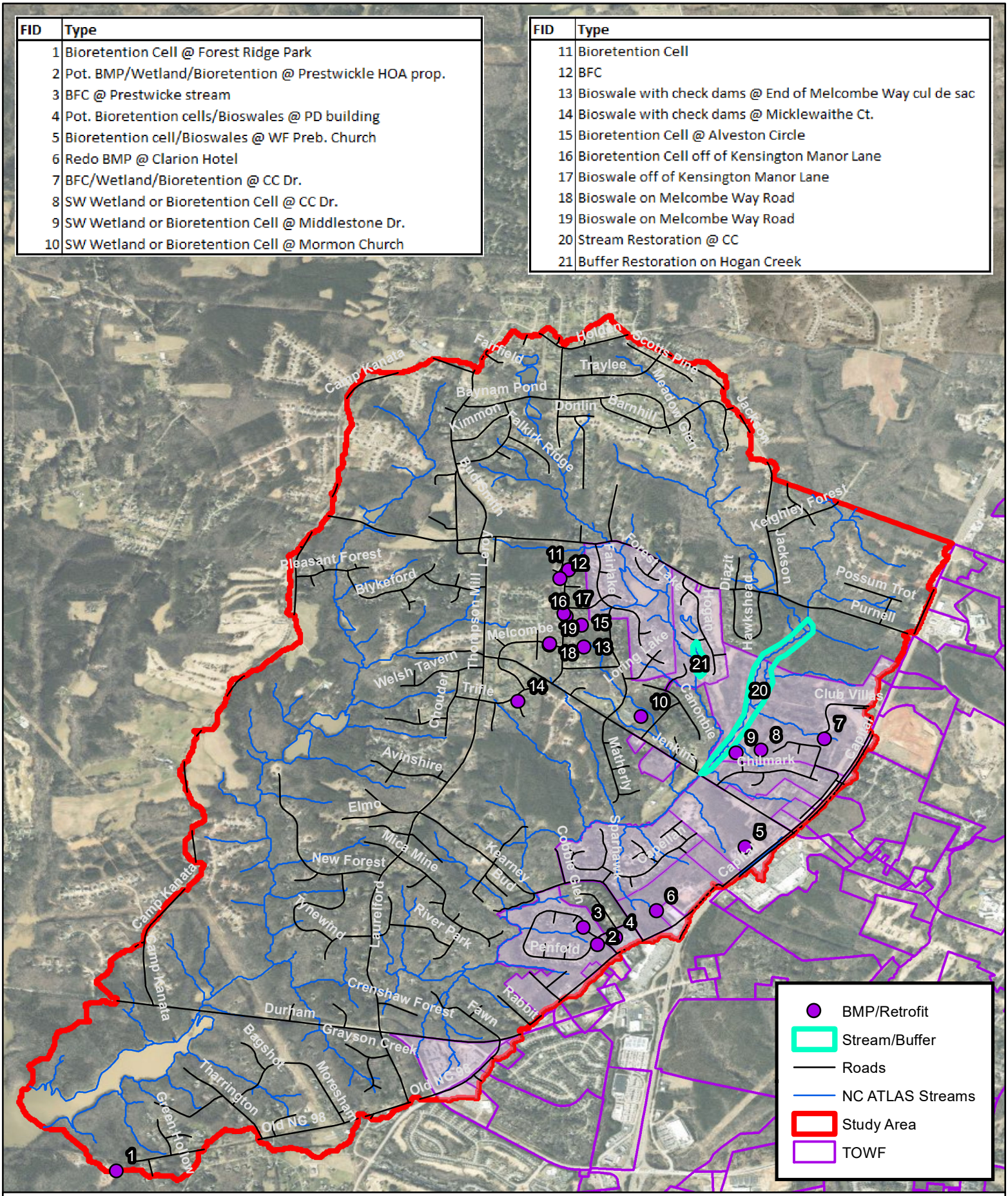
Implementation guidance set forth in the IAIA strategy documents stipulates that any Memorandums of Understanding (MOU), or other such agreements, which are necessary to facilitate collaborative project efforts must be developed by the participating member governments or collaborating partners themselves. An MOU developed in conjunction with a successful project submitted for compliance in FY2023 is also provided in Appendix D in order to illustrate the key points and provisions that the Town may wish to incorporate in any such agreement for a collaborative project implemented from this watershed plan. The project involved integration of green stormwater infrastructure in conjunction with the revitalization of the Odie Street community on the west side of Hillsborough in a partnership between the Town, Piedmont Conservation Council, and Habitat for Humanity.

Table 10. Strategies to Address Nonpoint Sources of Nutrient Pollution

BMP Type		**Upper Horse Creek**	**Lower Horse Creek**	**Mud Branch**
New BMPs	Biofiltration Conveyance	1	1	-
	Bioretention cell	5	3	1
	Bioswale	2	-	-
	Bioswale with check dams	1	1	-
BMP improvements	Bioretention cell	-	1	-
	Bioswale into bioretention cell treatment train	-	1	-
Stream Restoration		2	-	-
Total		***11***	***7***	***1***

FID	Type
1	Bioretention Cell @ Forest Ridge Park
2	Pot. BMP/Wetland/Bioretention @ Prestwickle HOA prop.
3	BFC @ Prestwicke stream
4	Pot. Bioretention cells/Bioswales @ PD building
5	Bioretention cell/Bioswales @ WF Preb. Church
6	Redo BMP @ Clarion Hotel
7	BFC/Wetland/Bioretention @ CC Dr.
8	SW Wetland or Bioretention Cell @ CC Dr.
9	SW Wetland or Bioretention Cell @ Middlestone Dr.
10	SW Wetland or Bioretention Cell @ Mormon Church

FID	Type
11	Bioretention Cell
12	BFC
13	Bioswale with check dams @ End of Melcombe Way cul de sac
14	Bioswale with check dams @ Micklewaithe Ct.
15	Bioretention Cell @ Alveston Circle
16	Bioretention Cell off of Kensington Manor Lane
17	Bioswale off of Kensington Manor Lane
18	Bioswale on Melcombe Way Road
19	Bioswale on Melcombe Way Road
20	Stream Restoration @ CC
21	Buffer Restoration on Hogan Creek



KCI ASSOCIATES OF NC

Horse Creek Watershed Study
Figure 5. Opportunity Map

N W E S

0 0.5 1 Miles

Map Created: February 2024
Image Source: NC Statewide Orthoimagery, 2015

The potential for nutrient reduction associated with all identified strategies for each subwatershed is detailed in Section 3.3. Each opportunity was also evaluated separately for its individual contribution to subwatershed nutrient reduction using WTM. The magnitude of potential nutrient reduction associated with each structural stormwater practice was used to rank and prioritize strategies for implementation, as discussed in Section 4.2.

Two potential opportunities for stream restoration were identified within the Upper Horse Creek subwatershed. One site is within the former Wake Forest Country Club property, and the other is along an unnamed tributary to Horse Creek along Hogan Drive within the Country Club Downs subdivision. WTM does not consider stream restoration as an urban BMP, and thus does not have mechanisms to estimate the uplift associated with this practice. Methods to estimate the potential nutrient reductions associated with these stream restoration projects were calculated per Doll et al (2018) and are documented in **Appendix B**.

During the 2023 public meeting, two sources of potential water quality impairments within the watershed received multiple comments from stakeholders. The first was the former Wake Forest Country Club golf course property; the second was erosion near a dam in the Fairlake neighborhood. As mentioned above, a stream restoration opportunity was identified within the Wake Forest Country Club property as a result of this watershed study. This project was evaluated and ranked alongside the other potential projects. More information on the project, including potential nutrient reductions, site history, and project constraints, is available in **Appendix B**.

The second opportunity identified through public outreach, at the Fairlake Dam (also known as Lewis Dam), involves a multifaceted set of issues on land owned by private landowners and under the legal jurisdiction of a private homeowners association, including structural issues with the dam and spillway that resulted from storm damage in 2017. In 2018, homeowners within the neighborhood commissioned a separate focused analysis that yielded a complete set of recommended actions to repair issues at the Fairlake Dam. Detailed assessment of the current sediment and nutrient storage provided by the lake, and analysis of how a repair could impact nutrient loading to Falls Lake, is outside the scope of this watershed study. If interested parties choose to pursue funding to repair the dam, an analysis of how the repair could affect nutrient loading is recommended in order to assess potential applicability of IAIA funding toward this project.

4.2 Implementation Priorities

Potential projects were assigned additional criteria to facilitate ranking and prioritization. Prioritization metrics are summarized in Table 11. Each project was assigned values on an 0-1 scale for each ranking metric, with 0 being least desirable and 1 being most desirable. Methodologies associated with the determination of each metric, along with a table of values for each metric for each project, are detailed in **Appendix C**. Opportunities were ranked using two methods: 1) Cost-effectiveness defined as cost of implementation per pound of nitrogen reduction, and 2) The sum of the community acceptance and feasibility scores.

The top five ranking opportunities according to cost per pound of nitrogen reduction are:

1) Clarion Point Hotel Bioretention Cell Retrofit ($6,707/lb N/year)
2) Kensington Manor Place BFC ($9,448/lb N/year)
3) Penfold Lane BFC ($9,569/lb N/year)

4) Wellons, Inc. Bioretention Cell ($10,092/lb N/year)
5) Preswicke Property Owners Association Bioretention Cell ($10,219/lb N/year)

The highest possible value for the sum of the community acceptance and feasibility scores was 2; the following five opportunities received this top score:

1) Clarion Point Hotel Bioretention Cell Retrofit
2) The Church of Jesus Christ of Latter-day Saints Bioretention Cell
3) Wake Forest Presbyterian Bioswale into a Retrofit Bioretention Cell
4) Forest Ridge Park Bioretention Cell
5) Micklewaithe Court Bioswale with Check Dams

The Clarion Point Hotel opportunity is in the Lower Horse Creek subwatershed. There is an existing dry detention basin adjacent to the parking lot in the rear side of the hotel property, which appears to be maintenance-neglected. The proposed retrofit project would improve the current structure by capturing additional drainage area and treating additional runoff appropriately. This project also happens to have the lowest overall cost of all the projects proposed in this study. However, it is acknowledged that investing public money to improve the function of a required private stormwater SCM may be setting a difficult precedent.

Dry detention basin at the Clarion Point Hotel

4.3 Community Engagement

BMPs are easiest to implement on public land. However, the Horse Creek Watershed Study Area encompasses a small watershed where nearly all the land is privately owned. It will be necessary to cultivate partnerships with private landowners to facilitate implementation of priorities identified within this study. The TOWF should prioritize efforts to reach out to individual private landowners who own properties identified in this study as being suitable sites for potential BMP retrofits. Engagement with existing neighborhood associations or homeowners' associations (HOAs) could also benefit future efforts to address nutrient loading. In particular, the Kensington subdivision is identified as having potential for multiple new BMPs and/or BMP retrofits, mainly due to the age of the development, in that it was developed during a period when stormwater management requirements were not as rigorous as those in the current day.

4.4 Schedules, Milestones, and Measures of Success

The TOWF is committed to spend $13,692 annually toward implementing NSW goals as a condition of the UNRBA IAIA (**Table 1**). As such, the Town has flexibility regarding the implementation of recommendations of this study. The Town may choose to implement the most feasible opportunities, or opportunities that are most cost effective with respect to nitrogen reduction. Project phasing could potentially be utilized as

an approach to allow individual projects to address multiple years of funding – for example, design and permitting could apply to one year, construction the next, and maintenance to a future year.

