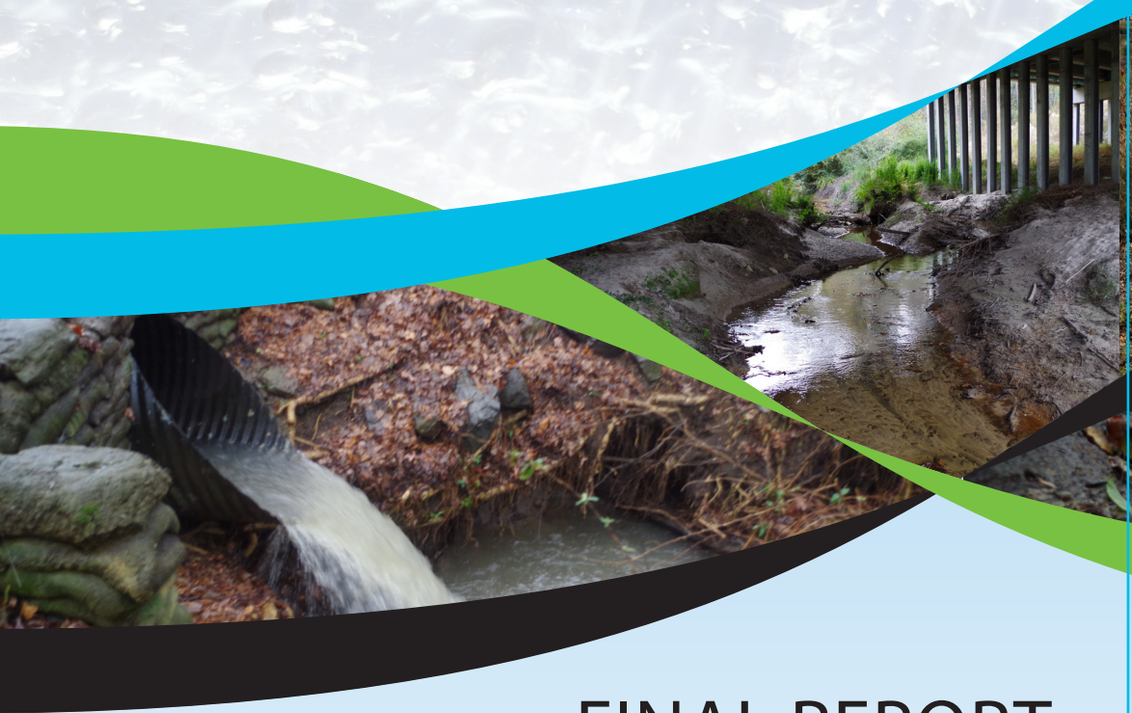
CITY OF GREENVILLE

Greenville
NORTH CAROLINA

Harris Mill Run / Schoolhouse Branch Watershed Master Plan

July 2016



FINAL REPORT

CDM Smith

CITY OF GREENVILLE

HARRIS MILL RUN / SCHOOLHOUSE BRANCH WATERSHED MASTER PLAN

CDM Smith #104324

July 2016

Prepared for
City of Greenville
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The City of Greenville has retained CDM Smith to complete a Master Plan for the Harris Mill Run/Schoolhouse Branch (HMR/SHB) watersheds. The goals of this master plan include: (1) evaluate the watershed for existing flooding, water quality, and erosion problems; (2) recommend and prioritize capital improvements to control existing flooding by reducing the frequency and severity of flooding for property owners; and (3) identify stream stabilization projects to reduce the risk of property loss along streams and to reduce sediment loads as a result of erosion. To assist in achieving the goals listed above, CDM Smith also completed a stormwater drainage infrastructure inventory for drainage structures and features within the HMR/SHB watersheds. The project included a broad range of stakeholders to collect as much data, information and tacit knowledge of the watershed as possible. The general public was solicited through questionnaires mailed to all property owners in the watershed and two open house public meetings where residents and business owners were encouraged to provide feedback on stormwater issues in the watershed. CDM Smith coordinated with residents that provided site-specific drainage concerns to gather additional information that could be used to both confirm the existing system evaluation and aid in developing improvement recommendations. Information collected from the questionnaires and public meetings can be found in Section 2.1 and Appendix D. City staff served as a critical stakeholder by providing valuable information on historical flooding and erosion problems in the watershed, as well as providing feedback on potential capital improvements and the prioritization of those improvements.

The HMR/SHB watershed is approximately 12 square miles and is located in the northern portion of Greenville south of the Tar River. The collective watershed extends west to encompass the Ironwood Golf Course and Country Club, east to near Beech Street, and is generally bound by Stantonsburg Road to the southwest. The downtown area of Greenville is part of this watershed. A portion of this watershed is outside the City limits to the west and part is in the undeveloped Tar River floodplain.

CDM Smith conducted an Existing and Future Conditions Analysis in order to evaluate the existing hydrologic and hydraulic characteristics of the HMR/SHB watersheds. Noted in this report as the primary systems, HMR, SHB, Sams Branch, and Sains Branch were hydraulically studied in detail to evaluate flooding of residential areas and roadways. In addition to the primary systems, select conveyance systems that drain directly to the Tar River were analyzed to determine if those systems met the desired City design requirements outlined in Section 1.2. Those secondary systems were identified based on feedback from public residents and City staff.

As a result of the existing conditions analysis, multiple capital projects were identified to reduce the severity and frequency of flooding, stabilize stream banks, and improve water quality through stormwater treatment practices. Flood control projects were evaluated to improve the desired level of service (LOS) or frequency of flooding achieved for roadway overtopping and roadway/structure flooding. The proposed capital projects are described below with the locations of each project shown in **Figure ES-1**.

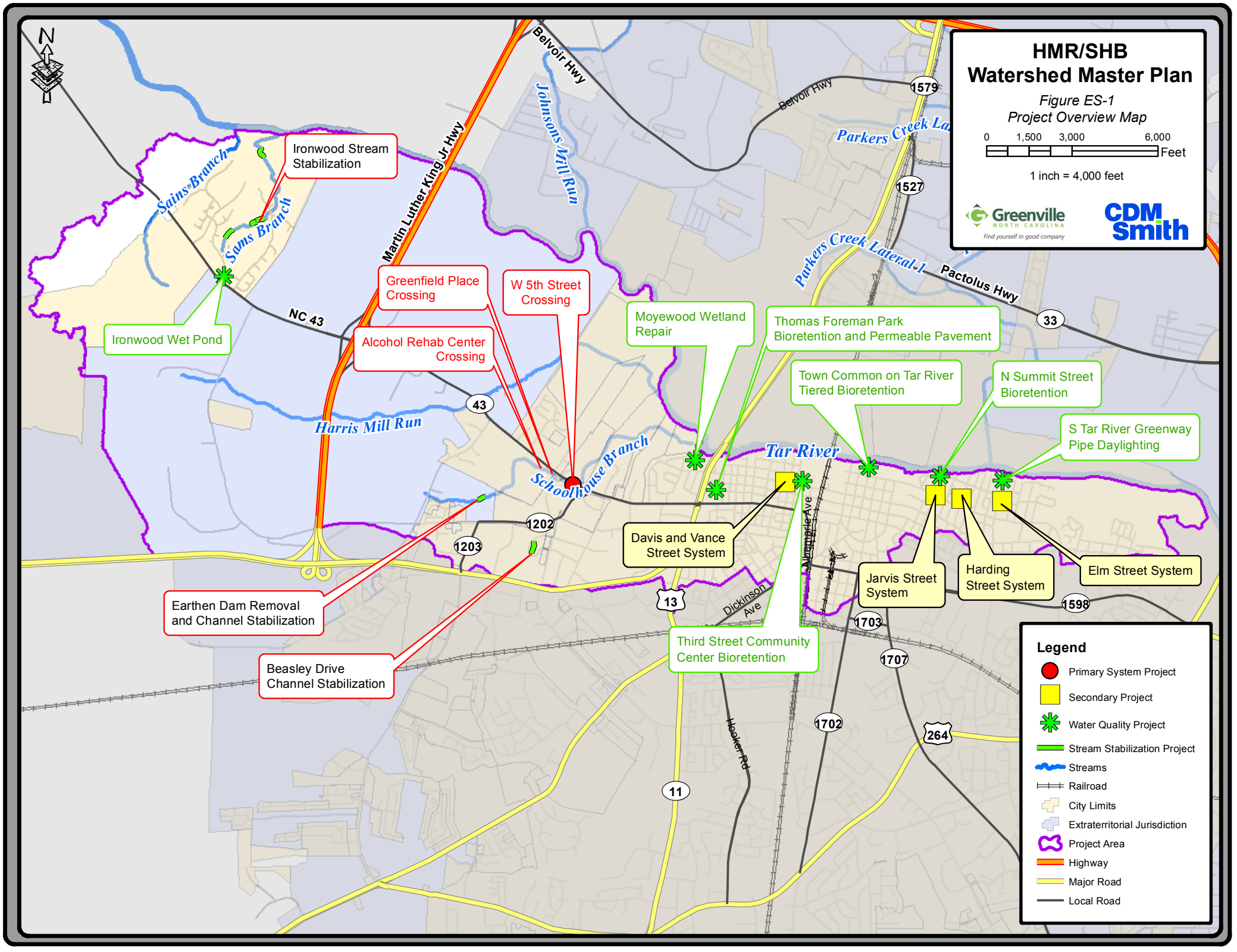
Watershed Conditions

The HMR/SHB Watershed is a 12.2 square mile collection of multiple smaller watersheds each draining to the Tar River. Beginning on the west side of the City, Sams Branch and Sains Branch drain the area including the Ironwood Golf Course. Proceeding toward the east, HMR drains the western edge of the City and SHB drains the area north of Stantonsburg Road to 5th Street, including the Vidant Medical Center and East Carolina University Health Sciences. Additional smaller tributaries to the Tar River drain the downtown area and areas to the east along the Tar River. Town Creek is the only named stream draining the downtown area and is comprised almost entirely of underground piped conveyance. With the exception of Sams Branch and Town Creek, each of the HMR/SHB streams enter the Tar River floodplain where their channels become less defined as they are dispersed through expansive wetlands.

All of the HMR/SHB watersheds are inside the City limits or extraterritorial jurisdiction (ETJ) except for part of the Sains Branch watershed on the west boundary of the City. Almost all of HMR watershed is within the City's ETJ, while almost all of SHB is within City limits. Only 34 acres of HMR are within the City limits. Conversely, only 0.2 of the 1.6 square mile SHB watershed extend outside City limits. Sains and Sams Branch drain the Ironwood Golf Course Subdivision which is part of the City, albeit disconnected from the main City limits.

Approximately half of the HMR/SHB watersheds are developed. Except for the undeveloped floodplain of the Tar River, the areas east of downtown, the downtown area, and the Vidant areas are built-out to Arlington Boulevard. The areas to the west of Arlington Boulevard in the City's ETJ in the HMR/SHB watersheds are expected to experience significant development of remaining open space in the near future. In HMR, the 50 percent of the watershed that is open space is expected to be developed into medium and high density residential land use. In SHB, the 25 percent of the watershed that is currently open space is zoned for high density residential and multi-family land uses according to the zoning. Similar percentages are expected to be developed in Sams and Sains Branches.

The topography of HMR/SHB is relatively flat with gentle slopes except for a steep embankment along the Tar River floodplain west of the downtown area. Within the City limits, many natural channels are maintained ditches and others are more natural channels with forested buffers. Within the City, channel conditions are occasionally unstable where large impervious areas have increased runoff and erosion occurs associated with high velocity flows.


HMR/SHB
Watershed Master Plan
Figure ES-1
Project Overview Map
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Feet
1 inch = 4,000 feet
Greenville
NORTH CAROLINA
Find yourself in good company
CDM Smith
N
Ironwood Stream Stabilization
Ironwood Wet Pond
Greenfield Place Crossing
W 5th Street Crossing
Alcohol Rehab Center Crossing
Moyewood Wetland Repair
Thomas Foreman Park Bioretention and Permeable Pavement
Town Common on Tar River Tiered Bioretention
N Summit Street Bioretention
S Tar River Greenway Pipe Daylighting
Davis and Vance Street System
Jarvis Street System
Harding Street System
Elm Street System
Third Street Community Center Bioretention
Earthen Dam Removal and Channel Stabilization
Beasley Drive Channel Stabilization
Sains Branch
Sams Branch
Johnsons Mill Run
Harris Mill Run
Schoolhouse Branch
Tar River
Parkers Creek Lateral-1
Martin Luther King Jr Hwy
Belvoir Hwy
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Legend
Primary System Project
Secondary Project
Water Quality Project
Stream Stabilization Project
Streams
Railroad
City Limits
Extraterritorial Jurisdiction
Project Area
Highway
Major Road
Local Road

Stormwater infrastructure throughout the watersheds was collected by survey personnel to compile a geographical information system (GIS) stormwater inventory database for the City. This was accomplished by using Global Positioning Systems (GPS) as the primary means of data capture to locate the x, y, and z coordinates of each visible stormwater system structure. Conventional surveying techniques were used to obtain other attributes such as dimensions, material, slope, and length. The data was collected using horizontal datum NAD 1983 and vertical datum NAVD 1988. A total of 2,948 closed system structures and 41 miles of pipe were collected as part of the City-wide inventory in the HMR/SHB watersheds.

Analysis

CDM Smith conducted an existing conditions analysis in order to evaluate the existing hydrologic and hydraulic characteristics of the HMR/SHB watersheds. Noted in this report as the primary systems, HMR and SHB were hydraulically studied. The main stems of these creeks were modeled as open channels with culverted and bridged crossings. There are 7 creek crossings in the HMR/SHB watersheds, 4 of which are crossing major thoroughfares, 2 minor thoroughfares, and 1 crossing of Highway 264.

In addition to the primary systems, select closed pipe drainage systems that drain to HMR, SHB, Sains Branch and Sams Branch tributaries were analyzed to determine if those systems meet the City's desired design requirements outlined in Section 1.2. Along with City staff input, those secondary systems were identified as part of the public education and outreach efforts conducted at key milestones. Initially, the City distributed and collected questionnaires to gather citizen information on flooding and erosion issues throughout the City. Existing conditions and proposed improvements were presented to the public during open meetings. The results and comments from the citizens' input contributed to the identification and prioritization of problem areas, and the validation of model results. Based on feedback from City residents and City staff, Davis and Vance, 1st Street and Jarvis, 1st Street and N. Harding Street, and 4th Street and Elm Street systems were included as part of the secondary system analysis.

The modeling analysis consisted of hydrologic and hydraulic modeling in standard public domain software. The US Army Corps of Engineers (USACE) HEC-HMS model was used to develop design flows for the primary systems. The USACE HEC-RAS model was used to model the channels and floodplains of the primary systems. The secondary systems were modeled in the EPA's Storm Water Management Model (SWMM).

According to the model results, structural flooding and roadway crossing overtopping occurs at multiple locations. Potential structural flooding was identified for buildings in the modeled floodplains for the 25- and 100-year design storms. Existing flood stages were compared with the City's desired LOS as designated in the standard operating procedure (SOP) manual. Proposed improvements were developed with the models to attain the LOS.

Regional detention was also evaluated as a solution to existing and future flooding issues in SHB.

Additionally, as part of the HMR/SHB Watershed Master Plan, an analysis was completed to determine if there are areas within the watershed and the ETJ that should be considered "well documented water quantity problems" requiring detention for the 25-year, 24-hour storm event. This evaluation yielded no such areas in HMR/SHB meeting the criteria, particularly the criteria for "well documented water quantity problems".

As a result of the existing and future conditions analyses and input from residents and City staff, multiple capital projects were identified to reduce the severity and frequency of flooding, stabilize stream banks, and improve water quality through stormwater treatment practices. Flood control projects were evaluated to meet the desired LOS for roadway overtopping and roadway/structure flooding.

Costs for each project were estimated using approved unit costs from the SOP with engineering, administrative, and contingency costs included for construction implementation. Anticipated permitting and funding opportunities were also evaluated for each project. The proposed capital projects are as follows with the locations of each project shown in **Figure ES-1**.

Flood Control Projects

Harris Mill Run Primary System

There are no crossings which flood for the modeled design storms and therefore no improvements are recommended.

Sams Branch and Sains Branch Primary Systems

There are no crossings which flood for the modeled design storms. Therefore, no improvements are recommended for the primary channels in the Sams Branch or Sains Branch watersheds, except for sediment removal maintenance at the Golf View Road culvert crossing.

Schoolhouse Branch Primary System

The crossing at W 5th Street is the only major City owned crossing of SHB. Immediately upstream, two access driveways also cross SHB, which provides access from W 5th Street to the NC Alcohol and Drug Abuse Treatment Center (ADATC) and the Greenfield Place, LLC, long-term care (LTC) facility. Neither roadway currently meets the 25-year assigned LOS, with the Rehab Center exceeding only a 2-year LOS and the LTC entrance not passing any modeled design storm (<2-year) without overtopping. The proposed improvements for the two service driveway crossings of SHB are a set of three 48-inch diameter reinforced concrete pipe (RCP) for each and are on private property, and therefore not included in the prioritization.

The W 5th Street crossing of SHB is comprised of twin 5.5 foot (ft) by 5.5 ft reinforced concrete box culverts (RCBC) and a 60-inch corrugated metal pipe (CMP) only meeting a 10-year LOS without overtopping the roadway. To attain the designated LOS, the recommended upgrade to the culverts includes three 8 ft by 5 ft RCBC or four 6 ft RCP culverts. .

Secondary Systems

Davis and Vance Street System – The Davis and Vance Street System shares a single outfall since the outfall at Davis Street was buried. The upstream portion of this system is cross-connected with the drainage system to the east near the 3rd Street Community Center. The upstream portion of the drainage area is part of the 10th Street connector which when constructed, will divert flows from this system to the Town Creek Culvert drainage system to the east.

City maintenance personnel report flooding in this area along the northern portions of both Davis Street and Vance Street, as well as near the intersection of Davis Street and Ward Street. Model results show that parts of the system operate at or below a 2-year LOS. Installation of a connecting pipe to allow the Davis Street line to flow into the Vance Street line is recommended along with multiple pipe upgrades.

Jarvis Street – 1st Street – Woodlawn Avenue System – The conveyance system is comprised of a combination of RCP and CMP ranging from 12 to 36 inches in diameter is in good condition based on data collected during the inventory. Model results show that the majority of the system exceeds a 10-year LOS, with only the last 500 feet of pipe approaching the outfall at or below the 10-year LOS. Recommended improvements are limited to replacement of downstream pipes with slightly larger size pipe and involve relocation of the drainage pipe outside private property onto City owned parcels and the right-of-way.

Harding Street and 1st Street System – Model results show that the majority of the system, particularly along E 1st Street operates below a 2-year LOS. This is consistent with the report by a resident on Harding Street that street flooding occurs frequently and the general report from City maintenance staff that flooding occurs in the area of 1st Street. Replacement pipes ranging in size from 24 to 36 inches are recommended to improve the LOS to 10-year, thereby alleviating recurrent flooding of roadways and yards.

Elm Street – 4th Street System – Flooding in this area was reported by City maintenance staff and confirmed by the modeling which shows that the majority of the system operates at or below a 2-year LOS. The downstream run of pipe at the north end of Elm Street right before the Tar River outfall was previously planned for replacement due to joint separation. Improvements to the Elm Street – 4th Street System include the addition of a parallel line along Elm Street to supplement capacity through the existing portion of the system on the Wilson Acres Apartment property, and remove the public water from flowing through private property. Moving the stormwater line into the public right-of-way will facilitate regular maintenance and repair of the public drainage system. Additionally, daylighting of the pipe at the end of the system is recommended as a water quality improvement project, which is discussed in Section 5.

Flood Control Prioritization

To appropriately allocate City resources, the flood control projects outlined above were prioritized based on the following categories, as described in Appendix M:

- Public health and safety
- Severity of street flooding
- Cost-effectiveness
- Effect of improvements
- Water quality best management practice (BMP)
- Open channel/erosion control
- Implementation constraints
- Grant funding
- Constructability

Scores were assigned to each project for the factors listed above to determine the priority list. In some instances, project prioritization will be impacted by the required sequencing of projects to provide the greatest possible flood reduction benefits and to reduce or negate any downstream impacts from the proposed projects. While both alternatives are shown for some projects, it is acknowledged that only one of the two alternatives would need to be constructed. Once an alternative has been selected, the remaining alternative for the same project can be removed from the prioritization list. **Table ES-1** shows the proposed prioritizations and conceptual cost estimates for the flood control improvements. The prioritization scoring for each project and a description of the aforementioned categories is included in Appendix M. The total cost for primary and secondary system improvements is approximately $7.7 million. Projects outside the City limits or on private property, as identified in the report, are not included in the City's prioritization for inclusion in the list of Capital Improvement Projects for implementation.

Table ES-1: Flood Control Prioritization

Prioritization	Project	Cost
1	W 5th Street Crossing (Schoolhouse Branch)	$1,010,000
2	Davis Street and Vance Street System (Tar River)	$1,130,000
3	Harding Street System (Tar River)	$1,240,000
4	Elm Street System (Tar River)	$3,310,000
5	Jarvis Street System (Tar River)	$990,000
	Total	$7,680,000

Stream Stabilization and Water Quality Projects

During the existing conditions analysis, the major streams were quantitatively assessed for stability. Based on this assessment, three stream stabilization projects were identified for Sams Branch, SHB, and an unnamed tributary to SHB as shown in Figure ES-1. Potential components of the stabilization projects include flattening the slope of the channel banks, installing erosion control matting and plantings, rock grade control structures, log grade control structures, retaining walls, and riprap. The stabilization projects will protect the stream banks from further erosion, and substantially decrease the instream sediment loads to downstream receiving waters.

In addition to the stream stability projects, water qualityBMP retrofit projects were also identified. Potential project locations were initially identified using available GIS data by focusing on locations with contributing drainage areas that are highly impervious and ideally on publically owned land. Impervious areas typically generate the highest concentration of pollutants, so treating the runoff from these areas would provide more pollutant removal than treating water that carried fewer pollutants. Publically owned land is ideal for BMP retrofits to reduce or eliminate potential land acquisition costs. See Section 5.2 for additional evaluation criteria for BMP retrofit sites. Potential locations that were identified using GIS were then inspected to determine if the site conditions were conducive to a BMP. This inspection typically included verifying that GIS data and aerial photography were accurate and current, and to determine if there were project constraints present that may not be visible from GIS data, such as utility conflicts, private property conflicts, or limited access to the site. Where possible, retrofit projects were located on public property to reduce potential land acquisition costs. A total of 10 BMP retrofit sites were evaluated for implementation of BMPs throughout the HMR/SHB watersheds, with 7 candidate sites included in the prioritization. Potential sites at Vidant, Greenville Utilities Commission, Lake Laupus, and Cypress Glen Retirement Community were considered, but not included due to criteria associated with on-site conditions and/or property ownership.

The stream stabilization projects and water quality retrofit projects were prioritized using similar categories as the flood control projects described above, which are located in Appendix M. Cost-effectiveness for stream stabilization projects was calculated based on a cost per linear foot of stabilized stream. Cost-effectiveness for water quality retrofit projects was calculated based on an estimated cost per pound of pollutant removed. **Tables ES-2 and ES-3** show the prioritization of the Stream Stabilization and Water Quality projects along with preliminary cost estimates. Additionally, several recommended maintenance locations were identified throughout the watershed, as listed in Section 10. The maintenance items are based on the condition assessment completed during the stormwater inventory and stream assessment.

Table ES-2 Stream Stabilization Prioritization

Prioritization	Project	Cost
1	Earthen Dam Removal and Stabilization (Schoolhouse Branch)	$250,000
2	Beasley Drive Channel Stabilization	$330,000
3	Ironwood Golf and Country Club Stream Stabilization	$730,000
	Total	$1,310,000

Table ES-3: Water Quality Prioritization

Prioritization	Project	Cost
1	Moyewood Wetland Retrofit	$42,000
2	Third Street Community Center Bioretention	$120,000
3	Town Common on Tar River Tiered Bioretention	$150,000
4	N. Summit Street Bioretention	$270,000
5	S. Tar River Greenway Pipe Daylighting	$150,000
6	Thomas Foreman Park Bioretention and Permeable Pavement	$390,000
7	Ironwood Golf and Country Club Wet Retention Pond	$320,000
	Total	$1,440,000

1.1 Project Description

The City of Greenville has retained CDM Smith to complete a Watershed Master Plan for the Harris Mill Run, Schoolhouse Branch, Sains Branch, and Sams Branch watersheds, collectively referred to as the HMR/SHB Watershed. As shown in Figure 1-1, the HMR/SHB Watershed is located in the northern portion of Greenville, along the south side of the Tar River, and drains from west to east (Harris Mill Run and Schoolhouse Branch) as well as south to north (Sains and Sams Branch) discharging to the Tar River.

The goals of this master plan include: (1) evaluate the watershed for existing flooding, water quality, and erosion problems, (2) recommend and prioritize capital improvements to control existing flooding by reducing the frequency and severity of flooding for property owners, and (3) identify stream stabilization projects to reduce the risk of property loss along streams and to reduce sediment loads as a result of erosion. To assist in achieving the goals listed above, CDM Smith also completed a stormwater drainage infrastructure inventory for drainage structures and features within the HMR/SHB watersheds. The Master Plan includes an evaluation of Harris Mill Run from its confluence with the Tar River at the downstream end to MacGregor Downs Road, Schoolhouse Branch from its confluence with the Tar River at the downstream end to B's Barbeque Road, and the two legs of Sams Branch from their confluence with the Tar River at the downstream end to approximately 4,200 feet upstream of NC Highway 43. The Master Plan also evaluates multiple piped conveyance systems that drain directly to the Tar River. For the purposes of this report, the main stems of Harris Mill Run, Schoolhouse Branch, Sains Branch and Sams Branch will be noted as primary systems. The conveyance systems, which drain directly to the Tar River in this watershed, will be noted as secondary systems. A project area map showing the HMR/SHB Watershed and the conveyance systems evaluated as part of this Master Plan is included as Figure 1-2. Detailed hydraulic analysis included the following:

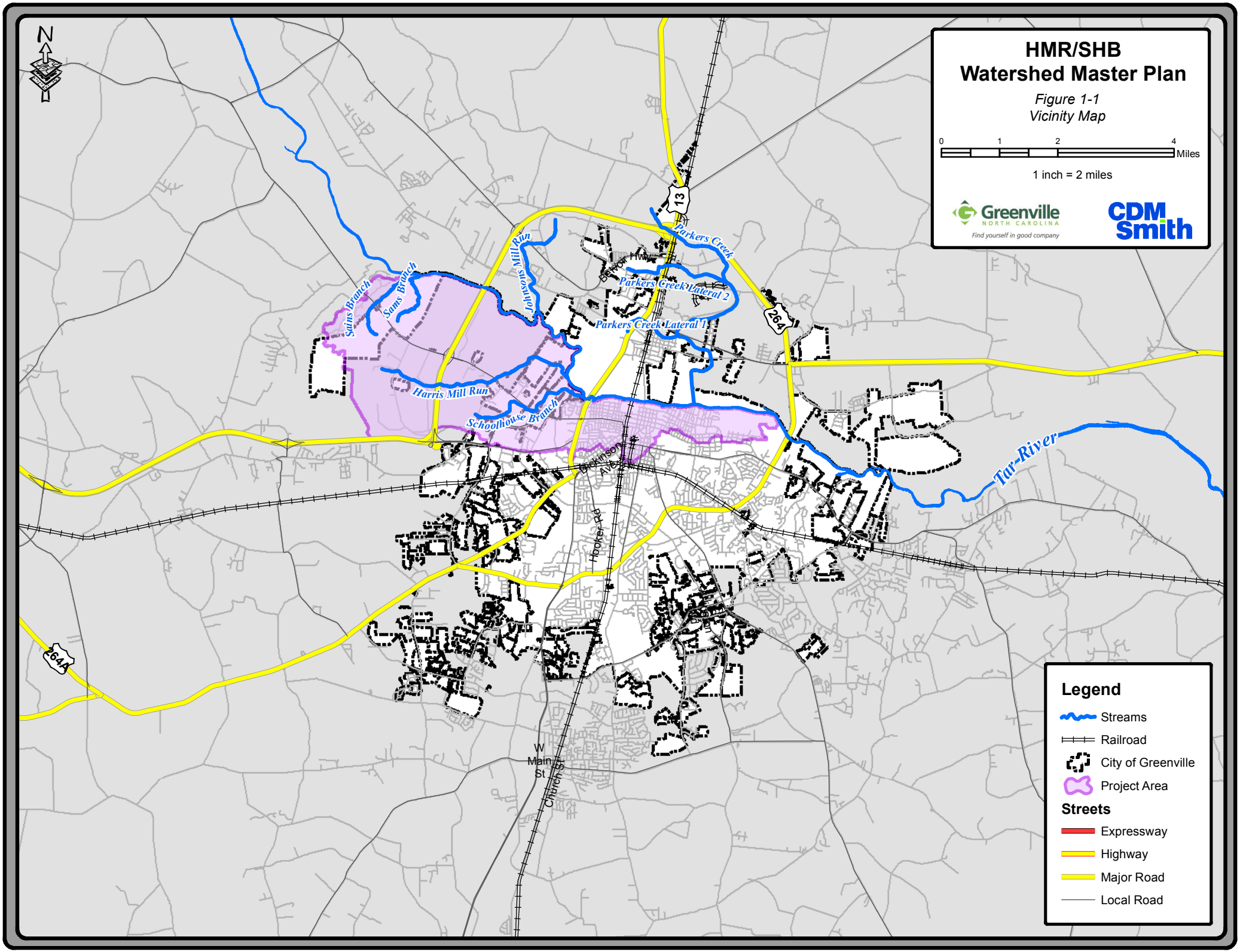
- Primary System – Harris Mill Run
  - North Carolina Hwy 43 Bridge
  - North Carolina Hwy 264 Bridge
  - Rock Spring Road Culvert
  - MacGregor Downs Road Culvert

