Gully Branch Watershed Plan

City of Florence
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AECOM Project number: 60583057

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RECORD OF REVISIONS

Date	Revision
October 2013	Gully Branch Watershed Plan – Final
January 2020	Gully Branch Watershed Plan – Update
June 2021	Gully Branch Watershed Plan – Update of Sections 5.5.2 and 5.6.2

This watershed plan is intended to be a dynamic document with revisions made during each cycle of the National Pollution Discharge Elimination System Permit. This implementation plan will be amended with the City of Florence Public Utilities Department approval.

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LIST OF ACRONYMS AND ABBREVIATIONS

AFO	Animal Feeding Operation
ASTM	American Society for Testing and Materials
BMP	Best Management Practice
City	City of Florence
E. coli	Escherichia coli
EMC	Event Mean Concentration
EPA	Environmental Protection Agency
FW	Freshwater Stream Designation
HUC	Hydrologic Unit Code
K	Soil Erodibility
LID	Low Impact Development
MF	Membrane Filter
MLRA	Major Land Resource Area
MS4	Municipal Separate Storm Sewer System
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resource Conservation Service
OSWD	On Site Wastewater Disposal
QA	Quality Assurance
QC	Quality Control
SCDHEC	South Carolina Department of Health and Environmental Control
SOP	Standard Operating Procedure
SSO	Sanitary Sewer Overflow
SWMP	Stormwater Management Plan
TMDL	Total Maximum Daily Load
UDO	Unified Development Ordinance
USGS	United States Geological Survey
UV	Ultraviolet
WQM	Water Quality Monitoring Station
WQS	Water Quality Standard
WWTP	Wastewater Treatment Plant

UNITS OF MEASURE

ac	Acre
C	Celsius
cfs	Cubic Feet Per Second
cfu	Colony Forming Units
cm	Centimeter
Ea	Each
ft	Feet
in	Inch
lb	pounds
lf	Linear Feet
mL	Milliliters
MPN	Most Probable Number
No	Number
yr	Year

EXECUTIVE SUMMARY

The Gully Branch Watershed Plan has been developed to assist the City of Florence (City) and stakeholders within the City to implement structural and non-structural best management practices (BMPs) to improve water quality within Gully Branch. The watershed has been identified by the South Carolina Department of Health and Environmental Control (SCDHEC) as having impairment for fecal coliform bacteria. This impairment was evaluated and defined as part of a Total Maximum Daily Load (TMDL) in 2005. As part of the TMDL, SCDHEC established pollution reduction requirements to achieve water quality standards for the watershed. However, the TMDL did not specifically define causes of impairment or potential solutions to the pollution problem. This watershed plan, funded through an Environmental Protection Agency 319 Grant by SCDHEC, established finite pollution reduction goals for each area of the City. Additionally, in 2013, SCDHEC established Escherichia coli (*E. coli*) as the new bacterial standard. This Watershed Plan incorporates monitoring and assessment protocol for *E. coli* as well as the previously utilized fecal coliform. Structural BMPs have been selected to reduce the overall pollutant loading to Gully Branch, and subsequently Jeffries Creek.

The Gully Branch watershed is a 1,344 acre (2.1 square mile) urban watershed located almost entirely within the city limits of Florence, South Carolina. The watershed is almost 100% developed consisting of residential, commercial and industrial facilities. Significant areas that have not been developed are primarily the City owned parks of Timrod, Maple and Lucas. The upper limits of the watershed, with the exception of a small portion around Maple Park, is piped, which daylights within Timrod Park. Lucas Park receives most of the runoff draining south of Timrod Park and Cherokee Road. Due to the piped nature of this watershed, the majority of restoration and water quality treatment activities will need to occur within Timrod Park and Lucas Park, where space and feasibility are greatest.

In order to define structural and non-structural BMPs for implementation, the City evaluated water quality at several locations within the watershed. Since only one (1) monitoring station was utilized to establish the TMDL, it was critical to define specific problem areas that could be remediated with water quality treatment practices. The overall watershed was broken into five (5) sub-watersheds and evaluated for pollutant loading. The results of this monitoring and modeling assessment indicated that each of the sub-watersheds do exceed the minimum SCDHEC standard for bacterial loading (fecal coliform). However, the sampling and modeling results indicated that the exceedance was not as significant as the established load reduction requirements in the TMDL. Therefore, success of the Watershed Plan and implementation goals is specifically based on meeting SCDHEC concentrations for bacteria and not a percentage reduction.

The City performed a detailed site assessment for potential locations for site-specific projects. It was determined from this investigation that the most successful options, in terms of both pollution reduction and feasible implementation, would involve implementation of structural BMPs within Lucas Park, Maple Park and Timrod Park. Additional water quality treatment activities will take place outside of these areas; these implementation practices include retrofitting existing roadside ditches with enhanced infiltration swales and installing vegetated filter boxes in several of the catch basins throughout the watershed. These practices will be implemented as sites and locations become available within the City as part of their ongoing stormwater maintenance activities. This watershed plan addresses water quality concerns within the Gully Branch watershed to the maximum extent practicable given the highly urbanized nature of the watershed. The piped nature of the system, as well as the lack of viable available sites for large implementation projects, has resulted in a plan that addresses a majority of the pollutant loading concerns. Additional BMPs will be implemented once the primary projects have been completed as discussed above. One significant concern, as described in this plan, is the probability of sanitary sewer seepage entering the receiving waters. While not currently identified, the modeling and sampling results indicate that there is the probability that this is occurring. A key element of this plan is to continue to monitor these waterways and evaluate the sanitary sewer infrastructure for possible seepage problems.

Overall, the proposed site-specific implementation projects identified in this Watershed Plan meets approximately 90% of the pollution reduction goal. The additional reduction required will be achieved through the increase in educational outreach, implementation of future identified retrofits as discussed above, as well as on-going monitoring and maintenance of the sanitary sewer infrastructure. Investigation undertaken as part of this project was unable to determine specific contribution that the sanitary sewer system may have to water quality impairments. However, due to the age and location of the infrastructure, the City acknowledges the potential for possible leakage within the Gully Branch watershed. As part of this project, the City will monitor and evaluate the infrastructure and make any necessary repairs where sanitary sewer may be adversely impacting the watershed.

BACKGROUND/PLANNING PROCESS

01

1. BACKGROUND/PLANNING PROCESS

1.1 INTRODUCTION

The Gully Branch watershed is a 1,344 acre (2.1 square mile) urban watershed located almost entirely within the city limits of Florence. Gully Branch flows underground throughout the majority of the watershed, but daylights at the Timrod Park recreation area and flows above ground the remainder of its length before draining into Jeffries Creek.

In September 2005, South Carolina Department of Health and Environmental Control (SCDHEC) developed a Total Maximum Daily Load (TMDL) for fecal coliform bacteria based on data collected at SCDHEC's Water Quality Monitoring Station (WQM) for Gully Branch at Cherokee Road (PD-065). The TMDL goal was developed to protect and restore the Gully Branch watershed from fecal coliform impairment. Additionally, in 2013, SCDHEC established Escherichia coli (*E. coli*) as the new bacterial standard. Potential sources of fecal coliform and *E. coli* bacteria were identified as residential runoff, pets, and sanitary sewer leakage.

In September 2007, the City of Florence (City) was granted coverage under the revised National Pollutant Discharge Elimination System (NPDES) General Permit for Small Municipal Separate Storm Sewer Systems (MS4s) (Permit No. SCR034101). In compliance with the permit, the City developed a Stormwater Management Plan (SWMP) and implemented a program to protect stormwater quality within its jurisdiction.

The City was awarded an Environmental Protection Agency (EPA) Section 319 Grant to develop the Gully Branch Watershed Plan in November 2012. The overall goal of the Gully Branch Watershed Plan is to meet the Water Quality Standard (WQS) criteria for fecal coliform and *E. coli* for primary contact recreational uses in Gully Branch.

1.2 CITY OF FLORENCE MS4 STORMWATER MANAGEMENT PROGRAM

As part of MS4 NPDES permit compliance, the City completed inspection of all stormwater outfalls contributing to Gully Branch, including follow-up investigations of any suspected non-stormwater discharges, resulting in the elimination of two illicit discharges in 2010. See **Appendix A**. Since 1998, sanitary sewer rehabilitation has been performed to minimize stormwater contamination from domestic wastewater sources.

Pet waste removal stations were installed at Timrod Park and Maple Park to minimize the transport of bacteria into Gully Branch from stormwater runoff. The City also installed two (2) bioretention areas in Timrod Park with funding from Clemson University in 2012.

Additionally, the City implemented a sanitary sewer and stormwater assessment project within the Jeffries Creek corridor in the City, which included the lower portion of the Gully Branch watershed

(Timrod Park). This project analyzed the Jeffries Creek gravity sewer, including the Gully Branch sanitary sewer line, to determine needed retrofits, upgrades and modifications to the line. This would increase efficiency and capacity, thereby reducing the potential for sanitary sewer overflows (SSOs). As part of this project, the City developed a stormwater model to predict potential flooding problems that could lead to excess inflow and infiltration, resulting in SSOs. Included in this research effort is the placement of a wet weather monitoring site at the current SCDHEC monitoring location for Gully Branch (PD-065). This data is being used to evaluate the watershed, and in the future to pinpoint pollution concerns and locations.

The City continues to make significant progress toward protecting and restoring the quality of its surface waters through the implementation of its Stormwater Management Program. The Gully Branch watershed is of particular interest to the City as it works toward adoption of a Unified Development Ordinance (UDO) to govern land use and development. The watershed encompasses one of the oldest development corridors in the City, making the need for stormwater retrofitting and upgrades within the watershed vitally important.

1.3 COOPERATING ORGANIZATIONS/STAKEHOLDERS

Stakeholders will play an important role in the overall development and implementation of the Gully Branch Watershed Plan. Stakeholders provide input, local knowledge and recommendations on how the watershed plan should be utilized within certain neighborhoods and portions of the City to restore the watershed and meet the overall development goals and standards of the community. The City is committed to the development and inclusion of stakeholder groups in every phase of the project.

The Timrod Park neighborhood has demonstrated their interest in restoring the watershed through several projects, including installation of pet waste removal stations and bioretention areas within the Timrod Park recreation area.

Stakeholders the City has developed a working relationship include:

- Clemson Extension
- Timrod Park Neighborhood Association
- Maple Park Neighborhood Association

Coordination with the Natural Resource Conservation Service (NRCS) or the local conservation district is not required due to the urban environment and absence of agricultural activities in this watershed.

1.4 PROJECT STAFF EXPERTISE

The City has a full Stormwater Department staffed with employees who are familiar with the Gully Branch watershed, the stormwater outfalls, and pollutant problems within the watershed. City staff has performed sanitary sewer assessment within the watershed, and the City has provided staff time for oversight and construction of best management practices (BMPs) within the watershed limits.

WATERSHED CHARACTERIZATION

02

2. WATERSHED CHARACTERIZATION

2.1 INTRODUCTION

This section describes the natural characteristics and land usage of the Gully Branch watershed.