5.0 Recommendations

Just as with the overarching Falls Lake NSW Strategy, this watershed management plan should be viewed and utilized within a context of adaptive management. The Falls Lake Rules require that DEQ report on the condition of the Lake and any improvements or declines in water quality every five years. These reports may lead to adaptive adjustments in the overall NSW Strategy and the IAIA. By the same token, as the regular reports and other new information and technologies emerge, the TOWF should update this watershed plan and revisit the management options and priorities set forth herein every five years.

Retrofitting new BMPs to already-built landscapes is a challenging and sometimes expensive undertaking. Retrofitting within the study area watershed is particularly challenging in that almost the entirety of the watershed land area is under private ownership, whereas lands that are already under public ownership are typically the easiest on which to implement such retrofits. In addition, the vast majority of land developed in the watershed is developed in single-family housing, which makes for limited spaces for new BMPs to be implemented (in comparison to places likes schools and public parks, which often have significant open spaces and make for excellent partners in such endeavors).

The team that developed this watershed plan identified as many retrofit opportunities as possible within the timeframe and resources allotted, but this plan should not be taken as the final enumeration of such opportunities. The search for viable BMP retrofit opportunities should be an ongoing effort within the cycle of adaptive management and updates to this plan. In addition, one of the most important keys to the successful implementation of this Plan will be the ongoing outreach to and communication with the private landowners where possible retrofit opportunities exist to cultivate their willingness to partner with the Town in this endeavor. To ensure successful and ongoing implementation, the TOWF will need to devote time and resources to this element of the overall effort.

Lastly, one of the key strengths of WTM is that once all the input data is assembled and the model(s) is properly built, exercises such as updating land uses to account for changing conditions and/or inputting new BMPs are relatively simple. With minimal training Town Staff could readily take full ownership of the model and have a readily adaptable tool for use within the adaptive management cycle to test new retrofit opportunities and “what if” management scenarios. As such, the WTM that support this Plan will be a great tool to track and optimize the Town’s compliance with the IAIA going forward.

6.0 References

Caraco, D. 2013. Watershed Treatment Model (WTM) 2013 Documentation. Center for Watershed Protection, Ellicott City, MD.

Doll, B., Johnson, J., Page, J., and Line, D., 2018. Evaluation of Nutrient Reduction Crediting Strategies for Stream Restoration. EPA 319 Grant Sponsored by the North Carolina Division of Water Resources.

Griffith, G.E, Omernik, J.M., Comstock, J.A., Schafale, M.P., McNab, W.H., Lenat, D.R., and MacPherson, T.F., 2002. Ecoregions of North Carolina, U.S. Environmental Protection Agency, Corvallis, OR.

Town of Wake Forest Unified Development Ordinance. Adopted July 16, 2013, Amended July 19, 2022. Accessed online at: https://online.flippingbook.com/view/703728449/

Upper Neuse River Basin Association, 2022. Final Program Document: Stage I Existing Development (ED) Interim Alternative Implementation Approach (IAIA). Submitted for review and approval to: North Carolina Division of Water Resources and the North Carolina Environmental Management Commission. Accessed online at: https://unrba.org/sites/default/files/UNRBA%20IAIA%20Program%20Document,Approved%20March%202022.pdf

Appendix A – WTM Model Methodology

Appendix B – Implementation Plan Methodology

Appendix C – Survey of Stakeholder Priorities

Appendix D – Implementation Support Materials

Appendix A: Horse Creek WTM Methodology

Sources and Existing Conditions in Watershed Treatment Model (WTM)

KCI selected the Watershed Treatment Model (WTM) from the Center for Watershed Protection to create water quality models for the Horse Creek Watershed study area to determine baseline nitrogen and phosphorus loads for three separate conditions: 1) existing land use conditions and mean annual precipitation with existing BMPs (best management practices); 2) future land use, incorporating future growth, and incorporating future BMPs that are currently required by Wake County zoning codes that apply to the Falls Lake watershed; and 3) existing conditions with retrofit scenarios, in which the BMPs available within the WTM framework were applied to existing developed areas to reduce pollutant loads below current existing conditions. Individual WTM runs were developed for each of three delineated sub-watersheds. These sub-watersheds subdivide the Horse Creek watershed study area to best match the catchments utilized in the WARMF model recently developed for the entire Falls Lake watershed on behalf of the Upper Neuse Basin Association to support re-examination of the nutrient management strategy for the lake. Close approximation of the WARMF catchments will better allow for future comparison of the pollutant load predictions from the separate modeling platforms.

WTM is a steady state spreadsheet modeling tool best utilized for the rapid assessment and quantification various watershed treatment options and management measures. While this study is focused primarily on nutrient loading and protecting and improving water quality in Fall Lake, it should be noted that WTM estimates pollutant loads for sediment, nitrogen, phosphorus, bacteria, and runoff volume. WTM calculates pollutant loading on an annual basis and will not simulate seasonal loads or the short-term variability of pollutant loads due to shorter periods of climate variability. The Pollutant Sources component of WTM estimates the load from a watershed without treatment measures in place. The Treatment Options component estimates the reduction in this uncontrolled load from a wide suite of treatment measures (structural and non-structural) for both existing and future conditions. Finally, the Future Growth component allows the user to account for future development in the watershed, assuming a given level of treatment for that development (Caraco, 2013).

Pollutant sources were modeled in the three unique watershed WTM scenarios by inputting information on the existing (or future) land use conditions, streams, annual rainfall, soils, riparian buffer conditions, sanitary sewer system lengths, and on-site septic systems. Point sources (wastewater treatment plant discharges), nutrient concentration in stream channels, combined sewer overflows, illicit connections, marina runoff, and road sanding were not considered in the models because none of these potential pollutant sources are applicable within the Horse Creek watershed. Existing stormwater management practices (structural and non-structural) and riparian buffers were included in the existing conditions models. The WTM model accounts non-structural management practices such as pet waste education programs, erosion and sediment control, street sweeping, catch basin cleanouts, and marina pump outs. However, these management practices were not accounted for in the WTMs that were built for this project, as no such measures have been applied within the watershed.

The following sections describe the data sources and pre-processing steps that were utilized to develop the Existing, Existing with Retrofits, and Future Conditions models.

Existing Land Use

Land use data was downloaded from the 2019 National Land Cover Dataset (Dewitz, J., and U.S. Geological Survey, 2021, National Land Cover Database (NLCD) 2019 Products (ver. 2.0, June 2021): U.S. Geological Survey data release, https://doi.org/10.5066/P9KZCM54) and was then clipped to each of the sub watersheds within Horse Creek. NLCD land use types were mapped to the 11 different land use categories recognized in WTM according to the table below. The NLCD code of 11 was associated to the WTM category of Open Water. The NCLD code of 21 was associated to the WTM category of Commercial. The NLCD code of 22 was associated to the WTM category of residential LDR. The NLCD code of 23 was associated to the WTM category of residential MDR. The NLCD code of 24 was associated to the WTM category of residential HDR. The NLCD code of 31 was associated to the WTM category of Roadway. The NLCD codes 41-43, 52, 71, 90, and 95 were all grouped in the WTM category forest. The NLCD codes of 81 and 82 were associated with the WTM category of Rural.

	NLCD Land Cover Codes	WTM Land Use Category
11	Open Water	Open Water
21	Developed, Open Space	Commercial
22	Developed, Low Intensity	Residential - LDR (<1 du/acre)
23	Developed, Medium Intensity	Residential - MDR (1-4 du/acre)
24	Developed, High Intensity	Residential - HDR (>4 du/acre)
31	Barren Land (Rock/Clay/Sand)	Roadway
41	Deciduous Forest	Forest
42	Evergreen Forest	
43	Mixed Forest	
52	Shrub/Scrub	
71	Grassland/Herbaceous	
90	Woody Wetlands	
95	Emergent Herbaceous, Wetlands	
81	Pasture/Hay	Rural
82	Cultivated Crops	

Rainfall

Annual rainfall was assumed to be 42.88 inches in all WTM runs (North Carolina State Climate Office, Station 312993 – Falls Lake).

Soils

GIS-based soils data were obtained from the USDA Web Soil Survey (https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm) and mapped for the entire Horse Creek Study Area. The soils data layer was intersected with subwatershed boundaries and the percentages of

soils in each hydrologic group were calculated for each subwatershed. The percentages of soils within each of the groundwater depth categories stipulated by WTM (< 3 feet, 3-5 feet, >5 feet) were also determined using the USDA soils data. The tabular soil data incudes a data table called “MUAGGATT” with a field named “WTDEPANNMIN” which stipulates the groundwater depth for each mapped soil unit in centimeters.

GIS Inventory of Drainage Infrastructure

By utilizing the most recent QL2 LiDAR (North Carolina Risk Management Office - Quality Level 2 (2014) and Level 3 (2015) LIDAR Data https://sdd.nc.gov/ (accessed June 2023)), aerial photography, and other remote data sources in a desktop analysis, the KCI Team developed a preliminary GIS Geodatabase, called “HorseCreek_Drainage_Study”, of drainage swales and ditches within public lands and rights-of-way throughout the Wake County Portion of the watershed. Also using the LiDAR, KCI documented the flow path direction of each drainage swale and ditch and included that in the attribute table of the feature class called “drain lines”. Areas that could not be determined by the desktop study were field-verified and then added into the feature class.

Structural Stormwater Management Practices (Existing and Future)

GIS data on the locations of existing structural stormwater measures within Town limits and the ETJ were available from the Town of Wake Forest. Additional BMPs were located by performing a desktop study of the watershed and then adding them to the KCI Geodatabase under the feature class “BMPs and Ponds”. These existing BMP types were input into the subwatershed WTM where they were located along with size of the drainage area they effectively treated. When necessary, BMP types and location were field verified.

For locating new potential retrofit BMPs, KCI examined LiDAR, contours, and parcel data to locate where BMPs could feasibly be located. The drainage area of each new location was determined by StreamStats to help determine what type of BMP would be most ideally suited to each location. Once the BMP location and selections were QA/QCed, KCI then conducted thorough field reconnaissance of each of these locations within the Horse Creek Watershed to verify the that the selected BMP would be a feasible option. While examining each location KCI was considering the elevation, utilities that could be a constraint, land availability, land ownership, and the drainage area the BMP would be treating. The BMP options deemed feasible were then put into the WTMs.

On-Site Sewage Disposal Systems

The Town of Wake Forest provided data on sanitary sewer services within the Study Area. The numbers of dwellings served by on-site septic systems within each subwatershed were determined by conducting a desktop GIS analysis of Wake County Tax Parcels in conjunction with a GIS data layer for the Town of Wake Forest’s sanitary sewer collection network. Tax parcels not located coincident with a sewer collection line were assumed to be served by on-site septic systems.

Streams

The ATLAS streams, developed by NCDOT, were used because they better characterize the extent of streams within the watershed, and were developed at a higher resolution than the existing USGS high

resolution streams layer. ATLAS streams were developed by the Department of Transportation (DOT) and can be obtained through their ATLAS program. The stream length for each sub watershed was determined by clipping the "Atlas Streams" layer to each sub watershed. The level of accuracy was used more specifically for the section below for the riparian buffers.

Potential Stream Restoration/Buffer Sites

KCI conducted a thorough search throughout the watershed to identify potential stream and buffer restoration sites within each sub-watersheds. The search began with a desktop analysis utilizing ArcGIS to examine land cover data and aerial photography along riparian corridors to identify stream reaches having little to no vegetation remaining within riparian buffers on either side. If vegetated buffers were degraded or if streams appeared heavily eroded, KCI staff then conducted field reconnaissance at the potential sites identified in the desktop analysis.

