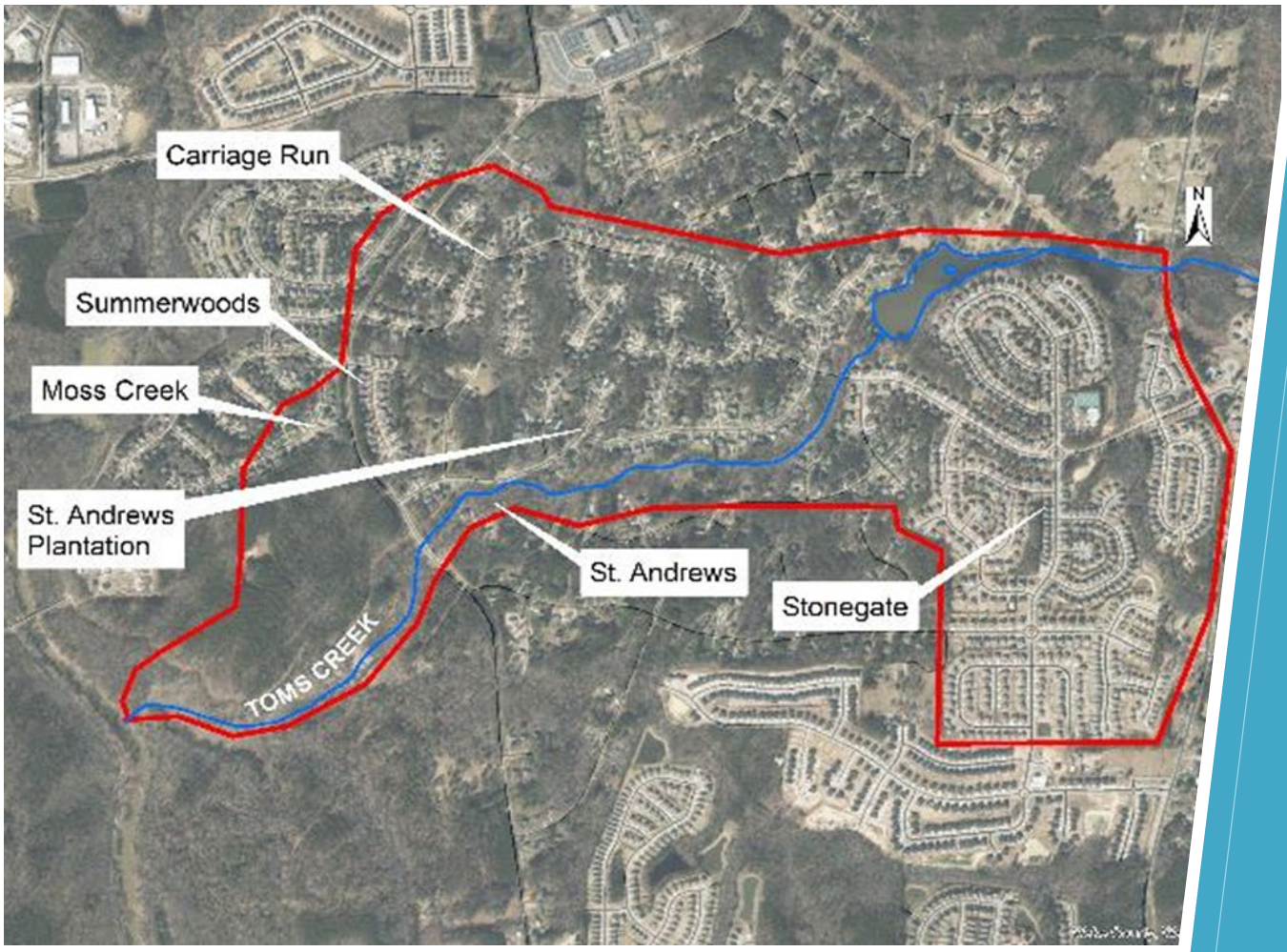
Toms Creek Watershed Plan Report

TOWN OF WAKE FOREST

FEBRUARY 2024



NORTH CAROLINA PROFESSIONAL SEAL 014113 ENGINEER CYNTHIA C. LANCASTER

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Cynthia C. Lancaster
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LJB Engineering PC

Executive Summary

The Town of Wake Forest is a community of 52,000± residents that encompasses an area of approximately 19.7 square miles in the northern portion of Wake County. The Town's Stormwater Program is responsible for the management and maintenance of storm drainage facilities, as well as protecting the water quality of its streams and waterbodies. In an effort to meet the increasing challenges from development and climate related stresses, as well as more proactively address existing/potential problems and identify enhancement opportunities, the Town is undertaking an initiative to study and develop stormwater plans for each of the Town's main watersheds. This report represents the study for the Toms Creek Watershed.

Introduction

The objective of this this watershed study is to identify and recommend projects (or other actions) that will improve, enhance, and/or protect the watershed drainage systems that are within the Toms Creek Watershed. The specific focus of this report is for the portion of the watershed that is within the Town limits (i.e. focus area). The scope of the effort generally included data compilation/collection, watershed characterization, watershed condition assessment, evaluation of improvements, and development of recommended actions.

Data Compilation and Collection

A wide variety of existing data and information was obtained and compiled to support the watershed analysis and mitigation evaluation, including general base mapping, topography, land use/land cover, buildings/parcels, drainage system infrastructure, previous studies, and many more. In general, many of the datasets were directly provided by the Town or obtained from Wake County or other public data sources. In addition to compilation of existing data, LJB performed field reconnaissance and assessments to verify/supplement existing datasets, as well as to assess more granular site/feature conditions. The Town also sought to engage residents to gather input of stormwater issues and concerns, understand resident priorities, and consider any resident-led ideas for improvements. The Town solicited input through an on-line community survey and then a follow-up public meeting.

Watershed Characteristics

The Toms Creek watershed is an approximate 4.7 sq mi area that drains portions of Wake Forest, Raleigh, Rolesville, and unincorporated Wake County. The drainage area extends east from its outlet at the confluence with the Neuse River and is roughly bounded by Burlington Mills Road to the north, Business US 401 to the south/southeast, and the Neuse River to the west. Toms Creek flows through the central portion of the watershed for a length of 3.5 mi. The Creek passes through several roadway culverts as well as through Browns Lake and under bridge crossings at Coach Lantern Avenue and Ligon Mill Road.

The portion of the watershed that is within the Town of Wake Forest municipal limits (i.e. focus area) is approximately 510 acres (0.8 sq mi) that is largely comprised of residential neighborhoods. The section of Toms Creek in the focus area extends 1.7± mi from the outlet of the Forestville Road culverts to the confluence with the Neuse River.

Watershed Assessment

As part of this study, LJB performed an assessment of existing conditions within the Toms Creek watershed, including planning level evaluations of drainage/flooding, infrastructure repair needs,

stream stability/erosion, and water quality conditions within the study focus area. Tom's Creek is a Federal Emergency Management Agency (FEMA) mapped stream and is designated as an AE zone with a regulated floodway and floodplain. Several homes along Toms Creek between Ligon Mill Road and Coach Lantern Avenue are projected to be at risk of flooding in extreme storm events and are mapped within FEMA's regulated Special Flood Hazard Area (SFHA). A separate 2D hydraulic model, developed as part of the study, mapped flood extents along the tributaries to Toms Creek. For locations along tributaries showing structures potentially at risk of flood damage, it is generally because the areas adjacent to the home are lower or roughly at the same elevation as the low point in the downstream roadway. Thus, floodwaters back up against the structure as the capacity of the culvert under the downstream road or driveway is exceeded and the road/driveway begins to overtop. The culvert hydraulic analyses for this study, based on a 4% annual chance storm typical of design standards for neighborhood streets, project very minimal overtopping at one crossing on Coach Lantern Avenue and one on Kemble Ridge Drive.

The stream reaches in the Toms Creek watershed area within the Wake Forest town limits were assessed for erosion severity and potential continued erosion problems. Approximately 3.6 miles of stream reaches were assessed in total, and nearly 1.3 miles (37%) of streams were categorized as "High" or "Extremely High" indicating a need for restoration/stabilization measures to limit shear stress and ongoing sediment export to downstream areas.

The NC Department of Environmental Quality (DEQ) classifies Toms Creek under North Carolina's 303(d) list as a water body with Class C, NSW (Nutrient Sensitive Waters). DEQ rates Toms Creek as impaired because it is unable to support an acceptable community of aquatic organisms, indicating that the stream does not fully support its designated uses. A 2002 DEQ study identified the most probable causes and sources of Toms Creek's impairment as chlorine toxicity from the Deer Chase wastewater treatment plant (WWTP) discharge and aquatic habitat degradation, manifested by sediment deposition and substrate instability. The WWTP later switched from chlorine to UV for disinfection, so chlorine toxicity is no longer a concern. However, streambank erosion and sediment deposition are still evident in parts of the watershed observed within the Wake Forest jurisdictional areas in 2022-23 by the LJB study team and streambank erosion remains the probable cause of poor aquatic habitat.

Stormwater Management Improvements Evaluation

There were a number drainage, stream stability, and general water quality issues noted within the study focus area, as well as a few needed infrastructure repair needs. The next phase of the study was to identify and evaluate improvements and/or other strategies that can be taken to mitigate the identified issues.

Potential flood risk reduction options for flood-prone structures and roadways in the Toms Creek were considered as part of the watershed study. Concern for homes along Toms Creek at risk of flooding prompted consideration of additional flood detention storage in Browns Lake and/or the smaller upstream lake, but these options were determined to be unfeasible. Floodplain benching, often incorporated into stream restoration projects to help reduce the shear stresses along the toe of a stream bank, is recommended as part of stream stability projects along Toms Creek between the bridges under Coach Lantern Avenue and Ligon Mill Road, as a means of lowering flood risk for homes as well as mitigating erosion. Culvert upgrades at Coach Lantern Avenue and Kemble Ridge Drive would reduce the risk of overtopping of the road and ponding of floodwaters beside and around homes.

Within Toms Creek watershed areas, potential stream restoration is limited by the available

corridor widths along the stream banks that could possibly be made available by an HOA or private property owner to facilitate wider floodplain benching. The goal for Toms Creek stream stabilization improvements is for restoration, with as much floodplain benching as is feasible, in most of the reaches with a very high or high Bank Erosion Hazard Index (BEHI) scoring. Where reaches are too short or narrow to accommodate better restoration measures, improvements may be limited to stabilization of banks.

Several of the streets in the western areas of the watershed are wide enough to accommodate "green streetscaping" near sag points, with bioretention areas built out into the street at about the width of a parked car and back into the area behind the curb. This would help to provide some water quality treatment for neighborhoods where no Structural Control Measures (SCMs) for stormwater were required when they were developed. In several areas along one tributary stream recommended for stream stability improvements, there is enough area outside of required buffers for installing new SCMs to better protect water quality and stream stability.

Summary of Recommended Watershed Actions

Table ES-1 provides a summary listing of recommended improvement projects for the Toms Creek watershed. A separate Town study by Timmons includes recommendations for improvements for culvert crossings under Falconhurst Drive between Hampton Chase Court and Ligon Mill Road.

Table ES-1. Summary of Recommended Projects

PROJECT ID	PROJECT	ESTIMATED COST
FALCONHURST[1]	Alternative 2, Phase 1 and 2 as Recommended by Timmons Group	$580,000
TC-DI-01	Culvert Replacements on Coach Lantern Avenue and Kemble Ridge Drive	$720,000
TC-DI-02	Culvert Replacements for Driveways on west side of Hampton Chase Ct	$190,000
TC-ER-06	Construct Stable Channel on UT-S5 Reach 3	$270,000
TC-ER-05	Priority 2/3 Restoration on UT-N4 Reach 6	180,000
TC-ER-07	Grade Control Structures on UT-S7 Reach 2&3	$240,000
TC-ER-03	Priority 3/4 Restoration on TC Reach 4	$360,000
TC-ER-01	Priority 3/4 Restoration on UT-N3 Reach 3, UT-N3A Reach 1	$610,000
TC-ER-04	Priority 3/4 Restoration on TC Reach 3	Varies depending on participating owners (~$450,000)
TC-ER-01A[2]	Outlet Stabilization on UT-N3 Reach 3, UT-N3A Reach 1	$250,000
TC-ER-02	Priority 3/4 Restoration on UT-N3 Reach 2	$500,000
TC-WQ-01	Green Streetscaping at 3 Sag Points on Coach Lantern Avenue	Dependent on number of installations – Estimated at $50,000 to $100,000 each (~$400,000)
TC-WQ-02	Pond SCMs at 3 sites on UT-S7 south of Coach Lantern Avenue	$100,000 to $150,000 per SCM dependent on size (~$400,000)
ESTIMATED TOTAL PROJECT COSTS		$4.9 Million

[1]Evaluation, recommendations, and project costs developed by Timmons Group under a separate study : [2] Project only to be considered if TC-ER-01 not feasible – not included in total project costs

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1. Introduction

1.1 Overview and Background

The Town of Wake Forest is a community of 52,000± residents that encompasses an area of approximately 19.7 square miles in the northern portion of Wake County. The Town's Stormwater Program is responsible for the management and maintenance of storm drainage facilities, as well as protecting the water quality of its streams and waterbodies. The Town implements measures required by its National Pollutant Discharge Elimination System (NPDES) Stormwater Permit, along with additional local initiatives to meet program goals. The Town has more than quadrupled in population since 2000, with an average annual growth rate of 7%. The growth and associated development have resulted in increased impervious area and have put increased strain on the Town's built and natural drainage systems.

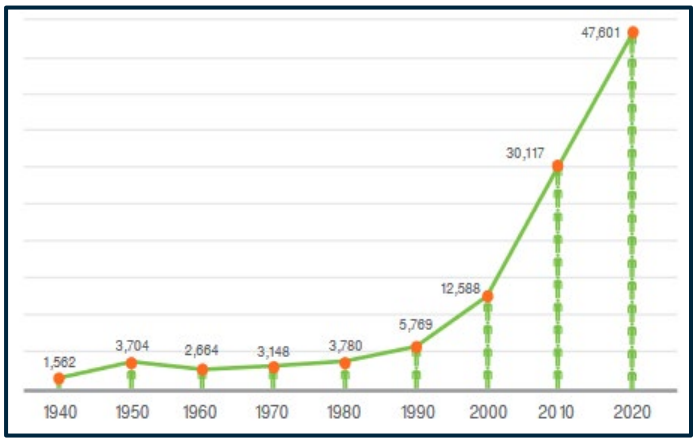


Figure 1. Town of Wake Forest Population Growth

In an effort to meet the increasing challenges from development and climate related stresses, as well as more proactively address existing/potential problems and identify enhancement opportunities, the Town is undertaking an initiative to study and develop stormwater plans for each of the Town's main watersheds.

The entire area of the Town drains to the Neuse River which borders the southern edge of the Town limits. There are four major streams that drain the Town - Horse Creek, Richland Creek, Smith Creek, and Toms Creek (see Figure 2). The Town has received American Rescue Plan Act (ARPA) funding to study two of the watersheds – Toms Creek and Horse Creek. This report represents the study for the Toms Creek Watershed. It is anticipated that a combination of local funding and grants will be utilized to fund improvements recommended by the watershed studies. In addition, the Town is in the process of implementing a stormwater utility that will provide dedicated funding to address stormwater needs.