2.2 PHYSICAL AND NATURAL FEATURES

2.2.1 Geography

The Gully Branch watershed (Hydrologic Unit Code (HUC) 03040201-0902) is a 2.1 square mile watershed located near the northern boundary of the Jeffries Creek watershed in the City (**Figure 2-1).**

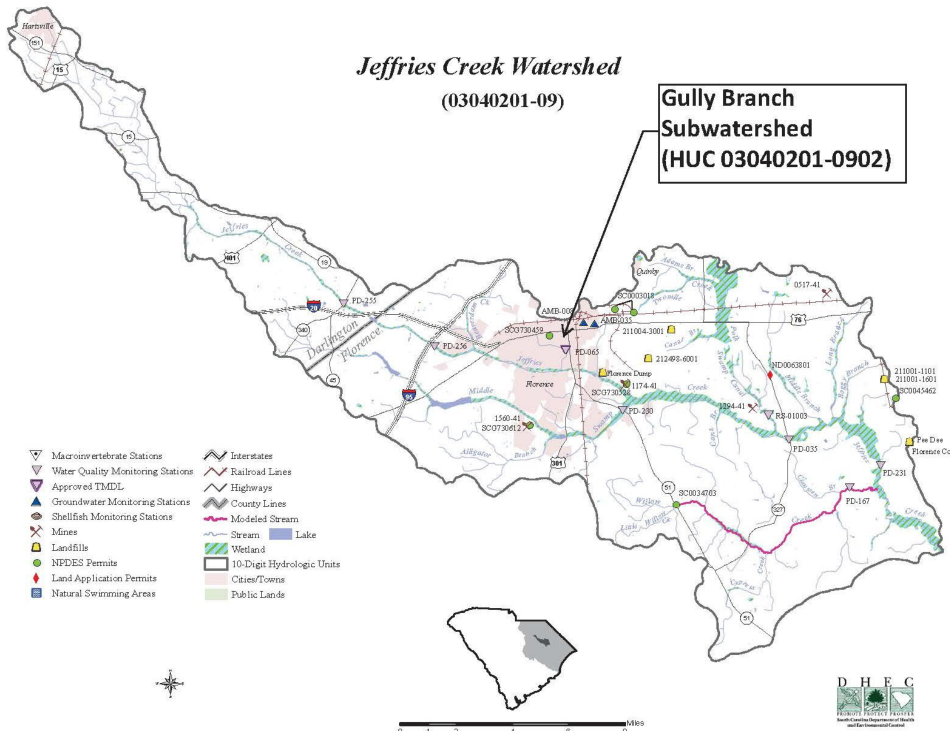

Figure 2-1. Jefferies Creek Watershed

The Jeffries Creek watershed (HUC 03040201-09) is one of 22 watersheds of the Great Pee Dee River Basin (HUC 03040201), which in turn is part of the Pee Dee River Basin of northeastern South Carolina (**Figure 2-2**).

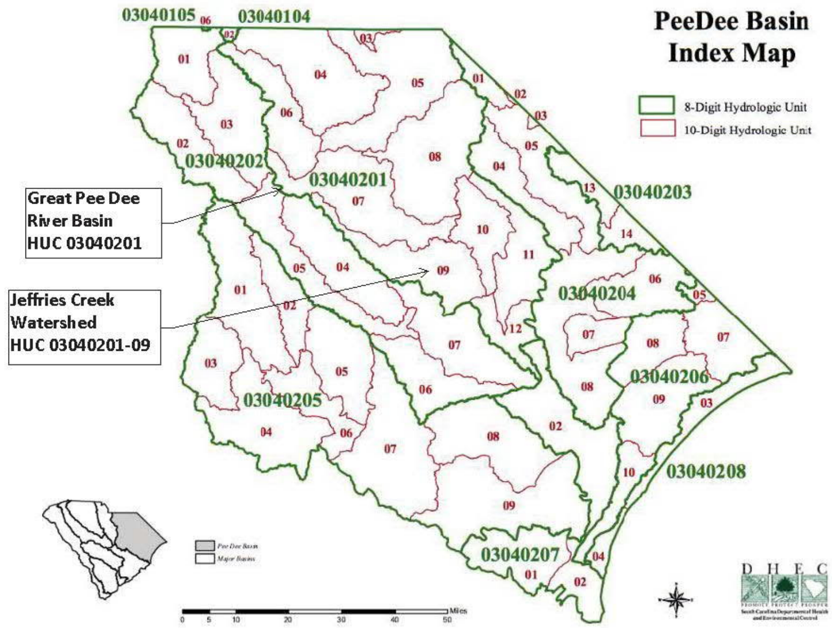

Figure 2-2. Pee Dee River Basin

Nearly the entire Gully Branch watershed is contained within the city limits of Florence, as shown in **Figure 2-3**, below, and in **Appendix B**.

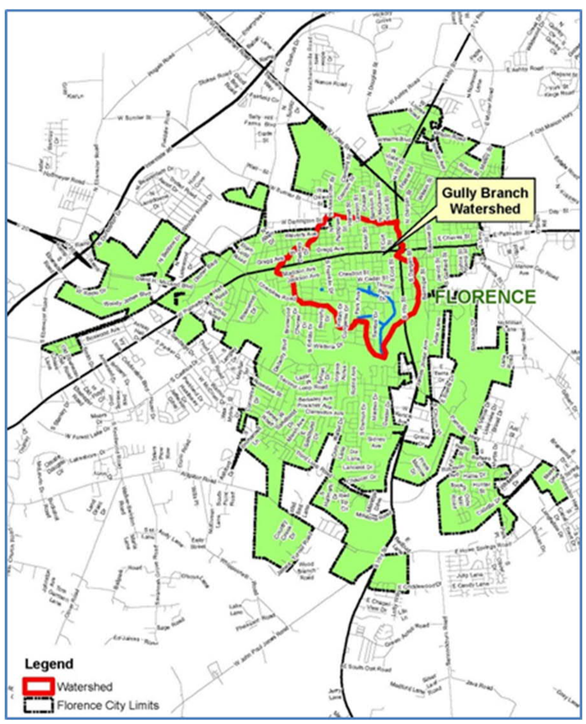

Figure 2-3. Gully Branch Watershed

2.2.2 Geology

The Gully Branch watershed is located within the Southern Coastal Plain Major Land Resource Area (MLRA). The MLRA, shown in orange in **Figure 2-4**, is bordered on the north and west by the fall line, which marks the northern and western extent of the unconsolidated Coastal Plain sediments. During the Jurassic and Cretaceous periods, rivers and streams to the south and east of the fall line that drain the Appalachians deposited thick wedges of silt, sand, and gravel as delta deposits in the Atlantic Ocean. Subsequent uplift of the Coastal Plain and fluctuating sea level resulted in cycles of erosion and deposition. The Coastal Plain is underlain by layers of sand, unconsolidated clay, silt, gravel and carbonates due to the area being exposed and submerged numerous times.

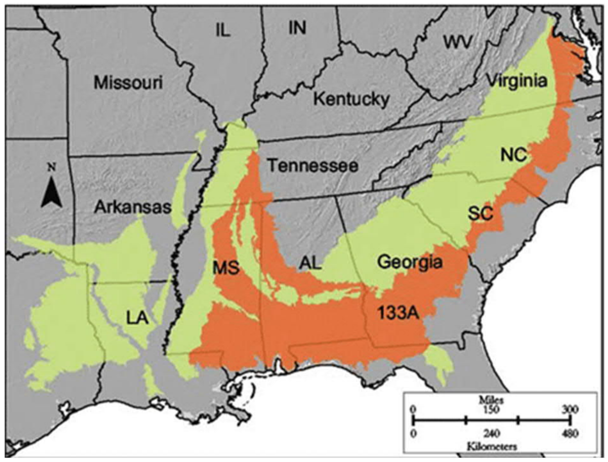

Figure 2-4. Southern Coastal Plain

2.2.3 Climate

Southern Coastal Plain in South Carolina has the least amount of precipitation during the autumn. The maximum precipitation falls during midsummer, typically occurring as high-intensity, convective thunderstorms; however, moderate-intensity tropical storms can produce large amounts of precipitation.

Precipitation data from National Oceanic and Atmospheric Administration (NOAA) stations in Florence, South Carolina indicate a normal yearly precipitation of approximately 47 inches. The highest seasonal rainfall occurs in the summer, averaging approximately 15 inches of rain. The average annual daily temperature is approximately 63°F. Seasonal mean temperatures range from approximately 46°F in winter to 80°F in summer.

2.2.4 Hydrology

Gully Branch is a spring-fed stream. Most of Gully Branch is routed through an underground pipe network; however, the stream flows through a natural streambed beginning at Timrod Park.

2.2.5 Soils

The predominant soil within the Gully Branch Watershed is of the Coxville-Norfolk association (93%), as shown in **Appendix C**. The Coxville series consists of deep, poorly drained soils in the uplands. Norfolk soils are deep, well-drained soils, with loamy subsoil in the uplands.

Soil erodibility (K) in the Pee Dee River Basin ranges from 0.10 to 0.28, suggesting that the soil is not highly prone to erosion from stormwater runoff. In general, clay soils have low K values (about 0.05 to 0.15) because the particles are resistant to detachment. Sandy soils, also have low K values (about 0.05 to 0.20) because they have high infiltration rates resulting in low runoff. Although sandy soil particles are easily detached, sediment eroded from these soils are not easily transported. Silt loams have moderate K values (about 0.25 to 0.45) because they are moderately susceptible to particle detachment, infiltration is moderate, and sediment is moderately to easily transported. Silt soils are susceptible to erosion and have high K values, which can exceed 0.45. Silt soil particles are easily detached, sediment is easily transported, and silt soils readily crust (becoming cement-like when dry) producing high runoff rates and amounts.

2.3 LAND USE AND POPULATION CHARACTERISTICS

2.3.1 Land Use and Land Cover Data (2013)

The land use for the majority of the Gully Branch watershed (60%) is classified as Urban and Auto-Urban Single and Multi-Family character (**Figure 2-5**). These are high intensity or densely developed areas, including a portion of the downtown Florence area, and single or multiple family neighborhoods. Approximately 82% of the total area contains houses, businesses and ancillary development, with approximately 17% forest, and less than 1% in pastures and row crops. Approximately 13% of the watershed is classified as Auto-Urban Commercial, which includes commercial uses along main corridors, shopping centers, and two large medical centers. Office and Institutional land use comprise 9% of the watershed, and an additional 8% is classified as Natural Areas and Parks. Other land uses within the watershed are Suburban/Estate Residential (3%) and Industrial (3%). Land designated as suburban contains large lots or liberal open space and vegetation. Approximately 5% of the watershed is currently vacant with no land use classification. The Existing Land Use Map is in **Appendix D**.