- Primary System – Schoolhouse Branch
  - W 5th Street Culvert
  - W Arlington Boulevard Culvert
  - Culvert under Greenfield Place Driveway
  - Culvert under Two-Lane Driveway near Greenfield Place
  - B's Barbeque Road Culvert

- Primary Systems – Sams Branch (SB1)
  - Ironwood Golf Club Bridges
  - Golf View Drive Culvert
  - Ironwood Golf Club Culvert

  - River Walk Drive Culvert

- Secondary Systems (Tributary to Tar River)
  - Davis and Vance Street System
  - 1st Street and N Jarvis Street System
  - 1st Street and N Harding Street System
  - 4th Street and Ash/Elm Street System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Watershed Master Plan
Figure 1-1
Vicinity Map
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Sams Branch
Johnson Mill Run
Parkers Creek
Parkers Creek Lateral 2
Parkers Creek Lateral 1
Harris Mill Run
Schoolhouse Branch
Tar River
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W Main St
Church St
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264
264A
Legend
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Project Area
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Major Road
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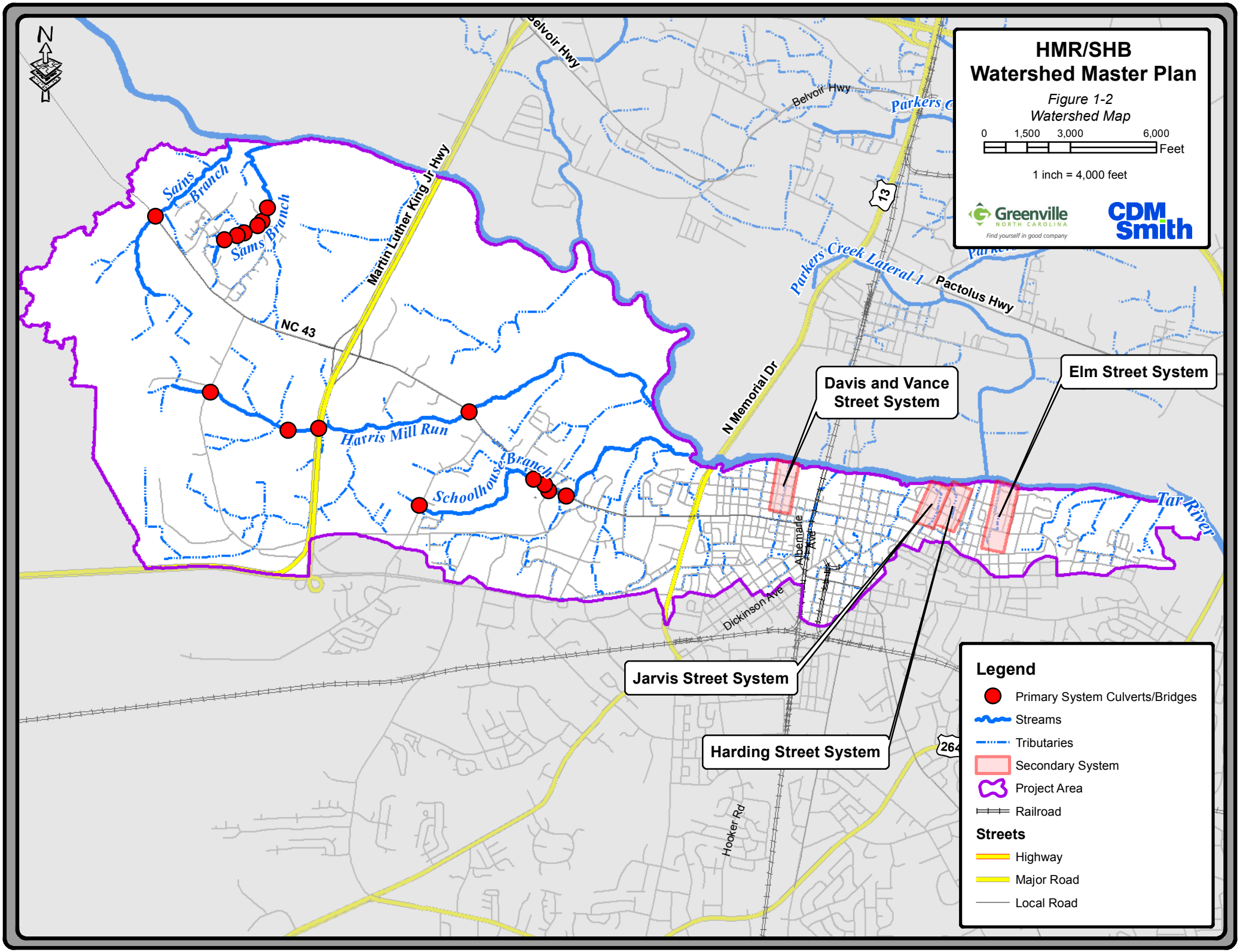
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Albemarle Ave
Dickinson Ave
Hooker Rd
13
264
Legend
Primary System Culverts/Bridges
Streams
Tributaries
Secondary System
Project Area
Railroad
Streets
Highway
Major Road
Local Road

- Primary Systems – Sains Branch (SB2)
  - North Carolina Hwy 43 Culvert

- Secondary Systems
  - Davis and Vance Streets
  - 1st Street and N Jarvis Street/Woodlawn Avenue
  - 1st Street and N Harding Street
  - 4th Street and Ash/Elm Street

1.2 Design Standards and Criteria

The following design storms were used to evaluate the performance of the primary and secondary systems in this Master Plan:

- 10-year storm event – piped collection systems and non-thoroughfare roads;
- 25-year storm event – minor thoroughfare roadway bridges and culverts;
- 50-year storm event – major thoroughfare roadway bridges and culverts;
- 100-year storm event – structural flooding of homes; and
- 100-year storm event – overtopping of railroad.

Major and minor thoroughfare roadway crossings were identified based on the City's Thoroughfare Plan. **Table 1-1** shows the applicable storm for the project areas evaluated as part of this Master Plan. The corresponding rainfall depths for the design storms are included in Appendix A.

Table 1-1 Project Area Design Standards and Criteria

Drainage Type	Desired Level of Service (Frequency Storm Event)	Project Area
Piped Collection Systems	10	▪ Davis and Vance Streets ▪ 1st Street and N Jarvis Street/Woodlawn Avenue ▪ 1st Street and N Harding Street ▪ 4th Street and Ash/Elm Street
Non-Thoroughfare Crossings	10	▪ MacGregor Downs Road (HMR) ▪ Rock Spring Road (HMR) ▪ Private crossings (2) near Greenfield Place along W 5th street (SHB) ▪ Ironwood Golf and Country Club (4) (SB1) ▪ Golf View Drive (SB1) ▪ River Walk Drive (SB1)

Minor Thoroughfare Roadway Crossings	25	▪ B's Barbecue Road (SHB)
Major Thoroughfare Roadway Crossings (Freeways, Expressways, Boulevards)	50	▪ North Carolina Hwy 43 (HMR, SHB & SB2) ▪ North Carolina Hwy 264 (HMR) ▪ W Arlington Boulevard (SHB)
Railroad Crossing	100	▪ None

2.1 Citizen Input

The Master Plan included a citizen input component to solicit feedback and information regarding stormwater impacts and the future of stormwater management in the City. In 2014, the City mailed out approximately 3,600 questionnaires related to stormwater management to all property owners within the City. Two hundred twenty-eight questionnaires (6%) were completed and returned to the City for consideration. Of the returned questionnaires for the entire city, 10 were from residents within the HMR/SHB Watershed. The questionnaire results were georeferenced according to the address of the questionnaire respondent (See **Figures 2-1 and 2-2**). 60 percent of the responses indicated some level of property flooding, with 3 property owners experiencing living space flooding at least once per year. Twenty percent of the completed questionnaires noted yard flooding and another fifty percent noted street flooding. Forty percent of the respondents reported that they were not experiencing any type of flooding. Only one resident reported erosion threatening either streets, yards, garages, or fences and this report could not be confirmed. Figure 2-2 shows the location of reported erosion. A sample questionnaire and the tabulated results are provided in **Appendix D**.

On November 12, 2014 and November 17, 2015 the City provided another avenue for obtaining citizen input by holding public meetings at the 3rd Street Community Center and City Hall, respectively. An open house format allowed property owners to attend at their convenience, and speak to City Staff or representatives from CDM Smith. No residents from the HMR/SHB watersheds attended the meetings.

The results and comments from the citizen's input contributed to the identification and prioritization of problem areas, and the validation of model results.

2.2 Watershed Characteristics

The HMR/SHB Watershed is a 12.2 square mile collection of multiple smaller watersheds each draining to the Tar River. Beginning on the west side of the City, Sams Branch and Sains Branch drain the area including the Ironwood Golf Course. Proceeding toward the east, Harris Mill Run drains the western edge of the City and Schoolhouse Branch drains the area north of Stantonsburg Road to 5th Street, including the Vidant Medical Center and East Carolina University Health Sciences. Additional smaller tributaries to the Tar River drain the downtown area and areas to the east along the Tar River. Town Creek is the only named stream draining the downtown area with mostly underground piped conveyance. With exception for Sams Branchand Town Creek, each of the HMR/SHB streams enter the Tar River floodplain where their channels become less defined and they are dispersed through expansive wetlands. With exception for the undeveloped floodplain of the Tar River, east of downtown, the downtown area, and the Vidant areas are builtout to Arlington Boulevard. The areas to the west of Arlington Boulevard in the City's ETJ in the HMR/SHB watersheds are expected to experience significant development of remaining open space in the near future.

2.2.1 Sains Branch and Sams Branch

Sams Branch and Sains Branch drain a 2 square mile area including the Ironwood Golf and Country Club. These branches appear to be formerly connected to each other at their headwaters according to USGS topographic maps, however recent development has split

them into two branches. Sams branch begins as a piped conveyance system at NC Hwy 43 draining the residential areas around Country Down Drive and runs straight through the golf course (Sams Branch). Sains Branch headwaters begin next to an agricultural field and drains through forest north of NC Hwy 43 and forest adjacent to the residences of the Ironwood Golf Club on the west side.

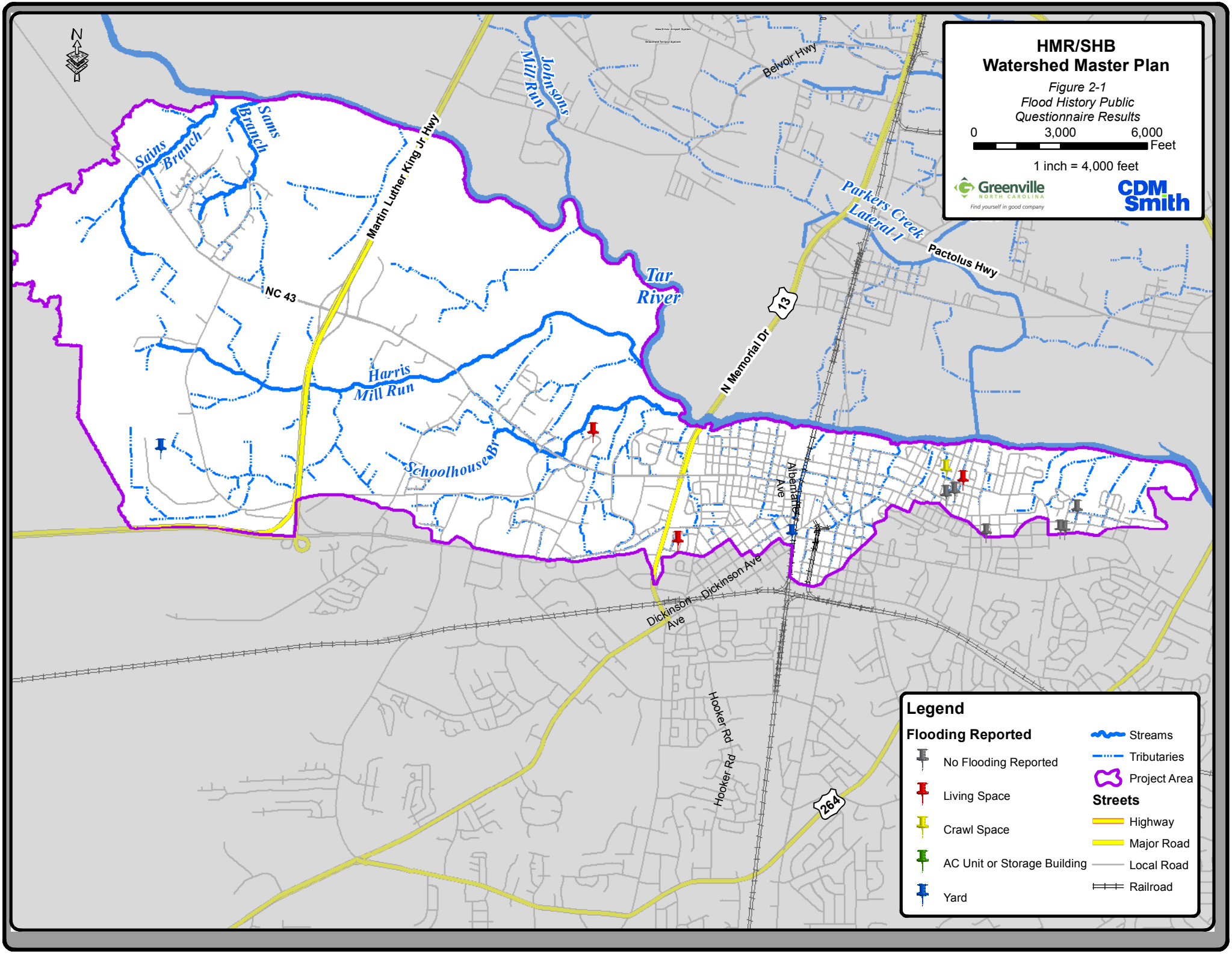
Land use in the Sams Branch and Sains Branch watersheds is mostly undeveloped as shown on the Existing Conditions Land Use Map included in Appendix C, and listed in **Tables 2-1A and B**. Sams Branch is currently less than 50% developed residential land use and is projected to undergo conversion of the open space to medium-density residential under future conditions.

Table 2-1A: Sams Branch Watershed Existing Land Use

Land Use Category	Area (acres)	
Medium Density Residential	23	3.0%
Low Density Residential	268	35.3%
Conservation/Open Space	453	59.6%
Right-of-Way	16	2.1%
Total	760	100.0%

Table 2-1B: Sams Branch Watershed Future Land Use

Land Use Category	Area (acres)	
Medium Density Residential	371	48.8%
Open Space	113	14.9%
Right-of-way	8	1.1%
Very Low Density Residential	268	35.2%
Total	760	100.0%


HMR/SHB
Watershed Master Plan
Figure 2-1
Flood History Public
Questionnaire Results
0
3,000
6,000
Feet
1 inch = 4,000 feet
Greenville
NORTH CAROLINA
Find yourself in good company
CDM Smith
N
Johnsons Mill Run
Belvoir Hwy
Sams Branch
Sams Branch
Martin Luther King Jr Hwy
Parkers Creek Lateral 1
Pactolus Hwy
Tar River
NC 43
13
N Memorial Dr
Harris Mill Run
Schoolhouse Br
Albemarle Ave
Dickinson Ave
Dickinson Ave
Hooker Rd
Hooker Rd
264
Legend
Flooding Reported
No Flooding Reported
Living Space
Crawl Space
AC Unit or Storage Building
Yard
Streams
Tributaries
Project Area
Streets
Highway
Major Road
Local Road
Railroad

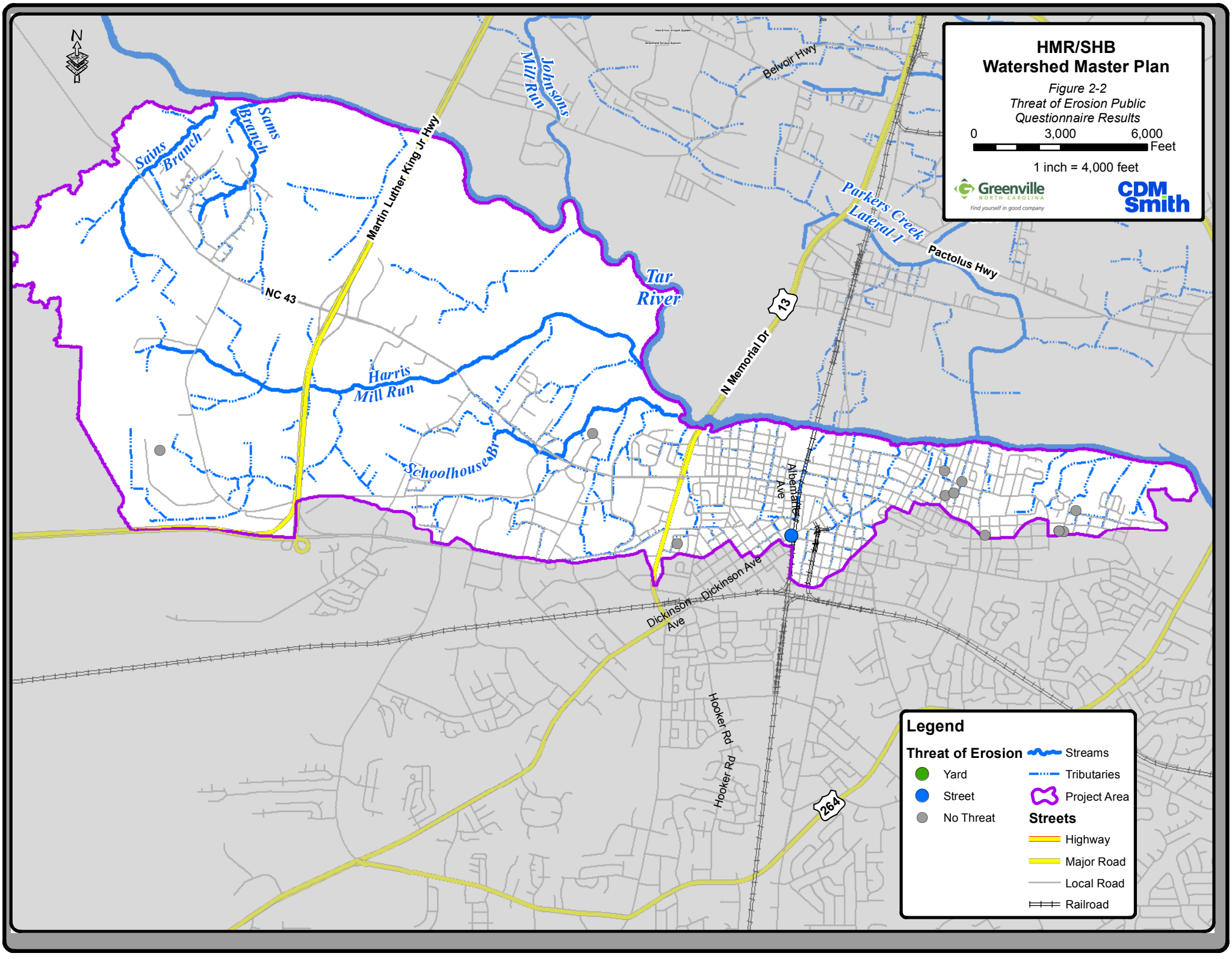

HMR/SHB
Watershed Master Plan
Figure 2-2
Threat of Erosion Public
Questionnaire Results
0
3,000
6,000
Feet
1 inch = 4,000 feet
Greenville
NORTH CAROLINA
Find yourself in good company
CDM Smith
N
Johnsons Mill Run
Belvoir Hwy
Sams Branch
Sams Branch
Martin Luther King Jr Hwy
Parkers Creek Lateral 1
Pactolus Hwy
Tar River
NC 43
13
N Memorial Dr
Harris Mill Run
SchoolhouseBr
Albemarle Ave
Dickinson Ave
Dickinson Ave
Hooker Rd
Hooker Rd
264
Legend
Threat of Erosion
Yard
Street
No Threat
Streams
Tributaries
Project Area
Streets
Highway
Major Road
Local Road
Railroad

Table 2-2A: Sains Branch Watershed Existing Land Use

Land Use Category	Area (acres)	Percent of Basin Area
Commercial	4	0.8%
Office/Institutional/Multifamily	2	0.4%
Medium Density Residential	100	19.0%
Low Density Residential	1	0.2%
Conservation/Open Space	380	72.2%
Right-of-Way	39	7.4%
Total	526	100.0%

Table 2-2B: Sains Branch Watershed Future Land Use

Land Use Category	Area (acres)	Percent of Basin Area
Commercial	20	3.8%
Medium Density Residential	247	47.0%
Multi-family	43	8.1%
Open space	203	38.7%
Right-of-way	13	2.4%
Total	526	100.0%

2.2.2 Harris Mill Run

The Harris Mill Run Watershed is approximately 3.6 square miles between its downstream boundary along the Tar River and its upstream boundary near US Hwy 264 to the south. Land use in the watershed is mostly undeveloped (75% open space) as shown on the Existing Conditions Land Use Map included in Appendix C, and listed in **Table 2-1C**. The future conditions land use is expected to be comprised of additional development with up to 40% additional medium density residential and some commercial/institutional uses according to the zoning.

Table 2-3A: Harris Mill Run Watershed Existing Land Use

Land Use Category	Area (acres)	Percent of Basin Area
Commercial	7	0.3%
Institutional	27	1.1%
Low density residential	5	0.2%
Medium density residential	216	9.3%
Multi-family	173	7.5%
Open space	1710	74%
Right-of-way	180	7.7%
TOTAL	2317	100%

Table 2-3B: Harris Mill Run Watershed Future Land Use

Land Use Category	Area (acres)	Percent of Basin Area
Commercial	94	4.1%
High Density Residential	166	7.2%
Medium Density Residential	1162	50%
Office/Institutional/Multifamily	273	12%

Conservation/Open Space	510	22%
Right-of-Way	113	4.9%
TOTAL	2318	100%

2.2.3 Schoolhouse Branch

The Schoolhouse Branch Watershed is approximately 1.6 square miles on the west side of Greenville and drains a large portion of the Vidant Medical Center and ECU Medical Campus. The watershed is bounded by Statonsburg Rd to the south, near Memorial Drive to the east and encompasses B's Barbeque Road to the west. Land use in the watershed is mostly developed (22% open space) as shown on the Existing Conditions Land Use Map included in Appendix C, and listed in **Table 2-4A and B**. The future conditions land use is expected to be comprised of additional high density development with medical related and multi-family land uses with some high density residential uses according to the zoning.

Table 2-4A: Schoolhouse Branch Watershed Existing Land Use

Land Use Category	Area (acres)	Percent of Basin Area
Commercial	24	2.3%
Office/Institutional/Multifamily	469	45.7%
Medium Density Residential	32	3.1%
Low Density Residential	9	0.9%
Conservation/Open Space	407	39.6%
Right-of-Way	86	8.4%
TOTAL	1,027	100.0%

Table 2-4B: Schoolhouse Branch Watershed Future Land Use

Land Use Category	Area (acres)	Percent of Basin Area
Commercial	50	4.9%
High Density Residential	100	9.8%
Medical	26	2.6%
Medical Core	177	17.3%
Medical Transition	164	16.0%
Multi-Family	307	29.9%
Open Space	152	14.8%
Right-of-way	49	4.8%
TOTAL	1,027	100.0%

The soils within the HMR/SHB watersheds are predominately NRCS hydrologic soils groups A and D as shown on the Soils Map included in Appendix C. More detailed information about the land use and soils in the HMR/SHB watersheds is contained in Appendix A.

2.3 Existing Conditions Survey and Field Data Collection

For the HMR/SHB Watershed Master Plan, stormwater utility infrastructure throughout the watershed was collected by CDM Smith to compile a Geographic Information System (GIS) stormwater inventory database for the City. This was accomplished by using Global Positioning Systems (GPS) as the primary means of data capture. CDM Smith employed CH Engineering, LLC which utilized survey grade GPS to locate the x, y, and z coordinates of each

visible stormwater system structure and conventional surveying techniques to obtain other attributes including but not limited to size, material, slope, and length. The data was collected using horizontal datum NAD 1983 and vertical datum NAVD 1988. A total of 2,948 closed system structures and 216,996 linear feet of pipe were collected as part of the inventory. **Tables 2-2 and 2-3** summarizes the inventory collected in the HMR/SHB Watershed.

Table 2-5: Inventory Summary – Closed System Structures

Structure Type	Number Surveyed
Yard Inlet	296
Drop Inlet	179
Junction Box	552
Pipe End	253
Pond Structure	11
Slab Top	11
Catch Basin	1341
Underground Pipe Junction	148
Difficult Access	162

Table 2-6: Inventory Summary – Pipes

Size	Length (Linear Feet)
12″ Diameter	11,541
15″ Diameter	57,568
18″ Diameter	41,568
21″ Diameter	31
24″ Diameter	35,509
30″ Diameter	17,654
36″ Diameter	17,033
42″ Diameter	6,315
48″ Diameter	3,840
54″ Diameter	1,521
60″ Diameter	5,775
66″ Diameter	1,856

Data was obtained for those open channels required to complete connectivity for modeling purposes. Attributes such as shape, lining type, bed type, flow, bottom width, top width, and bank heights were collected for 96 open channel sections totaling almost 10 miles in length. For those sections of open channel where more detailed information was required for model input, cross sections were surveyed. Data including elevations for the top of bank, bottom of bank, and channel centerline was obtained at 42 cross sections throughout the HMR/SHB Watershed. Five bridges were also included in the inventory. Refer to the City of Greenville Storm Water System Inventory Standard Operating Procedures for additional discussion on the processes and details of the inventory database.

3.1 Primary System Hydrologic and Hydraulic Analyses

3.1.1 Hydrology

The purpose of the hydrologic analysis is to estimate the magnitude of selected frequency floods for the HMR/SHB Watershed. The United States Army Corps of Engineers (USACE) Hydrologic Engineering Center, Hydrologic Modeling System (HEC-HMS) was selected to model the primary systems. HEC-HMS simulates the surface runoff response to precipitation for an interconnected system of surfaces, channels, and ponds. Input data for the HEC-HMS model was developed using topographic, land use, and soils maps in GIS to delineate and calculate the basin areas and Natural Resources Conservation Service (NRCS) hydrologic parameters. Detailed descriptions of the model parameters can be found in Appendices A and B.

The HEC-HMS model offers a variety of methods for simulating the rainfall-runoff response, hydrograph development, channel and pond routing. The selection of methods for the analyses is based on the study objectives, data availability, and watershed characteristics. The precipitation data for the 24-hour duration, Type III storm was used to represent the synthetic rainfall event. The Type III storm was selected based on the location of the City of Greenville. The geographic boundaries for the different NRCS rainfall distributions are shown on Figure B-2 of NRCS document Urban Hydrology for Small Watersheds, dated June 1986 and commonly referred to as TR-55 (See Appendix A). As shown in TR-55 for the coastal regions of North Carolina including Greenville, a Type III storm is more characteristic. The NRCS curve number approach was selected to calculate runoff volumes from the precipitation data, and the sub-basin unit hydrographs for these flood volumes were developed using the NRCS lag times.

Peak flows for the primary systems were developed for the 2-, 10-, 25-, 50-, and 100-year storm events. The existing conditions flows were developed assuming attenuation occurs throughout each reach varying with the topography. Storage routing was modeled to account particularly for accessible storage volume in the areas upstream of crossings. The results of the hydrologic model used as input for HEC-RAS are summarized in **Table 3-1**. A hard copy of the HEC-HMS output is included as Appendix H. The CD found in Appendix J contains this digital information.

3.1.2 Hydraulics

The purpose of the hydraulic analysis is to determine an existing level of flooding for the storm drainage network and to develop proposed solutions to mitigate flooding. The USACE HEC-RAS (River Analysis System) was selected to model the primary systems to remain consistent with the existing FEMA modeling. HEC-RAS calculates water surface profiles for steady, gradually varied flow in channels and floodplains. The standard backwater analysis for sub-critical flow was modeled for the HMR/SHB Watershed. The model calculates the effect of obstructions, such as culverts, and building structures in the channel and floodplain on the water surface profile. The hydraulic computations are based on the solution of a one-dimensional energy equation with energy loss due to friction evaluated by Manning's equation.