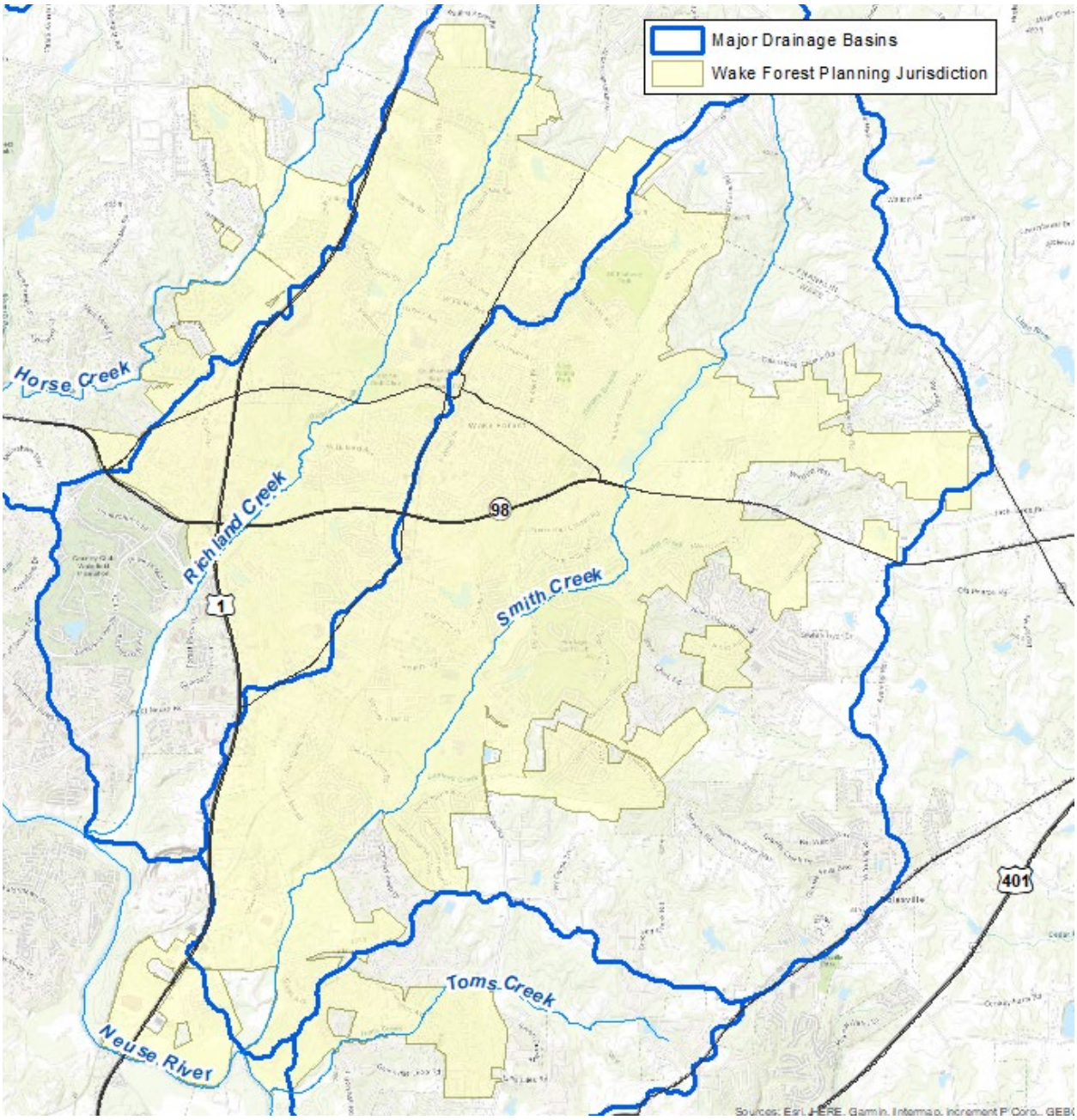


Figure 2. Major Streams and Drainage Basins

1.2 Project Objectives and Scope

The objective of this this watershed study is to identify and recommend projects (or other actions) that will improve, enhance, and/or protect the watershed drainage systems that are within the Toms Creek Watershed. The specific focus of this report is for the portion of the watershed that is within the Town limits (i.e. focus area). The scope of the effort generally included data compilation/collection, watershed characterization, watershed condition assessment, evaluation of improvements, and development of recommended actions. It is anticipated that the Town will seek/leverage local funding and/or grant opportunities to refine and implement improvement concepts and other actions recommended in this study.

2. Data Compilation and Collection

There is a variety of data and information from numerous sources that was collected, compiled, and processed to support this watershed study. This information was integrated to aid in more informed and refined evaluations. A summary of data collection is presented in the subsections below.

2.1 Compilation of Existing Data / Information

A wide variety of existing data and information was obtained and compiled to support the watershed analysis and mitigation evaluation, including general base mapping, topography, land use/land cover, buildings/parcels, drainage system infrastructure, previous studies, and many more. In general, many of the datasets were directly provided by the Town or obtained from Wake County or other public data sources. Table 1 below summarizes key data compiled for the study.

Table 1. Data Sources

ITEM	SOURCES	DESCRIPTION / USE
General Base Data / Mapping	Town, Wake County, ESRI, USGS, and others	Data layers used for general reference, such as aerials, streets, streams, political boundaries, planimetrics.
Property Information	Wake County	GIS tax parcels used for existing land use assessment, development age, and property ownership.
Drainage System	Town	Combination of GIS inventories of stormwater infrastructure used help assess drainage patterns and infrastructure sufficiency.
Topographic / Elevation Data	NCEM	Lidar-based digital elevation models (DEMs) used to support watershed classification and hydrologic/hydraulic evaluations
Flood Hazard Information	Town, FEMA	Includes 2022 Wake County FEMA Flood Insurance Study Used to assess flood risk
Previous Watershed Studies	Town, NCDEQ	Includes 2023 Toms Creek / Falconhurst Drive study, 2022 Wake Forest Storm Water Infrastructure Assessment Project, and 2002 Toms Creek Biological Impairment Study used to provide existing flood/infrastructure risk and environmental conditions as well as inform potential improvement options.
Soils	NRCS	GIS soils layer with associated properties used in watershed characterizations and hydrologic analysis.
Water Quality / Environmental	NCDEQ	Previous reports; current data on Deer Chase WWTP and 303(d) listings

2.2 Field Reconnaissance and Assessments

In addition to compilation of existing data, LJB performed field reconnaissance and assessments to verify/supplement existing datasets, as well as to assess more granular site/feature conditions. Field efforts consisted of the following items:

- walking and assessing erosion potential along most defined channels
- verification/inspection of significant culverts, water quality Structural Control Measures (SCMs), and other key drainage infrastructure
- limited collection/measurements of infrastructure missing from GIS inventory and as-built data

- limited discussion with property owners
- visual assessment of site conditions

Multiple field visits were made during Spring – Fall 2023. Field notes, measurements, and photo documentation were captured and integrated into the overall study evaluation. Observations and findings associated with the field effort are integrated with Watershed characterization and assessments included in Sections 3 and 4.

2.3 Community Engagement

In addition to compiling technical data and information, the Town sought to engage residents to gather input of stormwater issues and concerns, understand resident priorities, and consider any resident-led ideas for improvements. The Town solicited input through an on-line community survey and then a follow-up public meeting.

Seventy-five (75) residents responded to the survey. All but two of them listed themselves as residing within the Toms Creek watershed. Only one listed themselves as also having a business within the watershed. Nineteen of the respondents have lived in the watershed for 20 years or more. The average length of time stated for having lived in the watershed was 13.4 years.

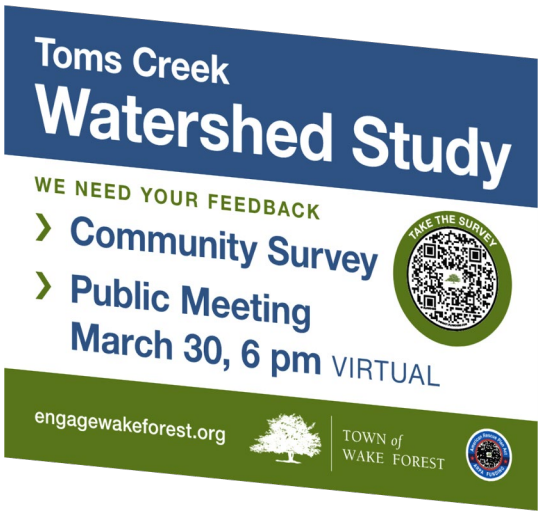


Figure 3. Community Engagement Meeting

Wildlife and water quality were listed by over 80% of respondents as topics of importance. Some specific concerns related to protection of wildlife habitat and water quality were expressed in survey comments:

- A need for the Town to collaborate with other jurisdictions in protecting the environmental health sustainability of the watershed.
- Concerns about residents removing vegetation within stream buffer areas.
- Worries about impacts of development projects on the water quality.
- Multiple references to erosion and sedimentation problems.

In regard to stormwater problems in the watershed neighborhoods, 50% of respondents said erosion is impacting their private property and 41% listed flooding as a direct impact. Just over 50% of respondents had observed flooding of streets due to overtopping and/or inadequate capacity at storm inlets.

The survey was also intended to gage public support for implementation of stormwater projects within the Toms Creek neighborhoods. Over 70% of residents responded that they would be supportive of streambank stabilization projects aimed at mitigating erosion and enhancing water quality, even if it didn't directly benefit their property.

More detailed information from the survey results is provided in Appendix A.

3. Watershed Characteristics

The Toms Creek watershed is an approximate 4.7 sq mi area that drains portions of Wake Forest, Raleigh, Rolesville, and unincorporated Wake County. The drainage area extends east from its outlet at the confluence with the Neuse River and is roughly bounded by Burlington Mills Road to the north, Business US 401 to the south/southeast, and the Neuse River to the west. Toms Creek flows through the central portion of the watershed for a length of 3.5 mi. The Creek passes through several roadway culverts as well as through Browns Lake and under bridge crossings at Coach Lantern Avenue and Ligon Mill Road.

The portion of the watershed that is within the Town of Wake Forest municipal limits (i.e. focus area) is approximately 510 acres (0.8 sq mi) that is largely comprised of residential neighborhoods. The section of Toms Creek in the focus area extends 1.7± mi from the outlet of the Forestville Road culverts to the confluence with the Neuse River. Figure 4 shows the Toms Creek watershed and study focus area.

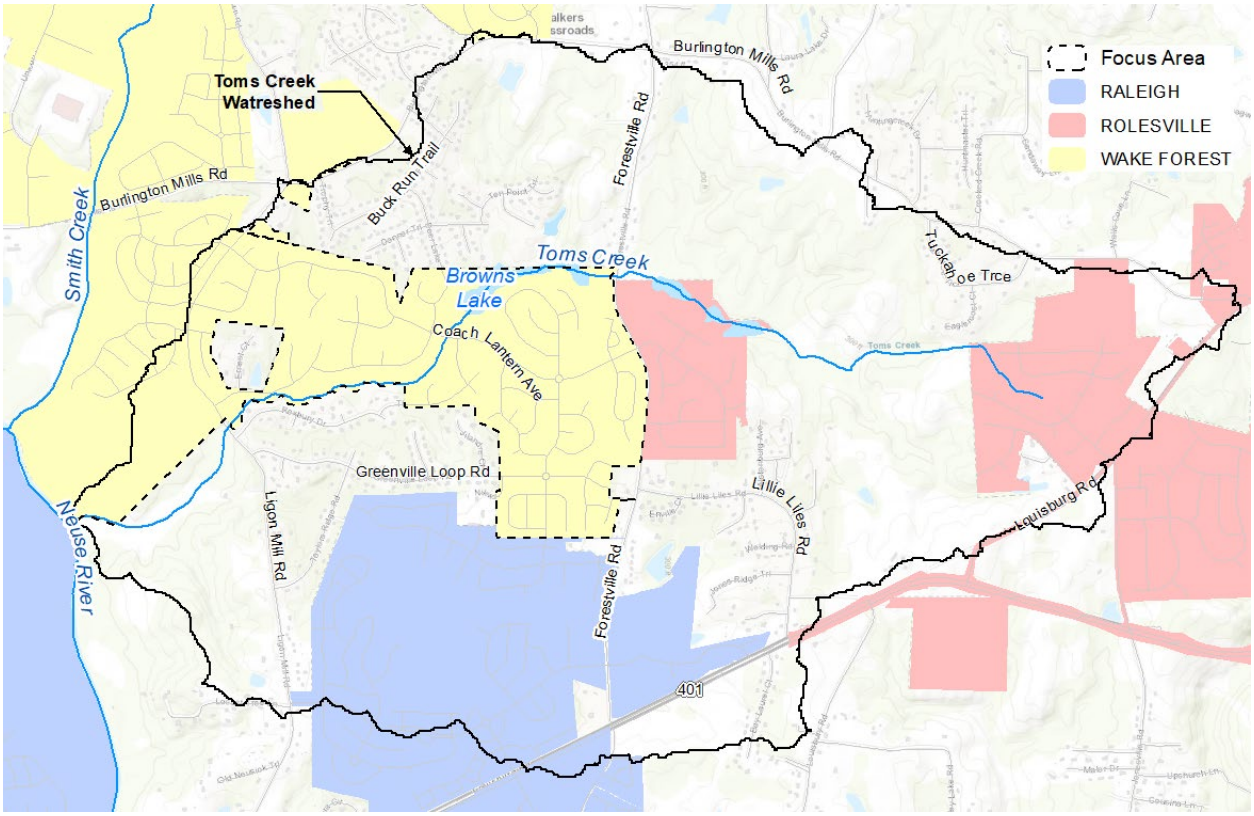


Figure 4. Toms Creek Watershed and Study Focus Area

3.1 Topography and Soils

The Toms Creek watershed (as is all of Wake County) is in the Piedmont physiographic region of North Carolina. The topography in the watershed is generally characterized by relatively steep slopes and well-defined drainage features as is typical in Piedmont areas. However, the reach of Toms Creek downstream of Ligon Mill Road flows through a relatively flat wetland area that is part of the floodplain for the Neuse River. Elevations in the watershed range from 180± ft near the outlet to 410± at the eastern headwaters. Within the focus area, elevations are generally between 200 – 300 ft.

Soil types play a crucial role in determining the amount of runoff from storms. Tom's Creek watershed aera is characterized by the presence of three soil types. Most of the Hydrologic soil groups (HSG) are as follows: group B comprise 31%, group C 47%, and group D 21% of the total area. (see Figure 5). Group B soils are moderately well drained with fine to moderate coarse texture providing moderate water transmission. Group C soils, consists of moderately fine to fine texture, have a slow rate water transmission. And group D soils characterized by claypan or clay layer at or near the surface, exhibit a very slow infiltration rate leading to high runoff potential. The B/D classification indicates a potentially high water table that will limit infiltration unless the soils are adequately drained.

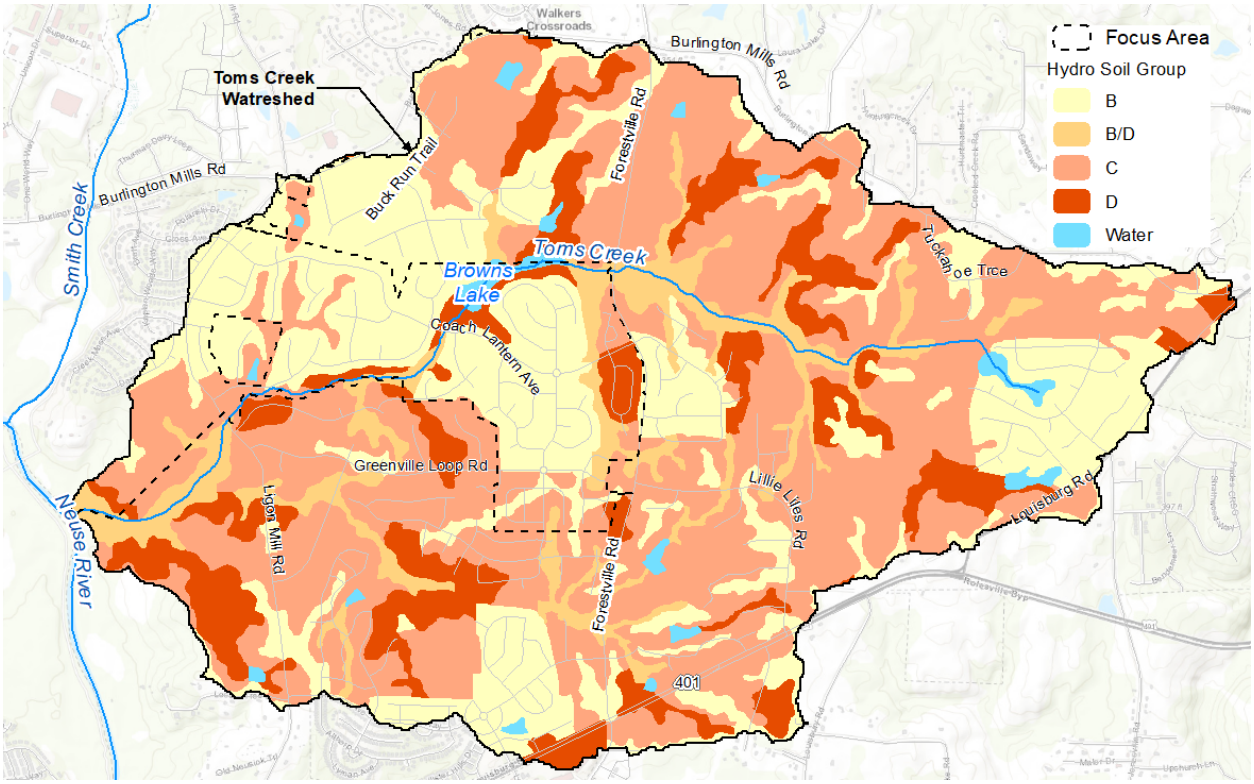


Figure 5. Hydrologic Soil Group Map

3.2 Land Use

The Toms Creek watershed consists predominately of single-family residential and undeveloped land uses, with limited institutional, commercial, and other uses. There are large undeveloped tracts of land in the unincorporated areas below Ligon Mill Road and above Browns Lake.

Within the focus area, land uses are almost entirely (92%+) single-family residential, typically with ⅓ to ½ acre lots. The west side of the focus area was built in the 1990's through early 2000's and is characterized by larger lot sizes and limited/no stormwater control measures (SCMs). In contrast, the east side features newer developments, smaller lot sizes, and numerous detention pond, level spreader, and other SCMs. Figure 6 shows the existing land use for the watershed.