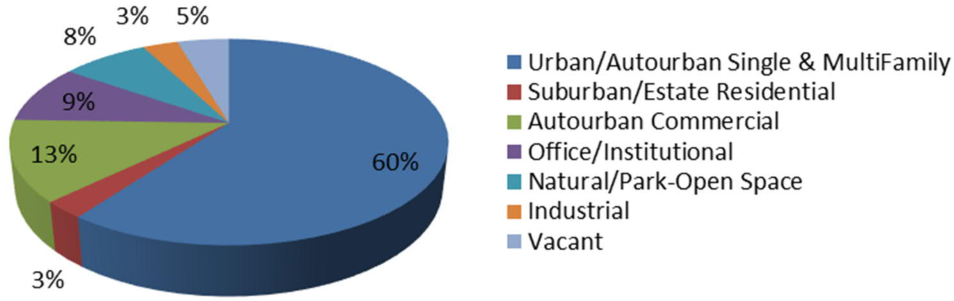

Figure 2-5. Gully Branch Existing Land Use (2013)

The neighborhoods within the watershed are older, established neighborhoods. Timrod Park, churches, restaurants, and other public amenities are within walking distance.

Approximately 12 acres within the watershed are owned by the City, shown in **Appendix E**.

2.3.2 Future Growth and Land Use Changes

The Florence urbanized area is a growing residential, industrial, and commercial center in the Pee Dee region of South Carolina. The City's Comprehensive Plan, updated in 2017, emphasizes the importance of high quality neighborhoods with accessibility to commercial facilities, employment, trails and parks, schools and public facilities, and re-establishment of the City center. These land usage changes are reflected in **Figure 2-6**, below. The plan proposes to protect the character and function of the established neighborhoods in the community by changing the land use for the majority of the urban residential and industrial areas to the Neighborhood Conservation category. Approximately 63% of the watershed will be classified as Neighborhood Conservation, with an additional 8% falling under a Residential category (Auto-Urban, Transition or Urban). Downtown (10%), Commercial (7%) and Business Parks/Public Institutional (4%) combined make up 21% of the watershed area under the future land use plan. **Appendix F** shows the proposed land use areas based on the updated Comprehensive Plan.

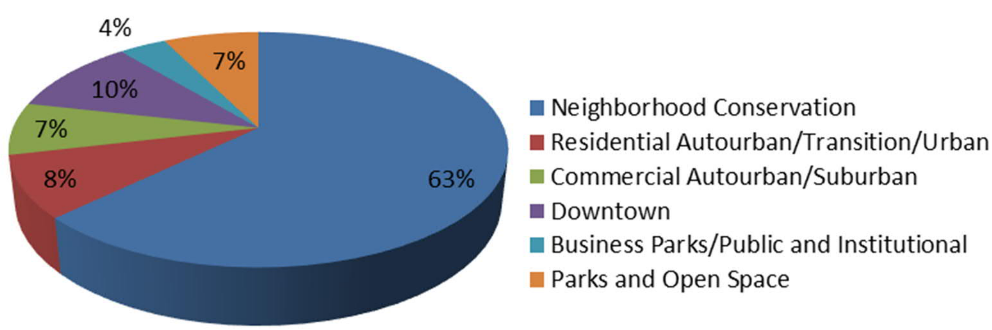

Figure 2-6. Gully Branch Future Land Use (2010 Comprehensive Plan)

2.3.3 Demographics

The total population of the City is 37,056 (2010 U.S. Census). The racial makeup is approximately 50% White, and 46% African American. By gender, the City is 46% male and 54% female. The population breakdown by age shows 25% under the age of 18, and 14% age 65 or older. The remaining 62% of the population is between 18 and 64 years old, the typical working age range. The median household income in the City is $42,719. **Figure 2-7** shows the City's demographic breakdown.

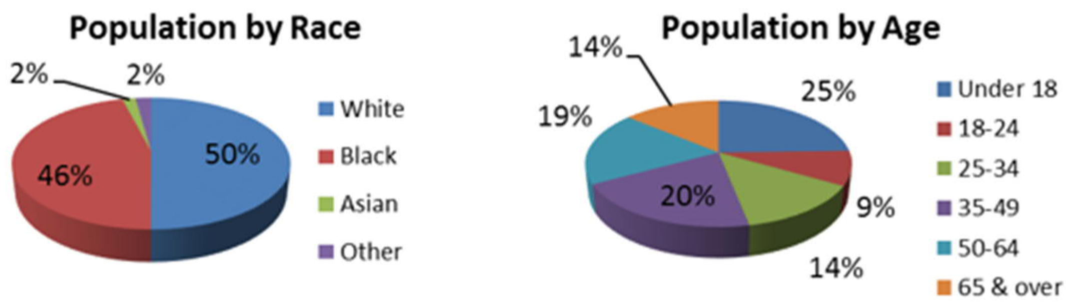

Figure 2-7. City of Florence Demographics

2.4 WATERBODY AND WATERSHED CONDITIONS

2.4.1 Water Quality Standards

Gully Branch is classified as a freshwater (FW) stream under the South Carolina Water Quality Standards Regulation, R.61-68, Water Classifications and Standards, with designated uses as follows:

> *Freshwaters (FW) are freshwaters suitable for primary and secondary contact recreation and as a source for drinking water supply, after conventional treatment, in accordance with the requirements of the Department. Suitable for fishing and the survival and propagation of a balanced indigenous aquatic community of fauna and flora. Suitable also for industrial and agricultural uses.*

South Carolina monitors the safety of its FWs through the use of indicator bacteria. Indicator bacteria are generally not harmful, but indicate the presence of a health risk. Fecal coliform bacteria are commonly monitored in FWs as an indicator of potential health risks for individuals exposed to recreational waters. SCDHEC considered a monitoring station impaired if greater than 10% of samples collected and analyzed for fecal coliform bacteria exceeded 400 cfu/100 mL.

In June 2012, *E. coli* replaced fecal coliform as the indicator bacteria for FW standards in South Carolina. *E. coli* bacteria are members of the fecal coliform group of bacteria that normally live in the intestines of warm-blooded animals, including humans. *E. coli* in surface waters are indicators of recent human or animal waste contamination, and have been found to be better indicators than fecal coliform for predicting the presence of pathogens in South Carolina FWs. The current State standard criteria for *E. coli* to protect for primary contact recreation use in freshwater is as follows:

> *Not to exceed a geometric mean of 126 MPN/100 mL based on at least four samples collected from a given sampling site over a 30-day period, nor shall a single sample maximum exceed 349 MPN/100 mL.*

In the absence of sufficient sampling data for *E. coli* under the new standard, SCDHEC's policy is to include all stations impaired for fecal coliform on future South Carolina §303(d) lists for *E. coli* exceedances. The §303(d) list is comprised of waters of the State that do not meet WQSs, and a TMDL must be developed for the pollutant of concern.

A TMDL calculates the maximum amount of the pollutant a waterbody can assimilate and still meet WQSs. A TMDL for *E. coli* has been established for the Gully Branch watershed (TMDL 2016 Update for Jeffries Creek and Tributaries).

2.4.2 Water Quality Monitoring Station

The Gully Branch watershed is monitored by SCDHEC at WQM PD-065 located at Cherokee Road as the stream exits Timrod Park. The watershed of PD-065 contains 1,055 acres, almost entirely within the city limits. The estimated median flow rate is very low, at 1.5 cfs, and ranging from 0.3 to 4.8 cfs.

In samples collected from 1998 through 2002, WQM Station PD-065 exceeded the WQS of 400 cfu/100 mL for fecal coliform bacteria in total of 24 out of 33 samples (73%). WQM station PD-065 was placed on the 2004 §303(d) list for impairment due to fecal coliform exceedances. In samples collected from 2007 through 2012, WQM Station PD-065 exceeded WQS for fecal coliform and *E. coli* in total of 36 out of 51 samples (71%).

2.4.3 Pee Dee River Basin TMDL

In September 2005, SCDHEC published Technical Report Number 029-05 (2005 Technical Report) establishing TMDLs for Fecal Coliform for certain watersheds within the Pee Dee River Basin that exceeded the WQS for fecal coliform bacteria for primary contact recreation. The 2005 Technical Report established a TMDL for fecal coliform bacteria for WQM Stations PD-065 on Gully Branch. SCDHEC updated the TMDL and published an updated Technical Report Number 1004-16 (2016 Technical Report) to include *E. coli*.

2.4.4 TMDL Goals for Gully Branch

Waste load allocations for stormwater discharges are expressed as a percentage reduction rather than a numeric loading because of the variability of stormwater discharge volumes and recurrence intervals. The 2005 Technical Report established a percent reduction goal for fecal coliform bacteria of 99% at PD-065 to restore and maintain the water quality in Gully Branch.

In 2012, the State of South Carolina replaced fecal coliform bacteria with *E. coli* as the bacterial indicator species for freshwaters such as Gully Branch. SCDHEC has established a conversion factor for use during the transition from fecal coliform to *E. coli* as the indicator bacteria. The conversion factor is derived from an established relationship between fecal coliform bacteria and *E. coli* WQS in FWs, as discussed in SCDHEC's June 2013 Pocotaligo River TMDL. The ratio is calculated by dividing the current single sample maximum WQS for *E. coli*, 349 MPN/100 mL, by the former single sample maximum WQS for fecal coliform bacteria, 400 cfu/100 mL. The conversion from fecal coliform bacteria in **Equation 2-1**. *E. coli* percent reduction goals were assumed to be the same as fecal coliform percent reduction goals from 2005 due to the lack of sampling data for *E. coli.*

Equation 2-1. Conversion from Fecal Coliform to *E. coli*

$$\frac{E.coli\ MPN}{100\ mL} = \frac{349\ MPN/100\ mL}{400\ cfu/100\ mL}\ x\ \frac{Fecal\ Coliform\ cfu}{100\ mL}$$

The 2016 Technical Report included amendments to the TMDL, including a revision to the percent reduction goal from the 2005 Technical Report. The 2016 Technical Report established a percent reduction goal for *E. coli* bacteria of 90% at PD-065 to restore and maintain the water quality in Gully Branch.

2.5 POLLUTANT SOURCES

Water samples with high concentrations of fecal coliform and *E. coli* indicate the water has received fecal matter from point and/or non-point source(s).

2.5.1 Point Sources

Typically, the two types of point sources that discharge fecal coliform bacteria into streams are continuous point sources (e.g., wastewater treatment plants (WWTP) and MS4s. There are no continuous point sources discharging to the Gully Branch Watershed. However, the watershed is located almost entirely within the designated City of Florence MS4 area. Stormwater runoff from MS4 areas can contain high fecal coliform and *E. coli* bacteria concentrations due to leaking sewers, SSOs, pets, and wildlife. The City of Florence WWTP reported 32 SSOs from March 1999 through April 2005, five (5) of which reached a waterbody. The largest SSO to reach a waterbody was comprised of 450,000 gallons on December 28, 2004. The City of Florence WWTP reported 53 SSOs from January 2015 through March 2019, fifteen (15) of which reached a waterbody. The largest SSO during this time period to reach a waterbody was comprised of 29,000 gallons on July 13, 2015.