Table 3-1: Existing Conditions Flows from HEC-HMS

HEC-HMS Node	Road Name / Location	HEC-RAS Station	Storm Event				
			2-year (cfs)	10-year (cfs)	25-year (cfs)	50-year (cfs)	100-year (cfs)
Harris Mill Run							
J_HMR_1300	U/S Limit of Harris Mill Run	XS-18138	23	57	83	107	134
J_HMR_1100	Rock Spring Road	XS-15394	42	109	163	214	273
J_HMR_1000	US Hwy 264	XS-14197	41	106	157	206	262
J_HMR_700	0.3 mile below US Hwy 264	XS-12085	117	297	447	590	756
J_HMR_400	State Hwy 43	XS-8501	137	354	539	720	936
J_HMR_300	0.4 mile below State Hwy 43 Bridge	XS-6212	140	364	563	755	980
J_HMR_200	D/S Limit of Harris Mill Run	XS-4881	153	396	606	808	1,048
Schoolhouse Branch							
J_SHB_030	U/S Limit of Schoolhouse Branch	XS-12202	3	7	10	13	16
J_SHB_028	0.3 mile below B'S Barbeque Rd	XS-10469	19	46	66	85	106
J_SHB_020	NC Alcohol Rehab Center Entrance Road	XS-7243	98	200	283	354	432
J_SHB_020	Nursing Home Entrance Road	XS-6790	98	200	283	354	432
J_SHB_018	W Arlington Boulevard	XS-6468	113	231	324	404	493
J_SHB_016	W 5th Street (State Hwy 43)	XS-5879	295	557	743	908	1,105
J_SHB_012	D/S Limit of Schoolhouse Branch	XS-1913	379	743	1,022	1,265	1,549
Sains Branch							
J_SB1_1300	U/S Limit of Sam's Branch 1 (west)	XS-7695	12	24	33	41	50
J_SB1_800	State Hwy 43	XS-4373	100	202	277	345	421
J_SB1_OUT	D/S Limit of Sam's Branch 1 (west)	XS-557	125	266	376	477	594
Sams Branch							
J_SB2_1100	U/S Limit of Sam's Branch 2 (east)	XS-6528	3	10	16	22	29
J_SB2_900	Golf Cart Crossing #3	XS-5065	16	45	71	95	122
J_SB2_800	Golf View Drive	XS-4011	18	62	102	140	186
J_SB2_500	River Walk Drive (Private)	XS-3392	93	222	323	418	526
J_SB2_200	D/S Limit of Sam's Branch 2 (east)	XS-825	122	271	391	500	627

Input data for HEC-RAS include:

- Cross-section geometry of the channel and floodplain;
- Roughness coefficients to describe characteristics of the channel and floodplain;
- Size, shape, and characteristics of culverts and roadways along the stream reach; and
- Energy loss coefficients for flow in the channel and at roadway crossings.

Channel cross sections utilized in the HEC-RAS model were based on the existing FEMA cross sections and CDM Smith surveyed cross sections. The channel cross sections were merged with North Carolina State LiDAR data (2007) to develop cross sections spanning the entire floodplain area. The starting water surface elevations for the HEC-RAS models were calculated using the slope-area method. They are as follows:

- 0.0001 feet/foot for Harris Mill Run; and
- 0.001 feet/foot for Schoolhouse Branch
- 0.0005 feet/foot for Sams Branch 1
- 0.01 feet/foot for Sams Branch 2.

3.1.2.1 Hydraulic Performance

Twenty roadway crossings were analyzed for flooding potential for the primary system. Four were located along Harris Mill Run, five were located along Schoolhouse Branch, ten were located along Sains Branch, while the remaining one was located along Sams Branch. Descriptions of the existing primary system crossings analyzed are summarized in **Table 3-2**. Pictures 3-1 through 3-20 of this report provide visual images of the primary system crossings.

Table 3-2: Existing Condition of Primary System Crossings

Location	Size/Material	Condition
Harris Mill Run		
Rock Spring Road	48" CMP	N/A – Not evaluated
US Hwy 264	Twin 8' x 6' Box Culverts	N/A – Not evaluated
State Hwy 43	4 span bridge	Good – Recent Construction
Schoolhouse Branch		
NC Alcohol Rehab Center Entrance Road	Triple 36" RCPs	Good
Nursing Home Entrance Road	36" RCP	Fair
W Arlington Boulevard	Twin 84" CMPs	Fair
W 5th Street (State Hwy 43)	60" CMP, Twin 5.5' x 5.5' Box Culverts	Fair
Sains Branch (west)		
State Hwy 43	Twin 5' x 5' Box Culverts	Fair
Sams Branch (east)		
Golf Cart Crossing #5	Wooden bridge	Fair
Golf Cart Crossing #4	Wooden bridge	Fair
Golf Cart Crossing #3	Wooden bridge	Fair

Location	Size/Material	Condition
Golf Cart Crossing #2	Wooden bridge	Fair
Golf Cart Crossing #1	Wooden bridge	Fair
Golf View Drive	10' x 4' Box Culvert	Good – Partially obstructed by sediment
River Walk Drive (Private)	Twin 36" CMPs	Poor – frequently overtopped dirt road

Photograph 3-1
Harris Mill Run: NC 43 Bridge – Upstream

Photograph 3-2
Harris Mill Run: NC 43 Bridge – Downstream

Photograph 3-3
Schoolhouse Branch: W 5th Street Culvert

Photograph 3-4
Schoolhouse Branch: W Arlington Boulevard Culvert

Photograph 3-5
Schoolhouse Branch: W 5th Street CMP Culvert – Upstream

Photograph 3-6
Schoolhouse Branch: W 5th Street Culvert – Downstream

Photograph 3-7
Schoolhouse Branch: Arlington Boulevard Culvert – Downstream

Photograph 3-8
Schoolhouse Branch: Arlington Boulevard Culvert – Upstream

Photograph 3-9
Schoolhouse Branch: Pipe West of Arlington Boulevard – Downstream

Photograph 3-10
Schoolhouse Branch: Pipe West of Arlington Boulevard – Upstream

Photograph 3-11
Schoolhouse Branch: NC Treatment Center Weir and Culvert

Photograph 3-12
Sams Branch 1: Ironwood Golf Cart Bridge 1

Photograph 3-13
Sams Branch 1: Ironwood Golf Cart Bridge 2

Photograph 3-14
Sams Branch: Ironwood Golf Cart Bridge 3

Photograph 3-15
Sams Branch: Ironwood Golf Cart Bridge 4

Photograph 3-16
Sams Branch 1: Golf View Drive Culvert – Downstream

Photograph 3-17
Sams Branch: Golf View Drive Culvert Upstream

Photograph 3-18
Sams Branch: Maintenance Road Culvert Upstream

Photograph 3-19
Sains Branch: NC-43 Culvert Downstream

Photograph 3-20
Sains Branch: NC-43 Culvert Downstream

The 2-, 10-, 25-, 50- and 100-year existing conditions flood elevations for the primary system crossings are identified in Table 3-3. The minimum elevations at the top of the road for each crossing are also listed in Table 3-3. Along Harris Mill Run, the only crossing in the City limits at NC HWY 43 is meeting the desired LOS. Along Schoolhouse Branch, the crossings beneath NC Hwy 43 and the immediate upstream facility access roadway crossings are not meeting the desired LOS. Along Sams Branch, the one public crossing is meeting its desired LOS. The golf cart crossings do not have a designated level of service. The single crossing for Sains Branch at Highway 43 meets its desired LOS.

Table 3-3: Hydraulic Performance for Existing Conditions Roadway Flooding

Location	Minimum Elevation at Top of Road (feet NAVD)	Desired Level of Service	Calculated Water Surface Elevations (feet NAVD)				
			2-year flood	10-year flood	25-year flood	50-year flood	100-year flood
Harris Mill Run							
Rock Spring Road	59.50	25-yr	50.74	53.63	57.52	**59.75**	**59.95**
US Hwy 264	62.36	100-yr	39.07	39.99	40.65	41.20	41.78
State Hwy 43 Bridge	52.19	50-yr	23.94	25.66	26.61	27.32	28.00
Schoolhouse Branch							
NC Alcohol Rehab Center Entrance Road	33.50	25-yr	31.41	**33.76**	**33.93**	**33.99**	**34.06**
Nursing Home Entrance Road	29.34	25-yr	**30.05**	**30.46**	**30.61**	**30.92**	**31.47**
W Arlington Boulevard	31.02	50-yr	26.15	28.62	30.05	30.81	**31.47**
W 5th Street (State Hwy 43)	28.51	50-yr	25.60	27.76	**28.77**	**28.95**	**29.10**
Sains Branch (west)							
State Hwy 43 Culvert	45.69	50-yr	36.72	38.12	39.00	39.73	40.63
Sams Branch (east)							
Golf Cart Crossing #5	52.07	-	43.22	43.80	44.14	44.39	44.63
Golf Cart Crossing #4	43.85	-	39.19	39.81	40.23	40.57	40.94
Golf Cart Crossing #3	43.26	-	35.78	36.62	37.11	37.49	37.90
Golf Cart Crossing #2	40.07	-	34.84	35.72	36.21	36.58	36.96
Golf Cart Crossing #1	34.93	-	28.36	29.56	30.07	30.50	31.00

Location	Minimum Elevation at Top of Road (feet NAVD)	Desired Level of Service	Calculated Water Surface Elevations (feet NAVD)				
			2-year flood	10-year flood	25-year flood	50-year flood	100-year flood
Golf View Drive Culvert	36.23	25-yr	28.06	29.30	29.74	30.15	30.66
River Walk Drive Culvert (Private)	25.75	-	**26.01**	**26.69**	**26.87**	**27.03**	**27.22**

*Bold text indicates the existing water surface has exceeded the crest or low point in the road thereby causing flooding. Red text indicates crossing not meeting designated LOS.
*Green shade indicates crossing meets desired level of service. Red shade indicates crossing does not meet desired level of service.
All stages are not considered backwater effects (BFE @ 25 HMR and SHB, and 27 for Sam's Br) from the Tar River.

In addition to evaluating the roadway crossings, an evaluation was performed to determine the buildings along Harris Mill Run, Schoolhouse Branch, Sains Branch and Sams Branch that are at risk of flooding during the 25- and 100-year storm event. The existing 25- and 100-year floodplains for all streams are shown in **Figures 3-1 through 3-3**. The mapped floodplains are based on model results obtained as part of the Master Plan and may differ from the published FEMA floodplains. For flood insurance purposes, the effective FEMA floodplain should be referenced. For structures outside of the 100-year effective FEMA floodplain, property owners must determine if purchasing flood insurance is necessary. The City is in no way responsible for determining if flood insurance is required or for notifying individual property owners of the potential risk of flooding.

Tables 3-4 through 3-6 list the lowest adjacent grade elevations along with the existing 25- and 100-year water surface elevation for the two properties that are at risk of flooding. The Walter B. Jones Rehabilitation Center has two main buildings and the East Carolina Care, LLC facility has one auxiliary building identified within the modeled floodplain. The lowest adjacent grade (LAG) elevations shown in the table are not surveyed and are estimated based on the State of North Carolina's LiDAR data. LAG flooding shown below may not result in actual LAG or finished floor flooding, but it is indicative of structures being at risk of flooding.

Table 3-4: Existing Conditions At-Risk Properties/Structures – Schoolhouse Branch

Address	LAG	Calculated Water Surface Elevation (feet NAVD)	
		25-year flood	100-year flood
2575 W 5th St	30.22	**30.61**	**31.47**
2577 W 5th St	34.00	33.93	**34.06**
2577 W 5th St	33.89	**33.93**	**34.06**

Bold text indicates LAG flooding.

HMR/SHB
Watershed Master Plan

Figure 3-1
Schoolhouse Branch and Harris Mill Run East
Existing Conditions Floodplain

800 400 0 800
Feet

1 inch = 750 feet

CDM Smith

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Legend

Flooding Reported

- No Flooding Reported
- Living Space
- Crawl Space
- AC Unit or Storage Building
- Yard
- Primary System Crossing
- 100-Year FEMA Floodplain
- 500-Year FEMA Floodplain
- 25-Year Existing Floodplain
- 100-Year Existing Floodplain
- Buildings in 25-Yr Floodplain
- Buildings in 100-Yr Floodplain
- Project Area

NC OneMap, NC Center for Geographic Information and Analysis, NC 911 Board

HMR/SHB
Watershed Master Plan

Figure 3-2
Harris Mill Run West
Existing Conditions Floodplain

800 400 0 800
Feet

1 inch = 750 feet

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N

NC 43
OPAL LN
HUNTINGRIDGE RD
NC 43 GREENVILLE BV NW WB RA
HUNT CLUB LN
Harris Mill Run
MILL RUN RD
BARN LN
MACGREGOR DOWNS RD
FORREST ACR
MARTIN LUTHER KING JR HW
264
MACGREGOR DOWNS RD

Legend

Flooding Reported

- No Flooding Reported
- Living Space
- Crawl Space
- AC Unit or Storage Building
- Yard
- Primary System Crossing
- 100-Year FEMA Floodplain
- 500-Year FEMA Floodplain
- 25-Year Existing Floodplain
- 100-Year Existing Floodplain
- Buildings in 25-Yr Floodplain
- Buildings in 100-Yr Floodplain
- Project Area

HMR/SHB
Watershed Master Plan

Figure 3-3
Sains Branch and Sams Branch
Existing Conditions Floodplain

800 400 0 800
Feet

1 inch = 750 feet

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N

Tar River
Sains Branch
Sams Branch
OAKSONG DR
WOODSPRING LN
SOUTHBERRY WD
GOLF CLUB WD
DEER CREEK LN
GOLF VIEW DR
OAK HILLS DR
COUNTRYDOWN DR
IRONGATE CT
HAWICK PL
PRESTWICK PL
NC 43

Legend

Flooding Reported
- No Flooding Reported
- Living Space
- Crawl Space
- AC Unit or Storage Building
- Yard

- Primary System Crossing
- 100-Year FEMA Floodplain
- 500-Year FEMA Floodplain
- 25-Year Existing Floodplain
- 100-Year Existing Floodplain
- Buildings in 25-Yr Floodplain
- Buildings in 100-Yr Floodplain
- Project Area

3.2 Secondary System Hydrologic and Hydraulic Analyses

While Harris Mill Run, Schoolhouse Branch, Sams, and Sains Branch are the primary source of flooding within the watersheds, undersized systems can also lead to structural and roadway flooding. Based on the questionnaire responses, public meeting, and feedback from City staff, four secondary systems were identified for further evaluation. The secondary systems evaluated are as follows:

- Davis and Vance Street System
- 1st Street and N Jarvis Street System
- 1st Street and N Harding Street System
- 4th Street and Ash/Elm Street System

3.2.1 Hydrology

The Environmental Protection Agency's Stormwater Management Model (EPA SWMM) was used in the evaluation of the secondary systems. A detailed description about the hydrologic modeling methodology is included in Appendix A.

3.2.2 Hydraulics

3.2.2.1 Davis and Vance Street System

The Davis and Vance Street System collects drainage from approximately 90 acres along N Davis Street and N Vance Street and discharges directly to the Tar River. This section is highly impervious and includes segments of Fairfax Avenue, Colonial Avenue, W 3rd Street, and W 4th Street. The conveyance system is comprised of a combination of reinforced concrete pipe (RCP), corrugated metal pipe (CMP), and clay pipe ranging from 15 to 42 inches in diameter in good condition based on data collected during the inventory. The downstream 42-inch outfall at Davis Street was not able to be located during the survey, only the outfall at Vance Street is in working condition. The upstream portion of this system is cross connected with the drainage system to the east near the 3rd Street Community Center and is also part of the 10th Street connector planned to divert flows from this system to the Town Creek Culvert drainage system.

City maintenance personnel report flooding in this area along the northern portions of both Davis Street and Vance Street as well as near the intersection of Davis Street and Ward Street. **Figure 3-4** shows the LOS being provided by the existing closed system. Model results show that the majority of the system operates at around a 5-year level of service.

3.2.2.2 Jarvis Street System

The Jarvis Street System collects drainage from approximately 43 acres along the northern portion of Jarvis Street and discharges directly to the Tar River. This drainage area is highly impervious. The conveyance system is comprised of a combination of RCP and CMP ranging

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Watershed Master Plan

Figure 3-4
Davis Street and Vance Street System
Existing Conditions

0 50 100 200
Feet

1 inch = 125 feet

CDM Smith

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N

EX 42-in CMP
EX 42-in CMP
EX 15-in RCP
EX 15-in RCP
EX 42-in CMP
EX 18-in Clay
EX 18-in Clay
EX 15-in RCP
EX 15-in RCP
EX 24-in RCP
EX 24-in RCP
EX 18-in Clay
EX 15-in RCP
EX 42-in CMP
EX 15-in
EX 42-in CMP
EX 15-in RCP
EX 18-in Clay
EX 15-in RCP
EX 15-in RCP
EX 18-in Clay
EX 18-in Clay
EX 15-in RCP
EX 42-in CMP
EX 15-in Clay
EX 15-in RCP
EX 18-in RCP
EX 15-in RCP
EX 18-in RCP
EX 15-in RCP
EX 15-in RCP
EX 15-in RCP
EX 15-in RCP
EX 15-in RCP
EX 15-in Clay
EX 15-in RCP
EX 15-in RCP
EX 42-in CMP
EX 42-in CMP
EX 42-in CMP

FAIRFAX AV
PARK AV
VANCE ST
COLONIAL AV
DAVIS ST
3RD ST
4TH ST
WARD ST
CONTENTNEA ST
LATHAM ST

Legend

Flooding Reported
- No Flooding Reported
- Living Space
- Crawl Space
- AC Unit or Storage Building
- Yard

- Catch Basin
- Yard Inlet
- Difficult Access Structure
- Drop Inlet
- Junction Box
- Pipe End
- Flared End Section
- Headwall
- Drainage Boundary

Modeled Pipe Level of Service
- < 2-Year
- 2-Year
- 5-Year
- 10-Year
- 25-Year
- 50-Year
- 100-Year
- Non-Modeled Pipes
- Channel

from 12 to 36 inches in diameter in good condition based on data collected during the inventory. **Figure 3-5** shows the level of service being provided by the existing closed system. Model results show that the majority of the system exceeds a 100-year level of service, with only the last 500-feet of pipe approaching the outfall at or below the 10-year level of service. A pipe near the intersection of Jarvis and Willow Streets has a LOS below 2-year according to the model.

3.2.2.3 Harding Street System

The Harding Street System collects drainage from approximately 32 acres along Harding Street and E 1st Street and discharges directly to the Tar River. The conveyance system is comprised of a combination of RCP and CMP ranging from 12 to 30 inches in diameter predominantly in good condition based on data collected during the inventory and also includes a length of open channel. The entrance to the CMP approaching Willow Street is assumed to be in poor condition since it is partly buried and only base flow does not appear to be blocked. The downstream 36" CMP outfall pipe is listed in fair condition and may be nearing the end of its useful design life. There is a report of yard flooding in this area and two reports of living space flooding near this area.

Figure 3-6 shows the level of service being provided by the existing closed system. Model results show that the majority of the system, particularly along E 1st Street operates below a 2-year level of service. This is consistent with the report by a resident on Harding Street that street flooding occurs frequently and the general report from City maintenance staff that flooding occurs in the area of 1st Street.

3.2.2.4 Elm Street System

The Elm Street System collects drainage from approximately 58 acres along Elm Street and discharges directly into the Tar River. This drainage area is highly impervious and includes segments of Willow Street, Brownlea Drive, E 3rd Street, and E 4th Street. The conveyance system is comprised of RCP and CMP ranging from 12 to 36 inches in diameter in good condition based on data collected during the inventory. The segment running through the Wilson Acres Apartments complex was not surveyed because the junction boxes are beneath the sidewalks and the condition is unknown. **Figures 3-7 and 3-8** show the level of service being provided by the existing closed system. Model results show that the majority of the system operates at or below a 2-year level of service which is consistent with the reports of roadway flooding by City maintenance staff. The downstream run of pipe at the north end of Elm Street was already slotted for replacement to repair apparent joint separation.

3.3 Stream Stability Field Assessments

There are 6.6 miles of major streams located in the HMR/SHB Watershed, including Harris Mill Run, Schoolhouse Branch, Sains and Sams Branch, which are classified for secondary recreation and aquatic wildlife survival and propagation (Class C) by the North Carolina Division of Water Resources (NCDWR). These streams are also classified as nutrient sensitive waters (NSW) by NCDWR, indicating they are subject to excessive growth of microscopic or macroscopic vegetation, or they contribute to downstream nutrient loading (NCDWQ 2010). None of the streams in the HMR/SHB watershed are listed on the NC Water Quality

HMR/SHB
Watershed Master Plan

Figure 3-5
Jarvis Street System
Existing Conditions

0 50 100 200
Feet

1 inch = 125 feet

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N

Tar River

EX 12-in RCP
EX 36-in CMP
EX 36-in CMP
EX 36-in CMP
EX 18-in CMP
EX 36-in CMP
EX 15-in CMP
EX 30-in RCP
EX 30-in RCP
EX 18-in
EX 36-in RCP
EX 15-in RCP
EX 36-in RCP
EX 36-in CMP
EX 15-in CPE
EX 36-in CMP
EX 18-in RCP
EX 24-in RCP
EX 36-in CMP
EX 36-in CMP
EX 36-in CMP

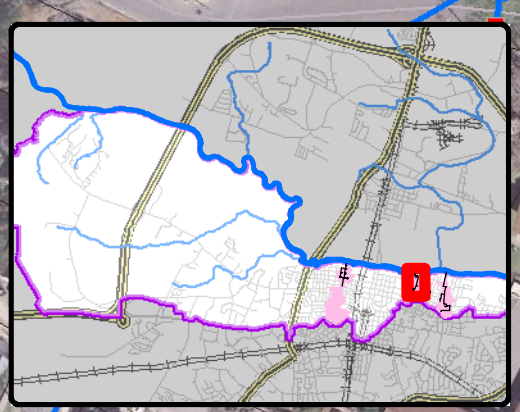
AVERY ST
HOLLY ST
WILLOW ST
RIVER DR
SUMMIT ST
JARVIS ST
WOODLAWN AV
PARK DR
1ST ST
2ND ST
3RD ST

Legend

Flooding Reported
- No Flooding Reported
- Living Space
- Crawl Space
- AC Unit or Storage Building
- Yard

- Catch Basin
- Yard Inlet
- Difficult Access Structure
- Drop Inlet
- Junction Box
- Pipe End
- Flared End Section
- Headwall
- Drainage Boundary

Modeled Pipe Level of Service
- < 2-Year
- 2-Year
- 5-Year
- 10-Year
- 25-Year
- 50-Year
- 100-Year
- Non-Modeled Pipes
- Channel



HMR/SHB
Watershed Master Plan

Figure 3-6
Harding Street System
Existing Conditions

0 50 100 200
Feet

1 inch = 125 feet

CDM Smith

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Tar River

JARVIS ST
RIVER DR
WOODLAWN AV
PARK DR
HARDING ST
LIBRARY ST
1ST ST
WILLOW ST
ROTARY AV

EX 30-in CMP
EX 24-in CMP
EX 12-in CMP
EX 24-in RCP
EX 12-in RCP
EX 24-in
EX 5-ft x 6-ft (bottom width by depth) Trapezoidal Channel
EX 24-in RCP
EX 15-in RCP
EX 12-in RCP
EX 12-in RCP
EX 24-in RCP
EX 18-in RCP
EX 15-in RCP
EX 12-in RCP
EX 24-in RCP
EX 15-in RCP
EX 18-in CMP
EX 24-in RCP
EX 24-in RCP
EX 15-in
EX 12-in RCP
EX 15-in RCP
EX 18-in RCP

Legend

Flooding Reported
- No Flooding Reported
- Living Space
- Crawl Space
- AC Unit or Storage Building
- Yard

- Catch Basin
- Yard Inlet
- Difficult Access Structure
- Drop Inlet
- Junction Box
- Pipe End
- Flared End Section
- Headwall
- Drainage Boundary

Modeled Pipe Level of Service
- < 2-Year
- 2-Year
- 5-Year
- 10-Year
- 25-Year
- 50-Year
- 100-Year
- Non-Modeled Pipes
- Channel

HMR/SHB
Watershed Master Plan

Figure 3-7
Elm Street System North
Existing Conditions

0 50 100 200
Feet

1 inch = 125 feet

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N

Parkers Creek

Tar River

RIVER DR

EASTERN ST

STANCILL DR

WILLOW ST

ELM ST

MEADE ST

ASH ST

OAK ST

1ST ST

EX 36-in CMP

EX 36-in CMP

EX 30-in CMP

EX 30-in CMP

EX 30-in CMP

EX 30-in CMP

EX 30-in CMP

EX 24-in CMP

EX 18-in RCP

EX 24-in RCP

EX 24-in CMP

EX 24-in CMP

Legend

Flooding Reported
- No Flooding Reported
- Living Space
- Crawl Space
- AC Unit or Storage Building
- Yard

- Catch Basin
- Yard Inlet
- Difficult Access Structure
- Drop Inlet
- Junction Box
- Pipe End
- Flared End Section
- Headwall
- Drainage Boundary

Modeled Pipe Level of Service
- < 2-Year
- 2-Year
- 5-Year
- 10-Year
- 25-Year
- 50-Year
- 100-Year
- Non-Modeled Pipes
- Channel

HMR/SHB
Watershed Master Plan

Figure 3-8
Elm Street System South
Existing Conditions

0 50 100 200 Feet

1 inch = 125 feet

CDM Smith

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N

MEADE ST
EX 24-in RCP
EX 24-in CMP
EX 18-in RCP
EX 24-in CMP
OAK ST
1ST ST
EX 18-in RCP
2ND ST
EX 18-in RCP
EX 24-in CMP
EX 12-in RCP
EX 12-in RCP
EX 24-in CMP
ELM ST
EX 24-in CMP
EX 24-in CMP
EX 24-in RCP
WARREN ST
3RD ST
EX 12-in RCP
EX 12-in RCP
EX 18-in RCP
EX 24-in RCP
MAPLE ST
EX 15-in RCP
EX 15-in RCP
EX 18-in RCP
EX 18-in RCP
4TH ST
EX 15-in RCP
EX 15-in RCP
OAK ST
5TH ST

Legend

Flooding Reported
- No Flooding Reported
- Living Space
- Crawl Space
- AC Unit or Storage Building
- Yard

- Catch Basin
- Yard Inlet
- Difficult Access Structure
- Drop Inlet
- Junction Box
- Pipe End
- Flared End Section
- Headwall
- Drainage Boundary

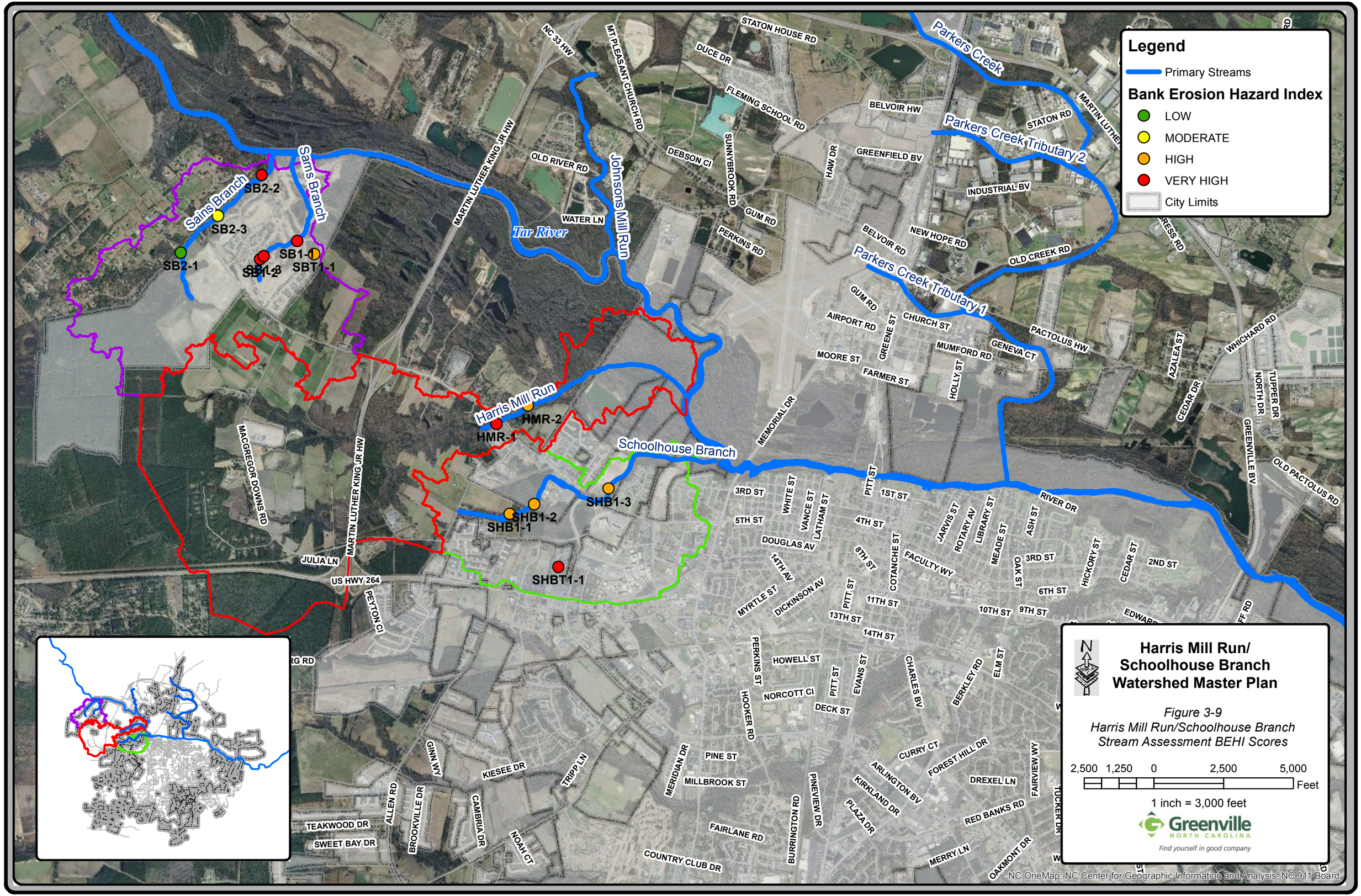
Modeled Pipe Level of Service
- < 2-Year
- 2-Year
- 5-Year
- 10-Year
- 25-Year
- 50-Year
- 100-Year
- Non-Modeled Pipes
- Channel

Assessment and Impaired Waters List (also known as the Integrated 305(b) and 303(d) Report).