The focus area is already developed and thus would not be expected to experience significant change in the future. The remaining "woods/undeveloped" portions are wetland areas downstream of Ligon Mill Road and buffers along streams and around lakes. The significant

portion of undeveloped land to the east of the focus area currently is predominately zoned low-density residential (generally 1 – 2 ac lot sizes). This suggests future development might be more modest, however, as the general area grows significantly the area could be developed at higher densities through rezoning or similar processes. Table 2 shows Land Use Category Summary across Toms Creek Watershed.

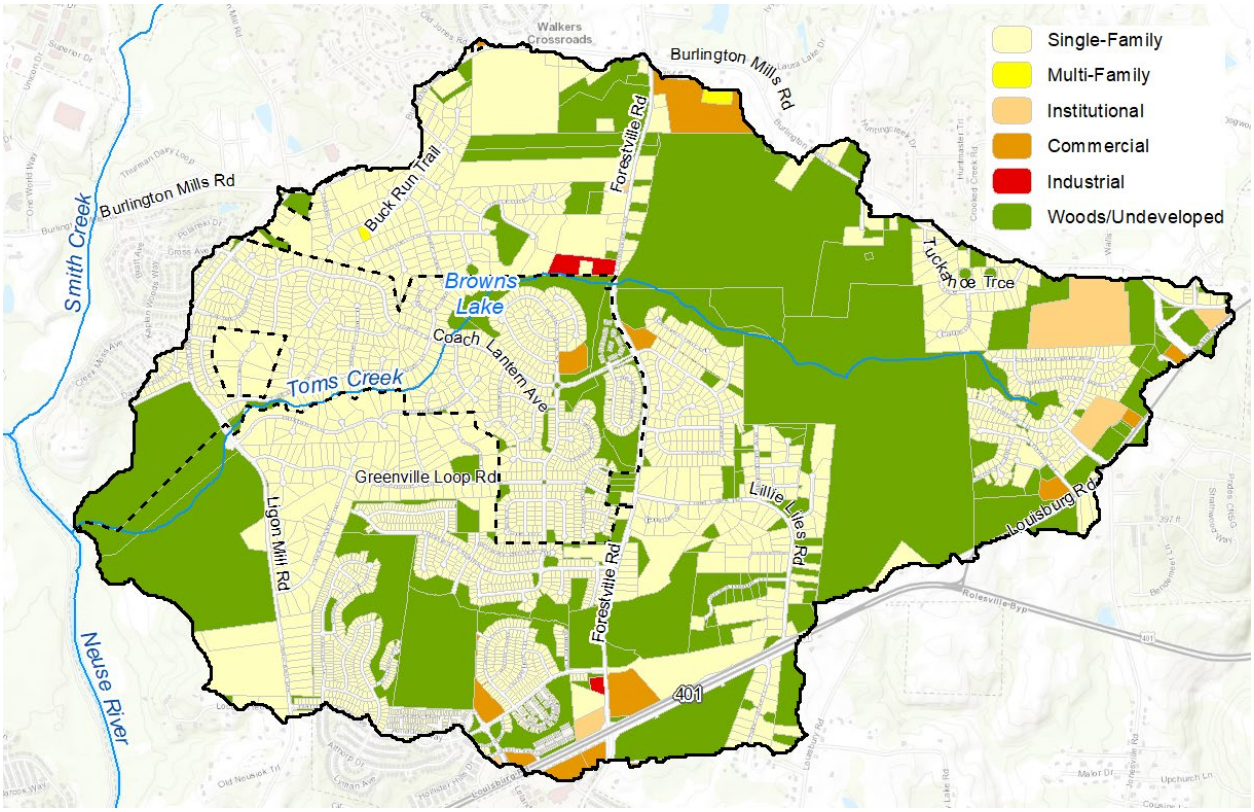


Figure 6. Existing Land Use Map

Table 2. Land Use Category Summary

LAND USE CATEGORY	% TOTAL AREA	TYPICAL % IMPERVIOUS
Commercial	2.2%	80-90%
Industrial	0.3%	70-80%
Institutional	1.9%	60-70%
Multi-Family	0.1%	60-70%
Single-Family	49.2%	20-35%
Woods/Undeveloped	46.3%	0-2%
Total	100%	

3.3 Drainage Systems

A drainage system is the collection of man-made and natural infrastructure that collects and transports stormwater runoff through a watershed. Pipes, drainage inlets, and other "hard"

infrastructure comprise the "closed" system, whereas, stream channels, ditches, and water bodies make up the open system. An evaluation was performed to better define and characterize the existing drainage system and as a basis for comparing alternatives considered in subsequent subsections. The drainage system evaluation also aided in the identification of data gaps and collection needs to support asset management and maintenance efforts by the Town.

Toms Creek is included in the Effective Flood Insurance Study (FIS) for Wake County (dated July 2022). There is a mapped floodplain/floodway from the confluence with Neuse River to approximately 4,500± upstream of Forestville Road. Based on GIS processing of topographic and drainage datasets Town-wide, there is an estimated 18.5 miles of drainage system components (primarily open-system) conveying drainage from 20 or more acres, of which 3.9 miles are within the focus area. Within the focus area, there are several notable unnamed tributaries (UT-N3 and UT-N4) that flow from the north to Toms Creek under Falconhurst Drive, just west of Hampton Chase Court, which drain much of the established neighborhoods (Carriage Run, St. Andrews Plantation) in the northwestern portion of the focus area. Many of these tributary stream channels are relatively small and flow along the back of lots where there is little to no natural buffer area. There are also significant tributaries which drain the eastern (more newly developed) portions of the focus area. One of the larger tributaries (UT-S7) has a substantial wooded stream buffer area, with two SCMs treating stormwater and several level spreaders to promote diffuse flow through the buffer.

The project focus area also includes Browns Lake and dam, as well as a smaller upstream dam. The dam at Browns Lake is rated by NC Dam Safety as high hazard. The lake has a surface area of about 8½ acres at the normal pool elevation. The dam is earthen with a concrete spillway chute as the main outlet. Additionally, there is a smaller masonry dam at the upstream end of Browns Lake. There are extensive wetland areas along Toms Creek from the smaller dam upstream to the Forestville Road culvert crossing and beyond.

Figure 7. Browns Lake Dam and Masonry Dam above Browns Lake

Drainage infrastructure information is not readily available for the entire watershed area, but the Town's compilation of infrastructure information includes the focus area. Inlets and pipe networks within the focus area/Town limits generally are adequately sized and function well. Reinforced concrete pipe was installed in all public rights-of-way when the residential areas were developed, so the Town isn't facing the problems common in areas where there was extensive installation of corrugated metal pipes that have aged and deteriorated.

Based on GIS drainage inventory information provided by the Town and supplemental compilation

and verification performed by LJB, it is estimated that the closed system consists of 420± "hard" drainage structures (e.g. catch basins, manholes, etc.) and 6.9± miles of connected pipes within the focus area. A significant majority (70%+) of the pipes are relatively small (<= 18"). The largest pipe size is 54" and there are only a handful of pipes that are 48" or greater. There are two primary bridges where Toms Creek passes under Ligon Mill Road and Coach Lantern Avenue. Figure 8 illustrates the drainage infrastructure within the watershed and Tables 3 and 4 list the pipe lengths and structures.

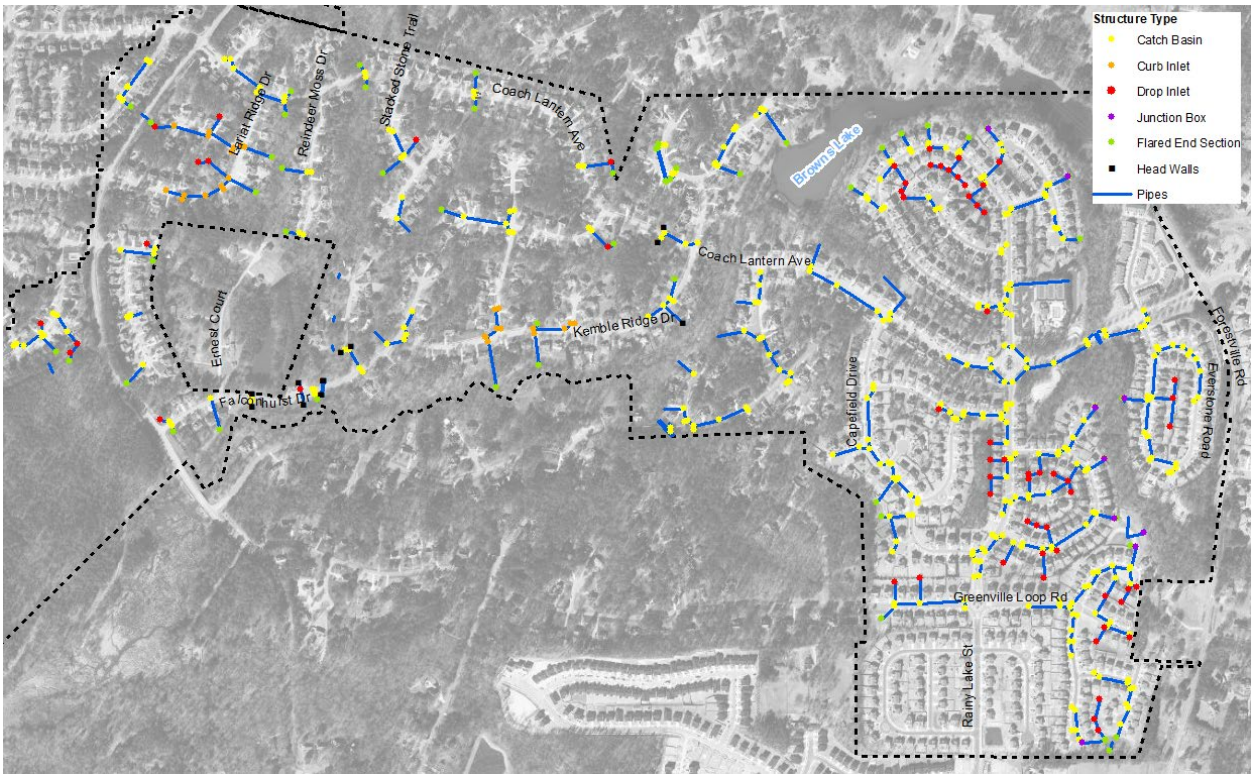


Figure 8. Drainage System Map

Table 3. Pipe Lengths by Size

Pipe Size (in)	Length(ft)
12	193
15	14,796
18	10,866
20	408
24	6,418
30	1,209
36	1,093
42	894
48	215
54	346

Table 4. Structure Numbers by Type

Structure Type	Number
Catch Basins	339
Curb Inlets	26
Drop Inlets	64
Junction Boxes	9
Flared End Sections	56
Headwalls	13

4. Watershed Assessment

As part of this study, LJB performed an assessment of existing conditions within the Toms Creek watershed. The assessment, largely based on the compilation (and supplemental field collection) of data/information discussed in Section 2, included planning level evaluations of drainage/flooding, infrastructure repair needs, stream stability/erosion, and water quality conditions within the study focus area.

4.1 Drainage and Flooding Assessment

Tom's Creek is a Federal Emergency Management Agency (FEMA) regulated stream located on Flood Insurance Rate Map (FIRM) panel 1748, map number 3720174800K, dated July 19, 2022, and is designated as an AE zone with a regulated floodway and floodplain. FEMA's HEC-RAS model for Toms Creek uses flows calculated from USGS regression equations, was developed in 2012, and includes modelling for projected future watershed conditions. A separate flood risk analysis, inclusive of the Smith Creek and Toms Creek watersheds and developed for the Town of Wake Forest by Freese and Nichols, Inc. (F&N), was based on a two-dimensional (2D) rainfall-on-grid HEC-RAS model.

LJB built a more refined 2D hydrologic and hydraulic model specifically for the Toms Creek watershed, but rooted in the same rainfall, land use, and roughness coefficients as were the basis of the larger F&N model. This model was used for the following assessments of existing conditions:

- Comparisons to FEMA Flood Rate Insurance Maps (FIRMs) in regard to projected limits of flooding along Toms Creek in a 1% annual chance flood event, especially regarding homes projected to be located within the inundation zones.
- Modelling of culvert performance in a 4% annual chance flood event for culvert pipes within the Town's watershed jurisdiction that are 30" or larger.
- Checking for flood prone structures along the tributaries to Toms Creek in areas of the Town's jurisdiction.

Flood Risk Along Toms Creek

Table 5 below lists projected 1% annual chance peak discharges used in FEMA's HEC-RAS model, computed from USGS regression equations, as compared to the peak discharges at the same locations in LJB's two-dimensional HEC-RAS rain-on-grid model. Table 6 compares projected maximum flood elevations at a couple of locations along Toms Creek in various configurations of the two models. FEMA estimated 10% impervious cover in their modelling and mapping for existing conditions and also ran future watershed conditions models for 20% and 35% impervious cover (IC). The 2D HEC-RAS model, developed by F&N and refined for Toms Creek as part of this study, was based on 2019 land use cover information for existing conditions and modifying some of the presently undeveloped areas to reflect future medium intensity development. Figure 9 shows a comparison map for the FEMA-mapped 1% annual chance floodplain limits, based on a one-dimensional HEC-RAS model, to the limits based on LJB's 2D model.

Table 5. Projected 1% Annual Chance Peak Discharges along Toms Creek

LOCATION	FEMA EX 10% IC (CFS)	FEMA 20% IC (CFS)	FEMA 35% IC (CFS)	2D HEC-RAS EX (CFS)	2D HEC-RAS FUT (CFS)
Ligon Mill Bridge	1950	2200	2640	2110	2250
Coach Lantern Bridge	1530	1850	2250	1930	2090

Table 6. Projected 1% Annual Chance Peak Flood Elevations along Toms Creek

LOCATION	FEMA EX (FT)	FEMA 20% IC (FT)	FEMA 35% IC (FT)	2D HEC-RAS EX (FT)	2D HEC-RAS FUT (FT)
1 - Upstream of Falconhurst pipe outlets	207.8	208.3	209.1	207.7	207.1
2 - At Kemble Ridge 54" RCP outlet	219.5	219.8	220.3	218.8	219.0
3 - Browns Lake	233.2	233.9	234.8	233.6	233.8

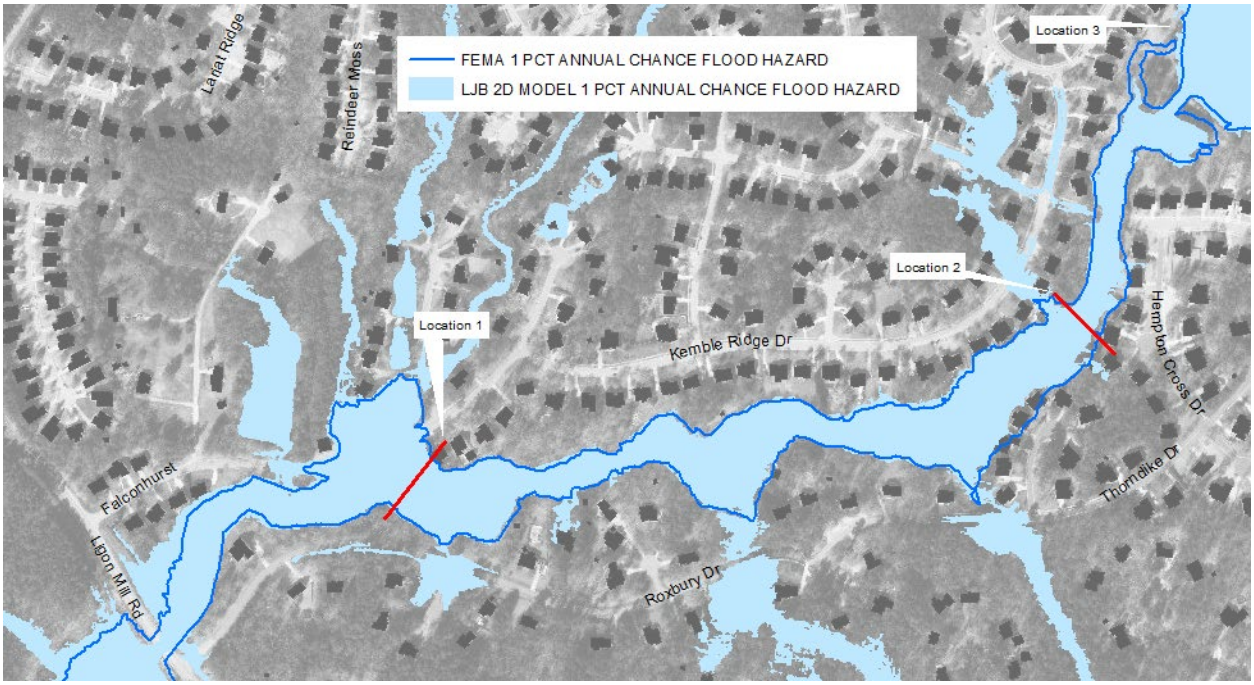


Figure 9. Comparison of FEMA vs. 2D Model 1% Annual Chance Flood Extents

The HEC-RAS 2D existing conditions model produces higher peak discharges along Toms Creek than does the FEMA model, likely because of the seven-year gap in the watershed land uses on which the models were based. For future conditions, the existing conditions 2D model estimates a peak discharge very close to FEMA's 20% model at the location of the Ligon Mill Road bridge, but a bit higher than the 20% model at Coach Lantern Avenue. Except in Browns Lake, the 2D model projects lower peak flood elevations along Toms Creek than does the FEMA model, likely because the 2D model is based on newer and more detailed topographical information.