There is one (1) facility (SCG730459) permitted as a minor industrial wastewater discharger in the Gully Branch watershed. This facility is the headquarters and storage yard of a heavy construction company. Based on company and SCDHEC information, it was determined that this discharger was not a significant potential source of bacterial loading within the Gully Branch watershed.

2.5.2 Non-Point Sources

Potential nonpoint sources of bacteria include wildlife, agricultural activities and domesticated animals, land application fields, urban runoff, failing On Site Wastewater Disposal (OSWD) systems, and pets. Agricultural activities and land application fields are not expected to contribute to non-point source loading in Gully Branch.

The estimated deer density for the WQM station is 15 to 30 deer per square mile, which suggests a relatively minor contribution of bacteria loading from wildlife. There are no known cattle within the watershed, and no permitted animal feeding operations (AFOs).

Although the City has been active in locating and repairing damaged sewers, the Gully Branch (PD-065) watershed is heavily developed, and leaking sewers may be a source of bacteria loading to Gully Branch. Sanitary sewers potentially contribute to bacteria loading in the Gully Branch watershed through both exfiltration, and infiltration and inflow. Exfiltration occurs when wastewater leaks from deteriorating pipes and manholes, contaminating groundwater. The contaminated groundwater may reach the water table that serves as the base flow for Gully Branch. Bacteria contamination from the sanitary sewer is not visible, and specific problem areas have not been identified. The potential for impairment of Gully Branch caused by leaking sewers must be addressed because untreated wastewater from exfiltration often contains high levels of pollutants, including fecal coliform and *E. coli*.

Additionally, infiltration and inflow of stormwater into the sanitary sewer during wet weather events can cause the sanitary sewer to surcharge and overflow, resulting in the transport of bacteria to Gully Branch via surface waters. Because of SSOs and leaking sewers, human sources likely play a major role in bacteria loadings in the Gully Branch watershed.

The density of OSWDs for the Gully Branch watershed is 4 per 100 acres, which could be a significant source of bacteria loading. Areas with more than 6.25 septic systems per 100 acres can potentially have contamination problems. Septic systems are designed to have a lifetime of 20 to 30 years if properly maintained. Failure can occur when soils are saturated by stormwater, pipes become blocked by roots, and soil around the absorption field becomes clogged with organic material. Bacteria loading from failing OSWD systems can enter streams in stormwater runoff or through groundwater springs and seeps.

Domestic pets can be another major contributor of bacteria to streams. The estimated daily dog waste produced in Florence County is 5.7 tons per day. Timrod Park is located upstream of PD-065, which could provide a significant source of bacteria loading.

The 2005 Technical Report found that bacteria exceedances at PD-065 occurred regardless of precipitation, and there is no apparent relationship between rainfall and bacteria exceedances.

Although the City's MS4 program has done extensive investigation regarding potential illicit connections and sanitary sewer seepage and has concluded that there are no visible illicit connections to the system, illegal dumping is still a concern to the City. Therefore, preliminary evaluation resulting from the MS4 program activities indicate that the primary sources for bacteria contribution in these headwater areas are most likely pet waste, illegal dumping, and potentially undiscovered illicit connections.

WATERSHED ANALYSIS

03

3. WATERSHED ANALYSIS

3.1 INTRODUCTION

This section describes the components of the watershed analysis for Gully Branch, and the major findings.

3.2 WATERSHED PLAN GOALS

The Gully Branch watershed is currently threatened by impairment from fecal coliform and *E. coli*. The number of fecal coliform and *E. coli* bacteria present in a stream or lake are indicators of the number of disease-causing organisms likely present. The State of South Carolina has established WQS, which include maximum levels of fecal coliform and *E. coli* bacteria. The goals of the Gully Branch Watershed Plan are to protect the natural resources by:

1. Identifying and mitigating stormwater pollution that could compromise the water quality of Gully Branch.
2. Educating the public about watersheds and stormwater treatment.

3.3 DETAILED WATERSHED ASSESSMENT

The headwaters of the Gully Branch watershed consist of an extensive network of previously piped stream channels and drainage networks. Fecal coliform and *E. coli* sources in these areas are likely limited to stormwater runoff associated with leaking sewers, SSOs, failing OSWD systems, domestic pet waste, illegal dumping into the MS4 system, and potential illicit connections to the MS4 system.

The piped system daylights within Timrod Park, the centerpiece of the Timrod Park neighborhood. Timrod Park is a highly utilized 18-acre recreation area with tennis courts, playgrounds, picnic areas, gardens, nature trails, fitness courses, and dog walking paths. Stormwater drainage enters Timrod Park through two major conveyances:

- A culvert inlet along Spruce Street between Graham Street and Timrod Park Drive
- The headwaters of Gully Branch, which originate approximately 600 feet upstream of the park and enters the park under Park Ave.

Runoff and base streamflow through the park discharge under Cherokee Road, ultimately draining to Jeffries Creek, approximately 1,500 feet downstream of Cherokee Road through a mature wooded buffer.

Evaluation of the Timrod Park neighborhood in 2011-2012 indicated that sources of fecal coliform within the park, and subsequently the downstream portions of the watershed to its confluence with Jeffries Creek, include pet waste runoff, sanitary sewer overflows, and some wildlife influences within the Park.

The major drainage breaks of the Gully Branch watershed were defined, resulting in the delineation of five (5) separate drainage basins as shown in **Figure 3-1**. **Table 3-1** lists the area for each drainage basin. **Appendix G** shows the location of five proposed water monitoring stations.

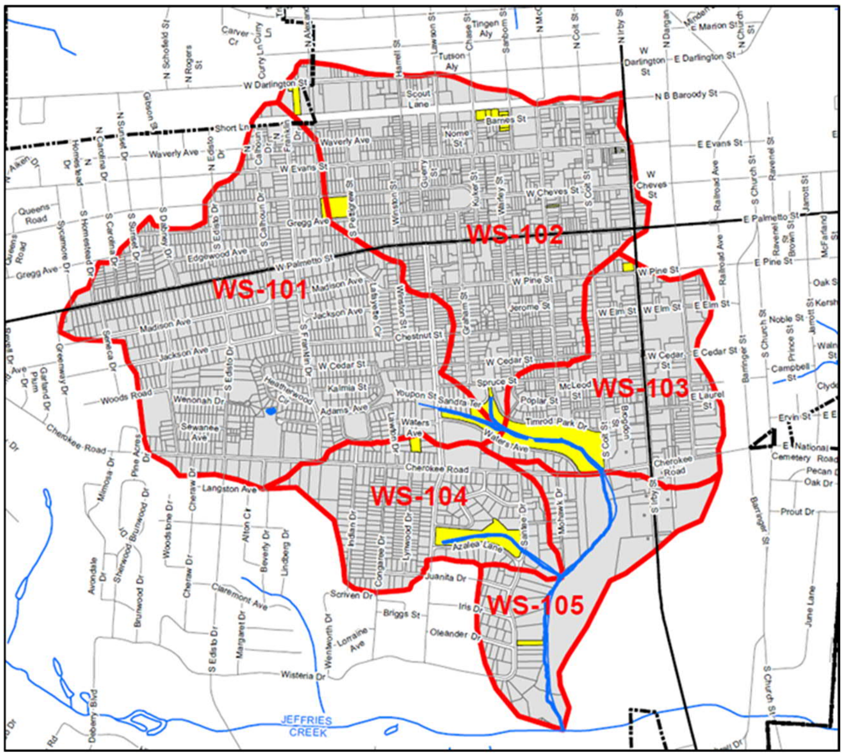

Figure 3-1. Gully Branch Drainage Basins

Table 3-1. Drainage Basin Areas

Drainage Basin	Area (Acres)	Percent of Watershed (%)
WS-101	462	34
WS-102	397	29
WS-103	187	14
WS-104	153	11
WS-105	145	11
Total	1345	100

3.3.1 Drainage Basin Base Flow

A base flow assessment of each drainage basin was performed by investigating the stormwater system through dry weather screening of outfalls (**Appendix A**). Base flow rates are shown in

Table 3-2.The baseflow rates at the sampling locations were back-calculated from the City of Florence Water Quality Sampling in 2013 (**Section 3.4.4**).

Table 3-2. Drainage Basin Base Flow Rates

Drainage Basin	Base Flow Rate (cfs)
WS-101	1.89
WS-102	0.95
WS-103	0.79
WS-104	0.62
WS-105	0.59

3.3.2 Drainage Basin Land Use

The drainage basins are comprised of a mixture of land uses discussed in **Section 2.3**. The majority of Timrod Park is located in WS-103 and Lucas Park is located in WS-104. **Table 3-1** shows the land uses associated with each drainage basin. A map of the watershed is located in **Appendix D**.

Table 3-3. Drainage Basin Land Use

Drainage Basin	Land Uses
WS-101	Auto-Urban, Industrial, Public Institutions
WS-102	Auto-Urban, Commercial, Industrial, Public Institutions
WS-103	Auto-Urban, Commercial, Business Parks/Public Institutions, Parks and Open Space
WS-104	Auto Urban, Park and Open Space
WS-105	Urban, Parks and Open Space

3.3.3 Drainage Basin Runoff Analysis

A peak runoff analysis and comparison was performed based on existing and future land use conditions. The results of the analysis indicate that under future land use conditions, the flow at the Gully Branch outfall to Jeffries Creek will decrease by approximately 66 cfs (10%) for a 1 year storm, 71 cfs (9%) for a 2-year storm and 104 cfs (6%) for a 10-year storm (**Figure 3-2**). This reduction in peak flow is a result of future changes with land usage in the downtown corridor. While the residential development concentration will likely not change, the City has, as part of their comprehensive plan, proposed a reduction in the overall impervious cover through the downtown corridor. This will increase infiltration of stormwater runoff and slightly reduce the overall stormwater loading to Gully Branch.