Two viable stream restoration sites were identified. The first site is on the Horse Creek mainstem on the former Wake Forest Country Club property. This section of Horse Creek was previously restored under the auspices of the predecessor agency to the North Carolina Department of Mitigation Services (DMS). The second potential restoration site identified was along Hogan Creek that runs behind Hogan Drive in Country Club Downs subdivision. Both sites are in the Upper Horse Creek sub-watershed. These two sites were then input into the WTMs. WTM models do not populate the nitrogen or phosphorous removed, so that was manually calculated using the methodology described in "Evaluation of Nutrient Reduction Crediting Strategies for Stream Restoration" (Doll, Barbara et al. "Evaluation of Nutrient Reduction Crediting Strategies for Stream Restoration" (2018)). Protocol one from Doll et al. was used to determine the pollutant removal for nitrogen, phosphorus, and sediment for both potential stream restoration projects.

Riparian Buffers

KCI staff conducted a spatial analysis to determine the width and length of existing riparian buffer widths for each stream reach and assigned each reach to a category reflecting a buffer width of < 50 feet, 50-100 feet, or > 100 feet. WTM will not accept buffer width inputs as ranges; therefore, the three categories of buffers were assumed to have widths of 25 feet, 75 feet or 100 feet wide, respectively. In WTM, riparian buffers have a design and maintenance discount factor to reflect any buffer disturbance. For existing riparian buffers, the maintenance and design factor were assumed to be 0.4, meaning that the buffer ordinance has no restrictions on activities within the buffer, or no ordinance in place and that the buffers are not maintained (Caraco, 2013). KCI assumed all municipalities had an existing ordinance to establish riparian buffers and the ordinance had no restrictions on activities within the buffers, and no public education programs on riparian buffers were being conducted.

Livestock

WTM can account for Livestock within the watershed, however this was not applied in the WTMs that were built because no livestock operations of consequential size were identified within the study area.

Future Conditions

GIS parcel data for Wake County were obtained from the County GIS Website. Existing land use data (as developed and described in a previous section) was intersected with the county parcel data to create a

land use by parcel layer for each sub-watershed, which facilitated comparison between existing and potential future land use. Parcels that were fully developed to the limits of their existing zoning were identified and captured to be reclassified for the future conditions model build out. For the future land use scenario, it was assumed that such parcels would be subdivided in the future and developed to the maximum density allowed by the current zoning. The table below shows how the applicable Wake County zoning classifications were mapped to WTM land use categories for input into each WTM subwatershed model.

Wake County Zoning Codes	**WTM Land Use Category**
R-40W – Residential-40W District	Residential LDR
GR3 – General Residential 3	Residential MDR
GR5 – General Residential 5	Residential HDR
NB – Neighborhood Business	Commercial
RMX – Residential Mixed Use	Multifamily
HB – Highway Business	Commercial

SOURCES:

Bradley, S.N., 2021. Ecosystem Services Provided by Alluvial Soils Across an Urban to Rural Gradient. A thesis submitted to the Graduate Faculty of North Carolina State University in partial fulfillment of the requirements for the degree of Master of Science. Raleigh, NC.

Caraco, D. 2013. Watershed Treatment Model (WTM) 2013 Documentation. Center for Watershed Protection, Ellicott City, MD.

Doll, B., Johnson, J., Page, J., and Line, D., 2018. Evaluation of Nutrient Reduction Crediting Strategies for Stream Restoration. EPA 319 Grant Sponsored by the North Carolina Division of Water Resources.

National Land Cover Database (NLCD) 2019 Products (ver. 2.0, June 2021): U.S. Geological Survey data release, https://doi.org/10.5066/P9KZCM54.

North Carolina Risk Management Office - Quality Level 2 (2014) and Level 3 (2015) LIDAR Data. Accessed June 2023. Available online at: https://sdd.nc.gov/

Town of Wake Forest Unified Development Ordinance. Adopted July 16, 2013, Amended July 19, 2022. Accessed online at: https://online.flippingbook.com/view/703728449/

Wake County, North Carolina Zoning Data. Accessed June 2023. Available online at: https://data.wake.gov/datasets/68140038aedf459986cd8910a3ad9215/explore?location=35.985599%2C-78.536209%2C13.25

Appendix B: Opportunity Ranking Methodology

Table 1. Attributes used for implementation priorities

Ranking Attribute	Ranking Value		
Nitrogen	Reductions in pounds per year, actual values		
Phosphorous			
TSS			
Cost per pound N reduction	Actual values, ranked low to high		
Cost of implementation	Under $150k (1)	$150 - $499k (0.75-0.25)	Over $500k (0)
Average lifespan	20 years or less (0-0.25)	20-30 years (0.5-0.75)	More than 30 years or in perpetuity (1)
Maintenance	Existing level of maintenance or none (1)	Slightly more frequent than existing maintenance or once every few years (0.75-0.5)	Annual or need to contract out (0.25-0)
Community Acceptance	Requires coordination with more than 3 landowners or public education measures (public meeting, etc.) (0-0.25)	Requires coordination with 3 or fewer landowners (0.5 - 0.75)	Out of public sight, on public land, or natural-looking (1)
Feasibility	More than a few constraints/potential challenges (0-0.25)	Mostly ideal conditions with a few constraints (0.5-0.75)	Ideal conditions for implementation (1)

Measures of Uplift Associated with Opportunities (Nitrogen, Phosphorous, TSS)

Structural Stormwater BMPs: WTM models potential load reductions for N, P, and TSS that may be attributed to structural stormwater BMPs. For N, P, and TSS reductions under the existing conditions with retrofits modeling scenario, the values of predicted reductions were assessed for each subwatershed, as well as individually for each proposed BMP opportunity (both new BMPs and retrofits). Values are presented as total (absolute) reductions, as well as reductions per unit of upstream area treated.

Stream restoration projects: WTM does not consider stream restoration as an urban land use BMP; therefore, measures of uplift were estimated using methods outlined in Protocol 1 in Doll et al (2018):

Step 1: Estimate stream sediment erosion rate

- Use BANCS and NBS, BSTEM, or appropriate method to calculate annual erosion rates
- Calculate annual sediment load as,

$$S = \frac{\sum(cAR)}{2000} \qquad (1)$$

where,

S = annual sediment load (tons/yr)

c = bulk density of streambank (lb/ft^3)

A = area subject to erosion (ft^2)

R = erosion rate (ft/yr)

Step 2: Calculate nutrient load by multiplying nutrient concentrations and sediment load estimate

- Multiply sediment load (Equation 1) by soil nitrogen and phosphorus concentrations (lb/ton).
    - Soil N and P concentrations either measured directly via onsite sampling, or with Tetra Tech (2013) proposed concentrations (TP = 0.46 lb/ton; TN = 1.78 lb/ton).

Proposed stream restoration project on Horse Creek at Wake Forest Country Club:

- The coefficient "c" is the bulk density of streambank which was determined by identifying the soils in the watershed (Cm soil series); the bulk density of that soil series is 81.16 lb/ft^3.
- The coefficient "A" is the area subject to erosion which was about 50% of the DMS easement and that equaled to 1,412.5 ft which is 28250 ft^2.
- The coefficient "R' is the erosion rate which was taken from guidance from the EPA's Pollutant Loading Estimation Tool (PLET), a watershed modeling platform similar to WTM. The ranges are from 0.3-0.5; the average, 0.4, was used for this part of the equation.

$$S=\frac{\sum(81.16x33750x0.4)}{2000}$$

S=547.83 tons/yr

TN= (547.83 x 1.78) = 975.13 lb/ton

TP= (547.83 x 0.46) = 252.00 lb/ton

- WTM input for nutrients of TSS, TN, and TP are in lb/ft so the results were converted from tons/yr and lb/ton to lb/ft.

S=0.19 ft/lb

TN=0.35 ft/lb

TP=0.09 ft/lb

Proposed stream restoration project on Unnamed Tributary to Horse Creek at Hogan Drive:

- The coefficient "c" is the bulk density of streambank which was determined by identifying the soils in the watershed (Cm soil series); the bulk density of that soil series is 81.16 lb/ft^3.

- The coefficient "A" is the area subject to erosion which was 2948.6 ft^2.
- The coefficient "R' is the erosion rate which was taken from guidance from the EPA's Pollutant Loading Estimation Tool (PLET), a watershed modeling platform similar to WTM. The ranges are from 0.3-0.5; the average, 0.4, was used for this part of the equation.

$$S=\frac{\sum(81.16x2948.6x0.4)}{2000}$$

S=47.86 tons/yr

TN= (47.86 x 1.78) = 85.19 lb/ton

TP= (47.86 x 0.46) = 22.02 lb/ton

- WTM input for nutrients of TSS, TN, and TP are in lb/ft so the results were converted from tons/yr and lb/ton to lb/ft.

S=0.05 ft/lb

TN=0.09 ft/lb

TP=0.02 ft/lb

Other Opportunity Ranking Metrics

Construction Cost:

- Methodologies from Wossink and Hunt (2003) were used to compute potential construction costs for most BMP types. The costs projected by the methods set forth in Wossink and Hunt were adjusted for inflation on the basis of the increase in the Construction Analytics (CA) non-building infrastructure composite index of construction costs (Zarenski 2024). CA Infrastructure composite index reflect an average of six established infrastructure construction cost indexes. In 2003, when Wossink & Hunt was published, the CA Infrastructure composite stood at 55.2, whereas in 2024, the index is projected to be 137, reflecting a 148% increase in infrastructure construction costs across that period.
    - Bioretention Cells:
        - Took 2.5% of the drainage area of each bioretention cells and multiplied it to the cost per sf ranging from $12-15. If the utility constraints were on the higher end, the $15 sf price was applied. If the utility constraints were on the medium end, $13.5 sf price was applied. If the utility constraints were on the low end, then the $12 sf price was applied. From there that number was increased by 148% to account for inflation as described above.
    - Bioswales:
        - The same method was used as above for bioretention cells but 10% was added to the cost per sf to account for the outlet structure for the bioswales.
    - Bioswales with check dams:
        - The same method was used as above for bioretention cells but 12.5% was added to the cost per sf to account for the outlet structure for check dams/outlet structures for the bioswales.
- BFC construction costs were based on actual construction costs acquired from NCDOT because they have contracted the construction of three BFC application across the state in Brunswick,

Alamance, and Iredell Counties. Given that the BFCs were constructed within a timespan from 2012 to 2017, construction costs were adjusted to account for inflation from the median year of the construction time and, 2014, forward to 2024. The increase was calculated at 48% based on the CA non-building infrastructure composite index just as described above.

  - For the BFC that was sized for a drainage area of 6.9 acres, used the Alamance County Rest Area price of $101,500 since the drainage area was around the same as the Alamance County Rest Area.
  - For the BFC that was sized for the drainage area of 10 acres, used the Alamance County Rest Area and increased the price to $150,000 because the drainage area for that Rest Area was for a drainage area of about 6 acres.

- Stream restoration project costs were estimated to be roughly $650/linear foot. This was determined using an average of recent urban stream projects and the current NC DEQ Division of Mitigation Services statewide stream mitigation fee.

Annual Maintenance Level of Effort: Based on recommendations for BMP type.

Annual Maintenance Cost: % of implementation cost per BMP type, per Price et al 2021.

Cost per unit N reduction: Implementation cost/pounds per year of N reduced.

Community Acceptance: Based on combination of how "natural" the BMP will look & the amount of potential coordination with landowners. Notes for factors related to individual opportunities are found in **Table 2**.