Several homes along Toms Creek between Ligon Mill Road and Coach Lantern Avenue are projected to be at risk of flooding in extreme storm events and are mapped within FEMA's regulated Special Flood Hazard Area (SFHA). The 2D model also computed flood risk along the tributaries to Toms Creek and mapped flood extents. For locations where the estimated inundation area is mapped against residences, it is generally because the areas adjacent to the home are lower or roughly at the same elevation as the low point in the downstream roadway. Thus, floodwaters back up against the structure as the capacity of the culvert under the downstream road or driveway is exceeded and the road/driveway begins to overtop.

Culvert Performance

Although 2D rain-on-grid models provide useful insights on flow patterns through a watershed, they aren't designed to account for every inlet and the pipe that is conveying flows underground. For this reason, LJB separately developed hydrologic analysis for the contributory drainage areas for each of the culvert crossings with pipe diameters that are 30 inches or more. Projected headwater depths in a 4% annual chance storm were computed using HydroCAD to check for overtopping of roadways. Consistent with F&N's modelling, LJB's 2D HEC-RAS model was developed for an SCS Type B storm distribution. LJB's independent hydrologic analysis for peak flows in a 4% annual chance storm event is based on a frequency storm developed from NOAA precipitation-depth-frequency tables for the Toms Creek watershed area, which reflects higher peak rainfall intensities.

F&N's culvert assessments, based on a 2% annual chance storm, indicated overtopping at several culverts within the Toms Creek watershed. In particular, significant sediment accumulation was noted as affecting culverts under Falconhurst Road conveying two tributary streams from the north (UT-N3 and UT-N4) to Toms Creek. A study was recommended for this area and has been completed by the Timmons Group. Recommendations include grading of floodplain benches along Toms Creek through confluence area, replacement of culverts, and floodplain benching along the downstream reach of UT-N3. Since a separate study of the Falconhurst culvert crossings had been contracted by the Town of Wake Forest, LJB did not separately analyze those crossings.

F&N's analysis of the 2% annual chance storm event in their 2D RAS model also indicated overtopping for the culvert crossings at Coach Lantern Avenue and Kemble Ridge Drive for UT-N5, conveyed through 48" and 54" RCPs at the respective crossings. The analyses for this study, based on a 4% annual chance storm typical of design standards for neighborhood streets, project very minimal overtopping at these crossings or headwater elevations that are within inches of the top of road. The specific results are dependent on the analysis model and applied parameters for land use and travel times. There is also some potential for houses upstream of these crossings to be impacted when the roads are overtopped. Upgrades for these two culverts are recommended for inclusion in the Town's capital improvement program.

The analyses for the 4% annual chance storm event also projected high headwater elevations upstream of the 3-42" RCP culvert crossing of UT-S7 under Coach Lantern Avenue between Rainy Lake Drive and Forestville Road. However, the upstream area has a wide stream buffer and no homes are projected to be impacted by the backup of water. Continuing upstream development east of Forestville Road, an eventual upstream culvert replacement at Forestville Road, and/or degradation of the upstream channel have potential to increase peak discharges and risk of overtopping at the Coach Lantern crossing.

4.2 Infrastructure Repair Needs

Although an overall condition assessment of the entire drainage infrastructure was not scoped as part of this study, some issues were noted in the course of the study either by Town staff, by citizens responding to the survey, or by LJB staff viewing structures and pipes in the field. The following stormwater assets have compromised function such that repairs or enhancements were considered as part of this study:

- In contrast to the almost 100% placement of concrete as the pipe material in this watershed, the culvert pipes conveying UT-N4 flows under three driveways along Hampton Chase Court are corrugated metal pipes (CMPs). As it typical for CMP, the bottoms have

rusted and partially deteriorated over time, with at least one of the pipes beginning to have enough bottom eroded out to cause structural integrity concerns.

- The earliest parts of the Stonegate neighborhoods were not required to treat stormwater, but were required to facilitate diffuse flow of stormwater discharges through stream buffer areas with the use of level spreaders. One of these level spreaders was observed to no longer be functional and several were noted as having compromised function.

Most of the SCMs providing stormwater treatment from newer areas of Stonegate seem to be well-maintained and functioning as intended. However, one of them seems to have received a significant volume of sediment and no longer drains properly. Wetland vegetation has become established within what was most likely intended to function as a dry pond. An owner of adjacent property noted that the SCM condition causes problems with mosquitoes during the summer.

4.3 Stability Assessments

The stream reaches in the focus area were assessed for erosion severity and potential continued erosion problems. LJB walked the streams and estimated bank height/bankfull depth ratios, bank angle, root density, root depths and surface protection. The Bank Erosion Hazard Index (BEHI) Ratings for the stream reaches were classified as Extremely High, High, Moderate, Low and Extremely Low based on observed existing conditions. The classifications are depicted in Figure 10 and detailed in Table 7.

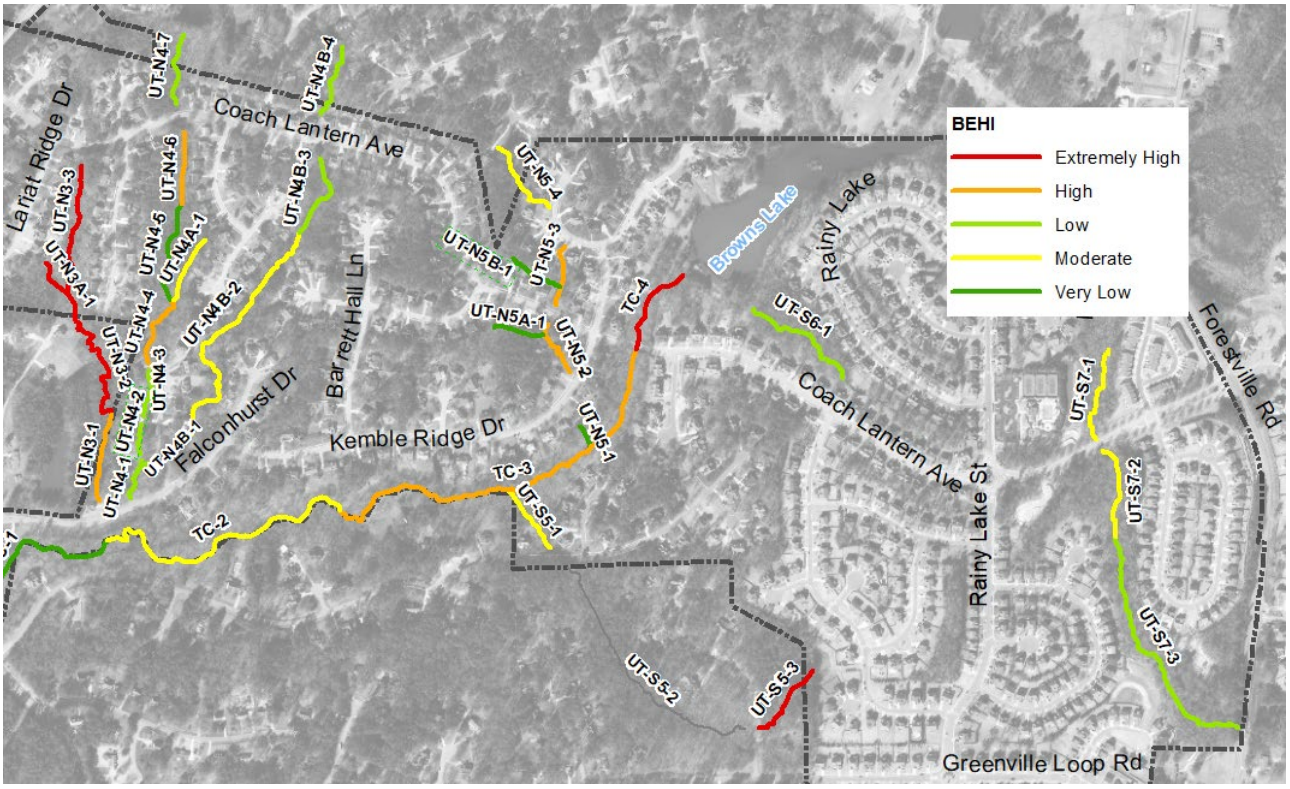


Figure 10. Erosion Hazard Rating Map

Table 7. Erosion Hazard Ratings

STREAM NAME	REACH ID	LENGTH (FT)	BEHI	COMMENTS
TC	1	1107	Very Low	Low velocities; potentially impacted by downstream beaver dams
TC	2	1587	Moderate	Banks mostly stable
TC	3	2198	High	Undercutting or steep banks in some areas
TC	4	592	Extremely High	Extensively eroded banks, particularly in area of SS aerial crossing; some scour below dam in spite of heavy armoring
UT-N3	1	466	High	Some downcutting with roots/rocks at drops; bank erosion at upstream end
UT-N3	2	989	Extremely High	Extensive downcutting and severely eroded banks
UT-N3	3	620	Extremely High	Extensive downcutting and severely eroded banks, substantial scouring below pipe outlets in spite of armoring
UT-N3A	1	221	Extremely High	Extensive downcutting and severely eroded banks
UT-N4	1	238	Low	
UT-N4	2	159	Low	
UT-N4	3	259	Low	
UT-N4	4	418	High	Some head cuts anchored by tree roots
UT-N4	5	543	Very Low	Very stable stream channel through this reach
UT-N4	6	375	High	Stream rerouted by a homeowner; erosion potential increased by the excavation and lack of vegetated buffer
UT-N4	7	390	Low	Stable
UT-N4A	1	371	Moderate	Some head cutting and bank erosion below armored area
UT-N4B	1	62	Low	
UT-N4B	2	1625	Moderate	Wooded area with good buffers, but banks are scoured in some areas; erosion worsens towards downstream end
UT-N4B	3	475	Low	Wetland-type area; braided stream
UT-N4B	4	413	Low	Wetland-type area; braided stream
UT-N5	1	134	Very Low	Outlet armored with riprap
UT-N5	2	337	High	Undercutting and eroded stream banks; only minimal downcutting
UT-N5	3	331	High	Undercutting and eroded stream banks where not armored
UT-N5	4	475	Moderate	Some bank erosion and undercutting beginning
UT-N5A	1	262	Very Low	Piped and/or armored by homeowners
UT-N5B	1	295	Very Low	Armored by homeowners

UT-S5	1	379	Moderate	Some areas have eroded banks and undercutting; well-buffered
UT-S5	3	439	Extremely High	Severe head cut; potential for extensive upstream erosion to cut a channel from SCM to current head cut location
UT-S7	1	536	Moderate	Well-buffered, but still has some erosion occurring
UT-S7	2	517	Moderate	Well-buffered, but still has some erosion occurring
UT-S7	3	1367	Low	Wetland-type area; braided stream

The only area noted where stream bank erosion has significantly and adversely affected infrastructure was the erosion around an aerial sanitary sewer crossing on Toms Creek above Coach Lantern Avenue, where stabilization work has been done by the City of Raleigh since LJB's initial observations. In some other areas, sedimentation has negatively impacted downstream drainage capacities as a result of upstream erosion. This is most strongly evident in the area along the west end of Falconhurst Drive specifically evaluated in the recent Timmons study.

Table depicts the distribution of Erosion Hazard Ratings as a percentage of total mileage of assessed streams. Approximately 3.6 miles of stream reaches were assessed in total, and nearly 1.3 miles (37%) of streams were categorized as "High" or "Extremely High" indicating a need for restoration/stabilization measures to limit shear stress and ongoing sediment export to downstream areas. Figure 11 illustrates severe erosion on Toms Creek between Browns Lake and Coach Lantern Bridge (TC-4) as an example of "Extremely High" category.

Table 8. Erosion Hazard Rating Summary

EROSION HAZARD RATING	TOTAL LENGTH (FT)	%TOTAL LENGTH
Extremely High	4125	22%
High	2862	15%
Moderate	5489	29%
Low	4033	21%
Very Low	2342	13%
Total	18851	100%

Figure 11. Severe Erosion on Toms Creek

4.4 Water Quality Observations

The NC Department of Environmental Quality (DEQ) classifies Toms Creek under North Carolina's 303(d) list as a water body with Class C, NSW (Nutrient Sensitive Waters). LJB did not conduct an independent water quality assessment for Toms Creek. This section presents current water quality information available from NCDEQ's Division of Water Resources (DWR) and a previous study conducted on Toms Creek. DWR rates Toms Creek as impaired because it is unable to support an acceptable community of aquatic organisms, indicating that the stream does not fully support its designated uses. A Watershed Assessment and Restoration Project (WARP) for Toms Creek was developed soon after the stream was listed an impaired (NCDENR-DWQ June 2002).

The WARP study identified the most probable causes and sources of Toms Creek's impairment as chlorine toxicity from the Deer Chase wastewater treatment plant (WWTP) discharge and aquatic habitat degradation, manifested by sediment deposition and substrate instability. The WWTP later switched from chlorine to UV for disinfection, so chlorine toxicity is no longer a concern. The rebuilding of Browns Lake dam in 2004-2005 addressed the accelerated erosion from a large gully noted in the WARP report. However, streambank erosion and sediment deposition are still evident in parts of the watershed observed within the Wake Forest jurisdictional areas in 2022-23 by the study team and streambank erosion remains the probable cause of poor aquatic habitat.

The Deer Chase wastewater treatment plant continues to discharge to Toms Creek under a permit from NCDEQ. The permit was renewed in July 2023, permitting continued discharge up to 50,000 gallons per day (GPD) with an allowance for potentially expanding to 200,000 GPD with an approved facility expansion. The new permit discontinues the requirement for Whole Effluent Toxicity (WET) monitoring but imposes more stringent ammonia-nitrogen limits to be met within an 18-month period. The plant was cited for exceeding their old ammonia-nitrogen average monthly discharge concentration violation in July 2023. DEQ maintains a website for public access to records of their oversight of the facility.

In the 20+ years since the WARP study, the Town of Wake Forest has developed effective regulations and management of land development planning and construction activities, which were among the WARP-recommended efforts for protecting water quality in Toms Creek. Newer development in the Stonegate areas includes five pond SCMs providing treatment of stormwater runoff, and the older sections have level spreaders to facilitate diffuse flows at pipe outfalls. Other recommendations for improving water quality included bank stabilization measures, riparian

buffer restoration, and watershed education, which have also become part of Town programs though not yet with specific projects applied within the Toms Creek watershed. Stream and buffer restoration and improvements remain important tools considered as part of this study along with installation of retrofit SCMs in older neighborhood areas and repairs and/or enhancements to SCMs in newer areas.

5. Stormwater Management Improvements Evaluation

As described in the previous section, there were a number drainage, stream stability, and general water quality issues noted within the study focus area, as well as some needed infrastructure repair needs. The next phase of the study was to identify and evaluate improvements and/or other strategies that can be taken to mitigate the identified issues. There are a number of potential structural and non-structural (e.g. programmatic) strategies that can be taken to mitigate identified issues. Table 9 below provides a list of the main strategies that were considered.

Table 9. Potential Stormwater Management Improvements

Drainage and Flooding	Stream Stability	Water Quality
• Drainage System Improvements • Flood Detention • Floodplain Benching	• Stream Restoration • Bank Stabilization • Energy Dissipation at Outlets • Grade Control Structures	• Green Streetscaping • SCM Enhancements • Roof-Drain Disconnects • Buffer Enhancements

5.1 Drainage and Flooding

Potential flood risk reduction options for flood-prone structures and roadways in the Toms Creek watershed were considered as part of the watershed study. Concern for homes along Toms Creek at risk of flooding prompted consideration of additional flood detention storage in Browns Lake. However, reducing flood risk for downstream homes would have to also protect upstream homes from increased risk in order for FEMA to permit any changes to the dam outlet structures. Due to the close horizontal and vertical proximity of homes to the flood risk areas, it was not deemed feasible to provide additional flood storage in Browns Lake. Raising the existing masonry dam to add flood storage upstream was also found to be impractical since the dam controls the tailwater conditions for the culvert crossing at Forestville Road, which is at risk of overtopping in extreme storm events. Other drawbacks to dam modifications would have included extensive costs for the Town, as well as the liability of responsibility for a high hazard dam in the case of Browns Lake. Thus, flood detention is not recommended as an option for this watershed.