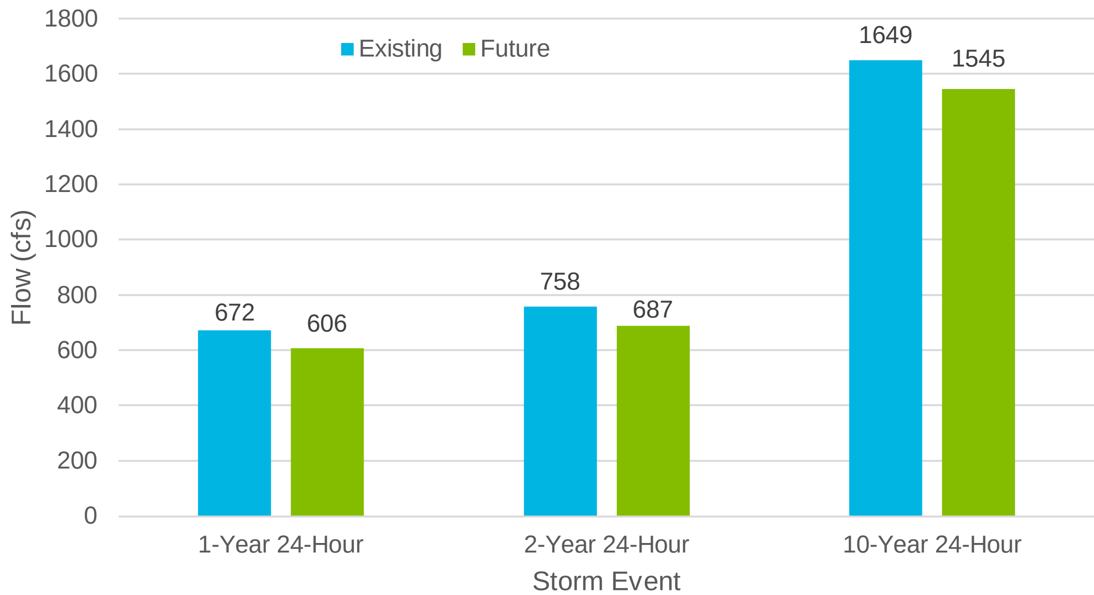

Figure 3-2. Existing and Future Flow to Gully Branch Outfall at Jeffries Creek

A hydraulic analysis was performed for the watershed to determine peak runoff from each of the sub-watersheds (**Table 3-4**). This data will be used in determining peak removal efficiency for the BMPs selected on a site-by-site basis. While detailed design specifications are not included as part of this watershed plan, it was important to determine peak flow rates to evaluate whether the proposed projects would be feasible under storm flow conditions. All projects proposed herein will be designed to meet the 10-yr design capacity, with a treatment volume equal to 1-inch of runoff per impervious acre draining to the BMP.

Table 3-4. Storm Flow Analysis

Station	Location	Future Flow Peak Runoff (cfs)		
		1-Year	2-Year	10-Year
WS01	Timrod Park	183.2	211.7	517.4
WS02	Timrod Park	217.7	245.2	530.8
WS03	Spruce Avenue	162.8	181.1	360.5
WS04	Waters Avenue	65.4	75.8	192.7
WS05	Azalea Drive	48.5	56.0	138.1

3.3.4 Theoretical Fecal Coliform Pollutant Loading

A theoretical assessment of pollutant loading for each drainage basin based on existing data suggests that WS04 – Waters Avenue has the highest average fecal coliform bacteria loading. WS04 is located in basin WS-101, which is the largest of the drainage basins, with majority land use Auto-Urban. The lowest average loading was estimated at WS03 – Spruce Avenue, in Basin WS-102, which has mixed land use. The theoretical pollutant loading is in **Table 3-5.**

Table 3-5. Theoretical Pollutant Loading

Station	Location	EMC Fecal Coliform Loading (cfu/100 mL)	EMC *E. coli* Loading (MPN/100 mL)	Loading Rank	Average Loading Category
WS01	Timrod Park	2408	2101	3	High
WS02	Timrod Park	2675	2334	2	High
WS03	Spruce Avenue	1	<1	5	Very Low
WS04	Waters Avenue	7255	6330	1	Very High
WS05	Azalea Drive	534	466	4	Low

3.4 WATER QUALITY ANALYSIS

3.4.1 TMDL Findings: SCDHEC Technical Report Number 029-05

The TMDL for Gully Branch (Gulley Branch) at WQM station PD-065 was published in September 2005 establishing the pollutant load reduction goals for the Gully Branch watershed. For the period examined (1998 to 2002) there were numerous days in which fecal coliform concentrations exceeded the maximum daily fecal coliform WQS of 400 cfu/100 mL. A summary of these monitoring results can be seen in **Table 3-6**. SCDHEC determined that there is no apparent relationship between rainfall and fecal coliform exceedances.

Table 3-6. Fecal Coliform Bacteria Observed from 1998 through 2002

Station	Total Number of Sample	Maximum Concentration (cfu/100 mL)	Total Number of Samples >400 cfu/100 mL	Percentage of Samples Exceeding WQS (%)
PD-065	33	12,000	24	73

SCDHEC found that SSOs and leaking sanitary sewers were point source contributors to the impairment of Gully Branch. Nonpoint source contributors included failing OSWD systems, human sources of fecal coliform, and pets.

3.4.2 TMDL Findings: SCDHEC Technical Report Number 1004-16

The TMDL update for Gully Branch at WQM station PD-065 was published in June 2016 revising the 2005 TMDL. The SCDHEC Technical Report Number 1004-16 updated the TMDL to use the maximum daily *E. coli* WQS to 349 MPN/100 mL. For the period of 2007 to 2012, 36 out of 51 samples exceeded WQS. A summary of these monitoring results can be seen in **Table 3-7.**

Table 3-7. E. coli Bacteria Observed from 2007-2012

Station	Total Number of Sample	Maximum Concentration (MPN/100 mL)	Total Number of Samples >349 cfu/100 mL	Percentage of Samples Exceeding WQS (%)
PD-065	51	9678.4	36	71

3.4.3 SCDHEC Water Quality Sampling (2015-2018)

SCDHEC submitted water quality samples from 2015 to 2018 to the National Water Quality Monitoring Council for WQM station PD-065. Thirty-three (33) samples were taken during that time period, in which 27 exceeded the WQS for *E. coli.* A summary is located in **Table 3-8**.

Table 3-8. E. coli Bacteria Observed from 2015-2018

Station	Total Number of Sample	Maximum Concentration (MPN/100 mL)	Total Number of Samples >349 cfu/100 mL	Percentage of Samples Exceeding WQS (%)
PD-065	33	*2908	27	82

*2908 was the highest known value. Multiple samples had *E. coli* present above quantification limit.

3.4.4 City of Florence Water Quality Sampling (2013)

As noted in the TMDL for Gully Branch the City has experienced fecal coliform and *E. coli* loading from SSOs and leaking sewers in the past. The City actively works to identify and repair these discharges when they occur.

A goal of the City was to collect and analyze water quality samples for the Gully Branch watershed prior to the development of the Gully Branch Watershed Plan. Grab samples were collected and analyzed at five (5) locations throughout the watershed on four (4) separate days between January 29, 2013 and February 21, 2013. A map of the sampling locations is included in **Appendix G**. Event mean concentration values were then calculated as the average of these four (4) sampling results. The results of these monitoring efforts are summarized in **Table 3-9**. Results at four of the five monitoring locations exceed the SCDHEC standard of 400 cfu/100mL.

Table 3-9. 2013 City of Florence Fecal Coliform Sampling Results (cfu/100 mL)

Sample Date	WS-101	WS-102	WS-103	WS-104	WS-105
	WS04 Timrod Park	WS03 Timrod Park	WS02 Spruce Ave	WS05 Waters Ave	WS01 Azalea Drive
1/29/2013	600	400	1	1	1
1/30/2013	233	100	1	50	933
2/19/2013	7000	6100	1	7600	1200
2/21/2013	1800	4100	1	21367	1
EMC	2408	2675	1	7255	534

The City was able to develop annual pollutant load estimates for fecal coliform within the Gully Branch watershed using the average concentration. The annual load is a function of land use, precipitation, and average concentration. The estimated annual load for fecal coliform is listed for each drainage basin within the Gully Branch watershed in **Table 3-10**, and the total estimated annual load for fecal coliform in Gully Branch is 1.23E+14 lb/yr, or equivalent to an average fecal coliform count of 2,575 cfu/100 mL. These annual loads were used to develop an implementation plan, and will be used in the future to evaluate the progress of the Gully Branch Watershed Plan. The goal is to reduce fecal coliform counts below the SCDHEC standard of 400 cfu/100mL.

Table 3-10. 2013 Estimated Annual Pollutant Loads

Drainage Basin	Area (acres)	EMC (cfu/100 mL)	Annual Load (lb/ac/yr)	Annual Load (lb/yr)	Reduction Required to Meet WQS (lb/yr)	Reduction Required to Meet WQS (%)
WS-101	462	2408	8.76E+10	4.06E+13	3.39E+13	83
WS-102	397	2675	1.00E+11	3.97E+13	3.38E+13	85
WS-103	187	1	3.75E+07	7.02E+09	Meets WQS	Meets WQS
WS-104	153	7255	2.61E+11	4.00E+13	3.78E+13	94%
WS-105	145	534	192E+10	2.79E+12	7.00E+11	25%
Gully Branch Total Estimated Annual Load				1.23E+14		

3.4.5 City of Florence Water Quality Sampling (2015-2019)

The City continued to monitor the Gully Branch Watershed. Sampling occurred from November 2015 to July 2019. Samples were originally taken at five (5) locations: (1) MS-01 Park Ave., Timrod Park, (2) MS-02 Spruce Ave., (3) MS-03 S. Coit Timrod, (4) MS-04 Cherokee (PD-065), and (5) MS-05 Azalea Drive. Monitoring at MS-05 Azalea Drive was discontinued after the October 2018 sampling event due to 83% of the samples taken met the standard. In January 2019, additional locations were added for sampling in WS-101 at MS-17 Park Ave. North Bank, MS-18 S. Franklin Drive (East), and MS-19 S. Franklin Drive (West). A map of the sampling locations is located in

Appendix G and monitoring data is located in Error! Reference source not found.. The results of these monitoring efforts are summarized in **Table 3-11** and **Table 3-12.**

Table 3-11. 2015-2019 City of Florence E.coli Sampling Results

Station	Number of Samples	Number of Exceedances	Percent of Exceedances	Min (MPN/100 mL)	Max (MPN/100 mL)
MS-01	33	28	84.8	<1	24196
MS-02	34	10	29.4	<1	24196
MS-03	34	22	64.7	8.5	41060
MS-04	33	20	60.6	1	25994
MS-05	24	4	16.7	1	4260
MS-17	8	8	100.0	1607	>24200
MS-18	8	6	75.0	279.5	24196
MS-19	8	8	100.0	387	>24200

Table 3-12. Percent of Exceedances Per Sampling Year

Station	2015	2016	2017	2018+	2019
MS-01	0.0	100.0	88.9	85.7	100.0
MS-02	0.0	0.0	55.6	28.6	30.0
MS-03	0.0	100.0	44.4	78.6	60.0
MS-04	0.0	N/A*	44.4	92.9	50.0
MS-05	0.0	0.0	0.0	33.3	N/A
MS-17	N/A	N/A	N/A	N/A	100.0
MS-18	N/A	N/A	N/A	N/A	60.0
MS-19	N/A	N/A	N/A	N/A	80.0

+Sewer break during sampling period
*N/A – Not available/no samples were recorded

The City was able to develop annual pollutant load estimates for *E. coli* within the Gully Branch watershed using the EMCs. The annual load is a function of land use, precipitation, and EMC. The 2016 Technical Report updating the TMDL revised the units from lb/yr to MPN/year. The conversion from MPN/100 mL to MPN/year is shown in **Equation 3-1**.