Feasibility: Combines potential challenges that may be associated with the project. Includes factors such as potential permitting requirements, utility coordination, and site suitability for the proposed practice. Notes for factors related to individual opportunities are found in **Table 2**.

Ease of Implementation = Community Acceptance + Feasibility

Table 2a. Opportunities for Nonpoint Source Reductions within the Town of Wake Forest and its ETJ

BMP Name	Watershed	Drainage Area (Ac)	SCM Type	Cost-JD	Cost Score	Maint Level	Maint Score	Lifespan	Lifespan Score	Comm Accept Score	Nitrogen Reduction (lbs/yr)	Nitrogen Reduction Cost($/lbs)	Phosphorus Reduction (lbs/yr)	Sediment Reduction (lbs/yr)	FC Reduction	Feasibility Score	Feasibility Notes	Implementation
Clarion Point Hotel	Lower Horse Creek	2.3	Convert Failing Dry Detention Basin into Bioretention cell	$62,372	1	Low	1	20 years	0.5	1	9.3	$6,707	1.5	170.7	350.1	1	There is a dry detention basin in the back of the hotel parking lot that is in need of maintenance and appears to be failing. Converting the failing BMP into a bioretention cell here will drastically improve performance with regard to water quality treatment, especially for nutrient reduction. Can use the back corner of the parking lot as a staging area.	2
Wellons Inc.	Lower Horse Creek	4.2	Bioretention Cell	$120,095	1	Low	1	20 years	0.5	0.5	11.9	$10,092	1.9	218.6	448.6	0.75	Adding an additional bio cell here or redoing the one that is already here to capture a larger drainage area. Should not be hard to get the business owners here on board since there is already one here. Could use the parking lot as a staging area too.	1.25
Preswicke Property Owners Association	Lower Horse Creek	6.5	Bioretention Cell	$193,144	0.75	Low	1	20 years	0.5	0.5	18.9	$10,219	3	347.1	712.1	0.5	More than enough room to implement a bio cell in the open lot of Preswicke Neighborhood, it is in the open space owned by the HOA so would need to get them on board. There are some utilities running here which may cause issues with implementation... a pipe is coming from the business lot and going UG across the empty lot. Staging may be a little tricky due to the roads not really having a shoulder to block off but could use the business park to the right of the entrance of the neighborhood as an area for staging.	1
Penfold Lane	Lower Horse Creek	10	BFC	$222,000	0.75	Low	1	20 years	0.5	1	23.2	$9,569	3.9	453.9	705.6	0.5	This BFC is in the same neighborhood as the BMP above, Preswicke and owned by the HOA there. There is enough slope and area to implement this BMP, just need to get the HOA on board. There is a water pressure line running parallel to the area where we want to place the BMP, so need to take that into account and make sure that is not effected during implementation of this BMP. Staging could be on Penfold Lane, on either side of where the BMP would be implemented.	1.5
Wake Forest Presbyterian	Lower Horse Creek	10.4	Treatment Train - Bioswale into Bioretention Cell (Convert current Dry Detention Basin)	$322,080	0.5	Low	1	20 years	0.5	1	24.2	$13,309	4.1	472	733.9	1	There is a rip rap swale that is leading into a bio cell in the back of the church that can be turned into bioswales and convert the existing dry detention absin (presumed) into a bioretention cell to improve water quality performance, especially for nutrients. The parking lot could be used as a staging area for the implementation of these two BMPs.	2
Middlestone Court	Upper Horse Creek	12.3	Bioretention Cell	$386,587	.25	Low	1	20 years	0.5	0.5	36	$10,739	5.3	665.9	1385.2	0.5	To place the BMP at the end of the cul de sac / behind houses, will have to get those landowners on board. It will help treat the drainage/run off in the part of this neighborhood, so can use that to try and get them on board. Would have to use the end of the cul de sac as a staging area which means blocking it off for some time during implementation.	1
Country Club Drive	Upper Horse Creek	12.7	Bioretention Cell	$400,285	.25	Low	1	20 years	0.5	0.5	36.6	$10,937	5.4	676.2	1406.6	0.5	Would have to get the landowner that owns the old country club on board to allow us to place this BMP here. Staging will be a bit tricky since there is no real entrance point to this area from the old CC and to access it from Country Club drive, you would have to use the end of the cul de sac which means getting those landowners on board for that.	1
Hogan Drive	Upper Horse Creek	30.4	Stream Restoration	$35,750	1	Low	1	> 30 years	1	0.5	85.2	$420	22.02	47.9	N/A	0.25	12 landowners would need to get on board for this project to happen which makes the feasibility a bit hard. The staging area for this project would also be a bit tight, could potentially be at the end of the cul de sac of Hogan Drive.	0.75
Wake Forest Country Club	Upper Horse Creek	6150.4	Stream Restoration	$2,193,750	0	Low	1	> 30 years	1	.5	975.1	$2,250	252	547.8	N/A	0.25	There is already a DMS conservation easement on this land so would have to get both the IRT and the land developer on board in order to do this restoration project. Staging area would not be difficult as this land is in flux with the developer, so before the land gets developed could potentially do the project that way construction of the stream would not be in conflict with the contruction/development of the land.	0.75

Table 2b. Opportunities for Nonpoint Source Reductions Outside of the Town of Wake Forest/ETJ

BMP Name	Watershed	Drainage Area (Ac)	SCM Type	Cost-JD	Cost Score	Maint Level	Maint Score	Lifespan	Lifespan Score	Comm Accept Score	Nitrogen Reduction (lbs/yr)	Nitrogen ($/lbs)	N (lb/yr/acre)	Phosphorus Reduction (lbs/yr)	Sediment Reduction (lbs/yr)	FC Reduction	Feasibility Score	Feasibility Notes	Implementation
Forest Ridge Park	Mud Branch	3.5	Bioretention Cell	$98,487	1	Low	1	20 years	0.5	1	7	$14,070	2.0	1.1	128.7	265.8	1	There is enough room here to place a bio cell and the county/Army Corps are on board to implement a BMP here. Could block off part of the parking lot for a staging area to implement the bio cell.	2
Kensington Manor Place	Upper Horse Creek	6.9	BFC	$150,220	0.75	Low	1	20 years	0.5	0.75	15.9	$9,448	2.3	2.5	313.3	494.6	0.75	This area where the BMP would be placed is owned by the Kensington Manor HOA, which means would have to get them on board. Shouldn't be too hard of a sell to them considering this is an older neighborhood without any existing BMPs there. Placing the BCF here will help catch the runoff in this section of Kensington Manor. Staging area could be the same area as the above BMP.	1.5
Melcombe Way	Upper Horse Creek	5.3	Bioswale	$170,151	.75	Low	1	20 years	0.5	0.75	12.3	$13,833	2.3	1.9	240.6	379.9	0.75	This bioswale would be placed within the DOT right of way on Melcombe Way to capture the run off the this section of the neighborhood. I think this would be easy to implement considering DOT would be on board. Staging area could be tricky but could possibly block off half the road to allow for traffic to get through during implementation.	1.5
Micklewaithe Court	Lower Horse Creek	6.4	Bioswale with check dams	$218,400	0.75	Low	1	20 years	0.5	1	14.9	$14,658	2.3	2.5	290.5	451.6	1	This BMP would be placed within the DOT right of way on Micklewaithe Court to capture the run off the this section of the neighborhood. I think this would be easy to implement considering DOT would be on board. Staging area could be on at the end of the cul de sac on this road during implementation.	2
Kensington Manor Lane	Upper Horse Creek	9.41	Bioretention Cell	$288,866	.5	Low	1	20 years	0.5	0.75	27.1	$10,659	2.9	4	501	1042.2	0.75	This area where the BMP would be placed is owned by the Kensington Manor HOA, which means would have to get them on board. Shouldn't be too hard of a sell to them considering this is an older neighborhood without any existing BMPs there. Placing the bio cell here will catch the swales running south and treat it in even more from this section of Kensington Manor. Staging area could be tricky since this area is right off the road but could possibly block off one half of the road to allow traffic to get through.	1.5
Blue Ravine Road	Upper Horse Creek	9.41	Bioswale	$317,753	.5	Low	1	20 years	0.5	0.75	21.7	$14,643	2.3	3.4	427.2	674.5	0.75	This bioswale would be placed within the DOT right of way on Blue Ravine Road to capture the run off the this section of the neighborhood. I think this would be easy to implement considering DOT would be on board. Staging area could be tricky but could possibly block off half the road to allow for traffic to get through during implementation.	1.5
The Church of Jesus Christ of Latter-day Saints	Lower Horse Creek	12.5	Bioretention Cell	$393,431	.25	Low	1	20 years	0.5	1	36.5	$10,779	2.9	5.8	667.4	1369.5	1	Place BMP in the front lot of church to capture runoff. Could use the parking lot as a staging are for implementation.	2
Alveston Circle	Upper Horse Creek	13.89	Bioretention Cell	$441,256	.25	Low	1	20 years	0.5	0.75	40	$11,031	2.9	5.9	739.6	1538.4	0.75	This area where the BMP would be placed is owned by the Kensington Manor HOA, which means would have to get them on board. Shouldn't be too hard of a sell to them considering this is an older neighborhood without any existing BMPs there. Placing the bio cell here will help catch the runoff in this section of Kensington Manor. Staging area could be at the end of the cul de sac of Alveston Circle.	1.5
Shorrey Place	Upper Horse Creek	18.7	Bioretention Cell	$609,810	0	Low	1	20 years	0.5	0.75	53.8	$11,335	2.9	7.9	995.7	2071.2	0.75	This area where the BMP would be placed is owned by the Kensington Manor HOA, which means would have to get them on board. Shouldn't be too hard of a sell to them considering this is an older neighborhood without any existing BMPs there. There is a sewer line that runs down between two houses that the BMP would be placed behind so need to make sure that is not effected by the implementation of this BMP. Could use the end of the cul de sac as a staging area.	1.5
Melcombe Way Cul de sac	Upper Horse Creek	24.66	Bioswale with check dams	$947,583	0	Low	1	20 years	0.5	0.75	56.9	$16,653	2.3	8.9	1119.6	1767.6	1	This area where the BMP would be placed is owned by the Kensington Manor HOA, which means would have to get them on board. Shouldn't be too hard of a sell to them considering this is an older neighborhood without any existing BMPs there. Placing the bioswale with check dams here will help catch the runoff in this section of Kensington Manor. Staging area could be at the end of the cul de sac of Melcombe Way.	1.75
Wake Forest Country Club	Upper Horse Creek	6150.4	Stream Restoration	$2,193,750	0	Low	1	> 30 years	1	.5	975.1	$2,250	94.1	252	547.8	N/A	0.25	There is already a DMS conservation easement on this land so would have to get both the IRT and the land developer on board in order to do this restoration project. Staging area would not be difficult as this land is in flux with the developer, so before the land gets developed could potentially do the project that way construction of the stream would not be in conflict with the contruction/development of the land.	0.75

References

Doll, B., Johnson, J., Page, J., and Line, D., 2018. Evaluation of Nutrient Reduction Crediting Strategies for Stream Restoration. EPA 319 Grant Sponsored by the North Carolina Division of Water Resources.

Price, E.W., T.H. Flemming, and L.A. Wainger. 2021. Cost Analysis of Stormwater and Agricultural Practices for Addressing Nitrogen and Phosphorus in Maryland. Prepared for Maryland Department of the Environment. UMCES Technical Report #TS-772-21.