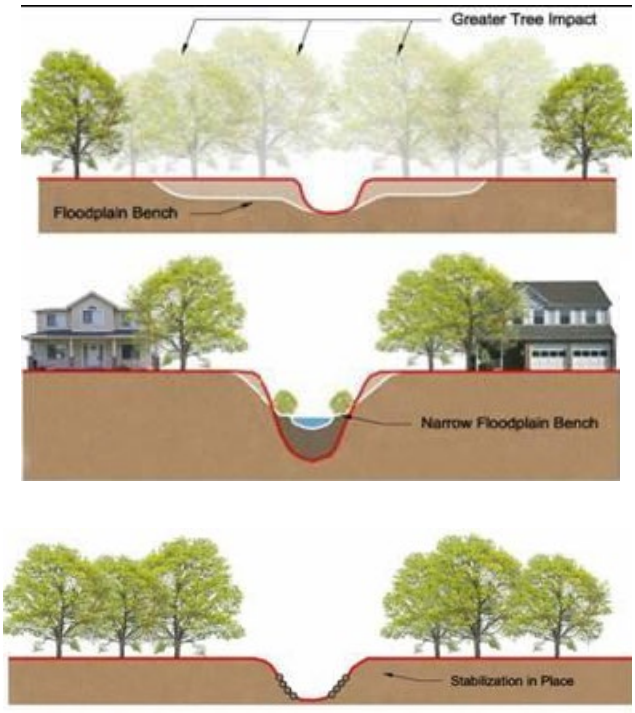
Floodplain benching is often incorporated into stream restoration projects to help reduce the shear stresses along the toe of a stream bank. "Benching" usually means that the upper part of a stream bank is excavated to create a flat shelf area at a lower elevation. This is recommended as part of stream projects along Toms Creek between the bridges under Coach Lantern Avenue and Ligon Mill Road, as a means of lowering flood risk for homes as well as mitigating erosion. The reduction to flood risk would vary depending on the location, linear extents, and space available for benching back the existing stream banks.

Culvert upgrades at Coach Lantern Avenue and Kemble Ridge Drive for conveyance of UT-N5 flows would reduce the risk of overtopping of the road and ponding of floodwaters beside and around

homes. Specifically, the pipes conveying under Coach Lantern should be upsized from 48" to 54" RCP and those under Kemble Ridge from 54" to 60" RCP, assuming that this is feasible with the existing sewer mains crossing below each of these two crossings. Cost estimates were developed assuming that larger single pipes can be installed and the double pipes will not be required for providing additional stormwater conveyance. Specific information for the culvert replacements is provided in Appendix B.

5.2 Stream Stability

Stream restoration measures are categorized based on the level of overall ecological improvement that can be expected. Prioritization level 1 measures are intended to replicate as fully as possible the stream horizontal and vertical profiles and cross-section geometry for a comparable reference stream that remains unaffected by urbanization and degradation. This is seldom feasible in a developed or developing watershed and no Priority 1 stream projects were considered practical within the Toms Creek watershed. Priority 2 restoration measures aim to establish a smaller lower floodplain bench for the incised channel. Priority 3 measures are similar, but the amount of benching is constrained by development in adjacent areas. Priority 4 measures involve only stabilization of the banks to reduce erosion and offer minimal improvement to aquatic habitat other than arresting the export of sediment to points further downstream.



Priority 2 Stream Restoration
- Requires wide corridor for floodplain benching
- Necessitates re-establishment of riparian vegetation for bench area and new buffer

Priority 3 Stream Restoration
- Available corridor width is limited by development so benches are narrower
- Stream bed may be raised to extent feasible

Priority 4 Stream Restoration
- Limited to armoring the stream banks with boulders and woody vegetation
- Ecological benefits are minimal

Figure 12. Stream Restoration Scenarios

Within Toms Creek watershed areas, potential stream restoration is limited by the available corridor widths along the stream banks that could possibly be made available by an HOA or private property owner to facilitate wider floodplain benching. The wider the bench and the longer the reach where it can be established, the greater would be the potential reductions to flood elevations and to the shear stresses driving the stream bank erosion. The goal for Toms Creek stream stabilization improvements is for Priority 3 restoration, with as much floodplain benching as is feasible, in most of the reaches with a very high or high BEHI scoring. Where reaches are too short

or narrow to accommodate better restoration measures, improvements may be limited to Priority 4 stabilization of banks. Table 10 provides a summary of recommended stream stability improvement measures. Proposed project locations are shown in Figure 13.

Table 10. Recommended Stream Stability Improvement Measures

PROJECT ID	REACH ID	LOCATION DESCRIPTION	EROSION HAZARD RATING	POTENTIAL PROJECTS
TC-ER-01	UT-N3 Reach 3, UT-N3A Reach 1	Behind homes along Lariat Ridge and Reindeer Moss Drive	Extremely High	Priority 3/4 Stabilization at Outlets
TC-ER-01A	UT-N3 Reach 3, UT-N3A Reach 1	Alternative project to TC-ER-01	Extremely High	Stabilization at Outlets
TC-ER-02	UT-N3 Reach 2	Through County jurisdiction and behind homes along Hampton Chase Court	High to Extremely High	Priority 3/4 Restoration/Stabilization
TC-ER-03	TC Reach 4	Between Browns Lake dam and Coach Lantern Avenue bridge	Extremely High	Priority 3/4 Restoration/Stabilization
TC-ER-04	TC Reach 3	Between Coach Lantern Avenue bridge and discharge pipe from Hampton Chase	High	Priority 3/4 Restoration/Stabilization
TC-ER-05	UT-N4 Reach 6	Behind homes along Stacked Stone Trail	High/ Future Risk	Priority 2/3 Restoration/Stabilization
TC-ER-06	UT-S5 Reach 3	From SCM off of Capefield Drive to headcut within County jurisdiction	Extremely High/ Future Risk	Establishing Stable Channel Upstream of Head Cut
TC-ER-07	UT-S7 Reach 2&3	From Forestville Road to Coach Lantern Avenue	Low to Moderate/ Future Risk	Grade Control at Access Points

Figure 13. Proposed Stream Stabilization Projects

On UT-N4 Reach 6, the small stream channel has been partially relocated by a property owner and shows some early signs of destabilization. Though the stream is rated as Extremely High erosion hazard, this mostly reflects future risk as the channel incision and bank erosion are in early stages. Thus, some limited restoration measures to maintain the stream profile and floodplain connection, in addition to re-establishment of vegetated buffers are considered appropriate and adequate for protecting the stream against the projected impacts of the recent disruption.

Though the conditions along UT-S7 Reaches 2 and 3 indicate low-to-moderate erosion hazard conditions, several large stormwater outlet pipes, for which no peak discharge controls were required, discharge to this channel. In spite of wide and well-vegetated buffers, there is risk of future channel incision and destabilization as the stream continues to adjust to a new flow regime reflecting the developed conditions. Installation of grade control measures such as cross-vanes or buried boulder structures could limit downcutting of the stream bed through this reach and thus the destabilization and sediment export.

Implementing improvements along the stream reaches in the Toms Creek watershed will present a number of challenges and considerations for the Town and for the surrounding property owners.

1. Lack of space for optimal restoration – Full ecological restoration and stabilization of a degraded stream reach ideally involves re-establishing a riffle-pool sequence with floodplain connection and meanders approximating pre-development conditions. The less width is available for optimizing these measures, the less ecologically effective the restoration is likely to be. Where space is severely limited, the project becomes more of a stabilization and/or flood reduction effort and is less effective in restoring a healthy biological stream habitat.
2. Need for permanent or temporary easements – For most of the recommended projects, there are either no easements or very limited easements along the stream channels. At a minimum, temporary easements will be required and for long-term maintenance the Town may want to acquire adequate permanent easements as part of the project. In addition to the need for easements along the stream channel, specific access corridors will need to be established and maintained at least long enough to assure adequate establishment of vegetative measures associated with the stream improvements.
3. Vegetation Issues – The tributary streams within the Toms Creek watershed generally have at least a small width of forested buffers. Implementing a stream improvement project for re-establishing stability and improving water quality and habitat often requires a substantial loss of trees for construction access and installation of in-stream structures. For some residents that can mean the visual buffers along the rear of their property will be compromised until trees grow to an adequate height. Using natural channel design measures along a stream can include very dense vegetation along a stream bank and adjacent area. For residents who have fenced off their backyards from the stream or for stream channels within HOA property, this is unlikely to be a problem. For residents who traverse over small footbridges and/or enjoy having a view of the stream, consideration of alternative vegetation options may be desirable.
4. Maintenance responsibilities - When a municipality implements a stormwater improvement on private property, it is important to have an agreement establishing maintenance responsibilities and what that will involve. For a stream improvement project, the Town would be responsible for ensuring adequate establishment of vegetation and for any needed repairs to instream structures. When a project is permitted under a Corps of

Engineers Nationwide Permit 27 for stream/wetland restoration or enhancement, there are inspection requirements for a specified time period after project construction.

5. Grant funding – Grant funding for stream projects is available from several funding sources, most notably from the NC Land & Water Fund. Grant funding is usually prioritized based on the degree of ecological "uplift" that is expected to result from project implementation. Additional weight is often added for projects in a public space where there is an educational component and broader public benefit than may be possible with the proposed projects within the Toms Creek watershed. However, the longer the reach of the proposed stream improvements the more likely it is that ecological uplift can be projected. Recently, there has been increasing funding available for projects aimed at improved "resiliency" related to flood impacts and damages. The prioritization schemes target projects where the most structures and/or citizens can expect reduced impacts from flooding.

5.3 Water Quality

One focus of the watershed study involved exploring options to incorporate water quality improvements within this mostly-developed watershed in addition to addressing the previously noted functional problems with existing SCMs and level spreaders.

For the western portion of the focus area, where neighborhoods were built before post-construction stormwater controls were required, the street rights-of-way are the only publicly owned or community-shared spaces available for locating SCMs to provide some water quality treatment. Several of the streets are wide enough to accommodate "green streetscaping" near sag points, with bioretention areas built out into the street at about the width of a parked car and back into the area behind the curb. Gutter flows would be directed to the bioretention area for treatment before discharge into the drainage pipe, with overflows beyond the SCM capacity routed directly to the curb inlet downgradient. The photos below show concepts for an SCM partially within the street and one within right-of-way behind the curb.

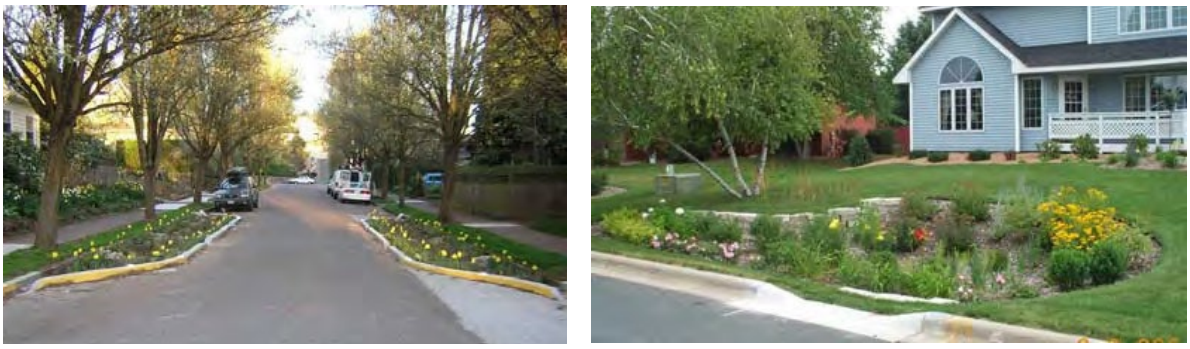


Figure 14. Examples of Green Streetscaping

For the stream stability protection discussed in the previous section for UT-S7 south of Coach Lantern Avenue, the access for grade control installations would be through existing drainage easements, most of which have a level spreader at the outfall to the HOA property. In several areas, there is enough area outside of required buffers for installing SCMs to better protect water quality and stream stability. See Figure 15 below.

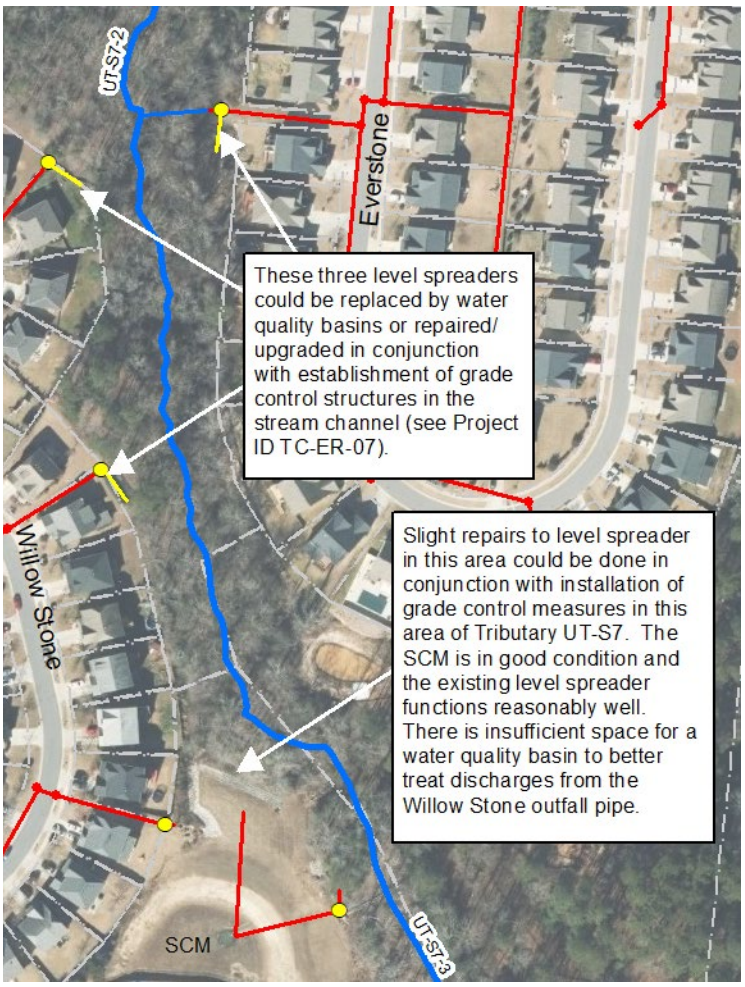


Figure 15. Potential Water Quality Improvements on UT-S7

Other potential options for improving water quality within the Toms Creek watershed could be implemented by individual property owners: disconnections of roof downspouts, installations of backyard rain gardens as SCMs, and/or preservation or enhancements of vegetated buffers along stream channels. The Town can provide public education, training, and possible financial incentives for encouraging property owners to invest in improving water quality.

6. Recommended Watershed Actions

Recommended stormwater improvements are summarized in this section, along with repairs needed for the problematic infrastructure components noted in Section 4.

1.1. Drainage Infrastructure Improvements

Culvert upgrades on Falconhurst Drive are already under consideration by the Town, with specific recommendations and costs detailed in the Timmons study. Additionally, replacements are recommended for the culvert crossings under Coach Lantern Avenue and Kemble Ridge Drive for UT-N5, though at a lower priority than the Falconhurst projects due to the lesser risk of overtopping.

For replacement of deteriorated driveway pipe on Hampton Chase Court, and possibly the other

two as well, there are existing drainage easements for the stream channel and driveway culverts. Due to the deteriorating condition of these pipes, planning in conjunction with the property owners for replacement of these pipes is recommended. Details on permitting and project costs are provided in Appendix B.

Project costs are listed in Table 11. The project cost listed for the Hampton Cross driveways assumes replacement of all three pipes. The project locations are shown in Figure 16.