Field assessments measuring bank stability were conducted on all of the major stream channels within the HMR/SHB Watershed. The Bank Erosion Hazard Index (BEHI) developed by Rosgen was used to evaluate the streams in the watershed. BEHI is an assessment tool that is used to quantify the erosion potential of a stream bank. Characteristics assessed as part of the BEHI rating include bank height ratio (stream bank height/maximum bankfull depth), ratio of rooting depth to bank height, root density, bank angle, percent surface protection, and bank material composition. Each of these variables that affect the potential rate of stream bank erosion is assigned points based on specific evaluation criteria. BEHI scores range from 5 to 50, with a score of 50 indicating the highest potential for erosion. A BEHI score of 5 to 19.5 indicates a very low or low potential for erosion; a score between 20 and 29.5 indicates a moderate potential for erosion; scores from 30 to 45 represent a high to very high potential for erosion; and scores between 46 and 50 indicate extreme erosion potential. The completed BEHI scores are provided in Appendix K.

There are four main drainage features within the HMR/SHB Watershed (See **Figure 3-9**). The largest of these is Harris Mill Run. Schoolhouse Branch lies in the southwest portion of the watershed and constitutes the second largest drainage feature. The remaining two drainage features are Sains Branch and Sams Branch. BEHI scores for each of these drainage areas are discussed below. All of the measured channels are primarily sand and gravel bed channels with high to very high ratings for root density, bank height/bankfull height ratios in the high to very high range. The sampling points also had low to moderate surface protection and low to high bank angles.

A total of 12 BEHI measurements were taken in the HMR/SHB watershed across all study streams with scores ranging from Low to Very High. Two BEHI assessments were performed along Harris Mill Run. Of these two assessments, one resulted in a Very High and another a High rating. Four BEHI assessments were performed in the Schoolhouse Branch watershed. These assessments were all rated as High with the exception of the unnamed tributary which was rated Very High. Three BEHI assessments were performed on Sams Branch. These assessments scored in the High to Very High range. Three BEHI assessments were performed on Sains Branch and scored in the Low to Very High range going from upstream to downstream.


Legend
Primary Streams
Bank Erosion Hazard Index
LOW
MODERATE
HIGH
VERY HIGH
City Limits
Harris Mill Run/
Schoolhouse Branch
Watershed Master Plan
Figure 3-9
Harris Mill Run/Schoolhouse Branch
Stream Assessment BEHI Scores
2,500 1,250 0 2,500 5,000
Feet
1 inch = 3,000 feet
Greenville
NORTH CAROLINA
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N
Parkers Creek
Parkers Creek Tributary 2
Parkers Creek Tributary 1
Tar River
Johnsons Mill Run
Sams Branch
Sains Branch
Harris Mill Run
Schoolhouse Branch
SB2-1
SB2-2
SB2-3
SB1-1
SB1-2
SB1-3
SBT1-1
HMR-1
HMR-2
SHB1-1
SHB1-2
SHB1-3
SHBT1-1
STATON HOUSE RD
DUCE DR
NC 33 HW
MT PLEASANT CHURCH RD
FLEMING SCHOOL RD
BELVOIR HW
STATON RD
MARTIN LUTHER KING JR HW
DEBSON CI
SUNNYBROOK RD
HAW DR
GREENFIELD BV
INDUSTRIAL BV
OLD RIVER RD
WATER LN
GUM RD
PERKINS RD
BELVOIR RD
NEW HOPE RD
OLD CREEK RD
GUM RD
AIRPORT RD
GREENE ST
CHURCH ST
PACTOLUS HW
MOORE ST
FARMER ST
HOLLY ST
MUMFORD RD
GENEVA CT
AZALEA ST
WHICHARD RD
CEDAR DR
NORTH DR
TUPPER DR
GREENVILLE BV
OLD PACTOLUS RD
MEMORIAL DR
3RD ST
5TH ST
WHITE ST
VANCE ST
LATHAM ST
PITT ST
1ST ST
4TH ST
JARVIS ST
ROTARY AV
LIBRARY ST
MEADE ST
ASH ST
RIVER DR
DOUGLAS AV
14TH AV
9TH ST
COTANCHE ST
FACULTY WY
OAK ST
3RD ST
HICKORY ST
CEDAR ST
2ND ST
6TH ST
MYRTLE ST
DICKINSON AV
11TH ST
10TH ST
9TH ST
13TH ST
14TH ST
EDWARDS
PERKINS ST
HOWELL ST
EVANS ST
CHARLES BV
BERKLEY RD
ELM ST
NORCOTT CI
DECK ST
HOOKER RD
CURRY CT
FOREST HILL DR
PINE ST
MERIDIAN DR
MILLBROOK ST
ARLINGTON BV
KIRKLAND DR
DREXEL LN
FAIRVIEW WY
PINEVIEW DR
PLAZA DR
RED BANKS RD
BURRINGTON RD
FAIRLANE RD
TUCKER DR
COUNTRY CLUB DR
MERRY LN
OAKMONT DR
MACGREGOR DOWNS RD
MARTIN LUTHER KING JR HW
JULIA LN
US HWY 264
PEYTON CI
KIESEE DR
TRIPP LN
GINN WY
ALLEN RD
BROOKVILLE DR
CAMBRIA DR
NOAH CT
TEAKWOOD DR
SWEET BAY DR
NC OneMap, NC Center for Geographic Information and Analysis, NC 911 Board

4.1 Primary Systems

Developing flood control alternatives in an urban environment is a complex process based on limitations imposed by the constraints within the environment such as floodplain encroachment, increased peak flows due to impervious areas, public and private utilities, and private property. Improvements in this portion of the study were identified through an iterative process of infrastructure improvements, increasing floodplain storage, and evaluating detention options. Alternatives were finalized based on discussions with City staff. The top alternatives that achieve the goals of the project while minimizing impacts to residents and traffic are presented.

4.1.1 Schoolhouse Branch

Facility Access Roads

Two access roadways cross Schoolhouse Branch providing access from W 5th Street to the NC Alcohol and Drug Abuse Treatment Center (ADATC) and the Greenfield Place, LLC, long term care (LTC) facility. These crossings are considered as City roads with respect to the applicable LOS due to their public service and residential capacity and therefore are assigned the associated 25-year LOS. Neither roadway currently meets the 25-year LOS with the Rehab Center exceeding only a 2-year LOS and the LTC entrance not passing any modeled design storm (<2-year) without overtopping.

On the ADATC property is a small pond, impounded by a rectangular weir around the discharge to triple 36" RCPs. At the LTC facility entrance road crossing is a single 36" RCP to convey flows which discharges immediately before the entrance to the W Arlington Boulevard culverts. The proposed improvements for the two service driveway crossings of Schoolhouse Branch are a set of 3-48" diameter RCP for each (See **Figure 4-1**). Daylighting of the piped segment of Schoolhouse Branch between the LTC entrance road and Arlington Blvd is also recommended.

W Arlington Boulevard

The existing twin 7' x 7' RCBC at Arlington Boulevard meet the desired 50-year level of service. The culverts appear to be in good condition, therefore no improvements are proposed at this location.

W 5th Street

The W 5th Street (State Hwy 43 west of Arlington Blvd) crossing of School House Branch is comprised of twin 5.5' x 5.5' RCBC and a 60" CMP only meeting a 10-year LOS without overtopping the roadway. Overtopping for the 50-year LOS design storm is estimated at approximately 0.4 feet. The crossing is in fair condition. Two alternatives were developed, Alternative 1 includes proposed upgrade to the culverts to 3-8'x5' RCBC to meet the 50-year designated LOS. Alternative 2 includes proposed upgrade to the culvert with 4- 6' RCP culverts to attain the designated LOS. Addition of another culvert to the existing three was considered, however the aged condition of the existing culverts warrants replacement of all in the event of an upgrade at this crossing. See Figure 4-1.

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Watershed Master Plan

Figure 4-1
Alcohol Rehab, Greenfield Place, W Arlington Boulevard, and W 5th Street Crossings

100 50 0 100 Feet

1 inch = 100 feet

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Alcohol Rehab Center Entrance Road
Existing: Triple 36" RCP
Alternative #1: Triple 48" RCP
Alternative #2: Triple 48" RCP

Greenfield Place Nursing Home Entrance Road
Existing: 36" RCP
Alternative #1: Triple 48" RCP
Alternative #2: Triple 48" RCP

W Arlington Boulevard
Existing: Twin 84" CMP
No Proposed Alternatives

W 5th Street (State Highway 43)
Existing: 60" CMP, Twin 5.5' x 5.5' Box Culverts
Alternative #1: Triple 8' x 5' RCBC
Alternative #2: Quadruple 6' RCP

Legend

- Catch Basin
- Yard Inlet
- Difficult Access Structure
- Drop Inlet
- Junction Box
- Pipe End
- Flared End Section
- Headwall
- Underground Pipe Junction
- Pipes
- Channels

Flooding Reported

- No Flooding Reported
- Living Space
- Crawl Space
- AC Unit or Storage Building
- Yard

A summary of the hydraulic performance for the Schoolhouse Branch improvements proposed is included in **Table 4-1**, respectively. The water surface elevations shown assume all proposed primary system improvements for Schoolhouse Branch are constructed. The level of improvement will be reduced if all projects are not implemented.

Table 4-1: Hydraulic Performance – Schoolhouse Branch

Location	Minimum Elevation at Top of Road (feet NAVD)	Desired Level of Service	Calculated Water Surface Elevations (feet NAVD)				
			2-year flood	10-year flood	25-year flood	50-year flood	100-year flood
NC Alcohol Rehab Center Entrance Road (Proposed 3-48" RCP)	33.50	25	29.42	30.83	31.98	**33.72**	**33.89**
Greenfield Place Nursing Home Entrance Road (Proposed 3-48" RCP)	31.50	25	26.42	28.05	30.21	**31.71**	**31.92**
W Arlington Boulevard (Existing Twin 84" CMP)	31.02	50	25.05	26.75	27.84	28.95	30.50
W 5th Street (State Hwy 43) (Proposed 3-8'x5' RCBC)	28.51	50	23.87	25.41	26.35	27.05	28.13

* Bold text indicates the existing water surface has exceeded the rim elevation at the road thereby causing flooding.

** Green shade indicates crossing meets desired level of service. Red shade indicates crossing does not meet desired level of service.

As noted in Table 3-4, three structures along Schoolhouse Branch are located at least partially within the existing conditions 100-year floodplain as modeled for this study and two of these structures along Schoolhouse Branch are located at least partially within the 25-year floodplain. As a result of either Alternative 1 or 2 improvements, all three structures will be removed from the 25-year floodplain and two structures will be removed from the 100-year floodplain. Water surface elevations for the 25- year and 100-year event will be lower resulting in a reduction in the frequency, severity, and duration of flooding, for the auxiliary building which remains a potentially floodprone structure for the 100-year storm event along Schoolhouse Branch. Flood stage reductions are dependent on each of the improvements at the private crossings as well as the crossing at W 5th Street.

4.1.2 Harris Mill Run

The three crossings of Harris Mill Run within the hydraulic study area all meet the designated LOS for crossing overtopping. There is no flooding which potentially impacts any structures associated with Harris Mill Run. The two downstream DOT bridges are recent construction, in good condition, and oversized to pass all flows for Harris Mill Run. The Rock Spring Road 48" CMP crossing at the headwaters of Harris Mill Run is outside the City limits and was not evaluated for condition. No improvements are proposed for any structures on Harris Mill Run.

4.1.3 Sams Branch

Of the seven stream crossings on Sams Branch, only one is not private, and only one private crossing overtops any of the modeled storms. There is only flooding which potentially

impacts one structure associated with Sams Branch. The potentially impacted structure is a residence at the corner of Golf View Drive and River Walk Drive.

Golf Cart Crossings

There are five golf cart crossings over Sams Branch. Each is a wooden bridge elevated slightly above the channel. Each golf crossing is able to pass the 100-year storm without overtopping.

Golf View Drive

The only public road crossing on Sams Branch exceeds the designated LOS (25-year) by passing the 100-year design storm. This crossing consists of a good condition 10'x4' box culvert which is experiencing sediment accumulation due to excessive upstream erosion. Maintenance removal of sediment blocking the culvert is recommended to maintain full capacity, but no other improvements are proposed.

River Walk Drive

A private maintenance dirt road crossing of Sams Branch overtops frequently resulting in a washed out roadway. The pond immediately downstream of the twin 36" culverts contains the washed out sediment so that it is not washed downstream. Stabilization of this crossing is recommended to prevent washout, but since this is a private crossing, no proposal is included.

4.1.4 Sains Branch

The singular crossing of Sains Branch meets and exceeds the designated LOS (50-year) for crossing overtopping by passing the 100-year. There is no flooding which potentially impacts any structures associated with Sains Branch. As such, no improvements are proposed for any structures on Sains Branch.

4.1.5 Hydrology

The future conditions land use was determined based on projected future use of the project area. Based on this assumption, the hydrologic parameters, such as curve numbers, time of concentration, and land cover, were updated to reflect the new conditions.

Peak flows for the primary systems were developed for the 2-, 10-, 25-, 50-, and 100-year storm events. The proposed conditions flows were developed taking into account attenuation for the proposed culvert sizes. The proposed peak flows used for sizing the proposed culverts are summarized in **Table 4-2**. The flows assume all proposed improvements within the watershed are completed based on the alternative selected. If individual projects are implemented or combined with projects from another alternative, the peak flows should be updated to make sure downstream impacts are sufficiently analyzed. A hard copy of the HEC-HMS output is included as Appendix H. The CD found in Appendix J contains this digital information.

4.1.6 Hydraulics

The hydraulic analysis for the proposed conditions was similar to the analysis completed for the existing conditions. The model was updated to reflect the proposed culvert

improvements, as well as proposed floodplain benching locations. The starting water surface elevations were the same for both existing and proposed conditions models.

Table 4-2: SHB Proposed Conditions Flows from HEC-HMS

HEC-HMS Node	Road Name / Location	HEC-RAS Station	Storm Event				
			2-year (cfs)	10-year (cfs)	25-year (cfs)	50-year (cfs)	100-year (cfs)
J_SHB_030	U/S Limit of SHB	XS-12202	3	7	10	13	16
J_SHB_028	0.3 mile below B S	XS-10469	19	46	66	85	106
J_SHB_020	NC Alcohol Rehab Center Entrance Road	XS-9397	29	64	91	115	143
J_SHB_020	Nursing Home Entrance	XS-7804	92	192	265	330	404
J_SHB_018	W Arlington Boulevard	XS-7243	105	213	281	347	421
J_SHB_016	W 5th Street (State Hwy	XS-6468	118	240	322	397	482
J_SHB_012	D/S Limit of SHB	XS-5879	317	598	796	957	1132
J_SHB_030	U/S Limit of SHB	XS-4051	330	640	855	1036	1238
J_SHB_028	0.3 mile below B S Barbeque Rd	XS-1913	397	782	1060	1294	1568

4.2 Secondary Systems

Developing flood control alternatives for the secondary systems typically included increases in pipe capacity and/or rerouting flows where more space was available for improvements. In general the proposed improvements for the secondary system are less complex from a permitting perspective since they typically do not require FEMA or 401/404 permits. However, the proposed improvements for the secondary system are oftentimes constrained by private property as space is typically limited between houses or other structures. Utility conflicts are another constraint that is typical for secondary system improvements. Secondary system improvements also considered feedback from City staff and residents as well as maintenance needs based on findings from the inventory and/or feedback from City staff.

The projects described are the recommended alternatives for each of the secondary systems.

Davis and Vance Street System

CDM Smith recommends the following improvements for the Davis and Vance Street System as shown in **Figure 4-2**:

- Replace 299 linear feet of 18" clay pipe with 30" RCP along Davis Street;
- Replace 117 linear feet of 15" RCP with 24" RCP near 904 Colonial Avenue;
- Replace 31 linear feet of 18" clay pipe with 30" RCP along Davis Street;
- Replace 280 linear feet of 18" RCP with 24" RCP along Davis Street;
- Replace 49 linear feet of 42" CMP with 48" RCP at the downstream end of Vance Street;
- Replace 84 linear feet of 42" CMP with 48" RCP along Vance Street;

- Replace 5 linear feet of 15" RCP with 42" RCP near 10 Vance Street;
- Replace 23 linear feet of 15" RCP with 36" RCP near 6 Vance Street;
- Replace 255 linear feet of 42" CMP with 48" RCP along Vance Street;
- Replace 22 linear feet of 18" RCP with 30" RCP along W 3rd Street across the intersection with Vance Street;
- Replace 10 linear feet of 18" RCP with 30" RCP along W 3rd Street near 806 W 3rd Street;

HMR/SHB
Watershed Master Plan

Figure 4-2
Davis Street and Vance Street System
Proposed Conditions

0 50 100 200 Feet

1 inch = 125 feet

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Replace 49 LF of 42-inch CMP with 48-inch RCP

Replace 5 LF of 15-inch RCP with 42-inch RCP

Abandon Existing Outfall Pipe (Not Shown in Inventory)

Install 143 LF of 30-inch RCP

Replace 144 LF of 15-inch RCP with 30-inch RCP

Replace 255 LF of 42-inch CMP with 48-inch RCP

Replace 84 LF of 42-inch CMP with 48-inch RCP

Replace 23 LF of 15-inch RCP with 36-inch RCP

Replace 30 LF of 18-inch Unnamed with 30-inch RCP

Replace 12 LF of 18-inch Clay with 30-inch RCP

Replace 299 LF of 18-inch Clay with 30-inch RCP

EX 15-in RCP

EX 24-in RCP

EX 24-in RCP

Replace 117 LF of 15-inch RCP with 24-inch RCP

Replace 31 LF of 18-inch Clay with 30-inch RCP

EX 15-in Unnamed Pipe

EX 15-in RCP

EX 15-in RCP

Replace 280 LF of 18-inch Clay with 24-inch RCP

Replace 10 LF of 18-inch RCP with 30-inch RCP

Replace 116 LF of 18-inch RCP with 30-inch RCP

EX 18-in Clay

Replace 100 LF of 18-inch RCP with 30-inch RCP

Replace 17 LF of 15-inch RCP with 24-inch RCP

EX 15-in RCP

EX 15-in RCP

EX 15-in RCP

Replace 39 LF of 15-inch RCP with 24-inch RCP

EX 15-in RCP

Replace 22 LF of 18-inch RCP with 30-inch RCP

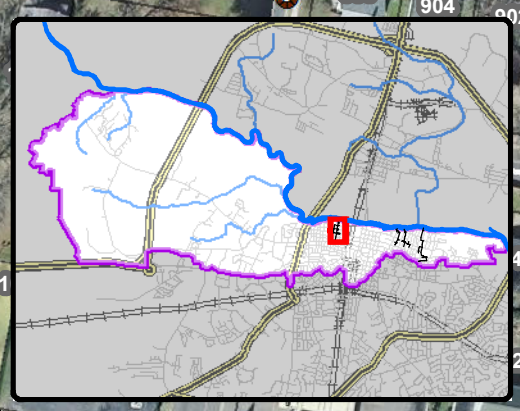
PARK AV
FAIRFAX AV
COLONIAL AV
VANCE ST
DAVIS ST
CONTENTNEA ST
3RD ST
4TH ST
WARD ST
EX 42-in CMP
EX 15-in Clay

Legend

Flooding Reported

- No Flooding Reported
- Living Space
- Crawl Space
- AC Unit or Storage Building
- Yard

- Catch Basin
- Yard Inlet
- Difficult Access Structure
- Drop Inlet
- Junction Box
- Pipe End
- Flared End Section
- Headwall
- Existing Pipes
- Proposed Pipe Improvements
- Proposed Channel Improvements
- Non-Modeled Pipes
- Channel
- Parcel Boundaries
- City-Owned Parcels



- Replace 116 linear feet of 18" RCP with 30" RCP along W 3rd Street near 804 W 3rd Street;
- Replace 100 linear feet of 18" RCP with 30" RCP along W 3rd Street in front of 800 W 3rd Street;
- Replace 39 linear feet of 15" RCP with 24" RCP along Contentnea Street at the corner of 300 Contentnea Street;
- Replace 17 linear feet of 15" RCP with 24" RCP along Contentnea Street at the corner of 206 Contentnea Street;
- Install 9 inlets; and
- Install 9 junction boxes.

The proposed improvements will provide a 10-year LOS for the Davis and Vance Street System. The total estimated cost for the recommended alternative is $1,038,000. The project will be located in the right-of-way therefore there will be no impacts to the driveways, landscaping, and/or fencing on any private properties.

There is curb and gutter located along Davis Street, Vance Street, and W 3rd Street that will need to be removed and replaced as part of this project. Gas lines, water mains, and sanitary sewer lines were identified as potential site restrictions and utility conflicts in the project area.

Jarvis Street – 1st Street – Woodlawn Avenue System

CDM Smith recommends the following improvements for the Jarvis Street – 1st Street – Woodlawn Avenue System as shown in **Figure 4-3**:

- Replace 146 linear feet of 36" CMP with 42" RCP near the end of N Summit Street on the City-owned parcel (parcel no. 018550) behind 200 N Summit Street;
- Abandon 42 linear feet of 36" CMP and replace with 83 linear feet of 42" CMP relocated onto the City-owned parcel (parcel no. 018550) behind 200 N Summit Street;
- Abandon 19 linear feet of 18" CMP and replace with 53 linear feet of 24" RCP relocated onto the City-owned parcel (parcel no. 018550) behind 200 N Summit Street;
- Abandon 60 linear feet of 36" CMP and replace with 42 linear feet of 42" RCP relocated onto the City-owned parcel (parcel no. 018550) behind 200 N Summit Street;
- Abandon 123 linear feet of 36" CMP and replace with 119 linear feet of 42" RCP relocated onto the City-owned parcel (parcel no. 018550) behind 607 Avery Street;
- Abandon 117 linear feet of 15" CMP and replace with 133 linear feet of 15" RCP relocated onto the right-of-way along Avery Street;
- Replace 58 linear feet of 18" unnamed with 42" RCP along Jarvis Street;
- Replace 28 linear feet of 30" RCP with 42" RCP across Jarvis Street;
- Replace 94 linear feet of 36" RCP with 42" RCP along Jarvis Street;

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Watershed Master Plan

Figure 4-3
Jarvis Street System
Proposed Conditions

0 50 100 200 Feet

1 inch = 125 feet

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Tar River

Replace 146 LF of 36-inch CMP with 42-inch RCP

Replace and Relocate 83 LF of 36-inch CMP with 42-inch RCP

EX 12-in RCP

Replace and Relocate 119 LF of 36-inch CMP with 42-inch RCP

Replace 28 LF of 30-inch RCP with 42-inch RCP

Replace and Relocate 53 LF of 18-inch CMP with 24-inch RCP

Replace and Relocate 42 LF of 36-inch CMP with 42-inch RCP

Replace 58 LF of 18-inch Unnamed with 42-inch RCP

Replace 94 LF of 36-inch RCP with 42-inch RCP

Relocate 133 LF of 15-inch CMP to Right-of-Way and Replace with 15-inch RCP

Relocate 56 LF of 36-inch RCP to Right-of-Way and Replace with 36-inch RCP

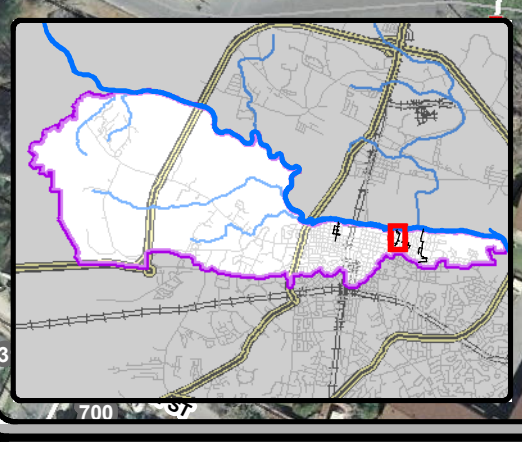
Relocate 435 LF of 36-inch RCP to Right-of-Way and Replace with 36-inch RCP

Relocate 256 LF of 36-inch RCP to Right-of-Way and Replace with 36-inch RCP

EX 36-in CMP

AVERY ST
HOLLY ST
SUMMIT ST
1ST ST
JARVIS ST
2ND ST
3RD ST
WILLOW ST
RIVER DR
PARK DR
WOODLAWN AV

EX 36-in CMP
EX 36-in RCP
EX 15-in RCP



Legend

Flooding Reported
- No Flooding Reported
- Living Space
- Crawl Space
- AC Unit or Storage Building
- Yard

- Catch Basin
- Yard Inlet
- Difficult Access Structure
- Drop Inlet
- Junction Box
- Pipe End
- Flared End Section
- Headwall
- Existing Pipes
- Proposed Pipe Improvements
- Proposed Channel Improvements
- Non-Modeled Pipes
- Channel
- Parcel Boundaries
- City-Owned Parcels

- Abandon 107 linear feet of 30" RCP on the City-owned parcel at 206 N Jarvis Street;
- Abandon 587 linear feet of 36" RCP on private-owned parcels from 120 N Jarvis Street to 705 E 1st Street;
- Relocate 56 linear feet of 36" RCP to right-of-way along Jarvis Street and replace with 36" RCP;
- Relocate 435 linear feet of 36" RCP to right-of-way along Jarvis Street and replace with 36" RCP;
- Relocate 256 linear feet of 36" RCP to right-of-way along 1st Street and replace with 36" RCP;
- Install 4 junction boxes; and
- Install 8 catch basins.

The proposed improvements will provide a 10-year LOS for the Jarvis Street – 1st Street – Woodlawn Avenue System. The total estimated cost for the recommended alternative is $913,000. Small segments of the project are located in the N Jarvis Street right-of-way. The curb and gutter along these roadways will need to removed and replaced. Gas lines, sanitary sewer lines, and water lines were also identified as a potential site restrictions and utility conflicts in the project area.

The majority of the proposed improvements will cause significant impacts to private property. There will be impacts to the driveways, landscaping, and/or fencing at the following private properties:

- 200 N Summit Street;
- 603 Avery Street;
- 605 Avery Street;
- 607 Avery Street; and
- 206 N Jarvis Street.

Harding Street and 1st Street System

CDM Smith recommends the following improvements for the Harding Street – 1st Street System as shown in **Figure 4-4**:

- Replace 44 linear feet of 30" CMP with 42" CMP across River Drive near 201 River Drive;
- Expand the 146 linear feet of the trapezoidal channel from a depth of 15.6" to a depth of 24" and a bank slope of 3:2 (H:V) along the rear of the City-owned parcel at the corner of Willow Street and River Drive;
- Replace 55 linear feet of 24" CMP with 42" CMP across Willow Street near 803 Willow Street;

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Watershed Master Plan

Figure 4-4
Harding Street System
Proposed Conditions

0 50 100 200 Feet

1 inch = 125 feet

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Tar River

RIVER DR

JARVIS ST

WILLOW ST

WOODLAWN AV

PARK DR

HARDING ST

LIBRARY ST

EASTERN ST

ROTARY AV

1ST ST

Replace 44 LF of 30-inch CMP with 42-inch RCP

Deepen Channel to 2-ft Adjust Bank Slope to 3:2 (H:V)

Replace 55 LF of 24-inch CMP with 42-inch RCP

EX 12-in CMP

EX 12-in RCP

Install 120 LF of 42-inch RCP

Install 43 LF of 42-inch RCP

Install 128 LF of 42-inch RCP

EX 24-in RCP

Install 638 LF of 42-inch RCP

Install 163 LF of 36-inch RCP

Replace 268 LF of 12-inch Unnamed with 30-inch RCP

EX 18-in CMP

Replace 263 LF of 24-inch RCP with 30-inch RCP

Replace 16 LF of 24-inch RCP with 36-inch RCP

Replace 16 LF of 15-inch Unnamed with 24-inch RCP

EX 15-in RCP

EX 12-in RCP

EX 24-in RCP

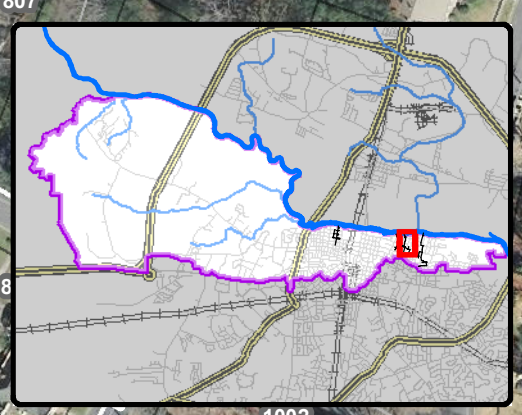
EX 18-in RCP

Legend

Flooding Reported

- No Flooding Reported
- Living Space
- Crawl Space
- AC Unit or Storage Building
- Yard

- Catch Basin
- Yard Inlet
- Difficult Access Structure
- Drop Inlet
- Junction Box
- Pipe End
- Flared End Section
- Headwall
- Existing Pipes
- Proposed Pipe Improvements
- Proposed Channel Improvements
- Non-Modeled Pipes
- Channel
- Parcel Boundaries
- City-Owned Parcels



- Abandon 20 linear feet of 24" CMP and replace with 43 linear feet of 42" RCP relocated onto the right-of-way along Willow Street;
- Abandon 88 linear feet of 24" RCP and replace with 120 linear feet of 42" RCP relocated onto the right-of-way along Willow Street;
- Abandon 91 linear feet of 24" unnamed pipe on the parcel at 806 Willow Street;
- Abandon 328 linear feet of 24" RCP from 114 Park Drive to 106 Park Drive;
- Abandon 134 linear feet of 24" RCP form 106 Park Drive to 101 N Harding Street;
- Install 128 linear feet of 42" RCP along Willow Street;
- Install 638 linear feet of 42" RCP along Harding Street;
- Install 163 linear feet of 36" RCP along Harding Street;
- Replace 268 linear feet of 12" unnamed pipe with 30" RCP along 1St Street;
- Replace 16 linear feet of 24" RCP with 36" RCP across the intersection of Harding Street and 1st Street;
- Replace 263 linear feet of 24" RCP with 30" RCP across 1st Street;
- Replace 16 linear feet of 15-inch unnamed pipe with 24" RCP along Library Street;
- Install two 42" flared end sections;
- Install 3 junction boxes; and
- Install 3 catch basins.