Tetra Tech, 2022. User's Guide, Pollutant Load Estimation Tool (PLET), Version 1.0. Developed for U.S. Environmental Protection Agency. Accessed online at: https://www.epa.gov/system/files/documents/2022-04/user-guide-final-04-18-22_508.pdf

Wossink, A. and Hunt, B., 2003. The Economics of Structural Stormwater BMPs in North Carolina. UNC-WRRI 2003-344. UNC WRRI, Raleigh, NC.

Zarenski, Ed, 2024. Construction analytics: economics behind the headlines. Accessed online at: https://edzarenski.com/category/inflation-indexing/

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Appendix C: Survey of Stakeholder Priorities

The Horse Creek Watershed Study was initiated to identify and address current issues within the Horse Creek Watershed related to water quality, inadequate drainage conveyances, stormwater infrastructure problems, and erosion. The study will help the Town of Wake Forest to develop compliance measures to meet the pollution reduction requirements in the Falls Lake Rules, and to comply with the Upper Neuse River Basin Association (UNRBA) Interim Alternative Implementation Approach (IAIA). The Town will use the Study to develop a watershed plan that will serve as a guide for efforts to manage water quality in the Horse Creek Watershed and help reduce the incidence of harmful algal bloom in Falls Lake in the future.

As a part of the Study, the Town is engaging with the public in several ways, including public meetings, an informational web page about the Study, and an online survey which solicited feedback from the public about the watershed and potential issues related to water quality and quantity. This document summarizes the results of the online survey.

The survey was live from April 20 to June 20, 2023. The survey was advertised on the Engage Wake Forest web page, the Horse Creek Watershed Study web page, and on signs advertising a public meeting that were placed within communities in the watershed. The survey was also recommended and preliminary results discussed at the public meeting on June 13. There were 126 legitimate responses out of a total of 128 (the first two responses were KCI tests). The following information summarizes the results. The full survey results should be consulted to match any specific response or issue to an individual.

General User Information Questions

The majority of respondents are long-term (more than 10 years) residents of both the Horse Creek Watershed and the Town of Wake Forest. Almost half of the residents have onsite septic systems. Most respondents have never participated in a watershed study. Residents were most interested in wildlife and water quality; the most common write-in issue of concern was overdevelopment, which was often expressed along with concerns about land use change.

Which best describes you?	
NOT a resident of Wake Forest, but live in Wake County	32
Resident of Wake Forest	93
Both	1
Total	***126***

Check which best describes you:	
I live in the Horse Creek Watershed	111
I work in the Horse Creek Watershed	0
Both	11
Neither	4
Grand Total	***126***

How long have you lived/worked in the Horse Creek Watershed?	
5 or less	31
6 to 10 years	22
11 to 20 years	27
21 to 30 years	37
more than 30 years	6
not selected	3
Total	***126***

Do you own a business in the Horse Creek watershed?	
No	122
Yes	4
Total	***126***

Do you have an onsite septic system?	
No	64
Yes	62
Total	***126***

Have you participated in a watershed study before?	
No	121
Yes	5
Total	***126***

The Following Topics are Important to Me *(select all that apply):*	
Wildlife	118
Land Use Change	88
Public Spaces (parks, greenways, gardens, etc.)	102
Water Quality	123
Water-based recreation (fishing, boating, swimming, kayaking, etc.)	54
Overdevelopment	7
Other	14
Total	***506***

Watershed Observations

I Have Observed These Issues *(select all that apply):*	**Count**
Excessive Eroding and/or Unstable Stream or Ditch Banks	69
Accumulation of Sediment in the Roadway	36
Beaver Activity	21
Changes in Water Quality or Quantity	24
Damaged Catch Basin or Other Drainage Structures	16
Damaged or Non-Functioning Stormwater Ponds	20
Excessive Erosion at Pipe Outlets	20
Stormwater Runoff Covering All or Part of the Road	58
Dam/stormwater pond issues	3
None of These	22
Other	6
Total	***295***

This survey question included a follow-up text-entry question that allowed users to comment on specific locations and/or frequency of observations. The full survey results should be consulted to match specific responses to issues. The additional information is also discussed in the additional information/comments section of this report.

Collaboration

Survey Question:

Some areas of the Town of Wake Forest and Wake County portions of the Horse Creek Watershed were developed before the implementation of modern stormwater control standards. By installing stormwater control devices (such as rain gardens, bioswales, and stormwater ponds) in those communities to bring them up to modern standards, runoff can be captured and treated to reduce harmful pollution to Falls Lake downstream. Please note your level of willingness to provide the Town access and/or easements to facilitate these types of projects: I would likely cooperate with the Town to facilitate a stream project impacting my property under the following circumstances:

Stormwater project participation willingness:	
For a project with the overall objective of capturing untreated runoff and improving water quality	98
For a project with the overall objective of capturing untreated runoff and improving water quality, but only if that project is small (like a residential rain garden or installation of rain barrels)	10
I am not interested in collaborating with the Town on stormwater projects	7
Only if stream improvements are needed to protect my property and/or preserve its value	11
Grand Total	***126***

Survey Question:

Many of the natural drainage channels in the Horse Creek watershed are along and between the back yards of residential properties. Repairing and improving the streams will require construction access, probable loss of some trees, and up to a couple of months of construction activity. Please note your level of willingness to provide the Town access and/or easements to facilitate these types of projects:
I would likely cooperate with the Town to facilitate a stream project impacting my property under the following circumstances:

Stream project participation willingness:	
For a project with the overall objective of stabilizing the streambanks to prevent further erosion and enhancing water quality	91
I am not interested in collaborating with the Town on stream projects	9
If stream improvements are needed to protect my neighbors' property and generally preserve neighborhood property values	20
Only if stream improvements are needed to protect my property and/or preserve its value	6
Grand Total	***126***

Additional Information and Comments

The most common themes were flooding (specifically, Horse Creek at Jenkins and Purnell Roads, and in the Fairlakes neighborhood), concerns about general rates and methods of development, concerns about specific development projects (most frequently, the former Wake Forest Country Club property), concerns about a sewage overflow associated with townhomes/apartments, concerns about the safety of the Lewis Dam in the Fairlakes neighborhood, and concerns about water quality (sediment, sewage, and potential chemicals from the former Wake Forest Country Club and Schrader sites). There is a perception that flooding is becoming more frequent, and water quality is at risk. There were several specific issues mentioned that are outside the Horse Creek Watershed.

Fairlake/Lewis Dam

I live in Fairlake on the lake built by Lewis dam. Lewis dam had issues and we had to keep the lake level lowered and the creek thst feeds it is in my back yard and trees have grown in. Heavy rains lead to a significant amount of water entering the creek from runoff and the HOA refuses to address the issue even though we have been ordered by the DEQ. This has been an issue for 7 years.

Fairlake/Lewis Dam outlet and spillway needs repair. Severe erosion putting dam at risk.

Fairlake spillway is damaged and eroding.

Is there any help that you can offer to help resolve the Lewis Dam in Fairlake?

Please repair the Lewis lake earthen dam.

I live in the Fairlake subdivision. The Lewis Dam has been damaged since Hurricane Matthew in 2016 and has not been repaired since. I would like to see some assistance from this grant in fixing the dam so the lake can continue to do the job of being a retention pond.

Wake Forest CC

I reside on the Wake Forest golf course and have personally observed over the last 17 years several issues. We are most concerned about future development on this property with known toxic chemical contamination. We know there will be runoff and want to have the soil tested as phase 2 testing in order to determine if remediation is needed prior to development. Flooding is another concern.

Over the years, Horse Creek river banks are changing. I walk these banks on the former WFGC property. There is significant sand and debris that has topped the banks. There is a beaver dam on the ponds flowing into the creek. There is severe backup of logs and debris on Horse Creek within the WFGC property which has damaged the small bridges and water flows further into the surrounding flood plain. (more below)

Horse Creek often cannot handle the amount of runoff. Development Plans (Jenkins/Capital) (Old WF Golf Course Property) will only add to the problem. Impervious zones will be eroded to

minimal amounts resulting in less absorption of water and even more runoff. I think WF is a bit out of control. Developers are going after rezoning of these properties to allow even MORE dense development on these parcels of land. Horse Creek and the water shed appear to be after thoughts for this town.

The Joyner property (Old WF Golf Course) ..... if developed, will also result in hazardous chemicals runoff into Horse Creek. It is an old golf course that has been treated with fertilizers, weed control, pest control, etc..... for decades. Concerned citizens have brought this concern forward but the town has either (1) not allowed them to speak at public meetings or (2) totally disregarded the info. With this type of reception it's difficult to believe that the Town is serious about protecting the watershed.

Residential development of the former wake forest country club will severely harm this water shed and negate the benefits you are trying to accomplish.

The irony of this survey is palpable. Based on the recent developments around the rezoning of the Old Wake Forest Golf Course, it is clear that the only motivation of the town is to satisfy the priorities of a few greedy developers (Jim Adams), a corrupt mayor who has once received (and never again will receive) my vote, and an unqualified and unscrupulous commissioner Nick Swalinski, who was elected to represent those in the watershed opposed to the development of the golf course but let down his entire constituency, presumably under pressure from the developers and the town. This is an environmental issue, and a political one. I am one of the residents (Kings Way Court) who has paid the high taxes for more than a decade to make this town what it is. I kayak and fish in Falls Lake. Will you cause the catfish I pull from the lake to be inedible simply for the financial gain of Mr. Joyner, Mr. Adams, Vivian Jones, and and few of the corrupt elite? There is still time to undo the damage, but Wake Forest is about to become "Cary Jr.", and you'll lose another resident who made this town what it is. DON'T DEVELOP THE GOLF COURSE!

Development of former Wake Forest Club will create MANY problems for area residents and those living downstream.

Sewage

Raw sewage smell in horse creek, excessive water flow in creek and flooding since apartments built. Road erosion over the creek.

Odor throughout our neighborhood and foam on the water and on the banks of the creek.

Flooding of small tributary to Horse Creek whenever there is much rain caused by large apartment complex. Same complex has suffered breakdown of septic systems or pipes.

There appears to be a sewage overflow at the apartments on the corner of Durham Rd and 98. Was reported to several agencies by my husband and nothing done and no apparent follow up with us or any residents on Fawn Drive to explain what happened or if even investigated. The sewage smell lasted for >2 weeks!

There was a serious sewer failure at the legacy apartments which allowed raw sewage to enter the creek upstream. This caused odor throughout the neighborhood. There was nasty yellow brown foam on the water and along the sides of the creek bed. Which still today appears in the pooling areas. The odor and foaming continued for about 25 days. I called every department in the state and was shuffled and run around for months. The City of Raleigh were the only ones that came here, walked the creek and found the source at legacy apartments. But the couldn't help because it wasn't the jurisdiction. Department of water quality was a huge waste of time too. I have requested the required reports to at least ensure the problem has been properly repaired. No one will help. Not the city, not the county, not the state. It was actually pretty sad that no one showed any interest in investing this problem. We have kids in our neighborhood that chase frogs in the creek and homes the creek flows behind. Not to mention the wildlife living in and around the creek. Also not to mention the lye that was spread at the spill sight. That also came downstream. If the next big rain brings more literal crap and more lye downstream again, i will be calling WRAL.

We had a problem in recent months involving very foul smelling apparently human waste pollution of a small creek adjacent to our property which was sewage from a nearby apartment complex. When it was reported to Wake County health department authorities they did nothing for several weeks until a second report was made to another branch of Wake County government. Should we have reported to Wake Forest instead.

Road Flooding

After storms I have noticed runoff partially covering Purnell Road many times.