Equation 3-1. Conversion from MPN (or cfu)/100 mL to MPN (or cfu)/year

$$\frac{MPN\ (or\ cfu)}{year} = \frac{\text{MPN (or } cfu)}{100\ mL} x \frac{1000\ mL}{1\ L} x \frac{28.3168\ L}{ft^3} x \frac{(Daily\ Flow) ft^3}{sec} x \frac{86400\ \text{sec}}{day} x \frac{365\ days}{year}$$

The estimated daily load for *E. coli* is listed for each drainage basin within the Gully Branch watershed in **Table 3-13**These loads were used to update the implementation plan, and will be used in the future to evaluate the progress of the Gully Branch Watershed Plan. The goal is to reduce *E. coli* below the SCDHEC standard of 349 MPN/100 mL.

Table 3-13. 2015-2019 Estimated Pollutant Loads

Drainage Basin	Area (acres)	EMC (MPN/100 mL)	Annual Load (MPN/ac/year)	Annual Load (MPN/year)	Reduction Required to Meet WQS (MPN/year)	Reduction Required to Meet WQS (%)
WS-101	462	5384	1.97E+11	9.09E+13	8.5E+13	93.5
WS-102	397	2299	4.91E+10	1.95E+13	1.65E+13	84.8
WS-103	187	3930	1.48E+11	2.77E+13	2.53E+13	91.1
WS-104	153	492	1.78E+10	2.73E+12	7.96E+11	29.2
WS-105*	145	--	--	--	--	--

*No samples were taken in WS-105 to estimate pollutant load

3.5 WATERSHED RESTORATION FIELDWORK AND PRIORITIZATION

The Gully Branch headwaters are contained within an extensive system of underground pipes and drainage networks. Once stormwater enters the underground network, there is limited opportunity for capture and treatment of stormwater, until the stream daylights at Timrod Park. The City investigated a total of six (6) City-owned properties, including Timrod Park, for potential stormwater BMP implementation sites.

1. **Darlington Street Water Plant**

   This property (**Figure 3-3**) is located at the northern extent of the watershed boundary. The City reviewed the site for potential stormwater treatment prior to draining into the underground network. Due to the layout of the facilities within the site, the property did not provide sufficient area for meaningful stormwater treatment.

Figure 3-3. Darlington Street Water Plant

2. **Barnes Street Complex**

   This is another property (**Figure 3-4**) that is located near the outer boundary of the watershed. The property is bounded to the north by railroad tracks, and is otherwise surrounded by streets with curb and gutter. The site contains an open area that would be available for a stormwater BMP; however, the topography is not conducive to collecting stormwater for treatment. Stormwater drains are present at the property corners.

Figure 3-4. Barnes Street Complex

3. **Vacant Property Adjacent to Gully Branch**

Figure 3-5. Vacant Property Adjacent to Gully Branch

This City-owned property (**Figure 3-5**) on Santee Dr. at W. Oleander Dr. is a rectangular lot that slopes downward to the banks of Gully Branch. The property is utilized by the City as a sewer line easement, and the lower end of the property contains an above-ground sewer pipe. This site contains a thickly vegetated riparian buffer which provides sufficient treatment for overland stormwater flow to Gully Branch, without the need for additional BMPs.

4. **Maple Park**

Figure 3-6. Maple Park

Located in the upper reaches of the Gully Branch underground network, Maple Park (**Figure 3-6**) is a 4-acre park with baseball fields, restrooms, concessions, a community center, playground and picnic shelter. The streets surrounding the Park have curb and gutter, with storm drains at each corner. The majority of the site is level, and a storm drain is located on the property to the east of the Maple Park Community Center.

5. **Lucas Park**

Figure 3-7. Lucas Park

Lucas Park (**Figure 3-7**) is located on W. Azalea Lane, between S. Park Ave. and Santee Dr. It is a 12-acre park with nature trails and gardens, a playground, picnic shelter and area, and two tennis courts. The underground stormwater network in Lucas Park is a tributary to Gully Branch. Numerous stormwater catch basins located within the Park collect and drain stormwater runoff into the pipe network, which exits the Park beneath Santee Drive and then flows via natural streambed to Gully Branch. Due to the topography and natural features of the Park, several areas were identified as potential BMP sites.

6. **Timrod Park**

Timrod Park (**Figure 3-8**) is a highly utilized 18-acre recreation area with tennis courts, playground, picnic areas, gardens, nature trails, fitness courses, and dog walking paths. The Park is located between Timrod Park Dr. and W. Waters Ave. As Gully Branch enters Timrod Park, it becomes a naturally flowing aboveground waterway. This Park is the largest City-owned property within the Gully Branch watershed, and it contains areas accessible to a free-flowing Gully Branch. Multiple locations within the Park have been identified as potential BMP sites. Furthermore, the Timrod Park recreation area is an ideal location for educating the public about watersheds and stormwater treatment.

Figure 3-8. Timrod Park

WATERSHED MANAGEMENT STRATEGIES

04

4. WATERSHED MANAGEMENT STRATEGIES

4.1 INTRODUCTION

This section describes the components of the watershed management strategies that provide removal of fecal coliform and *E. coli.* This section also describes educational and outreach opportunities to prevent fecal coliform and *E. coli* from entering the Gully Branch Watershed.

4.2 BEST MANAGEMENT PRACTICES FOR FECAL COLIFORM AND E. COLI REMOVAL

Unlike conventional stormwater pollutants, bacteria are living organisms that can be inactivated without being removed. Stormwater quality is impacted by their life status, rather than their presence.

Bacteria can be inactivated or removed through multiple mechanisms including sorption, sedimentation, filtration, predation, and UV light. BMPs for bacteria reduction should be designed to maximize exposure to sunlight, provide habitat for predation by other microbes, provide surfaces for sorption, provide filtration and/or allow sedimentation. Some proprietary BMPs utilize antimicrobial products to inactivate bacteria. In effect, all BMPs that reduce runoff volume will reduce bacteria loads to the receiving water.

Under conditions favorable for growth, bacterial concentrations within stormwater treatment systems may increase due to natural population growth. Bacteria may survive in sediments which if mobilized or resuspended could become a source of bacteria.

Numerous published studies of BMPs indicate that wet ponds, wetlands, and infiltration practices provide the highest bacterial removal rates, although the results show a wide range of removal efficiencies. Infiltration zones should be evaluated for minimal impact to groundwater quality, particularly in areas where shallow groundwater contributes considerably to a water body.

Stormwater BMPs are often used in combination, creating a treatment train for enhanced performance. For example, a vegetated swale or grass strip may provide pretreatment for a bioretention system by reducing sediment loading to the bioretention area.

4.2.1 Detention (Dry) Pond

Description: Dry Detention Ponds (**Figure 4-1** and **Figure 4-2**) are designed to receive stormwater from a drainage area and discharge it at a reduced flow rate over a determined period of time, allowing particles and associated pollutants to settle. Dry ponds do not have a permanent pool of water.

Bacteria Removal: Settling and sedimentation are the dominant mechanisms of bacteria removal in dry ponds. The results of studies vary widely, indicating the median bacteria removal efficiencies for dry ponds range from 35% to 88%. Studies for the removal of fecal coliform and *E. coli* show a mean removal efficiency for fecal coliform of 38%, and 79% removal for *E. coli.* Negative removal rates have been documented and may be due to resuspension of accumulated sediment during rainfall events.

Area Requirements: Dry detention ponds should be used on sites with a minimum drainage area of 10 acres. The surface area of a dry pond is approximately 1% to 3% of the contributing drainage area. Upstream pretreatment, such as a sediment forebay or equivalent, is required to settle out coarse sediment and reduce the maintenance burden.

Advantages:

- Dry ponds are less expensive to construct and require less maintenance than wet ponds and wetlands.
- Dry ponds may provide groundwater recharge, depending on the permeability of underlying soils.
- Dry ponds can be designed with a larger storage volume to provide flood control and channel protection.

Disadvantages:

- Studies indicate generally unreliable performance for removal of bacteria.
- Dry ponds are prone to clogging and resuspension of previously settled solids and may act as a source of bacteria.
- Discharge may cause thermal impacts/warming downstream.

General Maintenance:

- Regularly inspect and remove debris from outlet structures; maintain, mow side slopes; remove invasive vegetation.
- Monitor sediment accumulation and remove periodically.
  - Every 5 to 7 years: Remove sediment from forebay.
  - Every 25 to 50 years: Remove sediment when pond volume has been reduced by 25%.

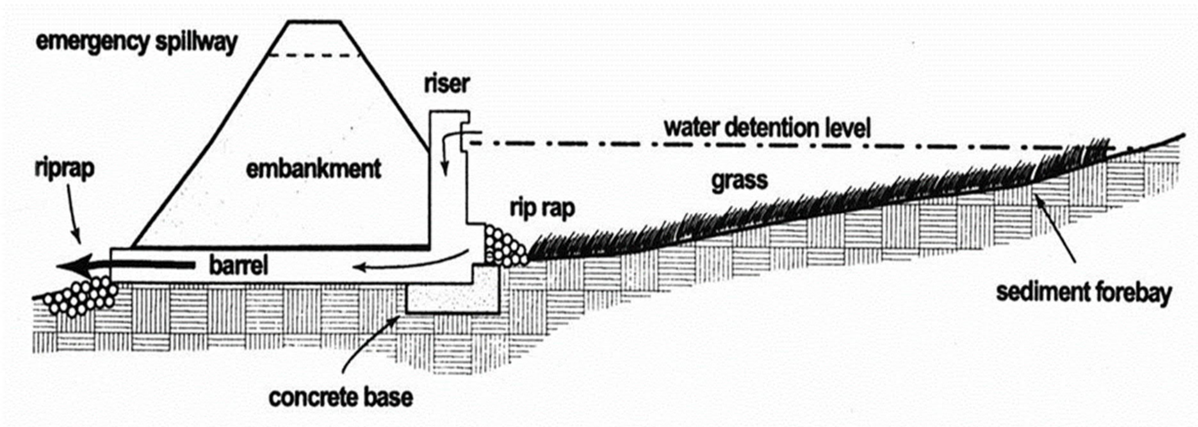

Figure 4-1. Example Dry Pond Design Profile

Figure 4-2. Detention (Dry) Pond

4.2.2 Retention (Wet) Pond

Description: Retention (Wet) ponds (**Figure 4-3** and **Figure 4-4**) are open water ponds constructed to store and treat stormwater runoff. Runoff from each rain event is detained and treated through gravitational settling and biological uptake until it is displaced by runoff from the next storm.

Bacterial Removal: Wet ponds remove bacteria primarily through sedimentation, solar irradiation, and natural predation. The permanent pool helps to protect deposited sediments from resuspension. Studies generally report high bacteria removal in wet ponds, although results vary. Removal may be countered by bacterial growth and bacteria inputs associated with wildlife. Bacteria may be shielded from damaging solar radiation by turbidity, water depth, or overhanging vegetation, decreasing bacteria die-off. The median bacteria removal efficiency for wet ponds is 70%. Studies for the removal of fecal coliform and *E. coli* show a mean removal efficiency for fecal coliform of 74%, and 93% removal for *E. coli*.