The proposed improvements provide a 10-year LOS for the Harding Street – 1st Street System. The total estimated cost for the recommended alternative is $1,142,000. Small segments of the project are located in the Willow Street right-of-way as well as the E 1st Street right-of-way. The curb and gutter along these roadways will need to removed and replaced. Gas lines, sanitary sewer lines, and water lines were also identified as a potential site restrictions and utility conflicts in the project area.

The majority of the proposed improvements will cause significant impacts to private property. There will be impacts to the driveways, landscaping, and/or fencing at the following private properties:

- 802 River Drive;
- 803 Willow Drive;
- 806 Willow Drive;
- 114 Park Drive;
- 112 Park Drive;
- 108 Park Drive;

- 106 Park Drive;
- 105 N Harding Street;
- 103 N Harding Street; and
- 101 N Harding Street;

One resident within the project area reported flooding. The resident at 105 N Harding Street reported crawl space flooding. The recommended improvements will reduce the frequency and severity of the LAG and yard flooding for these residents. However, without the elevation of the crawl spaces, it cannot be determined if the crawl space flooding will be eliminated. There are also two residents just outside of the project area that reported flooding. Residents at 100 N Eastern Street and 102 N Eastern Street both reported living space flooding.

Elm Street – 4th Street System

CDM Smith recommends the following improvements for the Elm Street – 4th Street System as shown in **Figures 4-5 and 4-6**:

- Replace 188 linear feet of 36" CMP with 48" RCP from River Drive to the Tar River outfall;
- Replace 35 linear feet of 36" CMP with dual barrel 42" RCP along the green space near River Drive;
- Replace 395 linear feet of 30" CMP with dual barrel 42" RCP along the green space near River Drive;
- Replace 239 linear feet of 30" CMP with dual barrel 42" RCP along N Elm Street;
- Replace 205 linear feet of 30" CMP with dual barrel 42" RCP along N Elm Street;
- Replace 184 linear feet of 30" CMP with dual barrel 42" RCP along Willow Street;
- Replace 26 linear feet of 30" CMP with dual barrel 42" RCP through the parcel at 117 Elm Street;
- Replace 349 linear feet of 24" CMP with dual barrel 42" RCP through the parcel at 117 Elm Street;
- Replace 222 linear feet of 24" CMP with dual barrel 42" RCP from the parcel at 117 Elm Street to E 1st Street;
- Install 34 linear feet of dual barrel 42" RCP along Elm Street at the corner of Elm Street and Willow Street;
- Install 364 linear feet of dual barrel 42" RCP along Elm Street right-of-way;
- Install 193 linear feet of dual barrel 42" RCP along Elm Street right-of-way;
- Replace 245 linear feet of 24" RCP with 273 linear feet of 36" RCP along 1st Street near the intersection of 1st Street and Elm Street;
- Abandon 277 linear feet of 18" RCP with 30" RCP along S Elm Street;

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Figure 4-5
Elm Street System North
Proposed Conditions

0 50 100 200 Feet

1 inch = 125 feet

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N

Tar River

RIVER DR
EASTERN ST
STANCILL DR
WILLOW ST
ELM ST
OAK ST
ASH ST
MEADE ST
1ST ST

Replace 188 LF of 36-inch CMP with 48-inch RCP

Replace 35 LF of 36-inch Unnamed with Dual Barrel 42-inch RCP

Replace 395 LF of 30-inch Unnamed with Dual Barrel 42-inch RCP

Replace 239 LF of 30-inch CMP with Dual Barrel 42-inch RCP

Replace 205 LF of 30-inch CMP with Dual Barrel 42-inch RCP

Install 34 LF of Dual Barrel 42-inch RCP

Replace 184 LF of 30-inch CMP with Dual Barrel 42-inch RCP

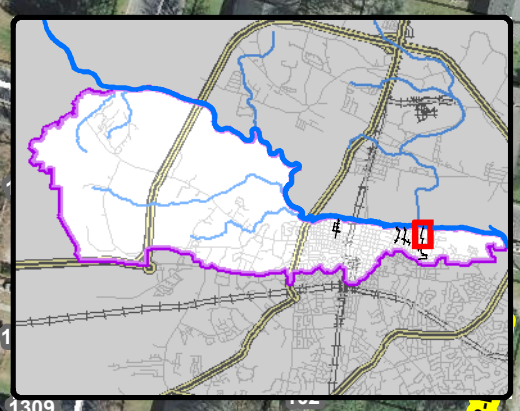
Install 364 LF of 42-inch RCP

Install 193 LF of 42-inch RCP

Replace 273 LF of 24-inch RCP with 36-inch RCP

EX 24-in CMP

EX 24-in CMP



Legend

Flooding Reported

- No Flooding Reported
- Living Space
- Crawl Space
- AC Unit or Storage Building
- Yard

- Catch Basin
- Yard Inlet
- Difficult Access Structure
- Drop Inlet
- Junction Box
- Pipe End
- Flared End Section
- Headwall
- Existing Pipes
- Proposed Pipe Improvements
- Proposed Channel Improvements
- Non-Modeled Pipes
- Channel
- Parcel Boundaries
- City-Owned Parcels

HMR/SHB
Watershed Master Plan

Figure 4-6
Elm Street System South
Proposed Conditions

0 50 100 200 Feet

1 inch = 125 feet

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Install 193 LF of 42-inch RCP

Replace 273 LF of 24-inch RCP with 36-inch RCP

Install 321 LF of 42-inch RCP

Install 217 LF of 42-inch RCP

Install 680 LF of 42-inch RCP

Replace 62 LF of 24-inch CMP with 42-inch RCP

Install 31 LF of 42-inch RCP

Replace 154 LF of 24-inch CMP with 42-inch RCP

Install 121 LF of 42-inch RCP

Replace 20 LF of 24-inch RCP with 42-inch RCP

Replace 20 LF of 24-inch RCP with 36-inch RCP

Replace 18 LF of 24-inch RCP with 36-inch RCP

EX 12-in RCP

Replace 112 LF of 12-inch CMP with 18-inch RCP

Replace 295 LF of 24-inch Unnamed with 36-inch RCP

Replace 222 LF of 18-inch RCP with 24-inch RCP

Replace 181 LF of 15-inch RCP with 24-inch RCP

Replace 44 LF of 15-inch RCP with 24-inch RCP

Replace 118 LF of 15-inch CMP with 24-inch RCP

Replace 126 LF of 18-inch CMP with 24-inch RCP

Replace 35 LF of 15-inch RCP with 24-inch RCP

EX 24-in CMP

EX 18-in RCP

EX 12-in RCP

EX 24-in CMP

EX 24-in CMP

MEADE ST

OAK ST

1ST ST

2ND ST

3RD ST

ELM ST

4TH ST

OAK ST

ASH ST

WARREN ST

MAPLE ST

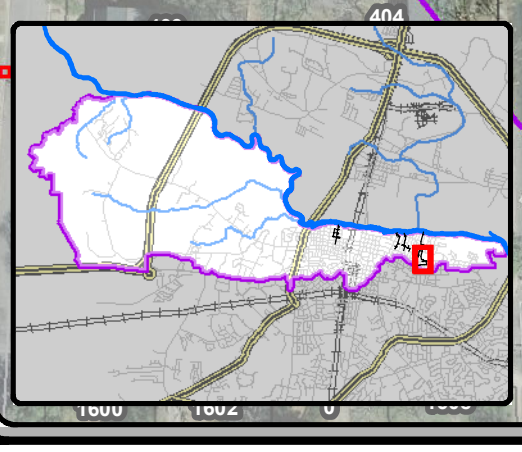
5TH ST

Legend

Flooding Reported

- No Flooding Reported
- Living Space
- Crawl Space
- AC Unit or Storage Building
- Yard

- Catch Basin
- Yard Inlet
- Difficult Access Structure
- Drop Inlet
- Junction Box
- Pipe End
- Flared End Section
- Headwall
- Existing Pipes
- Proposed Pipe Improvements
- Proposed Channel Improvements
- Non-Modeled Pipes
- Channel
- Parcel Boundaries
- City-Owned Parcels



- Abandon 438 linear feet of 24" CMP with 42" RCP from E 1st Street continuing into Wilson Acres apartment complex at 1806 E 1st Street;
- Abandon 532 linear feet of 24" CMP with 42" RCP through Wilson Acres apartment complex;
- Abandon 24 linear feet of 24" CMP with 42" RCP through Wilson Acres apartment complex;
- Install 321 linear feet of 42" RCP along Elm Street right-of-way;
- Install 217 linear feet of 42" RCP along Elm Street right-of-way;
- Install 680 linear feet of 42" RCP along Elm Street and 3rd Street right-of-way;
- Install 121 linear feet of 42" RCP along 3rd Street right-of-way;
- Replace 112 linear feet of 12" CMP with 18" RCP across the intersection of Oak Street and 3rd Street;
- Install 31 linear feet of 42" RCP along the 3rd Street right-of-way;
- Replace 62 linear feet of 24" CMP with 42" RCP along 3rd Street;
- Replace 154 linear feet of 24" CMP with 42" RCP along 3rd Street;
- Replace 20 linear feet of 24" RCP with 42" RCP across 3rd Street;
- Replace 20 linear feet of 24" RCP with 36" RCP across 3rd Street along Ash Street;
- Replace 18 linear feet of 24" RCP with 36" RCP along Ash Street;
- Replace 295 linear feet of 24" unnamed pipe with 36" RCP along Ash Street;
- Replace 222 linear feet of 18" RCP with 24" RCP along 4th Street;
- Replace 126 linear feet of 18" CMP with 24" RCP along 4th Street;
- Replace 118 linear feet of 15" CMP with 24" RCP along 4th Street;
- Replace 181 linear feet of 15" RCP with 24" RCP along 4th Street;
- Replace 44 linear feet of 15" RCP with 24" RCP across 4th Street at the intersection of 4th Street and Elm Street;
- Replace 35 linear feet of 15" RCP with 24" RCP across Elm Street;
- Install 10 junction boxes; and
- Install 10 catch basins.

The proposed improvements will provide a 10-year LOS for the Elm Street – 4th Street System. Upsizing the system will reduce the frequency and severity of the flooding experienced by neighboring business owners. The total estimated cost for the recommended alternative is $3,049,000.

The proposed improvements include upsizing and additional barrel segments of pipe through 117 N Elm Street and upsizing through Wilson Acres apartment complex at 1806 E 1st Street. There will be potential impacts to the parking lots, landscaping, and/or fencing at the following private properties:

- 117 N Elm Street;
- 1806 E 1st Street;

Small segments of the project are located in the E 1st Street right-of-way as well as the E 3rd Street right-of-way and the E 4th Street right-of-way. The curb and gutter along these roadways will need to removed and replaced. Gas lines, sanitary sewer lines, and water lines were also identified as a potential site restrictions and utility conflicts in the project area.

4.3 High Risk Areas for 25-year Detention

In 2014, the City of Greenville enacted legislation requiring attenuation for new development and re-development for the one-year, five-year, and ten-year, 24-hour storm events. In addition, Section 9-9-10 of Ordinance No. 13-054 states the following:
"New development and redevelopment, as described in section 9-9-3, in areas at special risk with well documented water quantity problems as determined by the City Engineer, shall not result in a net increase in peak flow leaving the site from pre-development conditions for the 25-year, 24-hour storm event."
As part of the Parkers Creek/Johnsons Mill Run (PC/JMR) Watershed Master Plan, an analysis was completed to determine if there are areas within the watershed and the ETJ that should be considered "well documented water quantity problems" requiring detention for the 25-year, 24-hour storm event. Areas may be defined as well documented water quantity problems if either of the following is true:

- Structural flooding has been historically noted by property owners during storms considered smaller than the design event and this structural flooding has been corroborated by either high water marks, City staff input, or model results.

- Model results indicate structural flooding or roadway overtopping during storms smaller than the design storm and models results are corroborated by City staff input.

Portions of the watershed draining to the "well documented water quantity problems" may be considered for 25-year detention if any of the following are true:

- Future condition flows are 10% or greater than existing flows for a given subwatershed upstream of the water quantity problem.

- Proposed capital projects are not deemed to be feasible or cost effective for providing the required level of service for these water quantity problems based on future land use conditions.

- Cost differential between designing for existing conditions and future conditions is deemed to be significant and/or a significant number of structures would become floodprone during the 25-year design storm based on future conditions flows when compared to existing conditions flows.

It is assumed that for this analysis, systems with a 10-year level of service design would not

be considered for the 25-year detention since the 10-year detention requirements would result in little to no increase in peak flows for the design event. Typically, this would include most secondary systems, although secondary systems with significant documented water quantity problems that also includes infrastructure requiring a level of service greater than a 10-year event may be evaluated for the 25-year detention requirement.

4.3.1 Evaluation

As noted in Section 3.1 crossings at W. 5th Street on Schoolhouse Branch do not meet the required level of service (LOS) based on model results. However, based on interviews with City staff and resident feedback these crossings are not considered well-documented water quantity problems as a history of overtopping at these crossings has not been observed. The future 25-year flows within the primary streams are a maximum of 17% higher than existing flows just upstream of the 5th Street crossing. However, since the W. 5th Street culvert improvements are required to provide a 50-year level of service, it is assumed that 25-year detention upstream of the culvert would not result in substantial cost savings when designing to a 50-year level of service. These crossings on Schoolhouse Branch are already subject to flooding for less than the design storm, requiring 25-year detention upstream of the project area is not recommended.

It is recommended that the City carefully consider any re-zoning applications and/or annexation requests in the ETJ draining to Parkers Creek to determine if a change from the projected zoning would change the projected future flows and thereby possibly necessitate detention for the 25-year storm event.

4.3.2 Results

In summary, based on an analysis of the PC/JMR watershed evaluating feedback from the public, City staff, model results, and anticipated future development, there are no recommendations for requiring 25-year detention for future development in the PC/JMR watershed.

SECTION 5
WATER QUALITY RECOMMENDATIONS

Traditional stormwater management has typically been designed to reduce flooding, but at times has neglected water quality by collecting runoff directly from impervious surfaces and discharging directly into a stream causing erosion and deterioration of water quality. Runoff from impervious areas collects high concentrations of pollutants and nutrients that if left untreated can cause negative impacts to water quality in the receiving waters. Negative impacts may include less biodiversity, hazards to the health of fish and wildlife, as well as human health hazards. High flows in streams cause bank erosion adding additional sediment into the riparian habitat. Many communities in North Carolina now require some form of water quality treatment for new development; however existing developments typically have little or no water quality treatment. The City of Greenville developed a Stormwater Management Program (September, 2004) to outline its water quality requirements.

The HMR/SHB watersheds do not currently have any identified water quality impairments. Stream stabilization and water quality improvement projects were evaluated and recommended below to protect and improve water quality within the watersheds and in the downstream receiving waters of the Tar River.

Stream stabilization projects can be constructed to reduce instream sediment loads and to protect private property from further erosion. Best management practices (BMPs) can be constructed to treat runoff prior to being discharged to the stormwater conveyance system and ultimately the receiving waters of the system. Retrofitting BMPs can be difficult due to limited space and other constraints. Stream stabilization projects and BMP retrofits identified in the HMR/SHB Watershed are described below.

5.1 Stream Stabilization Projects

Based on the basin wide stream assessment completed as described in Section 3.3, three stream stabilization projects were identified to help reduce instream erosion. Generally, streams with high bank erosion hazard index (BEHI) scores are good candidates for stabilization. However, not all sites with high BEHI scores are recommended for stabilization. Reaches along Sains Branch and Harris Mill Run have high BEHI scores due to incised channels with high, steep banks, but the channel reaches are relatively stable and surrounded by forest and are therefore not recommended for stabilization projects.

Instream erosion can be a significant source of sediment that ultimately can impair the biodiversity of the downstream receiving waterbodies. Furthermore, in urban watersheds such as HMR/SHB, stream erosion is often a threat to private property and potentially the safety of structures adjacent to the stream. The proposed stream stabilization projects will have impacts to property owners that will require temporary construction easements to complete the work and permanent easements for maintenance access. Proposed projects assume that the riparian buffers can be restored to existing conditions. During final design the City will need to refer to the current buffer regulations to determine if more significant buffer restoration is required. The three projects (not presented in order of importance) are described below.

5.1.1 Stream Stabilization Project 1 – Sams Branch Ironwood Golf and Country Club

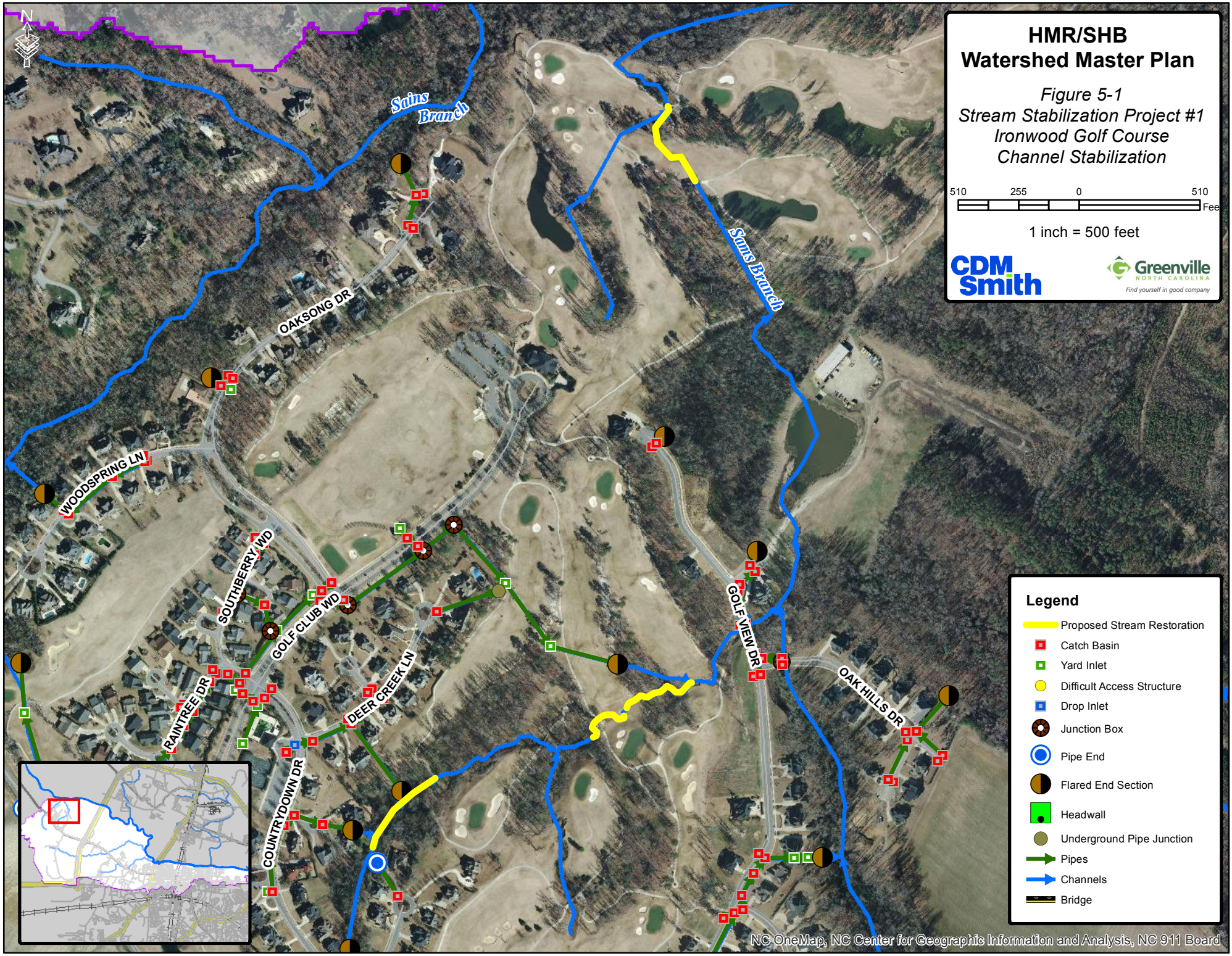
The Sams Branch Ironwood Golf and Country Club Project 1 consists of four sub-projects or reaches, which because of similarity and location are discussed together. Three are located on well-maintained golf course fairways, which consist of short-cropped turf grasses that do not stabilize stream bank soils as well as deeper-rooted woody vegetation. To maintain their intended uses as golf course fairways, corrective bank stabilization will likely include in-channel measures with riprap, root wads, or other materials with a low vertical profile and minimal lateral impacts. The projects are number progressing upstream as shown in **Figures 5-1 and 5-2**. The fourth and most upstream reach differs from the other reaches because it does not traverse directly through the golf course with maintained turf to the edge of top of the bank, but is in a narrow forested area between residential properties, and is more severely incised. The total cost for stabilization of all 4 reaches is estimated at $730,000 as listed in Appendix I.

5.1.1.1 Ironwood Golf Course Reach 1

Ironwood Golf Course Reach 1 is located on a segment of Sams Branch between the 14th and 17th Hole tee boxes of the Ironwood Golf Course. The project area begins approximately 25 feet south of the 14th Hole cart path bridge and follows the stream north until ending at the 17th Hole cart path bridge. While the entire 500-foot reach is actively eroding, the most severe erosion occurs in fairway areas near the two cart path bridges and on outside channel bends. Some areas, particularly around the 14th Hole cart path bridge, have been stabilized with riprap, but even these areas need supplemental stabilization measures.

Photograph 5-1: Bank Erosion on Right Bank Facing Downstream

Ironwood Golf Course reaches 1-3 are second order perennial sections of Sams Branch and have a drainage area ranging from of approximately 125 acres. Land use surrounding this project consists mainly of residential houses, fragmented woodlots, and a maintained golf course. The proposed project reach flows largely south to north and is confined within a very steep, eroded channel feature. The bottom width (streambed) ranges in width from approximately 5 to 12 feet wide. Both the left and right banks reach heights of 8 feet tall and have nearly vertical banks. The top channel width is between 15-30 feet wide. This channel has no forested buffer and cannot accommodate the high flows from upstream impervious and residential areas without high rates of erosion. Bank conditions are currently unstable and eroding at an accelerated rate due to highly-erodible, loamy sand soils and frequent, high-velocity flash storm events. In some project areas, erosion is severe enough to begin encroaching on golf course structures like cart paths and tee boxes and threaten cart path bridges.


HMR/SHB
Watershed Master Plan
Figure 5-1
Stream Stabilization Project #1
Ironwood Golf Course
Channel Stabilization
510 255 0 510
Fee
1 inch = 500 feet
CDM Smith
Greenville
NORTH CAROLINA
Find yourself in good company
Sains Branch
Sains Branch
OAKSONG DR
WOODSPRING LN
SOUTHBERRY WD
GOLF CLUB WD
RAINTREE DR
DEER CREEK LN
COUNTRYDOWN DR
GOLF VIEW DR
OAK HILLS DR
Legend
Proposed Stream Restoration
Catch Basin
Yard Inlet
Difficult Access Structure
Drop Inlet
Junction Box
Pipe End
Flared End Section
Headwall
Underground Pipe Junction
Pipes
Channels
Bridge
NC OneMap, NC Center for Geographic Information and Analysis, NC 911 Board

The proposed project reach has opportunities for bank stabilization to reduce sediment loading and bank erosion to Sams Branch East. Good accessibility is provided by open golf course areas and the golf course cart path adjacent to the project reach. To improve bank stability and reduce bank erosion along the proposed reach, several corrective measures can be implemented. Bank erosion can be reduced by grading channel banks to a minimum 2:1 slope and placement of coir erosion control matting along banks and bare areas. In areas where grading to such slopes is prevented due to nearby golf course structures, steep stream banks can be graded as shallow as possible and armored with wood retaining walls, or other stabilizing materials. Where possible, native vegetation should be preserved. Live staking with short willows within the channel may help prevent future undercutting and bank failures. To further reduce the effects of high velocities downcutting the stream bed, several large boulder structures or riprap can be placed within the streambed at the toe of the bank.

The stream project will run along Ironwood Golf Course Holes 14 and 17, which may result in potential impacts to cart paths, cart path bridges, and landscaping not included in the estimated cost.

5.1.1.2 Ironwood Golf Course Reach 2

Ironwood Golf Course Reach 2 is located approximately 175 feet upstream of the Golf View Drive crossing on Hole 12 of the Ironwood Golf Course. The project begins at the Hole 12 cart path, where the stream emerges out of a wooded lot on the east side of the Hole 12 fairway. It continues approximately 265 feet to the west, and ends at the wooded lot on the west side of the Hole 12 fairway. The last 100 feet consists of a reach where an incised, ephemeral tributary enters Sams Branch from the northwest. Both the ephemeral tributary and the Sams Branch main stem are actively eroding and would benefit from stabilization measures; therefore, the total reach length for the Golf Course Reach 2 is approximately 350 feet.

Photograph 5-2.: Bank Erosion on Right Bank Facing Downstream

Regardless of the chosen corrective action, the stream project will run along Ironwood Golf Course Hole 12, which may result in potential impacts to cart paths, cart path bridges, and landscaping.

Ironwood Golf Course Project 2 is a second order perennial section of Sams Branch and has a drainage area of approximately 125 acres. Land use surrounding this project consists mainly of residential houses, fragmented woodlots, and a maintained golf course. The proposed project reach flows largely west to east and is confined within a very steep, eroded channel feature.

5.1.1.3 Ironwood Golf Course Reach 3

Ironwood Golf Course Project 3 is located on the Sams Branch mainstream approximately 700 feet west of Golf View Drive in the fairway of Hole 10. The project begins at the edge of a wooded lot on the east side of the Hole 10 fairway and continues approximately 225 feet upstream to the cart path bridge located on the west side of the Hole 10 fairway. The downstream extent of the project is located approximately 175 feet from the upstream extent of Ironwood Golf Course Project 2. While the entire 225-foot reach exhibits moderate to severe erosion, the most severe erosion occurs along the middle 75-feet of the reach on a large outer bend in the channel.

Ironwood Golf Course Project 3 is a second order perennial section of Sams Branch and has a drainage area of approximately 100 acres. Land use surrounding this project consists mainly of residential houses, fragmented woodlots, and a maintained golf course. The proposed project reach flows largely west to east and is confined within a steep, eroded channel feature. The bottom width (streambed) is approximately 5 to 8 feet wide. While the left bank has a shallow slope and averages 5 feet in height, the right is steep and can reach 12 feet in height. The bank angle of the left bank is 60-70 degrees; whereas the right bank possess a bank angle of 85-90 degrees. The average top channel width is largely 18 feet. Within the project reach, the channel has no forested buffer and cannot accommodate the high flows from upstream impervious and residential areas. Bank conditions are currently unstable and eroding at an accelerated rate due to the absence of a buffer, highly-erodible, loamy-sand soils, and frequent, high-velocity flash storm events. In some project areas, erosion is severe enough to begin encroaching on golf course structures like cart paths, cart path bridges, greens, and sand bunkers.

Photograph 5-3: Bank Erosion on Right Bank Facing Downstream

The proposed project reach has opportunities for bank stabilization to prevent sediment loading and bank erosion to Sams Branch. Good accessibility is provided by open golf course areas and the golf course cart path adjacent to the project reach; however, mechanized equipment would have to travel 700 feet from the nearest paved road (Golf View Drive). To improve bank stability and reduce bank erosion along the proposed reach, several corrective measures can be implemented. Bank erosion can be reduced by grading channel banks to a minimum 2:1 slope and placing coir erosion control matting along banks and bare areas. In areas where grading to such slopes is prevented due to nearby golf course structures, steep stream banks can be graded as shallow as possible and armored with riprap, root wads, or other stabilizing materials. Where possible, native vegetation should be preserved. Live staking with willows or other short shrubs within channel may help prevent future

undercutting and bank failures. To further reduce the effects of high velocities, several large boulder structures or riprap can be placed within the streambed at the toe of bank.

The stream project will run along Ironwood Golf Course Hole 10, which may result in potential impacts to cart paths, cart path bridges, and landscaping.

5.1.1.4 Sams Branch Headwaters – Reach 4

Upstream of the reaches through the golf course outlined in Project 1, the Sams Branch Headwaters project begins on Sams Branch between the Bluebeech Lane and Silverleaf Court cul-de-sacs in the Ironwood Golf and Country Club residential subdivision. The project begins on Sams Branch at the riprap lined stormwater channel adjacent to 300 Silverleaf Court and continues downstream for approximately 400 feet to a bridged golf course cart path between the green of Hole 8 and the tee box of Hole 9. For the first 100 feet, the project reach includes a secondary, highly-eroded channel that originates from the riprap lined stormwater channel that parallels and eventually joins Sams Branch from the west. The stormwater channel and stream channel are separated by an elevated wooded island.

Photograph 5-4.: Channel Incision Facing Downstream

The Sams Branch Headwaters project is a first order perennial section of Sams Branch and has a drainage area of approximately 60 acres. Land use surrounding this project consists mainly of residential houses, fragmented woodlots, and offset from the channel, a maintained golf course. The contributing drainage area from NC Highway 43 and Country Down Drive has a piped drainage system concentrating and conveying flows to this channel without any apparent stormwater peak flow or volume controls. The proposed project reach flows largely south to north and is confined within an extremely steep, eroded gulley feature. The bottom width (streambed) is approximately 3 to 4 feet wide with clay bed and banks. Both the left and right banks are nearly 20 feet tall at the deepest and have nearly vertical banks. The average top channel width is roughly 55 feet wide. This channel has a narrow forested buffer that is about 150-feet wide; however, the drainage area is largely un-forested and the channel cannot accommodate the frequency and magnitude of runoff flows from

Photograph 5-5: Deeply incised channel and steep banks facing downstream

upstream impervious and residential areas. Bank conditions are held at such extreme heights by the predominantly cohesive clay soils, however upstream in the reach are unstable banks, eroding rapidly due to highly-erodible, loamy-clay soils and frequent, high-velocity flash storm events. In some project areas, erosion is severe enough to begin encroaching on residential backyards.