Table 11. Recommended Drainage Infrastructure Improvements

PROJECT ID	REACH ID	PROJECT	ESTIMATED COST
FALCONHURST*		Alternative 2, Phase 1 and 2 as Recommended by Timmons Group	$580,000
TC-DI-01	UT-N5 between Reaches 1 and 3	Culvert Replacements on Coach Lantern Avenue and Kemble Ridge Drive	$720,000
TC-DI-02	UT-N4 between Reaches 1 and 4	Culvert Replacements for Driveways on west side of Hampton Chase Ct	$190,000
ESTIMATED TOTAL PROJECT COSTS			$1.5 Million

**Evaluation, recommendations, and project costs developed by Timmons Group under a separate study*

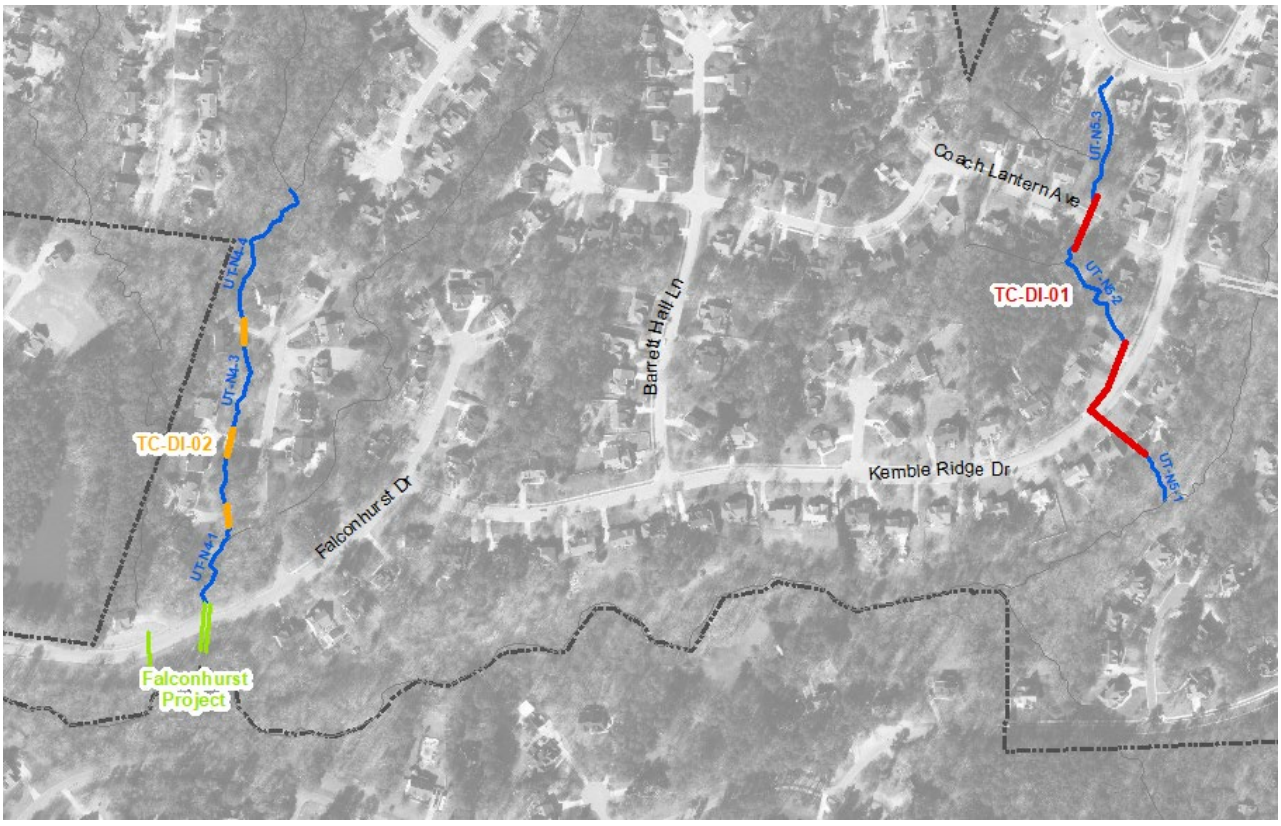


Figure 16. Proposed Drainage Infrastructure Improvements

6.1 Stream Stabilization Improvements

Appendix C provides discussion of stream restoration/stabilization projects recommended for consideration and prioritization, with detailed descriptions, photographs, affected properties, expected permit requirements, and an anticipated range of costs. A summary is listed below in

Table 12. The project locations are depicted in Figure 13. Information on scoring for Benefit and Access is included in the project descriptions in Appendix C.

Table 12. Ranking/Scoring for Stream Stability Improvement Measures

PROJECT ID	PROJECT	RANKING	EROSION HAZARD RATING	BENEFIT SCORE	ACCESS SCORE	ESTIMATED COST
TC-ER-06	Stable Channel on UT-S5 Reach 3	1	Extremely High/ Future Risk	1	4	$270,000
TC-ER-03	Priority 3/4 Restoration on TC Reach 4	2	Extremely High	1	3	$360,000
TC-ER-05	Priority 2/3 Restoration on UT-N4 Reach 6	3	High/ Future Risk	2	2	$180,000
TC-ER-07	Grade Control Structures on UT-S7 Reach 2&3	4	Low to Moderate/ Future Risk	3	2	$240,000
TC-ER-01	Priority 3/4 Restoration on UT-N3 Reach 3, UT-N3A Reach 1	5	Extremely High	1	5	$610,000
TC-ER-04	Priority 3/4 Restoration on TC Reach 3	6	High	3[1]	3	Varies depending on participating owners – estimated at $450,000
TC-ER-01A[2]	Outlet Stabilization on UT-N3 Reach 3, UT-N3A Reach 1	7	Extremely High	4	4	$250,000
TC-ER-02	Priority 3/4 Restoration on UT-N3 Reach 2	8	Extremely High/High	2[3]	5	$500,000
ESTIMATED TOTAL PROJECT COSTS						$2.6 Million

Notes: 1 – benefit dependent on conditions and length of project stream reach; 2 – project only to be considered if TC-ER-01 not feasible – not included in total project costs; 3 – benefit will be only be maximized with stabilization of upstream reach

6.2 Water Quality Repairs and Improvements

Recommended water quality measures to address problems with existing infrastructure include removal of a failed level spreader and restoration of a poorly functioning pond SCM, green streetscaping, and new pond SCMs. Proposed water quality improvements are installations of green streetscaping and new pond SCMs as listed in Table 12.

Table 13. Recommended Water Quality Improvements

PROJECT ID	PROJECT	LOCATION	ESTIMATED COST
TC-WQ-01	Green Streetscaping	3 Sag Points on Coach Lantern Avenue	Dependent on number of installations – Estimated at $50,000 to $80,000 each – Budgeted at $400,000
TC-WQ-02	Pond SCMs at 3 sites	UT-S7 south of Coach Lantern Avenue	$100,000 to $150,000 per SCM dependent on size—Budgeted at $400,000
ESTIMATED TOTAL PROJECT COSTS			$0.8 Million

The failed level spreader behind the home on Lower Lake Drive isn't recommended for restoration back to design conditions and there is insufficient space for installing an improved level spreader. Because the level spreader has failed to function in recent years, it is expected that the low area and downstream berm can be graded out without exacerbating conditions below the existing outfall. However, there is potential for installation of an SCM for this discharge flow within the HOA property downgradient between the sanitary sewer easement and Browns Lake.

The existing SCM behind homes on Capefield Drive, owned and maintained by the Stonegate HOA, is in need of restoration to restore proper function. The bottom area needs to be graded to facilitate gravity flow and draining of the SCM and the suitable vegetation needs to be re-established.

Green streetscaping SCMs are recommended for installation at several locations along Coach Lantern Avenue. Potential installation locations and associated costs are provided in Appendix D.

Construction of three SCMs along UT-S7 between Coach Lantern Avenue and Forestville Road at locations shown in Figure 14 is recommended to be incorporated into establishment of stream channel grade control measures. Project descriptions, permitting issues, and construction costs are noted in Appendix D.

7. Implementation Considerations

This study has identified a number of specific recommendations to address stormwater issues and/or to provide water quality benefits in the Toms Creek watershed. The next logical step is to develop a strategy for implementing the recommendations. Developing the strategy will require weighing the needs and recommendations identified in this report with other watershed studies (and Town needs), securing funding, refining the improvement concepts for project design/permitting, and then constructing/implementing the improvements. Considerations for each of these phases is presented below.

7.1 Integration/Prioritization with Other Watershed Studies

As indicated previously the Town has four main watersheds. Two watersheds (including Toms Creek) are currently being studied, and the remaining two likely will be studied in the relative near future. Once the studies are all complete, it would be prudent to integrate and prioritize the significant capital improvement project (CIP) recommendations from all the watershed studies into a combined CIP list. This would allow the Town to implement stormwater/water quality projects in a "needs-based" and equitable manner.

7.2 Funding Sources

The Wake Forest Town Council recently (November 2023) approved implementation of a stormwater utility fee for residential and non-residential properties in the Town. The fee is based on the amount of impervious area on a given property and will be assessed at $45 per Equivalent Residential Unit (ERU) (=1,200 sq. ft.) per year. The stormwater utility will be a new dedicated funding source to help support Town stormwater needs.


Wake Forest establishes stormwater fee

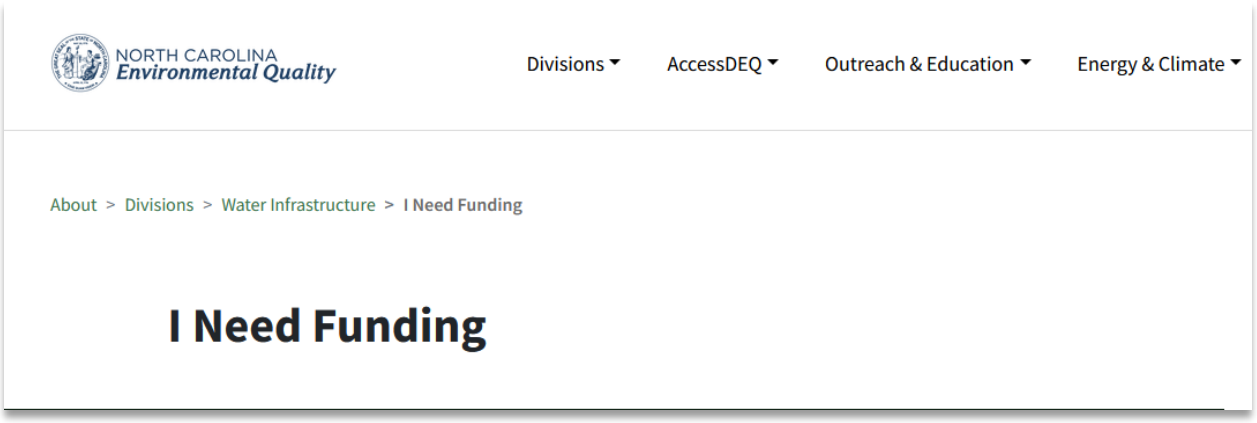
Open Audio Article Player

November 24, 2023

By Reggie Ponder

editor@wakeweekly.com | 919-556-3182

As the stormwater utility will also be used to support operations and maintenance needs, it may not be sufficient to fund desired capital improvements in a timely manner. In addition to the local funding, there are a number of state/federal grant opportunities and other external funding sources that are oriented towards stormwater management, water quality, flood control projects, as well as general infrastructure. The Town could pursue grants to help fund recommendations from the watershed studies. A number (8±) of state (and federal) grants are administered through the North Carolina Department of Environmental Quality (NC DEQ). Many of these grants have two application cycles per year. Information of available grants administered through NC DEQ, as well as information and resources for applying to these grants can be found at the 'I Need Funding' webpage at the link below.



https://www.deq.nc.gov/about/divisions/water-infrastructure/i-need-funding

Beyond grants administered by NC DEQ, there a number of additional grants that could be investigated. Select examples of other applicable grants and funding sources are listed below.

Agency/Source	Weblink
Golden LEAF	https://goldenleaf.org/
NC Land and Water Fund	https://nclwf.nc.gov/grants
FEMA Flood Mitigation Grants (BRIC, FMA)	https://www.fema.gov/grants/mitigation
EPA 319 Nonpoint Source Pollution	https://www.epa.gov/nps/319-grant-program-states-and-territories

7.3 Design/Permitting/Implementation

The improvement recommendations presented in this watershed study are conceptual in nature and based on higher-level planning evaluations. Before any recommendations could be implemented, the improvements would first need to be refined through additional engineering

analysis and evaluation, then they would need to go through the engineering design/permitting before they could be constructed/implemented. The integrated CIP list mentioned above could be used to determine the general "order" to implement each of the recommendations. Funding availability, internal/external resource capacity, and public/political will often drive how many and how quickly the improvement projects can be implemented.

APPENDIX A

WATERSHED CITIZEN SURVEY RESULTS

Compilations for responses and comments received in the citizen survey conducted as part of the Toms Creek Watershed Study are summarized below for each of the survey questions.

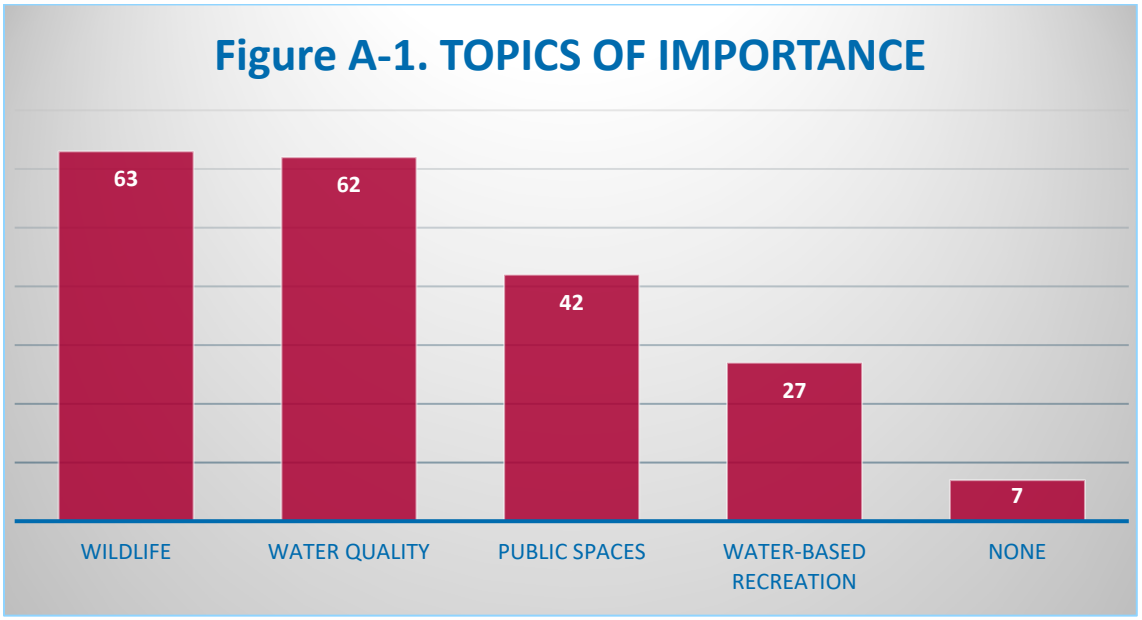
A.1. - Topics of Importance

Out of the 75 responses, 63 listed wildlife as a topic of importance and 62 listed water quality. Some specific concerns related to protection of wildlife habitat and water quality expressed in survey comments:

- A need for the Town to collaborate with other jurisdictions in protecting the environmental health sustainability of the watershed.
- Concerns about residents removing vegetation within stream buffer areas.
- Worries about impacts of development projects on the water quality, with particular reference to a large planned project east of Ligon Mill Road within the watershed.
- Multiple references to erosion and sedimentation problems.

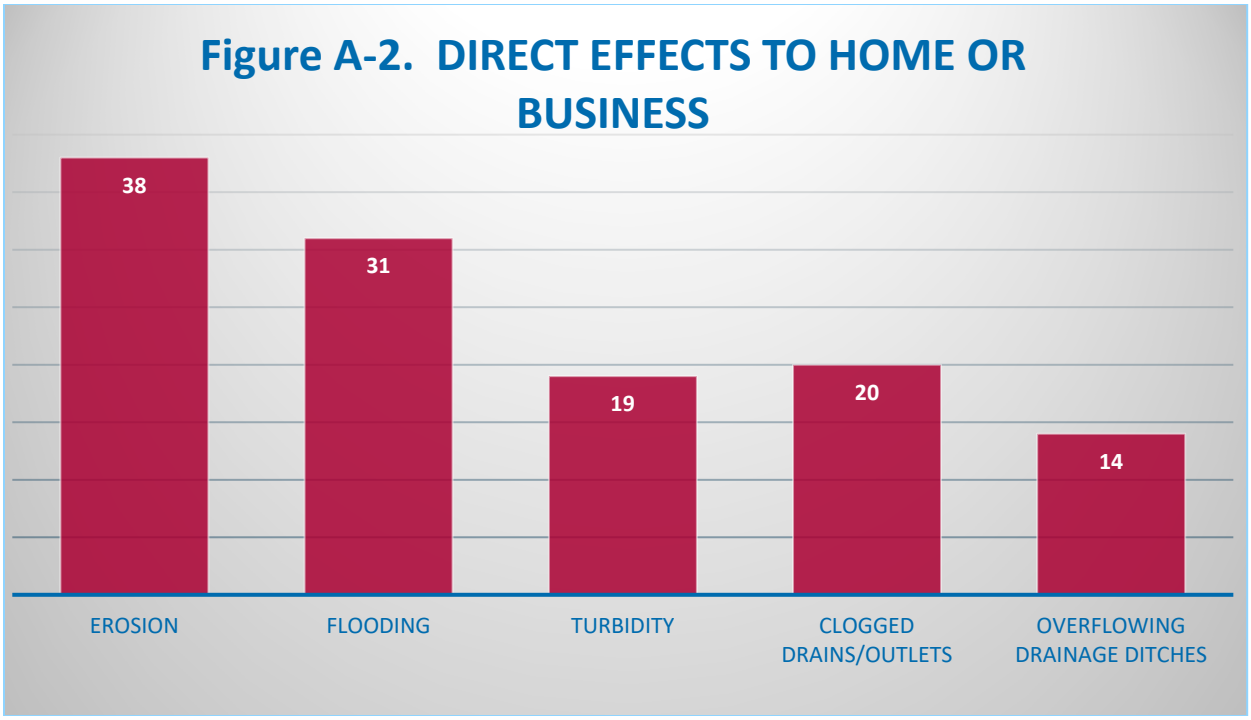
Presumably the residents' listing of "wildlife" as an important topic expresses a desire for protection of diversity and habitat. However, LJB staff doing field work have also heard concerns about the *presence* of wildlife such as coyotes in the watershed because of the danger to children and pets. Beavers are another concern to residents, due to the potential for beaver dams to impede stream flows and exacerbate flooding problems.