Both Purnell and Jenkins Road have had issues with flooding in the past. We have all kinds of wonderful wildlife, trees and plants in the Horse Creek Watershed. Please keep this watershed protected from more development. Don't allow rezoning for developers planning to max their profits by building as many units as they can. We need to keep some forest in Wake Forest.

During heavy rains (~ monthly), water in our neighborhood drains to the road in front of our house (7825 Fairlake Dr) and pools on the road and in our driveway,

I don't live directly on the creek, but RiverStone backs up to the creek. Access to the creek is via a utility road behind our neighborhood. The culverts along Chilmark collect so much water in the big storms, forcing water to run over our driveways about 3x per. This has been particularly noticeable the past 5 years. Debris from overflowing Horse Creek happens about once a year along Jenkins.

I have seen the entire area of Jenkins Rd. completely flooded and have seen the 2 ponds that have been constructed in the flood plain washed away.

I've lived in Wake Forest for 30 years and in the Horse Creek watershed for the past 3. I've noticed water running over Purnell Rd more and more with heavy rains. Seems to cause wrecks and dangerous driving. Seems to only be a matter of time before it washes out a section of road or the bridge.

Monthly we have water on the road (Fairlake Drive)

Stream and ditch banks are being destroyed without adequate knowledge of the impact on water runoff and damage. Horse Creek completely over ran Jenkins Rd in 2022 and I was nearly swept away in my car. Property owners need knowledgeable help to do the correct thing when they are changing ravine, stream and ditch banks. Landscapers are removing plants from streams causing more runoff. Educate on over use of fertilizers, pesticides and lawn spray treatments.

When there are strong storms, which are not infrequent, Horse Creek watershed will overwash Purnell

Runoff, Sediment and Erosion

Daily walks in Joyner Park i see run off from the new housing development and i see the pond a red muddy disaster. Its obvious all over that theres a problem. New development is going to ruin the environment if it hasnt already.

Every time it rains the stream turns red from construction runoff. It seems as if the stream banks have been eroding excessively in the last few years with the increase in new construction.

New construction often causes runoff and sediment on the roads

Occurs often with heavy or frequent rains. Stream is eroding towards my house. Pipes and wires have been exposed. Stream banks are getting higher and steeper.

Run off from properties as well as through running streams creates flooding conditions in fields and erodes yards monthly. Prevents me from accessing, let alone using my property.

Seems like this is closing the barn door after the horses have gotten out! The problem is all the clear-cutting with new construction. Every million dollar-plus home behind us has clear-cut their entire lots leading to increased erosion and run-off! Where are the common-sense rules and regulations that would have prevented some of this? I know there are rules about keeping a certain amount of trees- why are developers being allowed to skirt those rules?

since the development behind me - good ole Devon Square- I now have so many water issues in my backyard that I was promised I wouldn't. Slow down development.

Heavy thunderstorms often are too much for existing stormwater management systems. Too much development (rooftops and pavement) add to this problem. We do not have sufficient vegetation buffers around streams, channels, and rivers.

The Town engineer needs to closely inspect all storm water control measures proposed for adequacy and then inspect on site for proper construction and follow-up with the annual inspections. The town houses on Sienna Drive and highway 98 have non-functioning drainage that has created a ravine in the neighborhood of Pine Ridge Ct. This type of thing needs to be prevented--not just corrected. Want to see stronger measures in the updated UDO.

There is a large hole on Purnell that is an erosion hole close to the bridge. The storm water run off goes here and there is a potential for this to undermine the road at some point. We have

already reported erosion holes under the road and DOT has hot patched one of them. I do not walk on the golf course anymore, but when I did, there was evidence of beaver activity in sapling stumps and trails down to the stream. This was several years ago.

Water Quality

Given the history of the leaking sand pits from the former Schrader plant & purposely pouring out of harmful toxins in groundwater supply areas as told by former employees of the plant & given a large number of cancer cases within surrounding neighborhoods testing for contaminants is the most concerning for this particular watershed study.

My home and community is on well water and it's very important to me that we keep our streams, trees and any other natural resources in place to pre reserve the cleanest water possible.

Water quality is all important! The impact on Falls Lake must be addressed. It must be prioritized above all development projects.

We are interested in the watershed project but want to make sure no retention ponds are placed near our home doe to chemical contamination concerns from the golf course.

We are willing to give more feedback inn general. We do NOT want a stormwater containment pond due to chemical concerns, we are more than willing to continue to provide feedback and help in any way to make this a better situation for all and for the safety of the community. - Gina

Miscellaneous Comments

All of the above at least once/year in strong torrential storms. Flooding occurs multiple times/year

Altering runoff, muddying creeks, and pushing wildlife (including copperheads) into neighborhoods that responsibly preserve mature trees / underlying forest habitat throughout

Developing the property at a minimum on the west side of Horse Creek will impact water quality, increase run-off from installed roads and driveways and loss of trees and drive off wildlife which is abundant in the watershed. The town is getting in a critical position by not saving enough natural wet areas for future generations water supply. Development around Horse Creek will add polluted and tainted water into Falls Lake which provides all of Raleigh's water supply. Horse Creek dates back hundreds of years and is there for a purpose. Save it.

Dun Loring subdivision. The wooded area behind my property includes a dry streambed protected by a streambed set-aside. The woods with large trees is often home to hawks, pileated woodpeckers, Summer Tanagers, fox, and many other species.

Heavy beaver activity has increased size of storm water ponds and damaged surrounding natural habitat and banks on ponds

I am very concerned about developments at Capitol Blvd and Jenkins Rd and how they may impact water quality at the creek, wildlife nearby, and other issues not related to this survey.

I feel strongly about protecting the watershed and the wildlife around it. The wildlife around Horse creek has expanded exponentially since the construction across the highway at Joyner Park. The runoff from that development seems to have adversely affected the water/streams within that park. Very sad to see all the development around the watershed. Please protect our water by preserving the land and wildlife/trees around and within the watershed. I have lived in Wake Forest for 6 years and would like to see more thoughtful development that does not clearcut fields of trees.

I have been in communications with the engineers dept already

I would be very interested and supportive of having access to Falls Lake or Forest Ridge park via a greenway or public access along horse creek. This would also allow easier access for construction and/or repair and monitoring of horse creek.

I would like to see Horse Creek watershed maintained for its contribution to the water quality of Wake Forest and its wildlife habitat.

It appears the Town & County have severally compromised the watershed by allowing over development in and around Falls Lake.Re- Zoning properties is the exact opposite of what needs to be done to protect the fragile water supply.

Relevant to other area water concerns raised prior to a recent re-zoning action, because of space limitations and proximity, any widening of Purnell Road to accommodate traffic increases contributed to by new construction in the Wake Forest corporate limits and near Purnell would without question adversely affect the value of our home. Accordingly, although it would not be our preference, any attempt at ”imminent domain” could be met with an ongoing legal action which could trigger renewed examination of recent actions taken by the town relative to re-zoning which in our opinion will be affecting other watershed issues beside Horse Creek as well.

Residents on west side of a capital are a PART of town too….consider our needs with ALL plans and concerns

Stop trying to develop everything. You are ruining the spirit of our town.

Thanks for work on the streams in our area!

The increase in construction is too much for the current storm water design

The largest pine tree recorded in central NC is located on the Holding property that is currently being considered for a giant housing project. The published plan does not address any protection for this important tree.

We need a moratorium on development

Why does this construction/development issue continue to be brought up to the Town Board after the Army Corps of Engineers long ago cleaned out the creek, may have rerouted it, and stated that NO ONE OR ANY TOOL, etc. could be used to enter the creek to retrieve absolutely anything!! It is such a waste of everyone's time.

Would qualify as mild. Work has been done before and has helped.

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Three sets of duplicate contact information were removed from this list, indicating at least three people filled out the survey more than once. The last two entries were entered into the comments section, rather than in the contact information sections. The full list of results should be consulted to match specific concerns and responses to an individual.

Wake Forest Country Club Mitigation Project
Location: Wake Forest, NC
Long-term Steward: NC DEQ Stewardship Program
Additional Project Documents and Information:
https://www.deq.nc.gov/about/divisions/mitigation-services/project-documents

Definitions/Acronyms:
DEQ = North Carolina Department of Environmental Quality
DMS = Division of Mitigation Services, a division of DEQ (formerly known as the Ecosystem Enhancement Program, or EEP)
IRT = North Carolina Interagency Review Team, the regulatory agency for mitigation projects. Headed by the US Army Corps of Engineers.
KCI = KCI Technologies, Inc., consulting firm that conducted the Horse Creek Watershed Study under direction of the Town of Wake Forest in 2023-2024.
MY = Monitoring Year; typically, 5-7 years of monitoring and reports are required following mitigation project construction
UT = Unnamed Tributary

Project Timeline:

2002: Restoration plan established with the following original site goals:

- restore riparian buffer.
- reconnect Horse Creek and UT to floodplain.
- increase sinuosity/dissipate instream energy.
- reduce erosion, downstream sedimentation, and property loss within the golf course property.
- improve aquatic habitat; and
- N reductions to Falls Lake / source water protection

2003: Conservation easement (7.98 acres) enacted; contains provisions for active golf course including maintenance of several golf cart crossings, 1 culverted road crossing on Horse Creek, and paved golf cart paths within the easement. The landowner is responsible for maintaining infrastructure within the easement, and the easement and its responsibilities and restrictions transfer with the land upon sale.

2005: Site was constructed under design-build contract using Priority 1 restoration. The MY00 (as-built) report noted several major areas of concern:

- 7 of 18 vegetation plots met 75% survival rates; 2 of 10 had 0% survival; only 5 of 18 had 80% survival. “Vegetative problem areas” were identified in MY00 report but no corrective actions were recommended.
- The MY00 report identifies stream “Problem areas,” already showing instability, likely to require maintenance (3), “Areas of concern,” - currently stable but showing signs of change that might lead to future instability (6), and “Areas of Difference,” that differ from the design (2). The MY00 surveyed cross sections were all larger than the design cross sections.

2006: Design firm performed MY01 monitoring and issued MY01 report:

- 6 of 18 veg plots met 75% survival criteria; 6 of 18 had 0% survival; most problem areas were within the floodplain and were attributed to landowner actions: “Large portions of the riparian buffer have been denuded of the native woody and herbaceous species originally planted there and replaced only by maintained lawn grass.”
- 15 problem areas identified within the Horse Creek stream channel – mainly aggradation in the upstream reaches and degradation in the downstream reaches. No corrective actions were identified but it was noted that intervention would likely be necessary in the future.

2007: The golf course was permanently closed in the fall. Ownership was retained until 2010.

2008: A new firm assumed monitoring duties for MY02 – MY05.

2010: The MY05 report documents multiple failing structures along T1 and southern reach of Horse Creek. It identifies 8% of stream banks as “unstable”; the site was scheduled for invasives treatment and supplemental planting in 2011, but there is no documentation that this took place. Report notes beaver dams along Horse Creek. UT largely dry, with veg growing in lower portion of channel; 3 of 7 *(what happened to the original 18?)* veg plots met survival thresholds.

2010 – 2011: A bank assumed ownership of the property in 2010. The property was put up for sale in 2011.

2012: Property sold to E. Carroll Joyner; New landowner inherited all responsibilities associated with the conservation easement.

2012 to 2019: The new landowner appealed to the IRT to dissolve the conservation easement, which was denied. DMS did not visit the site during this time.

2019: Site closed out by the IRT. It appears that no structural repairs were made, and the site was not replanted; there are no public records of what was agreed upon to close out the site. DMS took approximately 50% credit loss with the IRT to get the site closed out. The conservation easement is now legally enforced by State Property through the DEQ Stewardship program.