Area Requirements: Wet ponds need sufficient drainage area to maintain the permanent pool, typically about 25 acres. The surface area of a wet pond is approximately 1% to 3% of the contributing drainage area. Upstream pretreatment, such as a sediment forebay or equivalent, is required to settle out coarse sediment and reduce the maintenance burden.

Advantages:

- Wet ponds can be an aesthetic feature, and community acceptance is generally high.
- The long residence time allows for the operation of numerous pollutant removal mechanisms, and results in moderate to high removal rates for a range of stormwater pollutants.
- Wet ponds provide storage of stormwater to limit flooding.
- Wet ponds provide an opportunity for wildlife habitat.

Disadvantages:

- Wet ponds may not be appropriate in dense urban areas because of the large size of the ponds.
- Wet ponds may pose safety hazards if constructed where there is public access.
- Waterfowl and wildlife attracted to wet ponds may increase bacterial levels.
- Discharge may cause thermal impacts/warming downstream.
- Base flow or supplemental water may be needed to maintain water levels.

General Maintenance:

- Regularly inspect and remove debris from inlet and outlet structures; maintain, mow side slopes; remove invasive vegetation.
- Monitor sediment accumulation and remove periodically.
  - Every 5 to 7 years: Remove sediment from forebay.
  - Every 20 to 50 years: Remove sediment when pond volume has been reduced significantly or becomes eutrophic.

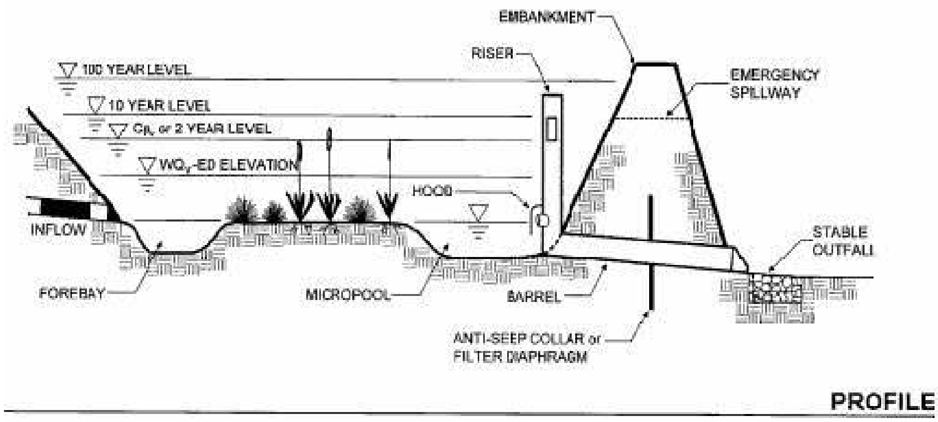

Figure 4-3. Example Wet Pond Design

Figure 4-4. Retention (Wet) Pond

4.2.3 Constructed Wetlands

Description: Constructed wetlands (**Figure 4-5** and **Figure 4-6**) consist of a combination of shallow marsh areas, open water, and semi-wet areas above the permanent water surface. Constructed wetlands are designed to receive stormwater runoff for treatment, and to replicate natural wetland ecosystems for efficient and reliable pollutant removal.

Bacteria Removal: In general, wetlands display medium to high removal efficiencies for bacteria. Bacteria reduction is achieved primarily through gravitational settling of sediment, which is optimized due to long residence times. Open water areas also allow exposure of bacteria to damaging UV radiation from sunlight. The median bacteria removal efficiency for constructed wetlands ranges from 60% to 78%. Studies for the removal fecal coliform and *E. coli* show a mean removal efficiency for fecal coliform of 67%, and 21% removal for *E. coli*.

Area Requirements: Constructed wetlands need a sufficient drainage area to maintain a permanent pool, typically a minimum of 25 acres in humid regions. The surface area of a constructed wetland is approximately 3% to 5% of the contributing drainage area. Upstream pretreatment, such as a sediment forebay or equivalent, is required to settle out coarse sediment and reduce the maintenance burden.

Advantages:

- Wetlands are generally perceived to have positive aesthetic and amenity values.
- Wetlands can reduce runoff volumes.
- Wetlands have high removal rates for a range of pollutants.
- Wetlands provide an opportunity for natural wildlife habitat.
- Construction costs are relatively low.

Disadvantages:

- Wetlands may not be appropriate in dense urban areas due to the relatively large amount of space they consume.
- Wetlands require continuous base flow to maintain viability.
- Wetlands may pose safety hazards if constructed where there is public access.
- Appropriate maintenance of proper vegetation is needed for good performance.
- Wetlands attract wildlife and waterfowl that may act as a source of bacteria.
- Wetlands must be properly designed to prevent mosquito and midge breeding.
- Constructed wetlands may release nutrients during the nongrowing season.

General Maintenance:

- After second growing season, replace vegetation to maintain at least 50% coverage.
- Regularly inspect and remove debris from outlet structures; maintain, mow side slopes; remove invasive vegetation; supplement/harvest wetland plants if necessary.
- Monitor sediment accumulation and remove periodically.
  - Every 5 to 7 years: Remove sediment from forebay.
  - Every 20 to 50 years: Remove sediment when pond volume has been reduced significantly, plants are “choked” with sediment, or the wetland becomes eutrophic.

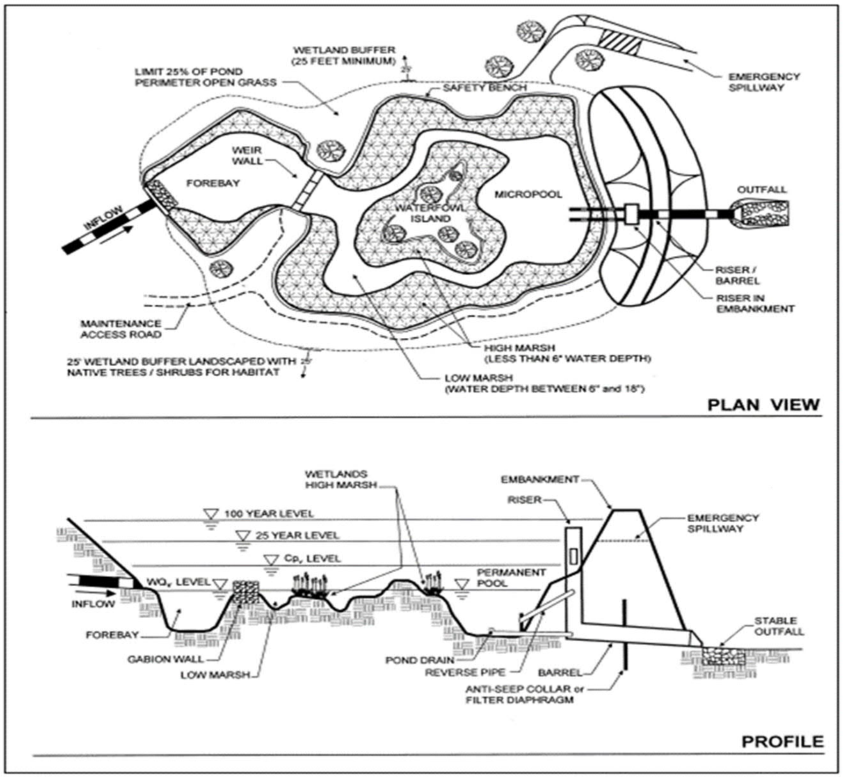

Figure 4-5. Example Constructed Wetland Design

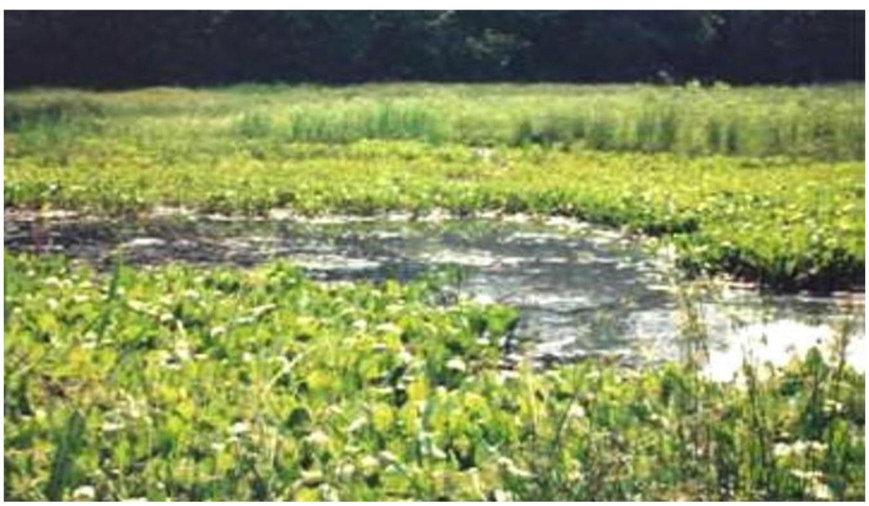

Figure 4-6. Constructed Wetland

4.2.4 Bioretention

Description: Bioretention systems (**Figure 4-7** and **Figure 4-8**)are excavated shallow surface depressions that utilize engineered soils and vegetation to capture and treat stormwater runoff. Runoff is temporarily stored and transported through a medium such as sand, compost, soil, or a combination to filter out sediment. Treated stormwater is allowed to infiltrate into the soil or return to the stormwater conveyance system. Bioretention systems are planted with selected adapted or native plant materials. Evapotranspiration and infiltration help to reduce the volume of stormwater runoff.

Bacteria Removal: Bioretention systems provide bacteria removal through sedimentation, sorption, and filtration. Microorganisms in the mulch and soils and substantial exposure to sunlight and dryness help to control and eliminate pathogens. Although data from monitoring studies are limited, the median bacteria removal efficiency for bioretention systems is estimated to be 40% based on the results for studies on filtering practices. Data from bioretention studies show a mean removal efficiency for *E. coli* of 58%.

Area Requirements: Bioretention areas are generally applied to small sites in urbanized settings, with a maximum contributing drainage area of 5 acres. Bioretention areas consume approximately 5% to 10% of the area that drains to them. Upstream pretreatment, such as a grass channel, filter strip, or pea gravel diaphragm, is required to settle out coarse sediment and reduce the maintenance burden.

Advantages:

- Bioretention is appropriate for high density/ultra-urban areas, and can be worked into most landscaping plans.
- Bioretention is generally perceived to have good aesthetic value.
- Bioretention provides water quality control, stormwater peak flow and volume control.
- Bioretention provides groundwater recharge.

Disadvantages:

- Bioretention areas cannot be used to treat large drainage areas.
- Bioretention is not suitable for areas with high water table or soils with low permeability.
- During construction, care must be taken to prevent compaction of in-situ soils.
- Extensive landscaping is required.
- Vegetation should be tolerant of hydrologic variability and environmental stress.
- Bioretention systems may clog if sediment loads are too high, restricting infiltration.
- Supplemental water may be needed during periods of extended drought.