Figure A-1 shows a tabulation of the residents' listing of topics of importance.



A-2. - Stormwater Issues Causing Direct Effects to Residents

Residents were asked what stormwater problems directly affect their home and/or business. Figure 2 shows a tabulation of the four drop-down choices:



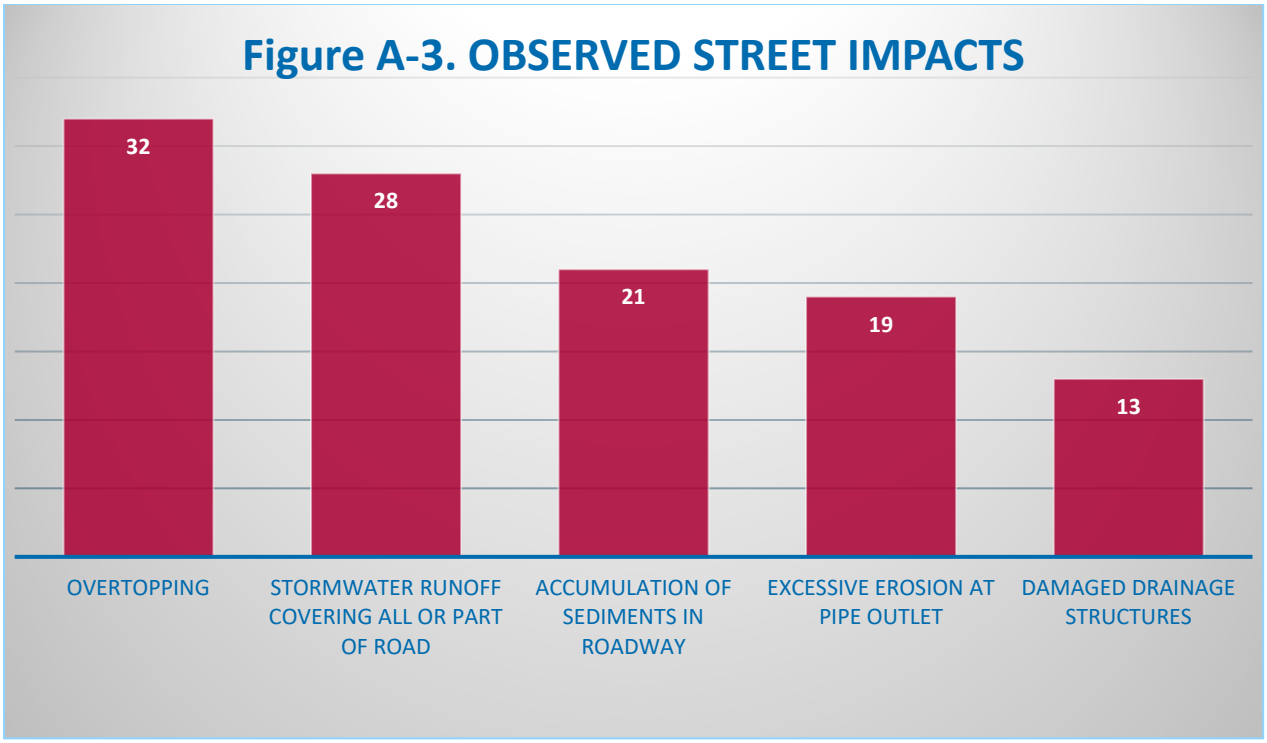
Thirty (30) respondents listed direct effects as "none" or left it blank. Additional effects listed under "other" included the following:

- algae in Browns Lake
- litter/trash carried in stormwater runoff
- water quality and odor problems
- spillway discharge from Browns Lake

Residents were also asked to describe the frequency and extent of problems experienced. In reference to erosion problems, the response was frequently "with every heavy rain" or a similar statement. Several residents noted erosion as having been observed over a number of years (5-6, 10, etc.) One 25-year resident on Toms Creek noted having lost 15 feet at the back of his property to streambank erosion. Backyard flooding problems and issues related to clogging infrastructure and overflowing ditches are noted to range in frequency from "every heavy rain" to "only in deluge storms". One resident along Toms Creek reported that his home is threatened with flooding during extreme storm events. Specific comments on problems affecting property owners are listed in Table A-1.

A-3. - Impacts to Streets

Many of the residents reported having observed stormwater problems related to streets in the Toms Creek watershed. Figure 3 illustrates the observed problems cited. Thirty-eight (38) of the 46 residents who listed observed problems noted flooding of roadways by overtopping of a stream channel and/or runoff not being drained off. Erosion and sedimentation problems were also frequently cited as having been observed by residents.



A.4 - Willingness to Support Stormwater Projects

Eroding stream channels tend to be located along the back property lines in a residential area such that repairing and improving the stream will require construction access, probable loss of some trees, and up to a couple of months of construction activity. Thus, residents were queried as to their level of willingness to provide the Town with access and/or easement to facilitate these types of projects. Clearly, the majority of respondents, having expressed that they view water and environmental quality as important, indicated a willingness to collaborate with the Town in efforts to improve natural streams in the Toms Creek watershed.

Figure A-4. WILLINGNESS TO BE INVOLVED

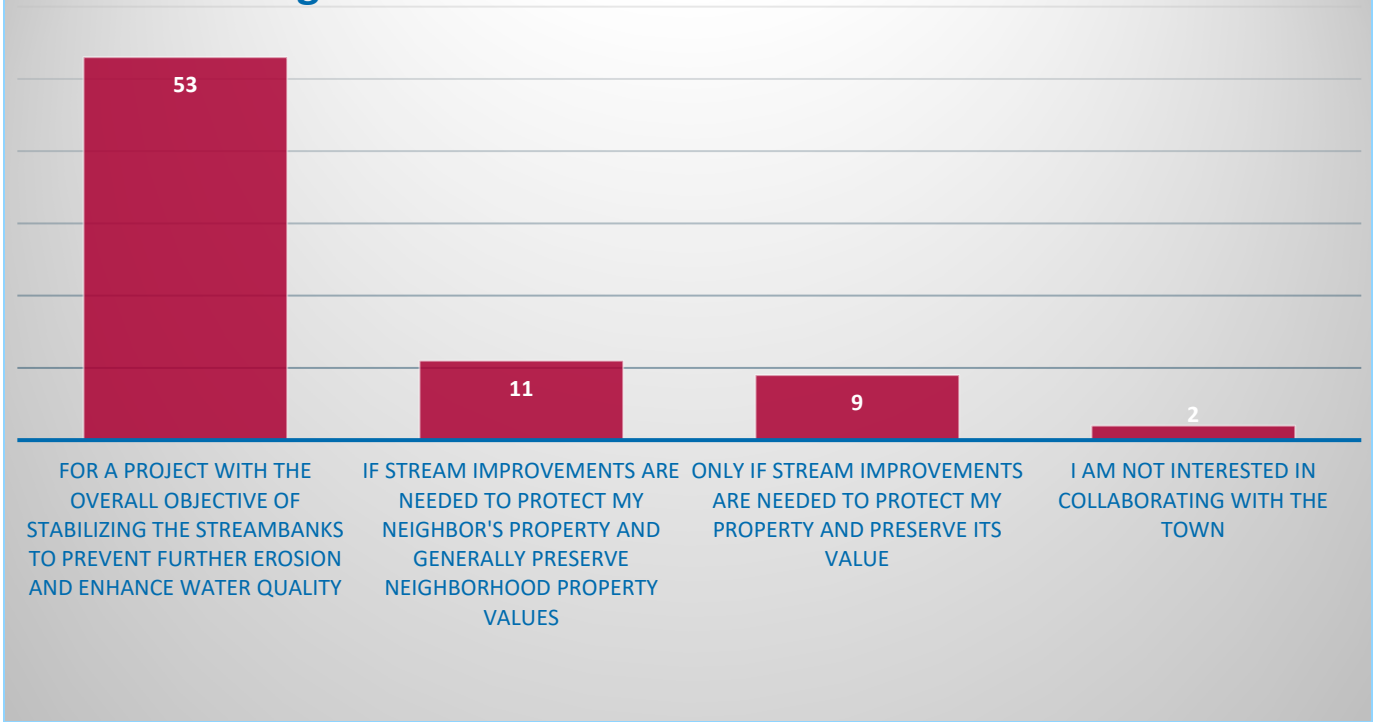


Table A-1. Listing of Specific Problems Affecting Property Owners

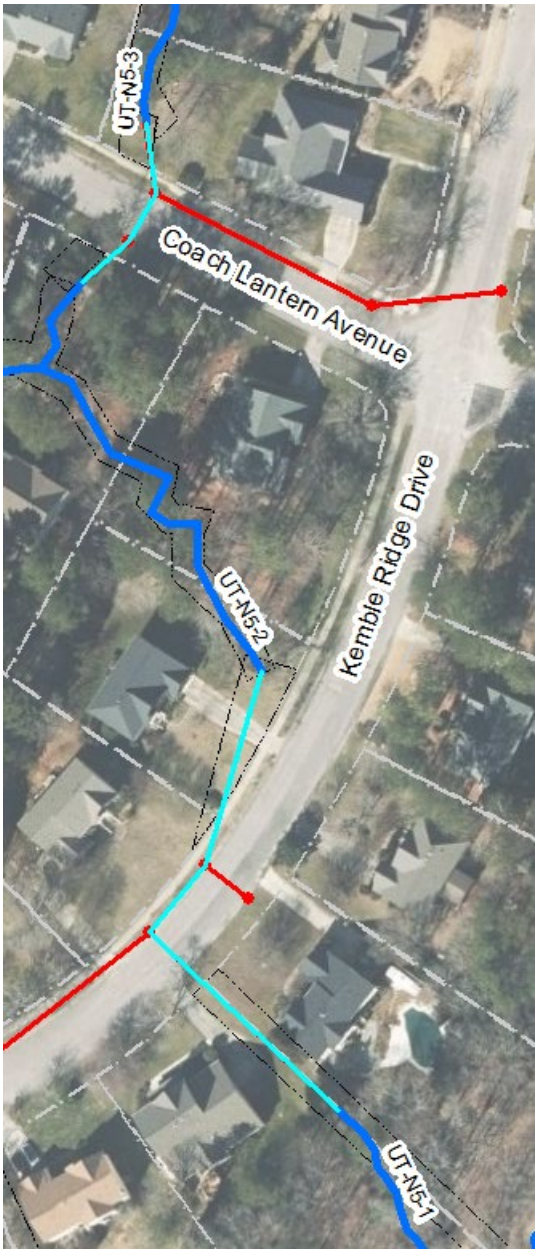
Street	Primary Categories	Adjacent Stream	Description
Falconhurst	Multiple	Toms Creek	Drainage pipes from the road discharge adjacent to this property. The creek overflows and causes drastic flooding through the easement. A portion of the owner's property ss unusable due to the frequent flooding and muddy conditions.
Falconhurst	Flooding/ Erosion	Toms Creek	Flooding and erosion have been observed for at least the past 5-6 years with every heavy rain event. Up to about 15 ft of land along the creek bank has been lost to erosion. Sediment deposition in the yard up to 12" deep has occurred, as well as downed trees along the bank.
Kemble Ridge	Erosion	Toms Creek	Erosion during heavy rain days.
Kemble Ridge	Multiple	Toms Creek	Large rain events cause Toms Creek to overflow its boundaries which creates flooding, erosion of its banks and sedimentation that has all but destroyed any living creatures that once thrived in the waters of Tom Creek when we first moved here. Storm water off of Kemble Ridge Dr. drains directly into Toms Creek, adding pollution. This creek once had abundance of clams and fish, but no more.
Kemble Ridge	Flooding/ Erosion	Toms Creek	When there are heavy storms/hurricanes, the creek floods resulting in erosion.
Kemble Ridge	Erosion	Toms Creek	My backyard is the bottleneck from the elevated spillway to the creek below.
Chelridge	Flooding	Toms Creek	Any substantial amount of rain, especially during high-intensity events, overflows creek into yard and threatens home.
Hempton Cross	Erosion	Toms Creek	Severe erosion along Toms Creek has been lost due to increased volumes and velocities of flows from Browns Lake after development of townhomes in Stonegate. Reports 3-5 feet of stream bank lost.
Hempton Cross	Flooding	Toms Creek	Infrequent topping of the banks
Hampton Chase	Flooding	UT-N3; UT-N4	It floods 3 or 4 times a year and makes a big mess.
Hampton Chase	Pipe Failure/ Flooding	UT-N4	Front yard began flooding from creek ~6 years ago. Owner lined the stream w/ large stone When we bought our property, we lined the stream (it really was nothing but a stream and dry most of the time) with large stone over 20 yrs ago, which is now buried. Culvert is being undercut and shared driveway is cracking. Front yard along stream has become "swampy" and can no longer be mowed.
Hampton Chase	Flooding	UT-N4	The creek has become eroded in recent years. When it rains hard it for long periods of time, there is overflow and drains are impacted. It also overflows into the roadway down the street, which has been impassable on several occasions.
Falconhurst	Multiple	UT-N4B	Flooding, erosion, clogged inlets, overflowing ditches all observed whenever there are hard rains.
Falconhurst	Flooding	UT-N4B	Back yard floods with every heavy rain. Home and concrete appears to be sinking in the direction of the creek.
Coach Lantern	Multiple	UT-N4B	Drainage conveyance eroding due to neighbor's removal of trees along the bank. Ponding of water occurs due to poor grading for routing runoff from neighboring properties. Turbidity is increasing since development of Stonegate.
Coach Lantern	Erosion	UT-N5	Excessive erosion at a pipe oulet.
Coach Lantern	Flooding/Erosion	UT-N5	All of the time.
Coach Lantern	Erosion	UT-N5B	Continued erosion in backyard over at least ten years.
Rainy Lake St	Turbidity	UT-S6, Browns Lake	Algae growth in shallow areas of Browns Lake from June to Sept
Kaytena	Flooding	Ephemeral	Backyard will flood in moderate to heavy rains.
Kaytena	Turbidity	Ephemeral	Ephemeral stream channels overflowing more and more over time during heavy rains and encroaching on backyards where this never happened before. Problems are worse during heavy rains. New construction is making the problems worse.
Falconhurst	Flooding	None	Creek overflows, usually during spring and early summer rains.
Falconhurst	Flooding/ Erosion	None	Water drainage along Ligon Mill Road water runs onto the road when drains become clogged. Also, the creek itself in our neighborhood backs up and comes up over the road in a couple of places.
Kemble Ridge	Erosion	None	With heavy rains there is runoff from property that heavily pools on the sidewalk. Poor drainage.

APPENDIX B

DRAINAGE INFRASTRUCTURE PROJECTS

Project ID: TC-DI-01

Reach ID: UT-N5- Reaches 1 to 3



Proposed Project:
Replace existing 48" culverts under Coach Lantern Avenue and existing 54" culverts under Kemble Ridge Drive with larger pipes or double pipes, dependent on utility conflicts and other issues affecting costs.

Location:
Highlighted pipe reaches shown west and south of Coach Lantern/Kemble Ridge intersection.

Impacted Properties:
The Town has 20-foot drainage easements along these pipes, but some temporary adjacent easement areas will be needed for the construction. Several property owners will be directly impacted by the pipe replacement under one driveway and along another.

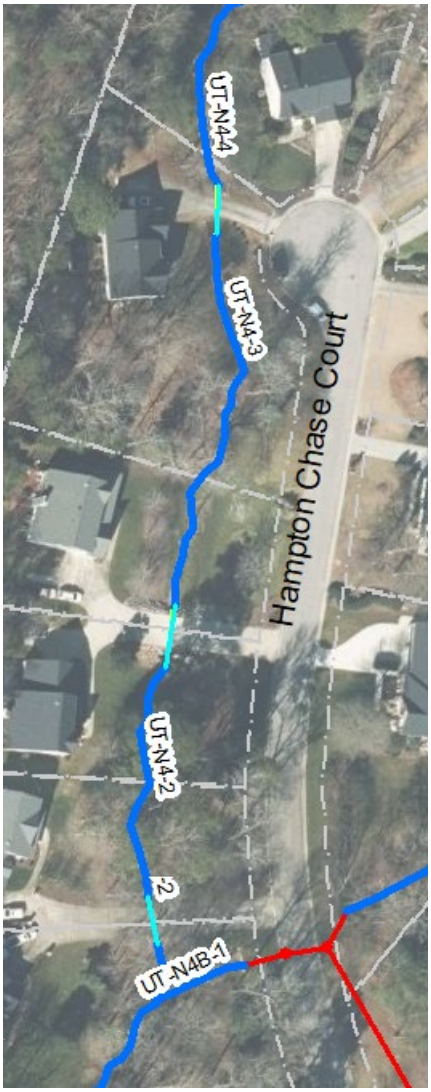
Implementation Issues:

1. Should be able to obtain 404/401 permits for stream and wetland impacts under NWP for maintenance.
2. Probable utility conflicts may present constraints requiring either relocations for mains or services or double drainage pipes.
3. Road closures and traffic detours.