2022: The landowner unsuccessfully appealed to the IRT to add an additional crossing within the UT in April. The landowner also attempted to gift the undevelopable land within the floodplain to the Town of Wake Forest for the creation of a park; this fell through partially because the Town was wary of taking control of the conservation easement, and partially because an adjacent parcel that would have provided access was purchased by an HOA.

2023: KCI staff visited the southern half of the project, which is failing. The banks of the lower portion of the project are sparsely vegetated. Multiple cross vane structures appear to have been designed or constructed incorrectly (not tied in to bankfull, stones are too small, etc.) KCI observed at least 3 structures where the stream was eroding out the bank around the tie-in, where structure materials have been mobilized by peak flows and were in the channel downstream, and where the channel was actively eroding and adjusting planform. Additionally, the two corrugated culvert pipes at the road crossing have become blocked by debris and the crossing is in the process of failing. Horse Creek has undermined the pavement, which is partially collapsed on the bank-left side of the crossing. There was evidence that the debris jam in the culvert has caused Horse Creek to flood the right bank of the project near the UT during peak flows.

Future events may result in complete crossing failure, mobilization of the culvert structure materials, downcutting, widening, and a potential migration of the channel.

Discussion

It is likely that the site's failure is due to a combination of factors, including inadequate design or construction that did not achieve the original design objectives, site constraints adjacent to the original project, including utility easements and maintained golf course fairways that limited the design, failure to achieve successful riparian corridor revegetation following construction, potential encroachments associated with golf course maintenance, and a lack of maintenance of the crossings and culverts once the golf course closed.

As it exists now, the site is not providing adequate riparian buffer to mitigate the effects of potential adjacent land use changes. Additionally, the unstable channel appears to be a source of both sediment, and potentially stored nutrients from within former golf course soils, into Falls Lake via Horse Creek. The project is not achieving its intended goals and will likely become more unstable as the instream structures continue to deteriorate and the proposed development of adjacent lands takes place.

Appendix D: Implementation Support Materials

- Table of Collaborative Projects Implemented Under the IAIA
- Example MOA for Collaborative Project

Summary Information for the Participating Jurisdiction:	
Local government submitting the annual report:	UNRBA CGC
Minimum annual investment level specified in the UNRBA Bylaws:	$1,521,080
Reporting period (fiscal year):	FY2023
Total investment for fiscal year (cash and inkind expended for specific project(s)):	$3,040,490
Carry over from previous year (not applicable the first year):	3990288
Carry over to next fiscal year(s):	$5,509,699
Contact information for the person submitting the report for this fiscal year:	Forrest Westall
Email	forrest.westall@unrba.org
Phone Number	(919) 339-3679

Individual Project or Activity Information:

Local Government Claiming Credit	Local Government project ID Number	Project Type	Funding Option	Project Location (County)	Partners	Benefits and Linkages to Water Quality or Quantity Improvement	Additional Benefits (if Applicable)	Project Status	Completion of Construction or Full Implementation (Fiscal Year)	Total Project Cost (All Partners, All Years)	Estimated Annual TN Reduction (lb-N/yr)	Estimated Annual TP Reduction (lb-P/yr)	Nutrient Credit Estimation Method	Date of Last Project Update	Narrative Project Description and Benefits
Franklin County	1	Stormwater control measures (State-approved SCMs)	Self-funded	Franklin	DMS	Nutrients	Flood Control	Design, Permitting	N/A	TBD	2.2 lbs	0.33 lbs	DWR Crediting document	10/26/2023	
Orange County	5	Hydrilla removal and control	Self-funded	Orange	Multiple (Eno River Hydrilla Management Task Force)	Other/Multiple	Hydrilla removal can improve water quality and quantity	Other	Ongoing effort	Multiple partners, total unknown at ths time	TBD	TBD	Other (user entered)	9/29/2023	Orange County Hydrilla Removal: Hydrilla removal was recently added to the list of eligible activities that would could towards jurisdictional investment in the IAIA. N & P reductions have yet to be assigned for hydrilla removal, so values are TBD. These efforts will be conducted throughout the Falls Lake watershed within Orange County so specific Lat/Long is not provided. Per Memorandum from DWR on 2/10/2022, hydrilla can lead to loss of recreational use of waters and increased flood duration and intensity from obstruction of waterways. It can also negatively impact water quality and harm aquatic life by depleting oxygen levels and can increase nutrients released from sediment. For those reasons, hydrilla containment and removal has been considered as likely benefitting water quality and quantity.
Person County	729-000	Stormwater control measures (State-approved SCMs)	Self-funded	Person	Piedmont Conservation Council for Env. Enhancement Grant	Peak flow reduction	Conservation; community outreach	Design, Permitting	2027	$ 571,970.00	TBD with BMPs	TBD with BMPs	DWR Crediting document	1/3/2023	Architectural/engineering firm selected to begin work on the design of a new SW control measure at the Rock Athletic Complex; benefits are co-location of needed SW mitigation within existing parks & getting BMPs to determine nutrient loads & their mitigation requirements. RFP issued for complete design of the County Farm site and a project schedule towards constructing a passive recreational park with stormwater controls for IAIA compliance; Special Use Permit approved to convert the site into a park.
City of Durham	CT 16214 Stream Vegetation Management	Stream and riparian buffer restoration and enhancement	Self-funded	Durham	City of Durham	Other/Multiple	ecosystem service benefits	In Service/Operation and Maintenance	2025	$ 54,842.25	n/a	n/a	Other (user entered)	6/30/2023	Invasive vegetation management within the Falls Lake watershed to preserve riparian buffer function, multiple locations. This is a three year contract. Benefits include improvements to buffer vegetation and reduction of invasive vegetation
City of Durham	CT 16301 Interlocal Agreement with SWCD	Green infrastructure and other best management practices (BMPs)	Self-funded	Durham	City of Durham	Other/Multiple	ecosystem service benefits	Other	2025	$ 90,000.00	n/a	n/a	SNAP version x.x.	6/30/2023	The City has entered into an interlocal agreement with the Durham and Soil and Water Conservation District and paid them $90,000 for the implementation of residential retrofits. Upcoming reports will show where the projects are, and these will be reported on next year. Nutrient reductions are calculated using latest version o the SNAP tool.
City of Durham	CT 18267 - catch basin pilot study	Green infrastructure and other best management practices (BMPs)	Self-funded	Durham	City of Durham	Other/Multiple	nutrients, gross solids removal	In Service/Operation and Maintenance	2023	$ 67,701.13	35.69 N/yr	3.16 P/yr	Monitoring data	6/30/2023	Catch Basin Insert Pilot Study - SP-2021-01. Pilot study to install gross solid filter inserts into catch basins in downtown Durham. Multiple locations. Benefits include nutrients, gross solid and sediment reduction. Study complete, but City is undertaking ongoing maintenance of two catch basins from this study.
City of Durham	CT 18728 South Ellerbe Soil Removal, Phase 2	Green infrastructure and other best management practices (BMPs)	Self-funded	Durham	City of Durham	Other/Multiple	ecosystem service benefits	Construction/Installation	2023	$ 1,536,744.00	n/a	n/a	Other (user entered)	6/30/2023	Phase 2 of the South Ellerbe Stormwater Restoration and includes soil removal in preparation for Phase 3 of the construction project. Benefits include reduction of nutrients, sediment, and peak flow reduction. Nutrient reductions will be indicated in the phase 3 construction
City of Durham	CT14277 - South Ellerbe Prof Services	Green infrastructure and other best management practices (BMPs)	Self-funded	Durham	City of Durham	Other/Multiple	ecosystem service benefits	Design, Permitting	2024	$ 3,952,037.00	n/a	n/a	Other (user entered)	9/1/2023	South Ellerbe Stormwater Restoration Professional Services. This project will create a combination of restored streams and a wetland that will provide a natural system for reducing and removing pollutants from an urban watershed, most of which was developed prior to the adoption of stormwater regulations . Nutrient reductions will be indicated in the phase 3 construction. Additional ecosystem service benefits will include flood reduction, native plantings, increased wildlife habitat, expanded green space, and educational opportunities.
City of Durham	Hydrilla Eradication	Green infrastructure and other best management practices (BMPs)	Self-funded	Durham	City of Durham	Other/Multiple	ecosystem service benefits	Other	2024	$ 8,300.00	n/a	n/a	Other (user entered)	7/10/2022	City Department of Water Management funding of hydrilla monitoring and eradication to improve water quality in the Eno River, multiple locations. Benefits include improvements to aquatic life and reduction of invasive aquatic plant
Durham County	DCO NMS Study	Administrative costs associated with the participation in the IAIA	Self-funded	Durham		Nutrients		Other	FY23	$ 221,243.00			SNAP version x.x.	9/25/2023	In February 2021, Durham County contracted WK Dickson for assistance in developing its Nutrient Management Strategy for addressing the requirements of the Falls Lake Rules. In accordance with the County's Stormwater Guiding Principles of Compliance, Efficiency, Resiliency, and Environmental Justice, WK Dickson developed a project selection rubric. They then identified potential 15 potential project sites for nutrient reduction. Those sites were narrowed to 10. Field evaluation by WKD and County staff finalized 6 sites for further project development. At the end of FY22, projects have been developed for those 6 sites including bioretention, stream restoration, stormwater wetlands, RSC, and other practices. Construction cost estimates and project renderings were also developed. In FY23, those projects were brought to the County Board of Commissioners and the Neal Middle School Bioretention Project was selected. Additionally, the Whispering Pines Mobile Home Park Stream Restoration Project was also selected for LASII Grant Application..
Durham County	AWCP	Hydrilla removal and control	Other organization agreement	Durham		Other/Multiple	Aqyatic weed removal	Other	FY23	$ 44,478.02				9/25/2023	Durham County's participation in the Aquatic Weed Control Program.
Durham County	Neal Middle School Bioretention Project	Stormwater control measures (State-approved SCMs)	Self-funded	Durham		Nutrients		Design, Permitting	FY25	$ 450,000.00	9.73	0.1	SNAP version x.x.	9/25/2023	The Neal Middle School Bioretention Project was selected as the County's first stormwater project to be funded by the Stormwater Utility for compliance with the IAIA and nutrient removal targets. The project will treat approximately 4.5 acres of previously untreated impervious area at Neal Middle School at the corner of Wake Forest Highway and Baptist Rd in Durham County. The project will also incorporate a significant educational element and will be incorporated into the Science curriculum at Neal Middle. The County received $225,000 in funding from the Environmental Enhancement Grant Program in the North Carolina Attorney General's Office. In FY23, the County published a request for proposals and WK Dickson was selected to design and manage construction of the project. Construction is scheduled for the summer of 2024.
Town of Hillsborough	IAIA-22-2	Green infrastructure and other best management practices (BMPs)	Other organization agreement	Orange	Piedmont Conservation Council, Orange Habitat for Humanity, NCEEG Grant	Nutrients	ecosystem services, sustainability, outreach, environmental justice, research	Construction/Installation	2024	$225,258.96	19.32	5.66	SNAP version x.x.	8/28/2023	Odie St GI Project - Design and construct stormwater green infrastructure treating impervious surface within the Odie Street Habitat for Humanity Neighborhood. Provides multiple benefits including nutrient reduction, peak flow attenuation, ecosystem benefits and includes an educational component to a historically underserved community.
Town of Hillsborough	IAIA-23-7	Hydrilla removal and control	Other organization agreement	Orange	Eno River Hydrilla Management Task Force	Other/Multiple	Nutrient reduction, aquatic habitat improvement	Other	On-going	unknown	tba	tba	Other (user entered)	8/28/2023	Eno River Hydrilla Management Project - Cost share for treating invasive hydrilla plant by the Eno River Hydrilla Management Task Force. Provides multiple benefits including nutrient reductions and aquatic habitat improvement.
Orange County	6	Stormwater control measures (State-approved SCMs)	Self-funded	Orange	N/A	Other/Multiple	Nutrient reduction, Peak Flow Reduction, Environmental Education	Design, Permitting	Spring 2024	Total unknown at this time (bid award in progress)	TBD	TBD	Other (user entered)	9/29/2023	Gravelly Hill Middle School Stormwater Wetland Retrofit: Project is a retrofit of a relic sediment basin that was never removed during the construction of Gravelly Hill Middle School to a stormwater wetland with an outdoor classroom area and educactional signage. We are only in the permitting / bid award phase of this project so total costs, N & P reductions, etc. are unknown at this time and TBD.
Town of Hillsborough	IAIA-23-9	Stream and riparian buffer restoration and enhancement	Other organization agreement	Orange	Piedmont Conservation Council, Orange Habitat for Humanity, NCEEG Grant	Other/Multiple	ecosystem services, sustainability, outreach, environmental justice, sediment	Design, Permitting	2024	$ 202,465.00	tba	tba	Other (user entered)	8/25/2023	Odie St Stabilization Project - Stabilize existing ephemeral/intermittent stream channel and plant riparian vegetation; while this is a separate project, it is part of the overall Odie Street/Habitat for Humanity project. Stabilizing the stream will reduce sediment and erosion, while stabilizing the road bed along the channel.
City of Durham	IDDE SSO Response	Illicit discharge detection and elimination	Self-funded	Durham	City of Durham	Other/Multiple	nutrients, sediment, pathogens, toxics, preservation of public and aquatic health	In Service/Operation and Maintenance	ongoing	n/a	14 lb N/yr	2.6 lb P/yr	DWR Crediting document	8/16/2023	Calculations based on Memorandum: Approval of Remedying Illicit Discharges Nutrient Reduction Practice, Zimmerman, NC DEQ DWR, 2017.. Source specific eliminated load method for dry weather sanitary sewer overflows (SSOs). Ongoing response program implemented by Water Management and Public Works to identify, contain, and properly dispose of SSO discharges.
Town of Butner	SGWASA I-85 Project	Illicit discharge detection and elimination	Interlocal agreement	Granville	SGWASA Creedmoor Granville Co. Stem	Peak flow reduction	Nutrients	Design, Permitting	Appx 2028	$ 44,100,000.00			DWR Crediting document	4/15/2023	Repair and replacement of surcharging pump stations, sewer pipes, and appurtenances currently leaking sewage, which lead to illicit discharges.
Town of Hillsborough	IAIA-23-6	Stormwater control measures (State-approved SCMs)	Self-funded	Orange	None	Water storage	Peak flow reduction, sustainability	In Service/Operation and Maintenance	2023	$ 10,017.04	Variable	Variable	DWR Crediting document	8/25/2023	CCP Cistern Project - Install an above ground cistern and associated appurtenances at the town's Cates Creek Park; water to be used for irrigation of plants and gardens within the park.
Town of Hillsborough	IAIA-23-8	Green infrastructure and other best management practices (BMPs)	Self-funded	Orange	None	Nutrients	ecysystem services, sustainability, pollinator habitat	In Service/Operation and Maintenance	2023	$ 593.64	0.05	0.01	DWR Crediting document	8/25/2023	Riverwalk Compost Blanket Project - Install compost blanket to alleviate erosion and increase infiltration on an eroded slope along Riverwalk Greenway. Project also provides native pollinator habitat.
Town of Hillsborough	IAIA-23-10	Stream and riparian buffer restoration and enhancement	Self-funded	Orange	None	Nutrients	ecysystem services, sustainability, sediment	In Service/Operation and Maintenance	2023	$ 3,500.00	0.18	0.13	SNAP version x.x.	8/28/2023	Murray St and Tumip Patch Park Riparian Buffer Enhancement Project - plant additional trees and shrubs within the riparian buffer at these two town parks.
Wake County		Stormwater control measures (State-approved SCMs)	Self-funded	Wake		Nutrients		Design, Permitting	FY 25	$317,800	2.48	0.32	SNAP version x.x.	8/17/2023	Wake County completed the design for retrofit of an existing dry detention to a bioretention and installation of a new linear bioretention at Northern Wake Fire Station #2. The 8.5 ac is located on a UT to Falls Lake. The project is located in the Protected Area of Falls Lake and ~0.5mi outside of the Critical Area. Initial project construction pre-dated Falls Lake Rules. The SNAP tool estimates an 86% reduction of nitrogen and 88% reduction of phosphorous with installation of the two bioretention projects. Wake County will seek partnerships to assist with funding construction in FY 25.
City of Durham	Tree Planting	Green infrastructure and other best management practices (BMPs)	Self-funded	Durham	City of Durham	Other/Multiple	ecosystem service benefits	Construction/Installation	2023	$ 805.00	n/a	n/a	Other (user entered)	6/30/2023	Enhancement of City's tree canopy . 25 of 564 trees were planted in the Falls Lake watershed. Benefits include improvement of urban tree canopy in partnership with General Services. Multiple locations.
Wake County		Stream and riparian buffer restoration and enhancement	Other organization agreement	Wake	Wake Soil and Water Conservation District	Sediment	Ecosystem Service Benefits	In Service/Operation and Maintenance	FY 23	$ 39,010.00			Other (user entered)	5/24/2023	Stream and riparian buffer restoration and enhancement
City of Raleigh		Land conservation	Self-funded	Granville	Durham County US Army National Guard	Other/Multiple	Reduces sediment load to downstream reservoirs	In Service/Operation and Maintenance	Completed	$ 1,402,254.00	6 lbs	102 lbs	Other (user entered)	10/3/2023	The project, known as the Newsome project, consists of 177 forested acres and approximately 5,000 linear feet of stream frontage along Camp Creek, which drains into Knapp of Reeds Creek before reaching Falls Lake. The Triangle Land Conservancy will hold the easement to property and will be responsible for the stewardship and monitoring requirements.