The proposed project reach has opportunities for bank stabilization to prevent sediment loading and bank erosion to Sams Branch. Good accessibility is provided by open lawn and golf course areas and the paved golf course cart path and residential cul-de-sacs adjacent to the project reach. Grading banks to stable dimensions would require prohibitively extensive lateral grading and removal of native woody vegetation. To improve bank stability and reduce further bed and bank erosion along the proposed reach, a step-pool stormwater conveyance is recommended. To further reduce the effects of high velocities, several large boulder structures or riprap can be placed within the streambed at the toe of bank.

The stream project will run along the backside of several private residential properties on Bluebeech Lane, Deer Creek Lane, and Silverleaf Court and Ironwood Golf Course holes 8 and 9, which may result in potential impacts to landscaping.

5.1.2 Stream Stabilization Project 2 – Schoolhouse Branch Earthen Dam

This dam removal and stream stabilization project begins approximately 1,200 feet east of the end of Reba Drive and 700 feet northeast of the Golden Living Centers building on MacGregor Downs Road on Schoolhouse Branch. As shown on **Figure 5-2**, the project consists of an earthen dam that currently impounds Schoolhouse Branch creating a shallow (0-3 feet deep) pond and wetland complex. The earthen dam has fallen into disrepair after years of neglect and its structural integrity has been compromised by erosion. The dam appears to be subject to piping resulting in a large hole in the dam rendering the dam subject to imminent failure. The impoundment currently stores reduces peak flows experienced by the downstream channel, which has some impact on reducing downstream flooding.

Photograph 5-6: Earthen Dam Failing

The recommended improvement project is staged removal of the dam and stream restoration which would eliminate the likelihood of sudden dam collapse and the potential sedimentation effects on the downstream system. A two-foot vertical drop at the end of pipe contributes to the deeply incised and actively eroding channel immediately downstream of the dam caused by the sediment starved discharge from the impoundment.

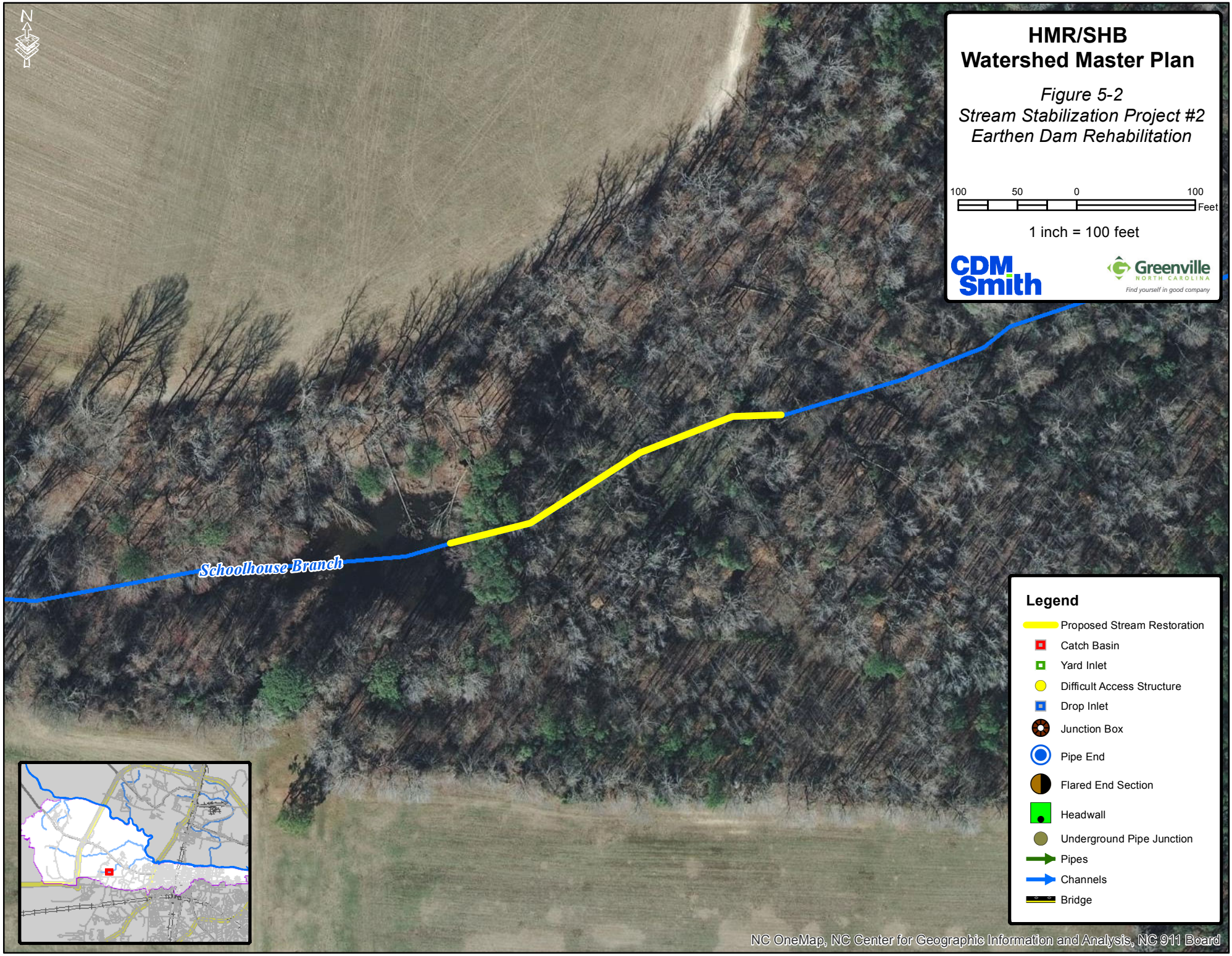
The Schoolhouse Branch Earthen Dam Erosion Control project is located on a first order perennial section of Schoolhouse Branch. The project reach, starting from the upstream extent of the pond to the downstream extent of severe erosion, is approximately 600 feet,

and has a drainage area of approximately 150 acres. Land use surrounding this project consists mainly of a retirement community, forest, and agricultural land. The proposed project reach flows largely west to east and is confined within a narrow riparian buffer approximately 400 feet wide. The bottom width (streambed) is approximately 4 to 5 feet wide. Both the left and right banks downstream are nearly 6 feet tall and have slightly less than vertical (80°) banks. The average top channel width is approximately 10 feet wide. Bank conditions are currently unstable and eroding at an accelerated rate due to a sudden drop in elevation, high-velocity flow coming out end-of-pipe, and highly-erodible, loamy-sand soils.

Photograph 5-7: Outlet pipe and resulting erosion downstream of earthen dam

The proposed project reach has opportunities for channel restoration and bank stabilization to prevent bank erosion and sediment loading to Schoolhouse Branch. Relatively good accessibility is provided by a dirt farm road to the north and the open lawn and parking lot of the Golden Living Centers to the southwest; however, the final 200 feet to the stream from the north and south is wooded. Grading banks to stable dimensions would require prohibitively extensive lateral grading and removal of native woody vegetation. Therefore, to improve bank stability and reduce further bed and bank erosion along the proposed reach, dam removal or modification and a step-pool channel morphology is recommended. To further reduce the effects of high velocities due to the sudden change in elevation, several large boulder structures or riprap can be placed within the streambed at the toe of bank.

The estimated cost for the Schoolhouse Branch – Earthen Dam Erosion Control project is $250,000. While the proposed project itself is located away from structures and facilities, construction staging areas will likely have to be located on private properties to the north or south, which may result in temporary impacts to desired land uses.


N
HMR/SHB
Watershed Master Plan
Figure 5-2
Stream Stabilization Project #2
Earthen Dam Rehabilitation
100 50 0 100
Feet
1 inch = 100 feet
CDM Smith
Greenville
NORTH CAROLINA
Find yourself in good company
Schoolhouse Branch
Legend
Proposed Stream Restoration
Catch Basin
Yard Inlet
Difficult Access Structure
Drop Inlet
Junction Box
Pipe End
Flared End Section
Headwall
Underground Pipe Junction
Pipes
Channels
Bridge
NC OneMap, NC Center for Geographic Information and Analysis, NC 911 Board

5.1.3 Stream Stabilization Project 3 – Beasley Drive Channel Stabilization

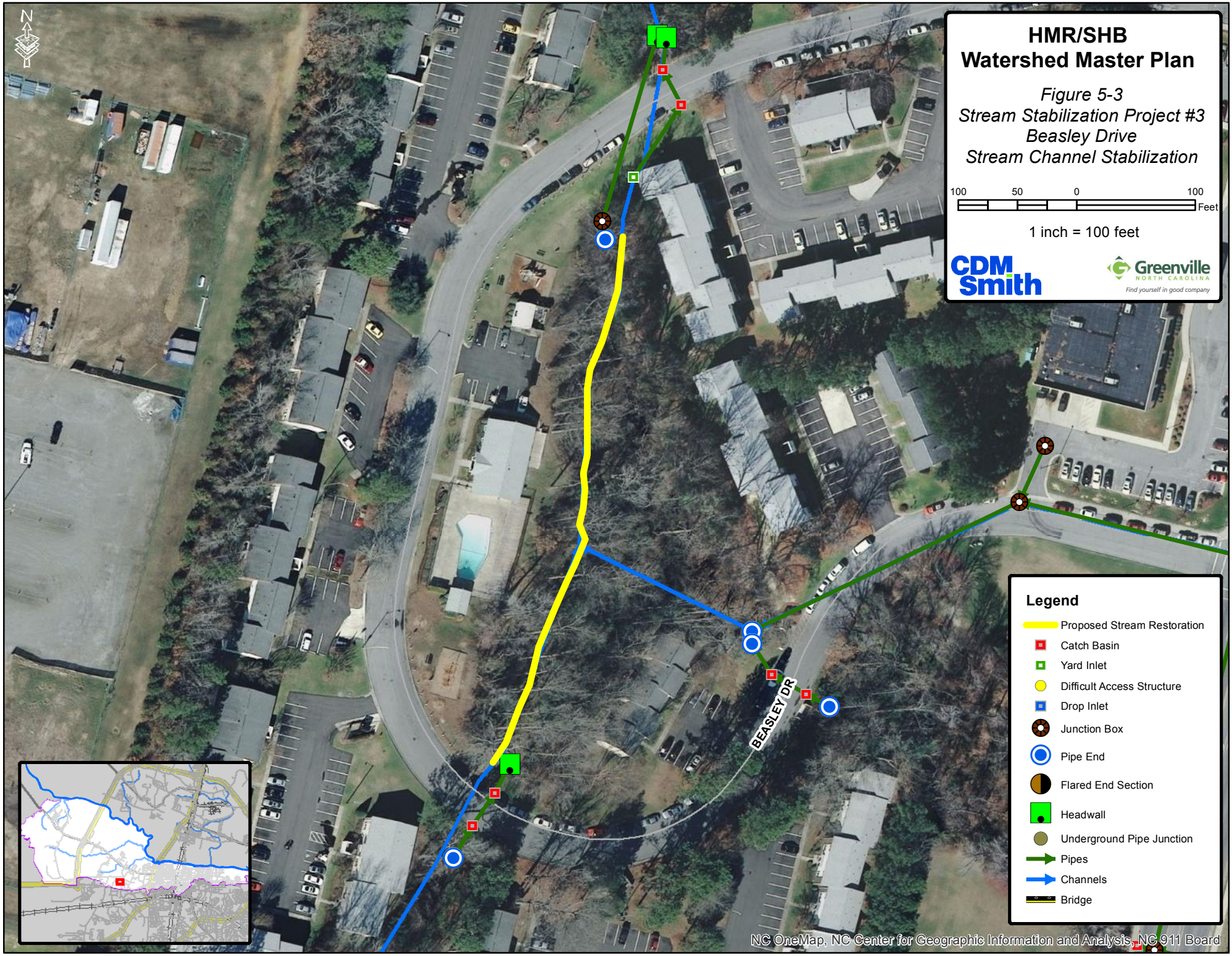
A channel stabilization project on unnamed tributary to Schoolhouse Branch is located approximately 2,500 feet south of its confluence with Schoolhouse Branch, which is near the intersection of W 5th Street (Route 43) and W Arlington Boulevard. The unnamed tributary originates from a stormwater retention pond behind the Stanton Square Shopping Center, approximately 300 feet upstream of the project reach. The upstream BMP intended to attenuate runoff flows is not functioning properly because it is not holding water above the low level outlet. Repair or replacement of the pond outlet control structure is recommended to regain storage capacity and volume control on this reach. As shown on **Figure 5-3**, the 500-foot project reach is bounded on both the north and south by Beasley Drive.

Photograph 5-8: Plunge pool formation at Beasley Dr. culvert

The channel is severely incised and rapid downcutting is evident, particularly at the top of the reach. Here the drop from the culvert spanning Beasley Drive to the water surface is approximately 6 feet. Active bank scour is also present, likely as a result of the impervious nature of much of the watershed causing high-velocity flows during storm events. The upstream 300 feet of the project reach are the most severely degraded, with the stream and banks gradually stabilizing along the downstream 200 feet of the reach. At the downstream terminus of the project reach is a 6-foot tall riser to help accommodate high storm flows.

Photograph 5-9: Near vertical banks upstream portion of the project reach

The Unnamed Tributary to Schoolhouse Branch project is located on a first order perennial section of an unnamed tributary to Schoolhouse Branch. The project reach has a drainage area of approximately 35 acres. Land use surrounding this project consists largely of impervious asphalt associated with the adjacent apartment complex and Stanton Square Shopping Center. Other land uses include residential lawns, fragmented woodlots, and vacant fields. The proposed project reach flows largely south to north and is confined within a narrow riparian buffer approximately 150 feet wide. An actively migrating headcut is present at the midpoint of the reach, and the resulting drop in elevation of 3 feet will likely progress rapidly upstream. The bottom width (streambed) of the upstream half of the project reach is approximately 6 to 7 feet wide becoming 2 to 3 feet wide downstream. Upstream, both the left and right banks are nearly 8 feet tall and have near


HMR/SHB
Watershed Master Plan
Figure 5-3
Stream Stabilization Project #3
Beasley Drive
Stream Channel Stabilization
100 50 0 100
Feet
1 inch = 100 feet
CDM Smith
Greenville
NORTH CAROLINA
Find yourself in good company
Legend
Proposed Stream Restoration
Catch Basin
Yard Inlet
Difficult Access Structure
Drop Inlet
Junction Box
Pipe End
Flared End Section
Headwall
Underground Pipe Junction
Pipes
Channels
Bridge
BEASLEY DR
NC OneMap, NC Center for Geographic Information and Analysis, NC 911 Board

vertical banks. Continuing downstream, the banks are shorter (3-8 feet) but remain vertical or near vertical. The average top channel width is approximately 15 feet wide. Bank and bed conditions are currently unstable and are eroding at an accelerated rate due to multiple sudden drops in elevation, high-velocity flow coming out end-of-pipe, and highly-erodible, loamy-sand soils.

The proposed project reach has opportunities for channel restoration and bank stabilization to arrest further bank erosion and sediment loading to the Schoolhouse Branch watershed. Relatively good accessibility is provided by adjacent apartment parking lots and Beasley Drive to the north and south; however, the final 100 feet to the stream from the east and west is wooded and gradients are moderately steep. Grading banks to stable dimensions would require prohibitively extensive lateral grading and removal of native woody vegetation. Therefore, to improve bank stability and reduce further bed and bank erosion along the proposed reach, a step-pool channel conveyance is recommended to raise the channel bed and prevent further incision. To further reduce the erosional effects of high-velocity flows, culverts may be modified and several large boulder structures or riprap may be placed within the streambed at the toe of bank.

The estimated cost for improvements for the Beasley Drive Channel Stabilization project is $330,000. While the proposed project itself is located away from structures and facilities, construction staging areas will likely have to be located on private properties to the north or south, which may result in temporary impacts to residential traffic and landscaping.

Other Minor Stream Improvement Projects

1. Sams Branch – Golf Course Maintenance Facility Access Road (River Walk Drive): Water backs up at the bridge due to improperly installed culverts and is beginning to erode around bridge supports (Lat/Long: 35°38'35.07"N; 77°26'31.84"W). To reduce impacts to the bridge, we recommend diverting overflows to the former floodplain to the west by opening the former flowpath from the existing channel towards the east for larger flows. This may also alleviate erosive stresses on the downstream channel.

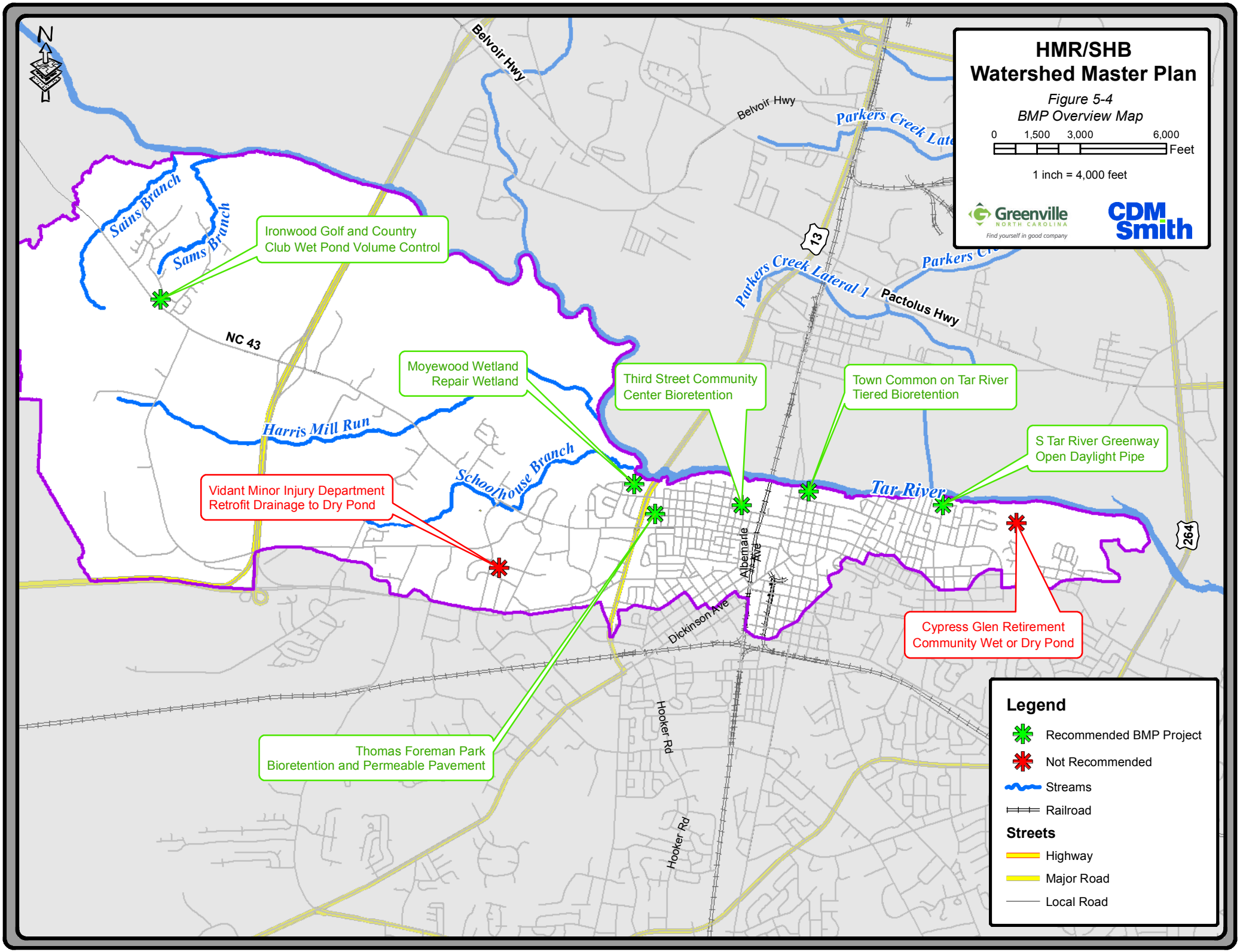
5.2 BMP Project Identification

Potential BMP locations were initially identified using various layers in GIS including the following: aerial photography, parcels, land use, storm water inventory, and topography. Ten potential BMP locations were initially identified. These locations were discussed with City staff and field visited by CDM Smith staff in October 2015 to determine the feasibility of each site for a BMP. An overview map has been provided showing these sites (See **Figure 5-4**).

The proposed locations for the BMPs were evaluated based on the following criteria:

- Watershed Size / Drainage Area – Larger watershed sizes allow an opportunity for more treatment. A significant contributing drainage area would allow the use of a larger, more regional BMP such as a wet pond or extended detention wetland.
- Percentage of impervious area – Areas with high impervious percentages allow an opportunity for more treatment.

- Proximity to existing conveyance system – Runoff will need to be diverted into the BMP and then discharged back to the conveyance system. Locations in close proximity to the existing conveyance system will reduce the cost associated with constructing new drainage structures.
- Land Availability/Ownership – The proposed BMPs will require undeveloped land. Attempts were made to concentrate on publicly owned land because the high cost of private land can make a project unlikely.
- Topography – Sufficient vertical relief, up to 5 feet, is required to allow certain BMPs (i.e., bioretention and wet ponds) to function per North Carolina Department of Environmental Quality (NCDEQ) design requirements.
- Hydrologic conditions – BMPs such as wet ponds or extended detention wetlands need the proper hydrologic conditions for plants to survive. The soils or existing water table must allow for the BMP facility to permanently hold stormwater runoff.
- There is a community center and multiple parks located in the HMR/SHB Watershed. These locations were closely examined due to the surrounding large impervious areas and the educational benefits of installing a BMP onsite. Several of the sites identified met multiple criteria for a successful project and are therefore recommended in this Master Plan.


HMR/SHB
Watershed Master Plan
Figure 5-4
BMP Overview Map
0 1,500 3,000 6,000
Feet
1 inch = 4,000 feet
Greenville
NORTH CAROLINA
Find yourself in good company
CDM Smith
N
Belvoir Hwy
Belvoir Hwy
Parkers Creek Late
Parkers Creek Lateral 1
Pactolus Hwy
13
Sains Branch
Sams Branch
Ironwood Golf and Country
Club Wet Pond Volume Control
NC 43
Moyewood Wetland
Repair Wetland
Harris Mill Run
Schoolhouse Branch
Third Street Community
Center Bioretention
Town Common on Tar River
Tiered Bioretention
S Tar River Greenway
Open Daylight Pipe
Tar River
Vidant Minor Injury Department
Retrofit Drainage to Dry Pond
Albemarle Ave
Dickinson Ave
Cypress Glen Retirement
Community Wet or Dry Pond
264
Hooker Rd
Hooker Rd
Thomas Foreman Park
Bioretention and Permeable Pavement
Legend
Recommended BMP Project
Not Recommended
Streams
Railroad
Streets
Highway
Major Road
Local Road

Sites at Vidant, Greenville Utilities Commission, and Cypress Glen Retirement Community were initially considered, but not included as recommend projects due not meeting physical or ownership criteria. The Vidant site was revealed to be too close to a building, and the Cypress Glen Retirement Community was found to discharge to a natural wetland providing treatment. The privately owned Cypress Glen site is a viable site for an additional constructed wetland in the rear of the property or a bioretention at the front, but is not included in the City's prioritization. Lake Laupus on the Vidant property was also investigated for enhancement of the existing retention pond volume and found to be limited by surrounding topography and elevation of the existing spillway. The pond could be dredged to attain additional retention volume, but the maximum water surface elevation cannot be raised above the normal water surface associated with the existing spillway weir without significant restructuring of the dam which is positioned in close proximity above W. 5th Street. Therefore, Lake Laupus is not recommend for wet pond retrofit enhancement.

5.3 Recommended BMPs

Based on the field visits and the above criteria, seven sites were recommended for BMP retrofits in the HMR/SHB watersheds. Factors that eliminated a site from consideration included the following: limited space, tree density, utility conflicts (i.e. high voltage transformers and other electrical distribution equipment), and insufficient topographic relief.

Preliminary conceptual design calculations were completed for each of seven BMPs (see Appendix I). The design calculations were based on methodologies found in the NCDEQ Stormwater BMP Manual. The size of the BMP is based on the contributing watershed area and the amount of impervious area within the watershed. Per NCDEQ requirements, the recommended BMPs were designed to treat runoff from the first one-inch of rainfall. The treatment volume is directly correlated to the amount of impervious area. Watersheds with larger amounts of impervious area convert more of the rainfall into runoff, thereby requiring a larger sized BMP. The majority of the recommended BMPs for this watershed were wet retention ponds or bioretention areas for the following reasons:

- Large regional BMPs were more feasible in this watershed since the watershed is not fully developed.
- Given the characteristics of the watershed, one of the most effective forms of water quality treatment is to treat stormwater runoff at the source. Bioretention areas are excellent BMPs at treating runoff directly from impervious areas such as parking lots.
- Bioretention areas have some of the highest removal rates for nutrients per the BMP manual. The Tar-Pam river basin is identified as a nutrient sensitive watershed and monitoring efforts by the Pamlico Tar River Foundation support this designation.
- Bioretention areas provide excellent educational opportunities particularly at schools as they are visible features that can be aesthetically pleasing. Furthermore, multiple treatment processes are occurring within a bioretention area providing additional opportunities for education.

5.3.1 Water Quality Project 1: Ironwood Golf and Country Club

A potential project is located upstream of the headwaters of Sams Branch in the existing shallow golf course ponds near the corner of NC 43 and Golf View Drive. The two ponds in series, shown in **Photograph 5-10** could be modified to capture and treat the runoff upstream of Sams Branch. Currently, the ponds provide very little volume control before discharging to Sams Branch. As a part of the water quality recommendations herein, both ponds could be deepened to allow for a greater volume of storage and the associated water quality benefits.

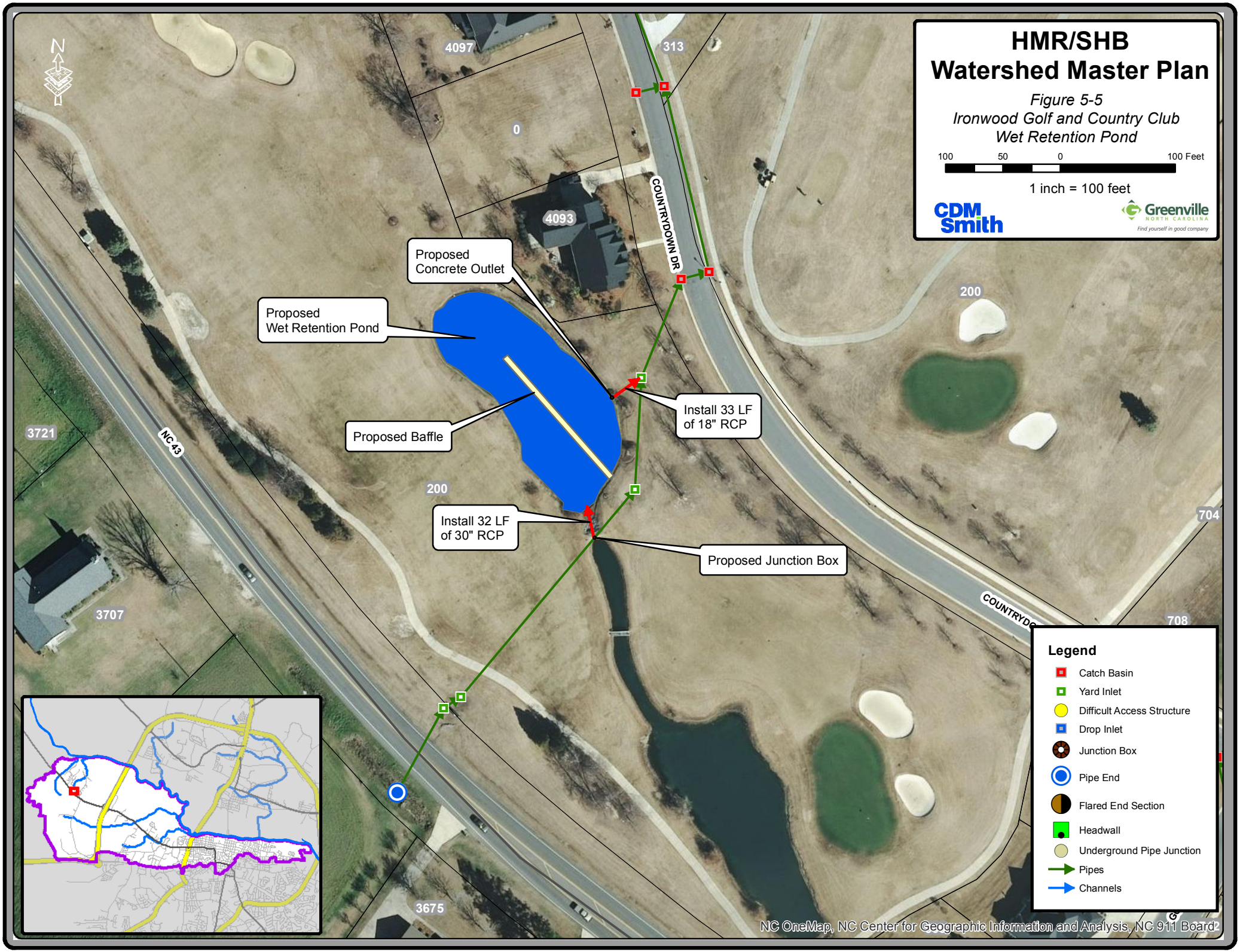
Photograph 5-10. Proposed Location for Ironwood Golf Course Wet Pond Retrofit– Downstream Pond

Photograph 5-11. Proposed Location for Ironwood Golf Course Wet Pond Retrofit

The existing area of the wet pond which is approximately 4,480 square feet (0.10 acres). The impervious area currently draining to the wet pond is 0.1 acres. Modifications to the existing drainage system are required to direct additional runoff from Country Down Drive and NC-43 to the ponds. A concept level plan of the proposed improvements is shown in **Figure 5-5**. The proposed Ironwood Golf Course wet pond upgrades project consists of the following improvements:

- Excavate the existing ponds to lower the water surface level and add a storage depth of approximately 1-foot designed to treat runoff upstream of Sams Branch.
- Install outlet piping to convey the treated effluent.