Approximate Cost: $720,000 (includes design, permitting, and construction) based on replacement with 54" and 60" RCP.

Project ID: TC-DI-02

Reach ID: UT-N4- Reaches 1 to 4



Proposed Project:
Replace three existing 48" CMP culverts under driveways along Hampton Chase Court due to deterioration in the bottom of the pipe. Recommendation is to replace with 54" HDPE buried 6" below stream bed for increased flow conveyance and improved aquatic passage.

Location:
Highlighted pipes shown under driveways.

Impacted Properties:
The Town has 20-foot drainage easements along these pipes. Each of the four directly affected homeowners will lose vehicular access during replacement of their specific crossing.

Implementation Issues:

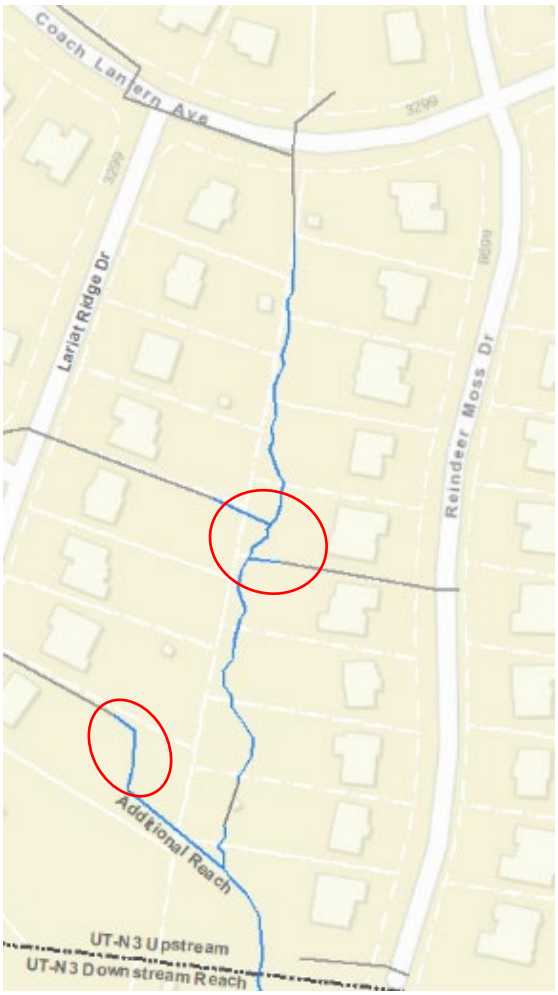
1. Given that these pipes are on private property and not within a public right-of-way, the Town will need to determine if and to what extent the Town will participate and/or manage replacement of the pipes.
2. The pipes adequately convey 4% annual chance peak flows, though not without significant backwater effects. Floodwaters are projected to impound against the structure upstream of the northernmost driveway crossing before it is overtopped.
3. A more detailed inspection of each pipes may determine that not all of them need to be replaced at this point and it may be beneficial for the Town and/or preferred by property owners to selectively replace as vehicular safety starts to become compromised.
4. Approvals would be expected for 404/401 permits for stream and wetland impacts under NWP 3 for maintenance.
5. Maintenance of emergency access to impacted homes.

Approximate Cost: $190,000 (includes design, permitting, and construction) for replacement of three pipes.

APPENDIX C

STREAM STABILIZATION IMPROVEMENT PROJECTS

Project ID:	**Reach ID:**
TC-ER-01	UT-N3-Reach 3
TC-ER-01A	UT-N3A-Reach 1



Proposed Project:
Stream restoration and stabilization to reduce ongoing sediment export to downstream areas, inclusive of instream structures, floodplain benching with stable slopes and appropriate riparian vegetation. Project 01 would cover the entire reach and is assigned a Benefit score of 1 (highest) due to the volume of sediment export that could be prevented by stabilization efforts. However, the assigned Access score is 5 (lowest) due to the numerous affected owners and the limited stream corridor space.

As an alternative, recommended target areas would be at the pipe discharge points along the reach. Specifically the areas circled in red would be stabilized with energy dissipation pools at pipe outlets and stabilized stream reaches. Benefit score is 4 and Access score is 4.

Location:
Behind homes fronting on Lariat Ridge and Reindeer Moss Drive

Impacted Properties:
There are 19 privately owned parcels along this reach. The Town has a 20-foot Drainage and Utility Easement along the stream centerline and along outfall pipes per plat map.

Implementation Requirements:

1. 404/401 permit for stream and wetland impacts
2. Permanent and temporary easements along stream
3. Easements for access and staging areas

Approximate Cost for Design, Permitting and Construction:

Project 01: $610,000 (includes design, permitting, and construction)

Project 01A: $250,000 (includes design, permitting, and construction)

Project ID: TC-ER-02

Reach ID: UT-N3- Reach 2

Proposed Project:
Stream restoration and stabilization to reduce ongoing sediment export to downstream areas, inclusive of instream structures, floodplain benching with stable slopes and appropriate riparian vegetation. Assigned Benefit score is 2 since stabilization of the stream will help protect downstream culverts from sedimentation problems, but that assumes stabilization of upstream reach also. Access score is assigned as 5 due to proximity of stream to some homes and need to work with non-Town property owners.

Location:
Through County jurisdiction and behind homes along Hampton Chase Court

Impacted Properties:
Private ownership totaling eight separate parcels. Within Town jurisdiction, the Town has a 20-foot Drainage and Utility Easement along the stream centerline per as-built drawings.

Implementation Requirements:

1. Buy-in from County property owners where the Town has no easements or jurisdiction.
2. 404/401 permit for stream and wetland impacts.
3. Permanent and temporary easements along stream.
4. Easements for access and staging areas.

Approximate Cost: $500,000 (includes design, permitting, and construction)

Project ID: TC-ER-03

Reach ID: TC- Reach 4

Proposed Project:
Stream restoration for improved energy dissipation and bank stabilization to reduce further impacts to private backyard areas and to downstream areas. Project will include improved dissipation below the dam and a series of boulder steps or cross vanes as drop structures to reduce velocities through the reach and under the bridge. It is expected that only minimal floodplain benching can be accomplished with this project. Benefit score is assigned as 1 due to severity of ongoing erosion and Access score is 3 since there are relatively few affected owners.

Location:
Between Browns Lake dam and Coach Lantern Avenue bridge

Impacted Properties:
Upstream end is owned by Adams Developments LLC, with the parcel (inclusive of dam) classified as HOA. There are four additional privately owned parcels adjacent to the stream channel. The plat maps show 50-foot stream buffers along Toms Creek, but no easements excepting a 20-foot public sanitary sewer easement on the property on the west side of the stream reach.

Implementation Requirements:

1. 404/401 permit for stream and wetland impacts
2. Permanent and temporary easements along stream
3. Easements for access and staging areas

Approximate Cost: $360,000 (includes design, permitting, and construction)

Project ID: TC-ER-04

Reach ID: TC-Reach 3

Proposed Project:
Stream restoration and stabilization, with an emphasis on floodplain benching to reduce flooding as part of limiting shear stresses along the stream banks. Specific projects would be identified based on willing an motivated property owners. Benefit score is assumed as 3 but will depend on erosion severity and lengths stabilized reaches. An Access score of 3 is based on cooperative property owners but impacts and tree loss related to projects.

Location:
Between Coach Lantern Avenue bridge and discharge pipes from Falconhurst Drive.

Impacted Properties:
All of this reach is along the backyards of private residential properties in both Town and County jurisdictions. A restoration project along the full length of the stream is estimated to potentially impact 26 Town parcels and 4 within County jurisdiction. However, it is assumed that projects would be developed based on support and cooperation of particular property owners and would possibly be limited to working on one side of a particular stream reach.

Implementation Requirements:

1. 404/401 permit for stream and wetland impacts
2. Permanent and temporary easements along stream
3. Easements for access and staging areas

Approximate Cost per 100 Foot per side of Stream Channel: $25,000 - $40,000 per 100 foot of bank stabilization (includes design, permitting, and construction) – dependent on type of bank stabilization and overall length of combined projects.

Project ID: TC-ER-05

Reach ID: UT-N4- Reach 6

Proposed Project:
Stream restoration and stabilization to protect against headcutting and erosion along this reach disturbed by homeowners and lacking vegetated buffers in some areas. Benefit score is assigned as 2 for expected reduction in sediment export for a relatively smaller project cost. Access score is 2 for fewer property owners and access to stream from back of properties.

Location:
Behind homes along Stacked Stone Trail

Impacted Properties:
This reach flows through the backyards of five property owners. A 20-foot drainage easement is shown on plat maps along the stream channel.

Implementation Requirements:

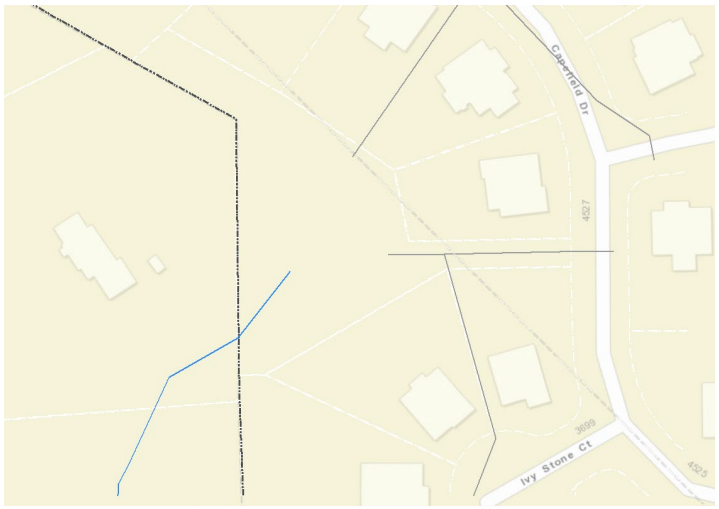
1. 404/401 permit for stream and wetland impacts
2. Permanent and temporary easements along stream
3. Easements for access and staging areas

Approximate Cost: $180,000 (includes design, permitting, and construction)

Project ID: TC-ER-06

Reach ID: UT-S5- Reach 3

Proposed Project:
Establishing a stable stream channel from the SCM outlet to the existing headcut location, with drop structures as appropriate for adequate energy dissipation and transition to downstream channel. The assigned Benefit score is 1 due to the volume of sediment export that can be prevented by implementing this project. Access score is 4 due to anticipated challenges of working with the affected property owners.



Location:
From SCM off of Capefield Drive to headcut on private property within County jurisdiction.

Impacted Properties:
The stream impacted by the existing headcut and threatened by further upstream destabilization crosses through two residential parcels within Wake County jurisdiction.

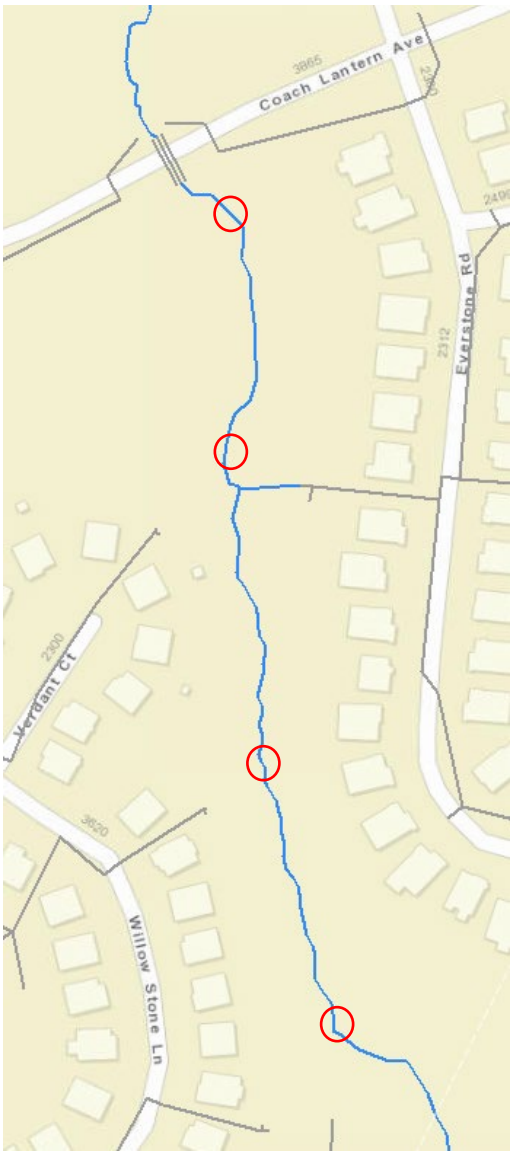
Implementation Requirements:

1. 404/401 permit for stream and wetland impacts.
2. Permanent and temporary easements along stream.
3. Easements for access and staging areas.

Approximate Cost: $270,000 (includes design, permitting, and construction)

Project ID: TC-ER-07

Reach ID: UT-S7- Reach 2&3



Proposed Project:
Grade control structures to guard against headcutting and exacerbated erosion along this stream reach while it is still relatively stable. The proposal is to install the grade control measures at locations accessible from existing drainage easements. A Benefit score of 3 is assigned based on prevention of probable sediment export to Browns Lake. An Access score of 2 reflects the project implementation with HOA property, but probable need to access along easements between homes.

Location:
From Forestville Road to Coach Lantern Avenue

Impacted Properties:
Most of this stream reach is within property of the Homeowners Association of Stonegate, Inc., with one parcel still owned by a developer (Stonegate Enterprises, LLC). A 60-foot conservation easement is in place along the stream.

Implementation Requirements:

1. 404/401 permit for temporary stream and wetland impacts for ecological protection and enhancements within a conservation easement.
2. Agreements with the HOA and developer for project implementation.
3. Notifications to property owners of planned access through existing drainage easements.

Approximate Cost: $240,000 (includes design, permitting, and construction)

APPENDIX D

WATER QUALITY IMPROVEMENT PROJECTS

Project ID:
TC-WQ-01 Green Streetscaping on Coach Lantern Avenue

Proposed Project:
Development of bioretention areas to be constructed upgradient of sag points on Coach Lantern Avenue. These SCMs would also serve as traffic calming measures for this thoroughfare.

Location:
Recommended SCM locations and potential sizes shown in green on aerial photos below.

Impacted Properties:
The SCMs would preclude parking along the street at those locations.

Implementation Issues:

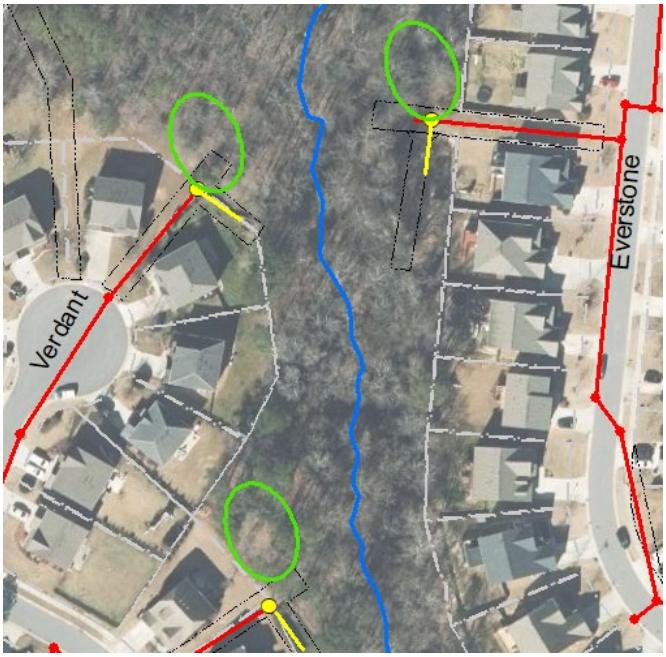
1. Investigation of utility conflicts, integration with existing drainage infrastructure.
2. Coordination within Town departments and with homeowners for maintenance responsibilities.
3. Some property owners may donate easement for expansion of SCM within their property, increasing the water quality volume (WQV) which can be treated.

Approximate Cost: $50,000 to $80,000 per SCM area, dependent on size (includes design, permitting, and construction)

Project ID:
TC-WQ-02 New SCMs at Outfalls to UT-S7

Proposed Project:
Development of SCMs to be constructed at outfalls to UT-S7 to replace existing level spreaders. These SCMs would be designed provide treatment of stormwater and stability protection for the downstream channel.

Location:
Recommended SCM locations shown in green on aerial photo.



Impacted Properties:
In addition to being located on HOA property, individual homeowners would be impacted during construction and for access through existing Town easements. The easements may also need to be used for ongoing maintenance access.

Implementation Issues:

1. If there are wetlands in any of the proposed areas, this may preclude installation of an SCM or present constraints and require 401/404 permitting.
2. Available space may constrain the water quality volume which can be treated. To be competitive for grant funding, a minimum treatment for one-half of the regulatory WQV is likely to be required.
3. Coordination with the HOA for construction of the SCMs.
4. Coordination with the HOA and homeowners for maintenance responsibilities and/or access.

Approximate Cost: $100,000 to $150,000 per SCM area (includes design, permitting, and construction) -- dependent on size, permitting issues, and whether multiple SCMs can be constructed under a single contract.