Odie Street Green Infrastructure
Memorandum of Agreement

This agreement is made and entered into between Piedmont Conservation Council, Inc. ("PCC") and the Town of Hillsborough (the "Town") to establish terms of agreement for the Odie Street Green Infrastructure Project (the "Project"). PCC and the Town are sometimes referred to herein as "the Parties".

Purpose/Background:

The overall goal of the Odie Street Green Infrastructure project is to design and construct green infrastructure that controls and treats stormwater runoff in the Town's Odie Street neighborhood and achieves environmental, social, and economic benefits for the Odie Street residents and the larger Fairview community. PCC has been awarded funding for the project from the North Carolina Environmental Enhancement Grant program (NCEEG). The purpose of this agreement is to set forth the terms by which PCC and the Town will cooperate to fulfill the proposed outcomes of the NCEEG Odie Street Green Infrastructure grant.

Whereas, The Town of Hillsborough operates a stormwater management program that works to reduce stormwater runoff impacts to local water bodies.

Whereas, the Odie Street neighborhood is located within the Town of Hillsborough municipal boundary and was developed prior to the enactment of current stormwater management regulations, and, therefore, stormwater runoff generated within the neighborhood is not currently being controlled or treated for water quality consistent with current stormwater management regulations.

Whereas, the construction of green infrastructure that controls and treats stormwater runoff would reduce nutrient and sediment pollution in stormwater runoff generated within the Odie Street neighborhood.

NOW, THEREFORE, in consideration of the parties and their mutual promises, covenants and agreements hereinafter set forth, the parties agree as follows:

Terms:

A. The Town will provide a total cash match of $30,000 over the NCEEG grant period for the GI design ($10,000), construction ($14,900) and installation of permanent educational signage ($5,100) for the Project. The cash match is allocated from funds budgeted to meet the Town's

required annual expenditures pursuant to the Upper Neuse River Basin Association's (UNRBA) *Interim Alternate Implementation Approach* (IAIA). The IAIA is a group compliance program administered by the UNRBA to comply with Stage 1 of the Stormwater Management for Existing Development rule (15A NCAC 02B .0278) which is part of the state's Falls Lake Nutrient Management Strategy (15A NCAC 02B .0275).

B. The Town will provide an in-kind match with a total value of $18,000 for the Project, broken down as follows: Town staff assistance and use of materials during education events ($2,900), development of a promotional video ($3,300), coordination of green infrastructure design process ($5,700), construction oversight ($3,600), design of an educational sign ($1,800), and documentation of the success measures for outcomes 1-3 and the design workshop evaluation ($700) as outlined in the NCEEG grant proposal.

C. The Town will report to PCC their in-kind hours and use of equipment/materials on a monthly basis. The Town will provide additional reporting or documentation, upon request as soon as reasonable.

D. If the Town pays any Project-related costs to vendors directly, the Town will retain a copy of the payment method and will make available to PCC the verification of payment.

E. PCC will provide invoices to the Town for portions of the design and construction to be paid by the Town as a cash match. The invoices may be in the form of a letter that specifies the items and amounts for which PCC seeks reimbursement. The invoice shall be signed by PCC and provide space for a Town signature and purchase order number.

Issue Elevation:

Any disputes arising out of this agreement shall be resolved in the most informal way possible for the mutual interest of all Parties. Claims should be submitted to the other Party in writing for prompt resolution. The Parties shall negotiate in good faith and use all reasonable efforts to resolve disputes.

Authorities:

Nothing in this Memorandum of Agreement shall be construed to or is intended to conflict with current laws or regulations of the United States of America, the State of North Carolina, Orange County, or the Town of Hillsborough. If a term of this agreement is inconsistent with such authority, then that term shall be invalid, but the remaining terms and conditions of this Memorandum of Agreement shall remain in full force and effect.

Amendments:

This Memorandum of Agreement may be amended when such an amendment is agreed to in writing by all Parties. The amendment will be effective on the date a copy of the amended MEMORANDUM OF AGREEMENT has been signed by all Parties.

Duration/Termination:

This Memorandum of Agreement shall become effective on **upon signing by both Parties.** If either party determines that the terms of the Memorandum of Agreement will not or cannot be carried out, that Party shall immediately consult with the other Party to develop an amendment to this Agreement. If within fourteen (14) days after initial notice by a Party of the inability to perform any term(s) of this agreement then either Party may terminate the Memorandum of Agreement upon written notification to the other Party.

This Memorandum of Agreement shall remain in effect for the duration of the NCEEG Odie Street Green Infrastructure funding period but in any event shall expire on December 31, 2024 unless further extended in writing by the Parties.

Principal Contacts:

The principal contacts for this agreement are:

PCC:

Ginell Rogers, Executive Director
201 E. Main Street, 5th Floor
Durham, NC 27701
252-412-0018
ginell@piedmontconservation.org

Town:

Heather Fisher, Stormwater Coordinator
Stormwater & Environmental Services Division
P.O. Box 429
Hillsborough, NC 27278
919-296-9622
heather.fisher@hillsboroughnc.gov

AND NOW, this 12th day of January 20 22, the parties hereby acknowledge the foregoing as the terms and conditions of this Agreement.

PCC

Jessica Perrin

Jessica Perrin, **Chair, PCC Board of Directors**

1/12/2022

Date

TOWN

Margaret Hauth

Margaret Hauth, **Assistant Town Manager**

Jan 13, 2022

Date

This instrument has been pre-audited in the manner required by N.C. Gen. Stat. 159-29.

Jiffany Long

Finance Director

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