The proposed water quality project is located on private property. In order to deepen the wet pond and install outlet piping, an easement would be required from the property owner at the Ironwood Country Club. The estimated construction cost for the wet pond project at Ironwood Golf and Country Club is $320,000. This project will have both water quality and flood reduction benefits by reducing the volume of runoff.


HMR/SHB
Watershed Master Plan
Figure 5-5
Ironwood Golf and Country Club
Wet Retention Pond
100 50 0 100 Feet
1 inch = 100 feet
CDM Smith
Greenville
NORTH CAROLINA
Find yourself in good company
N
Proposed Concrete Outlet
Proposed Wet Retention Pond
Proposed Baffle
Install 33 LF of 18" RCP
Install 32 LF of 30" RCP
Proposed Junction Box
COUNTRYDOWN DR
NC 43
4097
313
0
4093
200
3721
3707
704
708
3675
Legend
Catch Basin
Yard Inlet
Difficult Access Structure
Drop Inlet
Junction Box
Pipe End
Flared End Section
Headwall
Underground Pipe Junction
Pipes
Channels
NC OneMap, NC Center for Geographic Information and Analysis, NC 911 Board

5.3.2 Water Quality Project 2: Moyewood Pond

The existing wet detention pond at Moyewood is currently sized to provide treatment to approximately 230 acres of drainage area. However, the basin currently does not provide the design treatment because influent flows short circuit the detention volume and flow straight through from the inlet to the discharge. The discharge structure is not configured to control flows by storing runoff with a low level outlet and riser and the volume of the basin is not being utilized for the majority of rainfall events. Improvements are proposed to increase the detention time through installation of an outlet riser structure and addition of a sinuous flowpath through the bottom of the pond. The wetland basin should be capable of storing the 1-inch design storm with drawdown over 72 hours as outlined in the NCDEQ BMP Manual. Additionally, by controlling the discharge structure to retain a minimum depth of a few inches to a foot of water in the basin, it will effectively be converted to a stormwater wetland capable of supporting wetland vegetation as evident from the limited wetland vegetation currently growing near the inlet. A baffled flowpath will increase retention time providing a water treatment benefit and wetland vegetation will provide greater water quality benefit through contact and nutrient reduction. Replacement of the loose perimeter fence gate is also recommended.

Photograph 5-12. Proposed Location for Moyewood Wet Pond Repair

The surface area for the proposed wetland is approximately 70,000 square feet (1.6 acres). The impervious area draining to the proposed wetland is 73 acres. A concept level plan of the proposed improvements is shown in **Figure 5-6**. The proposed Moyewood wetland project consists of the following improvements:

- Install a baffle system composed of islands of shallow land designed to increase detention time in the existing 1.6-acre pond;
- Plant wetland/aquatic species;
- Install sediment forebay, sediment disposal area;
- Integrate deep pool into existing outlet structure; and
- Modify existing outlet structure.

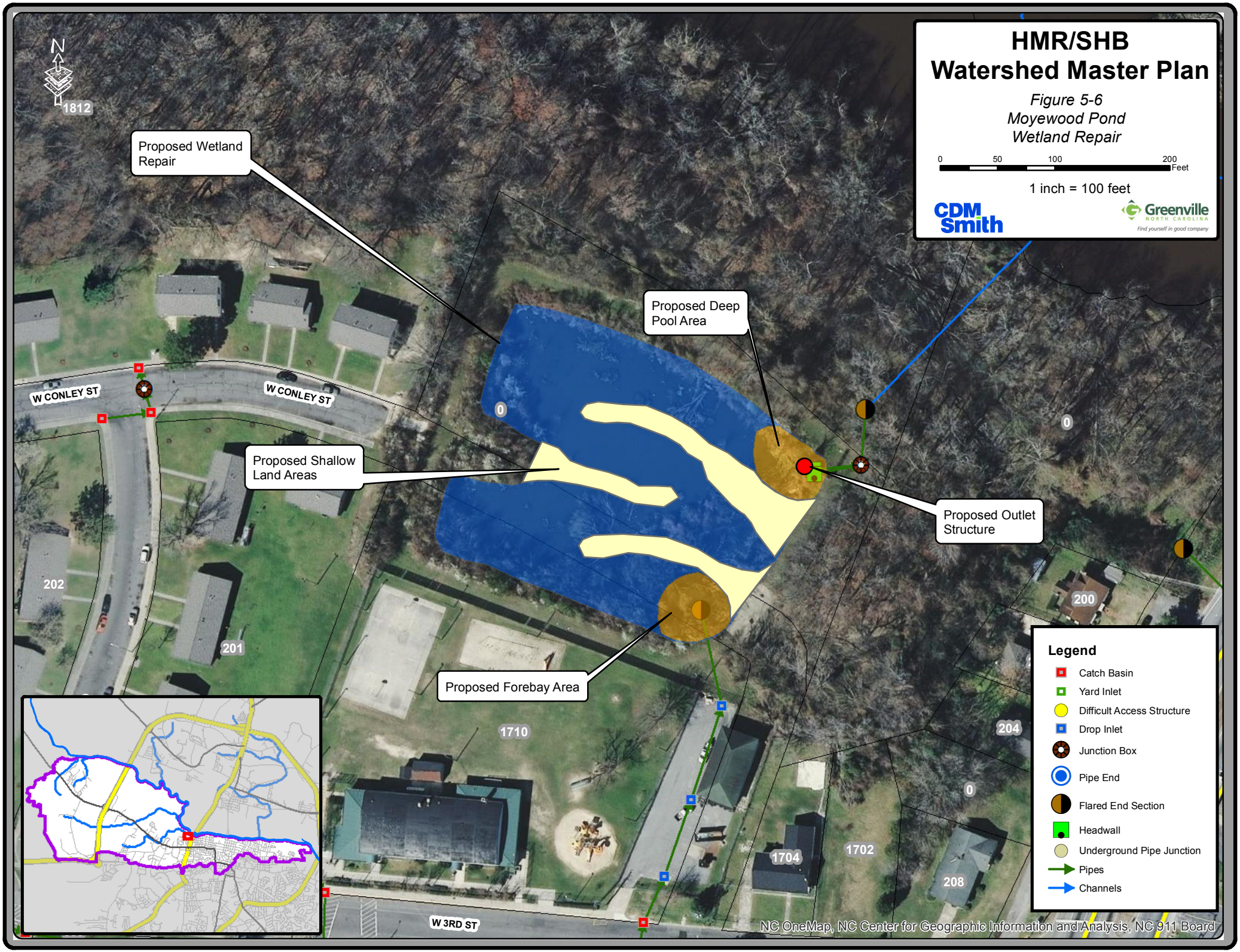
The proposed water quality project is located on public property. The estimated construction cost for the wetland project at Moyewood Pond is $42,000. This project will have both water quality and flood reduction benefits by treating runoff before it reaches the Tar River.

5.3.3 Water Quality Project 3: Thomas Foreman Park

Potential projects are located at two locations at Thomas Foreman Park at 400 Nash Street. A bioretention area is proposed to capture runoff from the parking lot along Nash Street and a repaving of the rear parking lot along W 4th Street with permeable pavement is also recommended. Presently, the rear parking lot drains overland past the tennis courts causing erosion and transporting sediment into the closed system at the end of W 4th Street. The impervious areas draining to the proposed area is approximately 0.5 acres.

Permeable pavement in this lot would reduce this runoff and the associated sediment load being transported into the existing drainage system. The rear parking lot is in poor condition and in replacement with permeable pavement is recommended.

Photograph 5-13: Proposed Location for Thomas Foreman Park Bioretention


HMR/SHB
Watershed Master Plan
Figure 5-6
Moyewood Pond
Wetland Repair
0 50 100 200 Feet
1 inch = 100 feet
CDM Smith
Greenville NORTH CAROLINA
Find yourself in good company
Proposed Wetland Repair
Proposed Deep Pool Area
Proposed Shallow Land Areas
Proposed Outlet Structure
Proposed Forebay Area
W CONLEY ST
W CONLEY ST
W 3RD ST
1812
202
201
1710
1704
1702
208
204
200
0
Legend
Catch Basin
Yard Inlet
Difficult Access Structure
Drop Inlet
Junction Box
Pipe End
Flared End Section
Headwall
Underground Pipe Junction
Pipes
Channels
NC OneMap, NC Center for Geographic Information and Analysis, NC 911 Board

Photograph 5-14: Proposed Location for Thomas Foreman Park Permeable Pavement

The required surface area for the proposed bioretention is approximately 630 square feet (0.01 acres) and the required surface area for the proposed permeable pavement is approximately 3,250 square feet (0.07 acres). A concept level plan of the proposed improvements is shown in **Figure 5-7**.

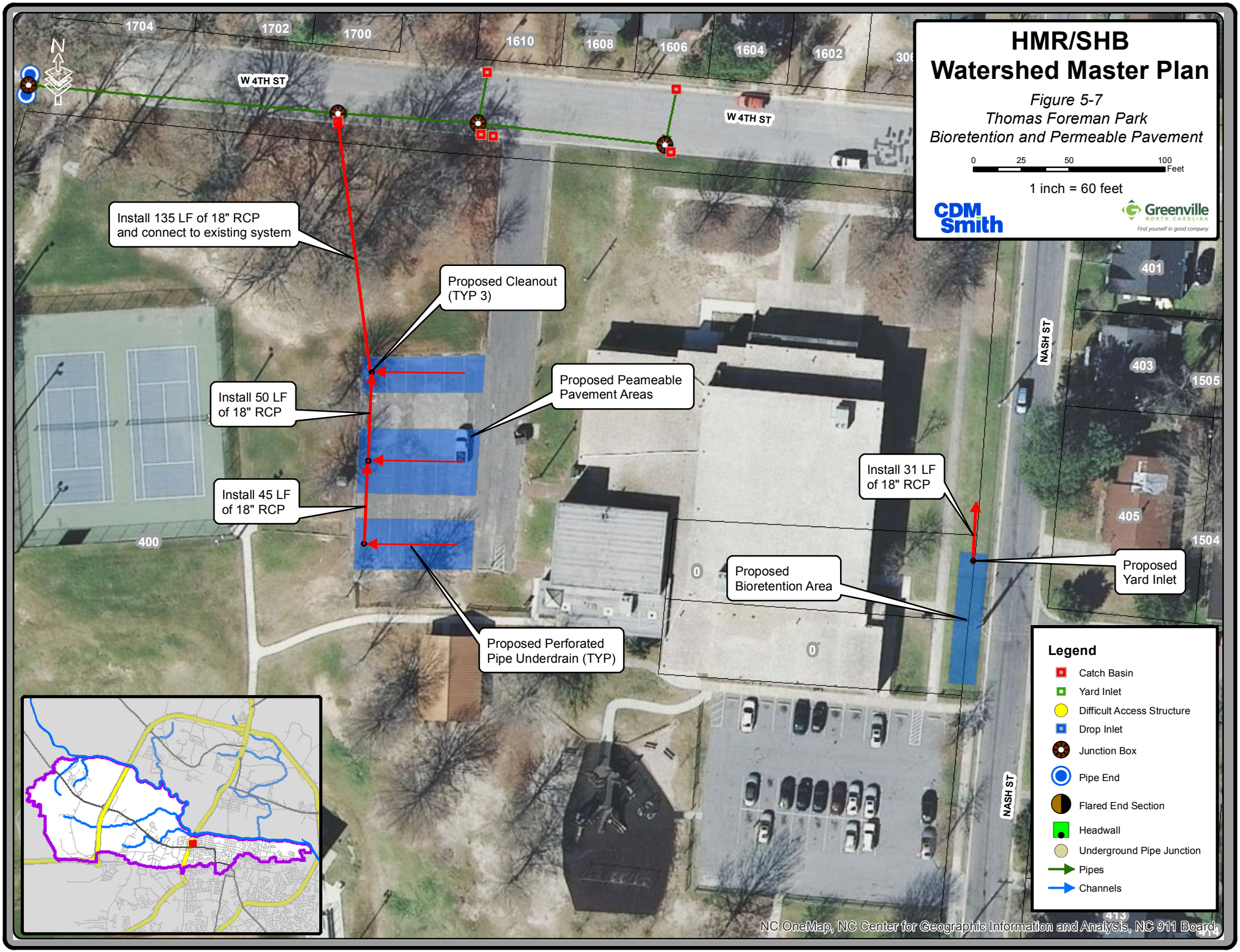
The proposed water quality projects at Thomas Foreman Park consists of the following improvements:

- Install a bioretention area designed to treat runoff from the parking lot along Nash Street.
- Replace the parking lot along W 4th Street with permeable pavement.
- Install underdrain systems and connect to existing draining for both projects.

The proposed water quality project is located on City-owned property. The estimated construction cost for the bioretention project at Thomas Foreman Park is $130,000. The estimated construction cost for the permeable pavement project at Thomas Foreman Park is $260,000. These projects will have both water quality treatment benefits and reduce the volume of runoff.

5.3.4 Water Quality Project 4: Third Street Community Center

A potential project is located at the Third Street Community Center at 600 W 3rd Street. A bioretention area is proposed on the western end of the parking lot where there is a large rectangular grass area as shown in **Photograph 5-15**. This area could be used to capture and treat the runoff from the parking lot.


HMR/SHB
Watershed Master Plan
Figure 5-7
Thomas Foreman Park
Bioretention and Permeable Pavement
0 25 50 100 Feet
1 inch = 60 feet
CDM Smith
Greenville NORTH CAROLINA
Find yourself in good company
Install 135 LF of 18" RCP and connect to existing system
Proposed Cleanout (TYP 3)
Proposed Peameable Pavement Areas
Install 50 LF of 18" RCP
Install 45 LF of 18" RCP
Install 31 LF of 18" RCP
Proposed Bioretention Area
Proposed Yard Inlet
Proposed Perforated Pipe Underdrain (TYP)
W 4TH ST
NASH ST
1704
1702
1700
1610
1608
1606
1604
1602
401
403
405
1505
1504
400
Legend
Catch Basin
Yard Inlet
Difficult Access Structure
Drop Inlet
Junction Box
Pipe End
Flared End Section
Headwall
Underground Pipe Junction
Pipes
Channels
NC OneMap, NC Center for Geographic Information and Analysis, NC 911 Board

Photograph 5-15: Proposed Location for Third Street Community Center Bioretention Area

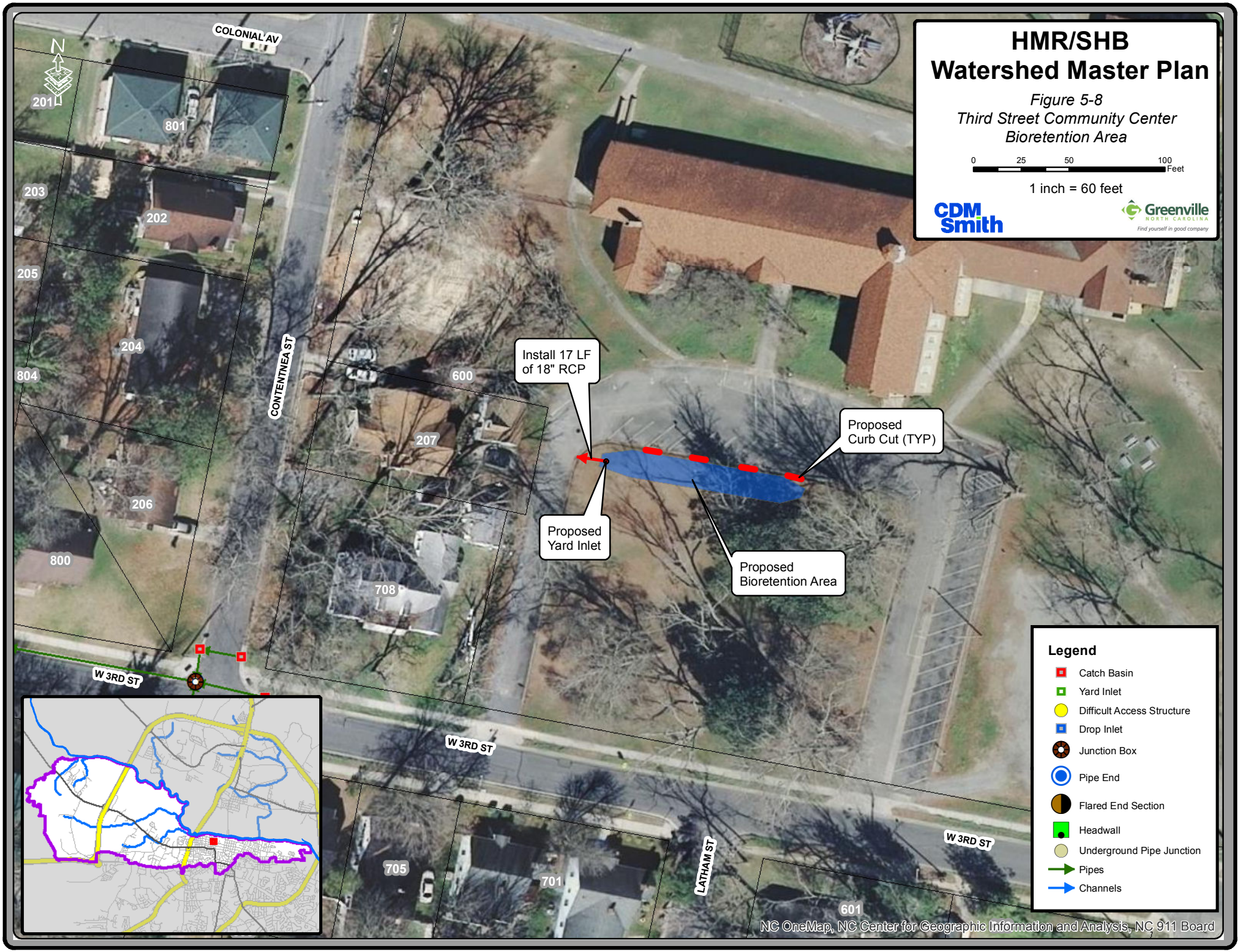
The proposed impervious areas draining to the proposed area is 0.5 acres. The required surface area for the proposed bioretention is approximately 1,300 square feet. A concept level plan of the proposed improvements is shown in **Figure 5-8**. The proposed Third Street Community Center bioretention project consists of the following improvements:

- Install a bioretention area designed to treat runoff from the adjacent parking lots.
- Install concrete curb cuts on the west side of the parking lot at 600 W 3rd Street that will allow water to access the proposed bioretention area. There is currently one inlet in the parking lot.
- Install a yard inlet with a 15" outfall pipe directing flow into W 3rd Street conveyance system.

The proposed water quality project is located on private property. In order to construct the bioretention area, an easement would be required from the property owner at 600 W 3rd Street. The estimated construction cost for the bioretention project at the Third Street Community Center is $120,000. This project will have both water quality and flood reduction benefits by reducing the volume of runoff.

5.3.5 Water Quality Project 5: Town Common on Tar River

The Town Common on Tar River located near the corner of N Greene Street and W 1st Street is a potential site for a water quality project. This public common area has ample greenspace for a tiered bioretention area which would serve as a water quality project and possibly as a public amenity. The large grassy area could be used to capture and treat the runoff from the highly impervious downtown area immediately upstream. The area currently drains directly to the Tar River.


HMR/SHB
Watershed Master Plan
Figure 5-8
Third Street Community Center
Bioretention Area
0 25 50 100 Feet
1 inch = 60 feet
CDM Smith
Greenville NORTH CAROLINA
Find yourself in good company
COLONIAL AV
CONTENTNEA ST
W 3RD ST
LATHAM ST
201
801
203
202
205
204
804
600
207
206
800
708
705
701
601
Install 17 LF of 18" RCP
Proposed Curb Cut (TYP)
Proposed Yard Inlet
Proposed Bioretention Area
Legend
Catch Basin
Yard Inlet
Difficult Access Structure
Drop Inlet
Junction Box
Pipe End
Flared End Section
Headwall
Underground Pipe Junction
Pipes
Channels
NC OneMap, NC Center for Geographic Information and Analysis, NC 911 Board

Photograph 5-16: Proposed Location for Town Common on Tar River Tiered Bioretention

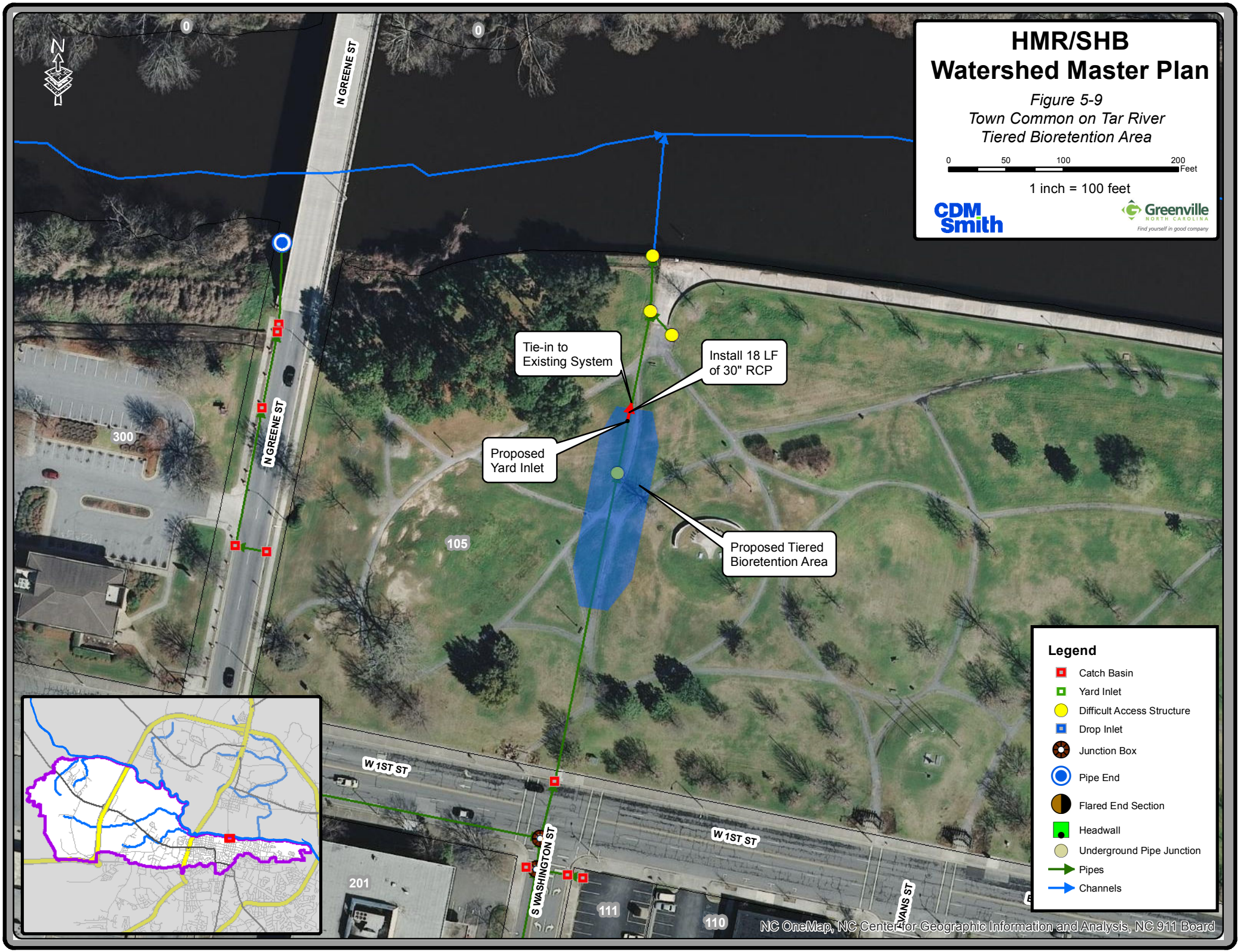
The required surface area for the proposed bioretention is approximately 6,000 square feet (0.13 acres). The proposed impervious areas draining to the proposed area is 8.9 acres. A concept level plan of the proposed improvements is shown in **Figure 5-9**. The proposed Tar River Town Common tiered bioretention project consists of the following improvements:

- Install a bioretention area designed to treat runoff from the upstream downtown area.
- Install concrete curb cuts along W 1st Street across from the end of S Washington Street that will allow water to access the proposed bioretention area.
- Install a yard inlet with a 15" outfall pipe directing treated flow into the conveyance system and ultimately into the Tar River.

The proposed water quality project is located on public property. The estimated construction cost for the bioretention project at the Town Common is $190,000. This project will have both water quality and flood reduction benefits by reducing the volume of runoff.

5.3.6 Water Quality Project 6: South Tar River Greenway

A potential project is located along the South Tar River Greenway along the end of N Elm Street. The grass area between the greenway near the end of N Elm Street and the South Tar River Greenway along River Drive could be daylighted to restore the form and function of a natural stream. Flows were observed by CDM Smith personnel in the existing closed system during dry weather that suggest that a perennial stream could possibly exist and be a good candidate for daylighting to restore this closed system into an above-ground channel with a well-developed riparian zone to improve water quality through infiltration, bioremediation, and filtration. This proposed water quality project would be in addition to the proposed


HMR/SHB
Watershed Master Plan
Figure 5-9
Town Common on Tar River
Tiered Bioretention Area
0 50 100 200 Feet
1 inch = 100 feet
CDM Smith
Greenville NORTH CAROLINA
Find yourself in good company
N GREENE ST
N GREENE ST
W 1ST ST
W 1ST ST
S WASHINGTON ST
EVANS ST
Tie-in to Existing System
Install 18 LF of 30" RCP
Proposed Yard Inlet
Proposed Tiered Bioretention Area
300
105
201
111
110
Legend
Catch Basin
Yard Inlet
Difficult Access Structure
Drop Inlet
Junction Box
Pipe End
Flared End Section
Headwall
Underground Pipe Junction
Pipes
Channels
NC OneMap, NC Center for Geographic Information and Analysis, NC 911 Board

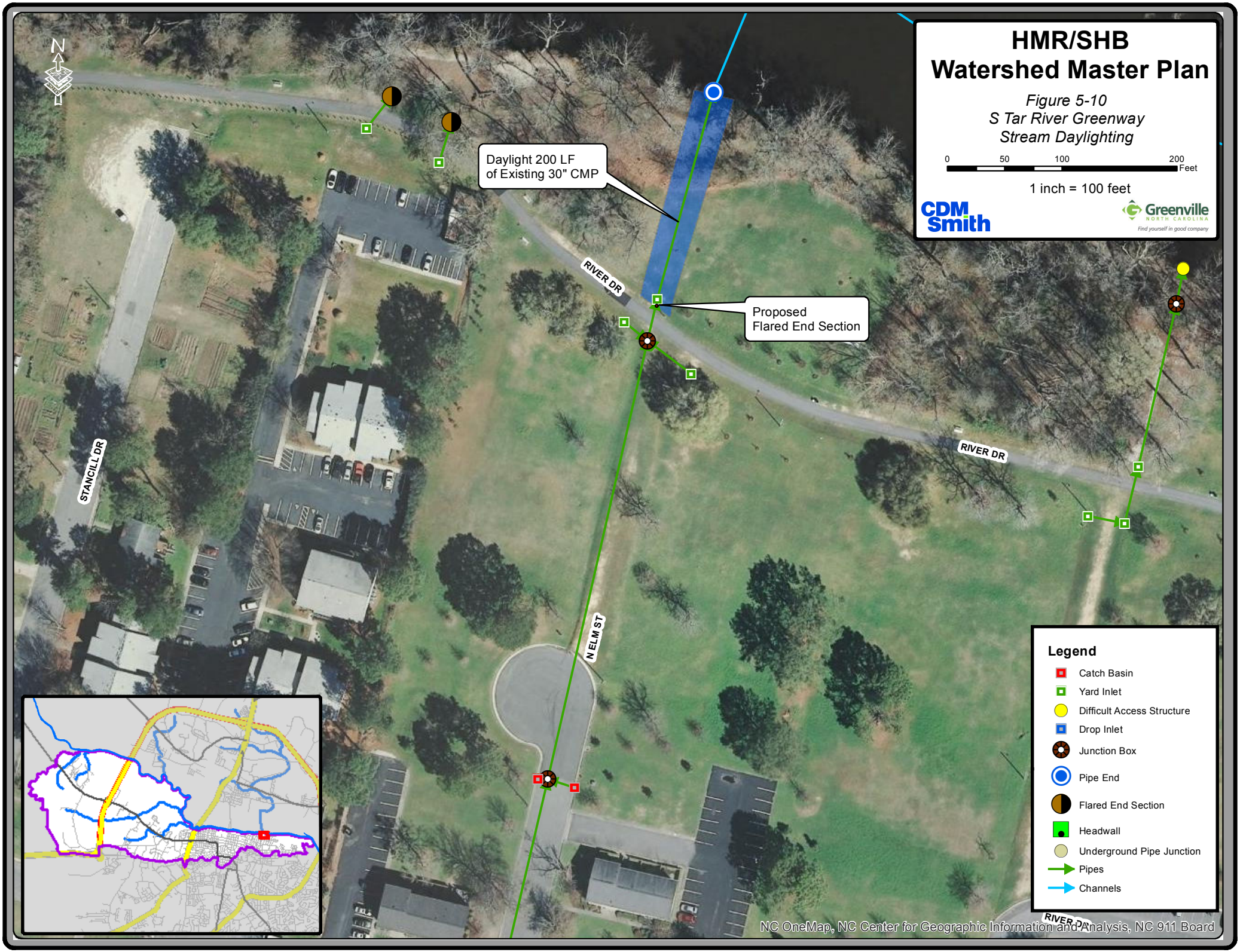
Photograph 5-17: Proposed Location for S Tar River Greenway Pipe Daylighting

improvements to the existing Elm Street secondary conveyance system which has an approximate drainage area of approximately 60 acres.

The required surface area for the proposed daylighting is approximately 3,200 square feet (0.02 acres). A concept level plan of the proposed improvements is shown in **Figure 5-10**. The proposed South Tar River Greenway daylighting project consists of the following improvements:

- Excavate to daylight 150 linear feet of the existing 30-inch RCP
- Grade and seed the new open channel
- Install inlet and outlet flared end sections
- Install riprap outlet protection

The proposed water quality project is located on public property. The estimated construction cost for the proposed Tar River Greenway daylighting project is $150,000. This project will have water quality benefits by providing treatment to the stormwater runoff.


HMR/SHB
Watershed Master Plan
Figure 5-10
S Tar River Greenway
Stream Daylighting
0 50 100 200 Feet
1 inch = 100 feet
CDM Smith
Greenville NORTH CAROLINA
Find yourself in good company
Daylight 200 LF
of Existing 30" CMP
Proposed
Flared End Section
RIVER DR
RIVER DR
STANCILL DR
N ELM ST
RIVER DR
Legend
Catch Basin
Yard Inlet
Difficult Access Structure
Drop Inlet
Junction Box
Pipe End
Flared End Section
Headwall
Underground Pipe Junction
Pipes
Channels
NC OneMap, NC Center for Geographic Information and Analysis, NC 911 Board

5.3.7 Water Quality Project 7: North Summit Street

A potential project is located along the greenway at the end of N Summit Street. The grassed area between the cul-de-sac at the end of N Summit Street and Jarvis Street shown in Photo 18 is owned by the City and presents an opportunity for integrating a BMP along the greenway trail. This proposed water quality project would be in addition to

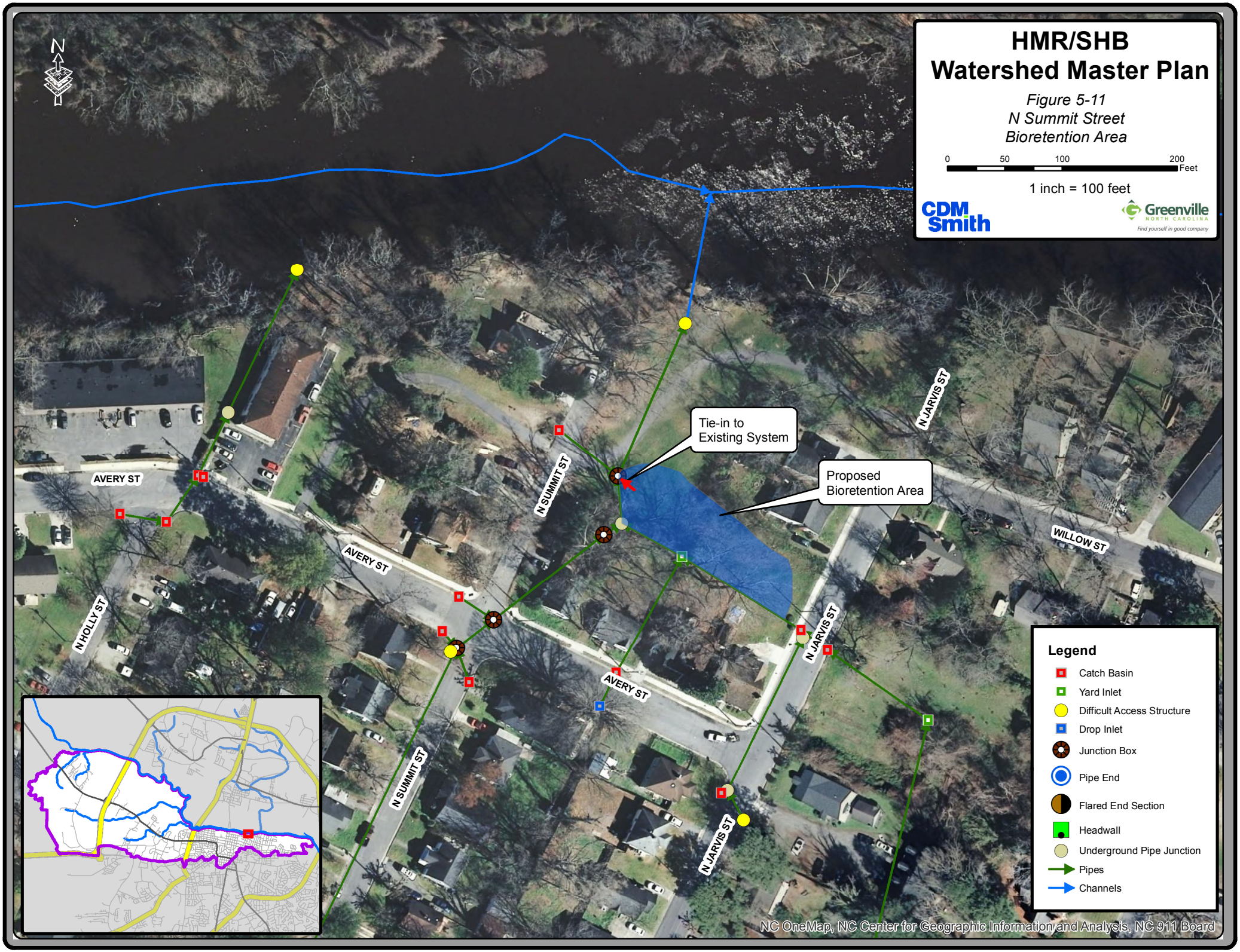
Photograph 5-18: Proposed Location for N Summit Street Bioretention Area

the proposed improvements to the Jarvis Street secondary conveyance system which has an approximate drainage area of approximately 25 acres at this location.

The required surface area for the proposed bioretention is approximately 32,000 square feet (0.74 acres). A concept level plan of the proposed improvements is shown in **Figure 5-11**. The proposed N. Summit Street bioretention project consists of the following improvements:

- Install collecting swales to direct runoff to bioretention area
- Bioretention area designed to treat runoff from the surrounding streets
- Install underdrain systems and connect to existing drainage

The proposed water quality project is located on public property. The estimated construction cost for the proposed N. Summit Street bioretention project is $270,000. This project will have water quality benefits by providing treatment to the stormwater runoff.


HMR/SHB
Watershed Master Plan
Figure 5-11
N Summit Street
Bioretention Area
0
50
100
200
Feet
1 inch = 100 feet
CDM Smith
Greenville
NORTH CAROLINA
Find yourself in good company
Tie-in to Existing System
Proposed Bioretention Area
AVERY ST
N SUMMIT ST
N JARVIS ST
WILLOW ST
N HOLLY ST
Legend
Catch Basin
Yard Inlet
Difficult Access Structure
Drop Inlet
Junction Box
Pipe End
Flared End Section
Headwall
Underground Pipe Junction
Pipes
Channels
NC OneMap, NC Center for Geographic Information and Analysis, NC 911 Board

SECTION 6
PUBLIC EDUCATION AND OUTREACH

Successful implementation of the HMR/SHB Watershed Master Plan and stormwater management as a whole requires extensive public education and outreach. The City has taken important steps in public outreach within the HMR/SHB Watershed through the use of direct mail questionnaires, web-based applications, and public meetings. Questionnaires were mailed to residents throughout the watershed requesting feedback on flood-prone areas and any water quality concerns. Residents indicating flooding or erosion issues who provided contact information were contacted via phone or email to gather additional details regarding the survey reported property or identified roadway flooding issue. Residents who wanted to show the extent of flooding concerns were interviewed at their residences and the site conditions were evaluated in relation to the local stormwater drainage system. Notes from these interviews and compiled results of the questionnaires can be found in Appendix D.A public meeting was held on November 12, 2014 to introduce the project and facilitate further feedback from the public. The initial public feedback is critical to identifying flood-prone areas and validating model results. A follow-up meeting was held to share results of the Master Plan with the public on November 17, 2015. As selected projects proceed into design and construction, continuous public outreach will be critical to the success of the projects. Most of the proposed improvements include some impacts to private properties which will require permanent drainage easements and temporary construction easements. Public meetings and individual property owner meetings through the design process will help educate property owners on the benefits of the proposed projects and the temporary and permanent impacts from construction.

Aside from the public education and outreach completed for projects specific to the HMR/SHB Watershed Master Plan, the City has several programs dedicated to educating the public about water quality and pollution. The City's website provides information about the Stormwater Program and the development of the Stormwater Utility and associated fees. Another outreach measure that could be considered would be to target those City residents that live adjacent to the stream. For this select group, quarterly newsletters could be mailed presenting information regarding the importance of not illegally discharging items (i.e. yard waste, car batteries, and other miscellaneous debris) into the stream. The newsletter should encourage the residents to keep the stream clean and report any blockage.

Coordinating with the local schools to teach the students about age-appropriate stormwater issues is another approach to consider. There are many benefits to teaching children about stormwater issues including the students relaying the information they learn in school to their parents. A presentation can be done in conjunction with an afternoon spent visiting and cleaning up the nearby stream. An educational BMP with permeable pavement at Thomas Foreman Park is recommended as and educational opportunity. The bioretention projects proposed at 3rd Street Community Center and N. Summit Street are other examples where educational signage could accompany the stormwater BMPs. This along with the previously mentioned newsletter could be included in the Public Education section of the City's Action Report and Plan that must be completed annually to meet the requirements of Tar-Pamlico River Basin stormwater program.

The proposed improvements described in Section 4 may require local, State, and/or Federal permits or approvals prior to the onset of construction. Based on the types of projects identified in the Meetinghouse Branch Watershed, permits or approvals may be required for any of the following reasons:

- Stream and/or wetland impacts;
- FEMA floodway impacts;
- Land disturbance; and
- Potable water and sewer line adjustments.

The permitting matrix shown in **Table 7-1** shows the different types of permits that are anticipated for each proposed flood control project. The water quality retrofits may require erosion control permits if the area of disturbance is greater than 1.0 acres, but permits or agreements from DWR, US Army Corps of Engineers (USACE), Federal Emergency Maintenance Agency (FEMA), and North Carolina Department of Transportation (NCDOT) are not anticipated for these projects.

The types of 404/401 permits are described below and may vary based on the length of stream impacts and/or acreage of wetland impacts. Wetlands will need to be delineated to determine the acreage of impacts. Permit requirements for a given project may change based on the final design and any changes to the existing regulations. The appropriate permitting agencies should be contacted during the design process to determine if permits will be required for the proposed project.

7.1 North Carolina Division of Water Resources 401 Water Quality Certification and US Army Corps of Engineers 404 Permit

Proposed improvements within the City of Greenville must adhere to the requirements set forth in Sections 401 and 404 of the Clean Water Act. Required permitting can range from activities that are pre-authorized to those requiring a pre-construction notification (PCN) for a Nationwide Permit (NWP) to those requiring an Individual Permit (IP). Individual permits may be required for projects with stream impacts greater than 300 feet and wetland impacts greater than 0.5 acres. It is anticipated that NWP #3 (Maintenance) and NWP #13 (Bank Stabilization) may be required to support the projects that include work within streams or channels that are claimed jurisdictional by the USACE. Individual permits may be required for floodplain benches where significant wetland impacts may be encountered. More detailed explanations of the types of 404 permits are provided below.

7.1.1 NWP 3 – Maintenance

This permit authorizes the repair, replacement or rehabilitation of any previously permitted or currently serviceable structure. A PCN is not required if minor deviations in the structure's configuration or filled area that occur as a result of changes in materials, construction techniques, or safety standards necessary to make repair or replacement, provided that environmental impacts are minimal. A PCN to the USACE is required if a significant amount

of sediment is excavated/filled within the channel. NC Division of Water Quality (DWQ) does not typically require a PCN for NWP 3 but usually receives one as a courtesy.

Other provisions imposed by the State of North Carolina require that culvert inverts must be buried a minimum of 1-foot below the streambed for culverts greater than or equal to 48 inches in diameter to allow low flow passage of water and aquatic life. Culverts less than 48 inches in diameter should be buried to a depth of 20% or greater of the diameter of the culvert.

7.1.2 NWP 13 – Bank Stabilization

This permit authorizes the reshaping of channel banks or bank stabilization activities that are necessary for erosion prevention. The placement of material is prohibited in any special aquatic site in a manner that may impede surface water flow into or out of a wetland area, or in a manner that will be eroded during normal or high flows. The activity must be part of a single and complete project and cannot exceed 1 cubic yard per running foot placed below the high water mark line. If stabilization activities exceed 500 linear feet, then a PCN is required for both the USACE and DWQ. DWQ must also be notified should fill be placed within the streambed.

7.1.3 NWP 27 – Stream and Wetland Restoration Activities

This permit authorizes stream enhancement, stream restoration, and channel relocation for restoration purposes that provide gains in aquatic functions. Stream channelization and the conversion of streams to other aquatic uses such as impoundments or waterfowl habitat are not authorized. A PCN to the USACE is required for any restoration activities occurring on private or public lands. DWQ requires a PCN if impacts are proposed for greater than 500 feet of stream bank or if in-stream structures are used.

Impacts proposed to the streams may need evaluation under the State Environmental Policy Act (SEPA). An Environmental Assessment (EA) is required under SEPA if greater than 500 linear feet of perennial stream is disturbed and stream restoration or enhancement is not performed. Channel disturbances are defined as activities that remove or degrade stream uses such as channelization, culvert placement, riprap, and other hard structures.

A list of some other conditions that should be followed under regulations provided by the USACE and DWQ are as follows:

- Soil erosion and sediment controls must be used and maintained in effective operating conditions during construction, and all exposed soil and fills should be stabilized at the earliest possible date.
- No activity is authorized under any NWP that is likely to jeopardize the existence of a threatened or endangered species, or which will destroy or adversely modify the habitat of such species.
- No activity is authorized that may affect historic properties listed or eligible for listing in the National Register of Historic Places.
- More than one NWP used for a single and complete project is prohibited.

- Impacts to waters of the US should be avoided and minimized to the greatest extent practicable.
- Mitigation in all its forms will be required to the extent necessary to ensure that the adverse effects to the aquatic environment are minimal.
- Hardening techniques should be avoided and minimized to the greatest practicable extent.

7.2 Individual Permits

Individual Permits are required when stream or wetland impacts do not meet the conditions of a nationwide permit. Permit applications may be reviewed by multiple agencies including but not limited to USACE, DWQ, EPA, SHPO, NCWRC, and USFWS. The application is also made available for public review. There is no defined timeframe for review of the application for an IP; therefore, the permitting process for an IP is typically significantly longer than the review time for a NWP. Typically, 404 and 401 Individual Permits are applied for jointly and their review is concurrent.

7.3 Federal Emergency Management Agency (FEMA)

Streams with a drainage area greater than one square mile are typically modeled and mapped by FEMA for flood insurance purposes. The 100-year floodway and floodplain has been mapped for Bells Branch from the York Road culvert crossing to its confluence with Meetinghouse Branch. Approximately 250 feet upstream of Quail Ridge Road to York Road is defined as a Limited Detail Study where a floodplain is mapped, but no floodway has been defined. A floodway is the portion of the floodplain that must remain undeveloped to prevent an increase in the base flood elevation (BFE) of more than a specified amount. The specified amount as regulated by FEMA is typically 1.0 feet. For HMR, the limits of the FEMA Detailed Study are Highway 264, Martin Luther King Jr. Highway to its confluence with the Tar River floodplain.

Any proposed projects that will include grading within a FEMA defined floodway will require a Conditional Letter of Map Revision (CLOMR) submitted to FEMA for pre-approval purposes and a Letter of Map Revision (LOMR) upon completion of construction. No projects in the HMR/SHB Watersheds are along the FEMA mapped HMR or expected to require FEMA permitting.

7.4 Erosion and Sedimentation Control

North Carolina Department of Environmental Quality (NCDEQ) is another agency that requires notification before proposed activities are constructed. NCDEQ requires that an erosion and sedimentation control plan be submitted to the Land Quality Section for approval before the start of construction for any disturbance greater than one acre. Erosion and Sedimentation Control permits are anticipated for most of the proposed projects as shown in Table 7-1.

Table 7-1: Permitting Matrix for Proposed Projects

	FEMA	404/401 (NWP)	404/ 401 (IP)	NCDEQ/ NPDES	NCDOT	RAILROAD
PRIMARY SYSTEM PROJECTS						
W. 5th Street Culvert Replacement		X		X	X	
NC Alcohol Rehab Center Entrance Road		X		X		
Nursing Home Entrance Road		X		X		
SECONDARY SYSTEM PROJECTS						
Davis and Vance Streets System				X		
1st Street and N Jarvis Street System				X	X	
1st Street and N Harding Street System				X	X	
4th Street and Ash/Elm Street System				X	X	
STREAM STABILIZATION PROJECTS						
Sams Branch Headwaters		X		X		
Sams Branch Golf Course		X		X		
Earthen Dam Stabilization		X		X		
Beasley Drive Stream Stabilization		X		X		
WATER QUALITY PROJECTS						
Ironwood Golf and Country Club		X		X		
Vidant Minor Injury Department				X		
Thomas Foreman Park				X		
Greenville Utilities Commission Parcel				X		
Town Common on Tar River				X		
S Tar River Greenway		X		X		
Moyewood Pond				X		

8.1 Water Quality Improvement Funding

As the final designs of the proposed improvements are evaluated, the City is encouraged to investigate the potential funding mechanisms that are available for water quality projects. There are a wide range of funding mechanisms that may be available to the City. Sources include the Clean Water Act Part 319 funds administered by the US EPA and the North Carolina Cleanwater Management Trust Fund (CWMTF). CWMTF funding can include land acquisition costs, design fees, and construction costs to help finance projects that improve and protect water quality. In the 2015 cycle, the CWMTF awarded $19 million to fund projects throughout North Carolina. The Clean Water State Revolving Fund (CWSRF) is another option. It offers low-interest loans that can be used to fund stormwater projects with water quality components. It should be noted that typically, grants require some type of matching funds. The matching requirements vary for each different type of grant. For example, the CWSRF requires a 20 percent match from State based on the amount of Federal dollars awarded while the CWMTF does not have a specified match requirement.

The NCDEQ DWR has a Water Resources Development Project Grant Program. The program provides cost-share grants and technical assistance. The grants are offered for the following purposes: general navigation, recreational navigation, water management, stream restoration, beach protection, land acquisition and facility development for water-based recreation, and aquatic weed control. The current matching limit for the program is 50 percent. This past year, the program awarded grants ranging from $16,000 to $200,000. The total amount awarded across nineteen recipients was over $1.3 million.

8.2 Flood Mitigation Funding

FEMA's Flood Mitigation Assistance (FMA) is a pre-disaster grant program designed to provide funding to States and communities to help in their efforts to reduce or eliminate the risk of repetitive flood damage to building and structures insured under the National Flood Insurance Program (NFIP). In order to be eligible, communities must have completed and approved Flood Mitigation Plans that assess flood risk and identify actions to reduce that risk. Any State agency, participating NFIP community, or local agency is eligible to participate and should contact community officials.

Additional project grant eligibility criteria include a project that is:

- Cost effective;
- Cost beneficial to the National Flood Insurance Fund;
- Technically feasible; and
- Physically located in participating NFIP community or must reduce future flood damages in an NFIP community.

A project must also comply with (1) the minimum standards of the NFIP Floodplain Management Regulations; (2) the applicant's Flood Mitigation Plan; and (3) all applicable laws and regulations. The State is the grantee and program administrator for FMA. FEMA distributes FMA funds to States that in turn provide funds to communities. FEMA may provide up to 75% of

the total eligible costs. The remaining costs must be provided by a non-Federal source of which no more than half can be provided as in-kind contributions from third parties.

8.3 Revenue and General Obligation Bonds

Municipalities in North Carolina have the authority to use bonding for capital improvement projects under the State's General Statues. There are two types of bonds available for use – general obligation and revenue bonds. General obligation bonds are funds received after voter approval of bond referendum. A vote is required because general obligation bonds are secured using the City's taxing power. All revenues, including different taxes, can be used to pay off a general obligation debt. Revenue bonds, on the other hand, are backed by income generated by the City through fees collected (i.e. various utility fees including stormwater). Because their security is not as great as that of general obligation bonds, revenue bonds may carry a slightly higher interest rate.

8.4 Utility Rate Study

The City should consider completing a utility rate study to determine if the current rate is appropriate for funding the required operations of the Stormwater Division as well as capital projects. The enterprise fund was originally established in 2001 with collections beginning in 2003. Since that time the rates have not been adjusted based on the needs of the program. In May 2013, City staff requested a fee increase of $0.50/ERU each year for the next 5 years to support capital projects and completion of the citywide master plan. Once the planning is complete, the City should complete a detailed rate study based on the capital needs identified in the planning process.

SECTION 9
COST ESTIMATES

The cost estimates provided in this study were prepared to assist City staff in making planning level decisions and prioritizing improvements. These cost estimates are not final design estimates. These costs were developed using recent bid tabulations from other communities and NCDOT projects within North Carolina and include easement acquisition, surveying, engineering, legal, and administrative costs. A detailed breakdown of the costs for the projects listed below in Table 9-1 is included in Appendix G. Projects are not listed based on priority. See Section 10 for the prioritization list. The cost estimates are approximate and are subject to change due to local costs for materials, delivery, construction, and other factors. BMP costs are based on the size of the BMP, the estimated excavation required, and any associated structure or planting costs.

The stormwater drainage systems evaluated in this report are composed of a series of culverts, closed drainage systems, open channels, floodplain grading, and BMPs. For these drainage systems to function as designed they must be properly maintained.

Table 9-1: Preliminary Project Cost Estimates

Projects	Preliminary Project Cost
PRIMARY SYSTEM PROJECTS	
W 5th Street Crossing (Schoolhouse Branch) - Alternative 1	$893,000
W 5th Street Crossing (Schoolhouse Branch) - Alternative 2	$469,000
SECONDARY SYSTEM PROJECTS	
Davis Street and Vance Street (Tar River)	$1,038,000
Jarvis Street (Tar River)	$913,000
Harding Street (Tar River)	$1,142,000
Elm Street (Tar River)	$3,049,000
STREAM STABILIZATION PROJECTS	
Project 1 - Ironwood Golf Course (4 Reaches) (Sams Branch)	$704,000
Project 2 - Beasley Drive - Channel Stabilization (Schoolhouse Branch)	$301,000
WATER QUALITY PROJECTS	
Ironwood Wet Pond (Sams Branch)	$304,000
Moyewood Wetland Repair (Tar River)	$39,000
Thomas Foreman Park Bioretention and Permeable Pavement (Schoolhouse Branch)	$327,000
Town Common on Tar River Tiered Bioretention (Tar River)	$174,000
Third Street Community Center Bioretention (Tar River)	$107,000
S Tar River Greenway Pipe Open Daylighting (Tar River)	$138,000

- The primary goal of this study is to make improvement recommendations to reduce flooding within the Harris Mill Run/Schoolhouse Branch watersheds. Currently, several conveyance systems do not meet the City hydraulic design requirements. CDM Smith has provided recommendations that help to reduce or eliminate the identified problems. Success criteria used to measure each proposed flood control project included the following:
- Providing improved level of service for roadways and structures
- Economic feasibility
- Minimizing stream and wetland impacts
- Confirming physical feasibility using available GIS and survey data
- Minimizing easement acquisition

Two different prioritization lists were developed for the proposed projects identified in Sections 4 and 5: Flood Control Improvements, and Water Quality/Stream Stabilization Improvements. Projects were prioritizing using a Prioritization Matrix provided in Appendix M. The improvements were prioritized based on the following factors:

- Public health and safety
- Severity of street flooding
- Cost effectiveness
- Effect of improvements
- Water quality – BMP
- Open channel – erosion control
- Implementation constraints
- Grant funding
- Constructability

In some instances project prioritization will be impacted by the required sequencing of projects to provide the highest possible flood reduction benefits and to reduce or negate any downstream impacts from the proposed projects. Downstream impacts are included in the scoring for the implementation constraints factor, however upon completion of the scoring process, the prioritization list should be reviewed to ensure that projects are appropriately ranked based on sequencing. Some projects have two alternatives listed in the prioritization table. Once an alternative for that project has been selected, the alternative not selected can be removed from the prioritization list. **Table 10-1** shows the proposed prioritization for the Flood Control Improvements. The City should re-visit the prioritization lists annually to determine if the priorities should change.

Table 10-1: Flood Control Prioritization

Prioritization	Project	Cost
1	W 5th Street Crossing (Schoolhouse Branch)	$1,010,000
2	Davis Street and Vance Street System (Tar River)	$1,130,000
3	Harding Street System (Tar River)	$1,240,000
4	Elm Street System (Tar River)	$3,310,000
5	Jarvis Street System (Tar River)	$990,000
	Total	$7,680,000

Tables 10-2 and 10-3 show the recommended priorities for the stream stabilization and water quality projects.

Table 10-2 Stream Stabilization Prioritization

Prioritization	Project	Cost
1	Beasley Drive Channel Stabilization	$330,000
2	Earthen Dam Removal and Stabilization (Schoolhouse Branch)	$250,000
3	Ironwood Golf Course Stream Stabilization	$730,000
	Total	$1,310,000

Table 10-3: Water Quality Prioritization

Prioritization	Project	Cost
1	Moyewood Wetland Retrofit	$42,000
2	Third Street Community Center Bioretention	$120,000
3	Town Common on Tar River Tiered Bioretention	$150,000
4	N. Summit Street Bioretention	$270,000
5	S Tar River Greenway Pipe Daylighting	$150,000
6	Thomas Foreman Park Bioretention and Permeable Pavement	$390,000
7	Ironwood Golf Club Wet Retention Pond	$320,000
	Total	$1,440,000

Table 10-4 shows the recommended priorities for maintenance projects in the watershed. Maintenance locations were identified based on the stream assessment and structure condition assessment completed during the stormwater inventory. Structures receiving a condition of "poor" or "repair" for reasons besides debris blockage or cosmetic damage which are threatening the structural integrity of the drainage system or presenting safety hazards are listed below for maintenance. In addition, the Golf View Drive culvert and Willow Street drainage systems require sediment/debris removal maintenance to adequately convey flows and to minimize future risks to the structures as described in detail in Section 4.1.2.

Table 10-4 Maintenance Recommendations

Prioritization	Project	Cost
1	Retention pond behind shopping center at intersection of Stantonsburg and Arlington Boulevard requires replacement of discharge riser. Severe erosion downstream along Beasley Drive is attributed in part with failure of this pond structure to store runoff above the low level outlet.	$46,000
3	Golf View Drive culvert requires sediment removal on the upstream side to maintain conveyance capacity and prevent overtopping.	$3,000
4	Pipe inlet at the River Bank Apartments (TRMB03030) on Willow Street is failing/blocked and requires repair to prevent potential damage associated with overtopping.	$12,000
5	Asphalt is being undermined and collapsing around catch basin structure (TRM01025) on Wyndham Circle. Structure repair and asphalt replacement is required.	$3,000
6	Yard inlet (TRM01030) near Wyndham Circle is failing due to corrosion on box floor causing safety hazard as surrounding soils erode away. Repair and replacement fill is required.	$3,000
	Total	$67,000

SECTION 11
REFERENCES

1. Municipal Storm Water Management, by Debo and Reese, 1995
2. National Weather Service http://hdsc.nws.noaa.gov/hdsc/pfds/orb/nc_pfds.html
3. Stormwater Best Management Practices; North Carolina Department of Environment and Natural Resources, Division of Water Quality, July 2007.
4. Urban Hydrology for Small Watersheds, United States Department of Agriculture, Natural Resources Conservation Service, Conservation Engineering Division, Technical Release 55, June 1986.
5. Booth DB, Jackson CR (1997) Urbanization of aquatic systems: Degradation thresholds, stormwater detection, and the limits of mitigation. Journal of the American Water Resources Association 33(5):1077-1090.
6. Brant, T. R. 1999. Community Perceptions of Water Quality and Management Measures in the Naamans Creek Watershed. Masters Thesis for the Degree of Master of Marine Policy. 146 pp.
7. Stepenuck KF, Crunkilton RL, Wang L (2002) Impacts of urban land use on macroinvertebrate communities in southeastern Wisconsin streams. Journal of the American Water Resources Association 38(4):1041-1051.
8. Environmental Protection Agency http://www.epa.gov/caddis/ssr_urb_is4.html
9. North Carolina Department of Environment and Natural Resources http://www.ncwater.org/Financial_Assistance/
10. Sheridan. J.M, W.H. Merkel, and D.D. Bosch, 2002. Peak Rate Factors for Flatland
11. Watersheds. Volume 18(1) 65-69. American Society of Agricultural Engineers.
12. Applied Engineering in Agriculture.

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