General Maintenance:

- At project completion, plants must be watered regularly until established.
- Standard maintenance as needed: Pruning and weeding; mulch replacement where erosion is evident; removal of trash and debris.
- Standard maintenance required twice per year: Inspect for clogging, inspect filter strip for erosion; inspect health of trees and shrubs; pruning of vegetation.

- Standard maintenance required annually: Check pH of planting soils and adjust as needed; replace mulch that has degraded.
- Every 2 to 3 years, replace mulch over the entire area; aerate unvegetated areas if required to ensure adequate infiltration; maintenance of vegetation (reseeding/replanting, thinning).

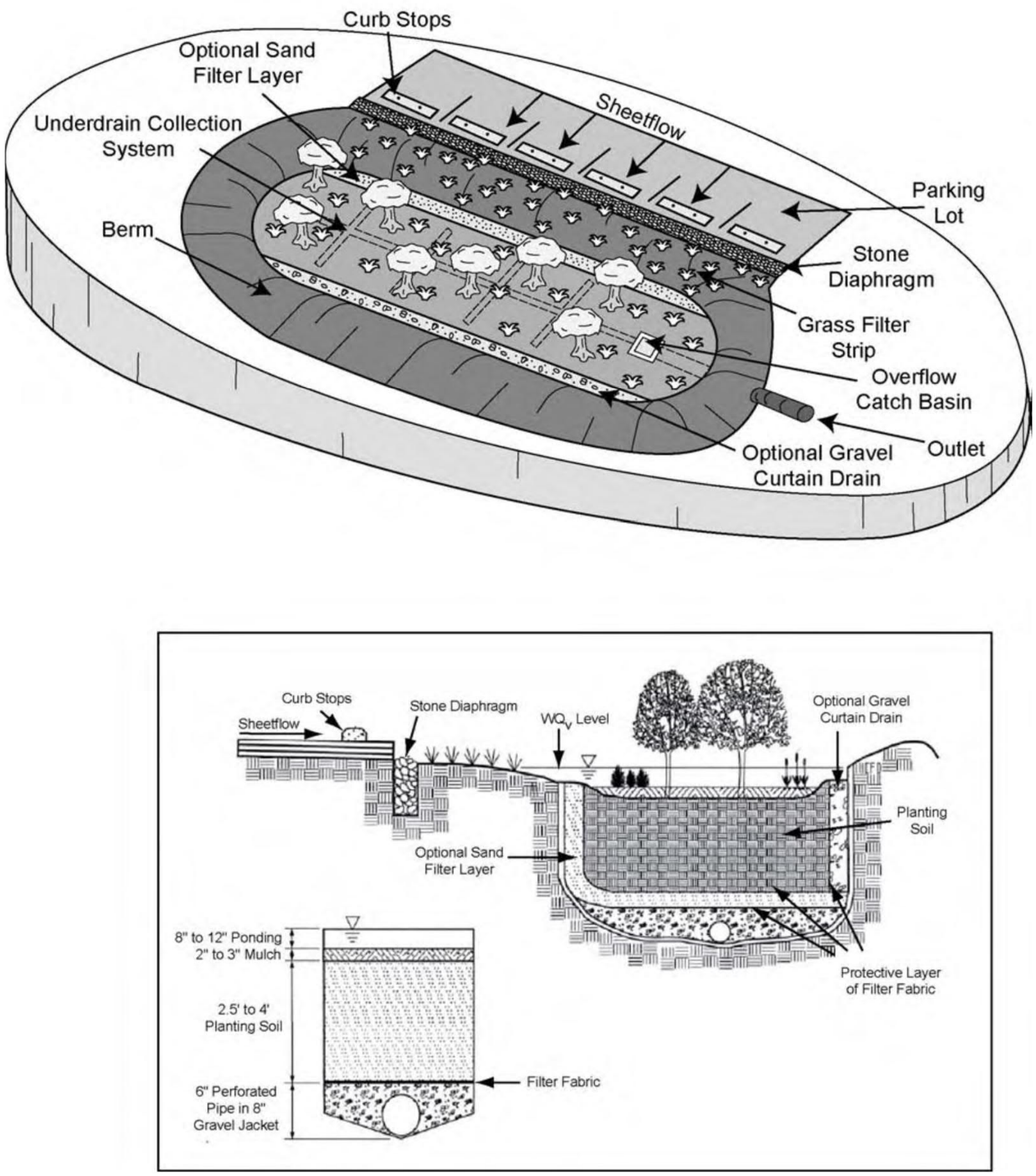

Figure 4-7. Example Bioretention Design

Figure 4-8. Bioretention in a Parking Lot Turnaround

4.2.5 Infiltration

Description: Infiltration systems (**Figure 4-9** and **Figure 4-10**) capture and temporarily store stormwater runoff in a rock-filled chamber with no outlet, allowing for infiltration into the underlying soil. An infiltration trench is an excavated trench, typically 3 ft wide and 4 ft deep, filled with rock or gravel media. Sheet flow from runoff is stored in the void spaces within the media and allowed to infiltrate into the surrounding soils through the bottom and sides of the trench.

Bacteria Removal: Infiltration trenches reduce bacteria loading through soil adsorption and filtration and by reducing flow. The median bacteria removal efficiency for infiltration systems is estimated to be 40% based on the results for studies on filtering practices.

Area Requirements: Infiltration trenches can be applied in high density areas. The maximum drainage area for an infiltration trench is 5 acres. Infiltration trenches can consume up to 5% of the drainage area. Adequate upstream pretreatment such as a swale or sediment basin must be provided to reduce sediment loads to the infiltration trench and prevent clogging.

Advantages:

- Infiltration trenches are suitable for small sites with porous soils.
- Infiltration provides groundwater recharge.

- In addition to water quality treatment, infiltration reduces both the volume and peak discharge.

Disadvantages:

- Significant setbacks may be required from wells, leach fields, and surface waters, etc.
- Infiltration trenches provide no visual enhancements.
- Infiltration is not suitable for areas with high water table or soils with low permeability.
- Maintenance of infiltration systems can be burdensome, since they are susceptible to clogging and sediment build-up which reduces their hydraulic efficiency and storage capacity to unacceptable levels.
- Infiltration trenches have a relatively high rate of failure and are difficult to restore to functioning once clogged.

General Maintenance:

- Standard maintenance as needed: inspect for clogging, remove sediment from forebay, replace pea gravel layer
- Upon failure the bioretention cell needs to undergo total rehabilitation.

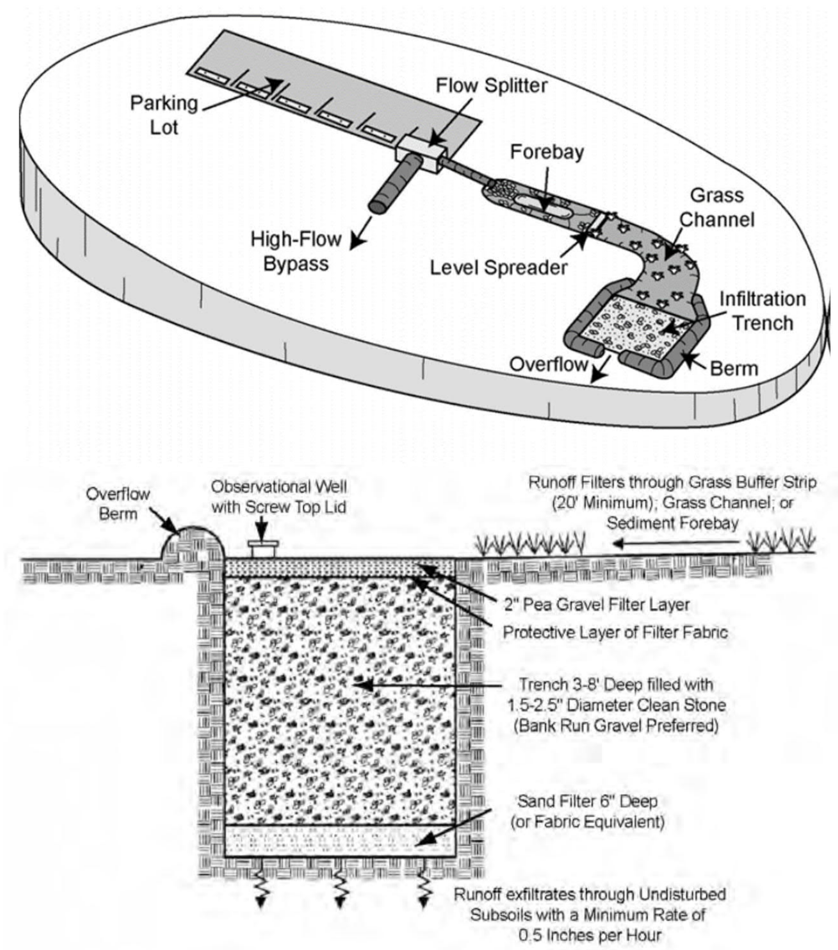

Figure 4-9. Example Infiltration Trench Design

Figure 4-10. Infiltration Trench

4.2.6 Filtering

Description: Filtration practices (**Figure 4-11**,**Figure 4-12**, and **Figure 4-13**) are designed to capture and temporarily store stormwater runoff, and treat it by passing runoff through an engineered filter media of sand, compost, soil or a combination to filter out sediment. Treated stormwater is allowed to infiltrate into the soil or is collected in an underdrain and conveyed to the storm drain system. The most widely used filtration practice is the surface sand filter, which is typically designed with two chambers. The first chamber provides pretreatment and settling and the second chamber is a sand filter bed.

Bacteria Removal: Media filters remove bacteria primarily through settling and sedimentation in the first chamber, and straining, sorption and filtration in the media chamber. Studies indicate the median removal efficiency for bacteria is 37% to 40% for sand filters.

Area Requirements: Stormwater filters are useful for treating stormwater runoff from small, highly impervious sites. The maximum contributing drainage area for a sand filter is 2 to 5 acres, and they can consume up to 5% of the drainage area. Sand filters require approximately 5 to 8 feet of elevation drop to allow flow through the system. Perimeter sand filters, located at the edges of parking lots, can be applied with as little as 2 feet of elevation drop.

Advantages:

- Stormwater filters have a relatively small footprint and few site restrictions.
- Stormwater filters are a good option for treating stormwater hot spot sites and smaller parking lots.
- Stormwater filters have no vegetation to maintain.
- Underground sand filters and perimeter sand filters are not visible and do not detract from the aesthetic value of a site.

Disadvantages:

- Stormwater filters generally require more hydraulic head than other BMPs to operate properly.
- Stormwater filters have a propensity to clog.
- Surface sand filters are not aesthetically pleasing.
- Sand filters have potential for odor problems.

General Maintenance:

- Monthly maintenance: inspect facility, inlets and outlets, remove trash and debris; check filter for clogging.

- Annual maintenance: inspect sediment chamber, remove sediment if more than half full, inspect for deterioration of facility.
- Maintenance as needed: manual manipulation of surface layer of sand or replacement of sand filter media if filter bed is clogged.

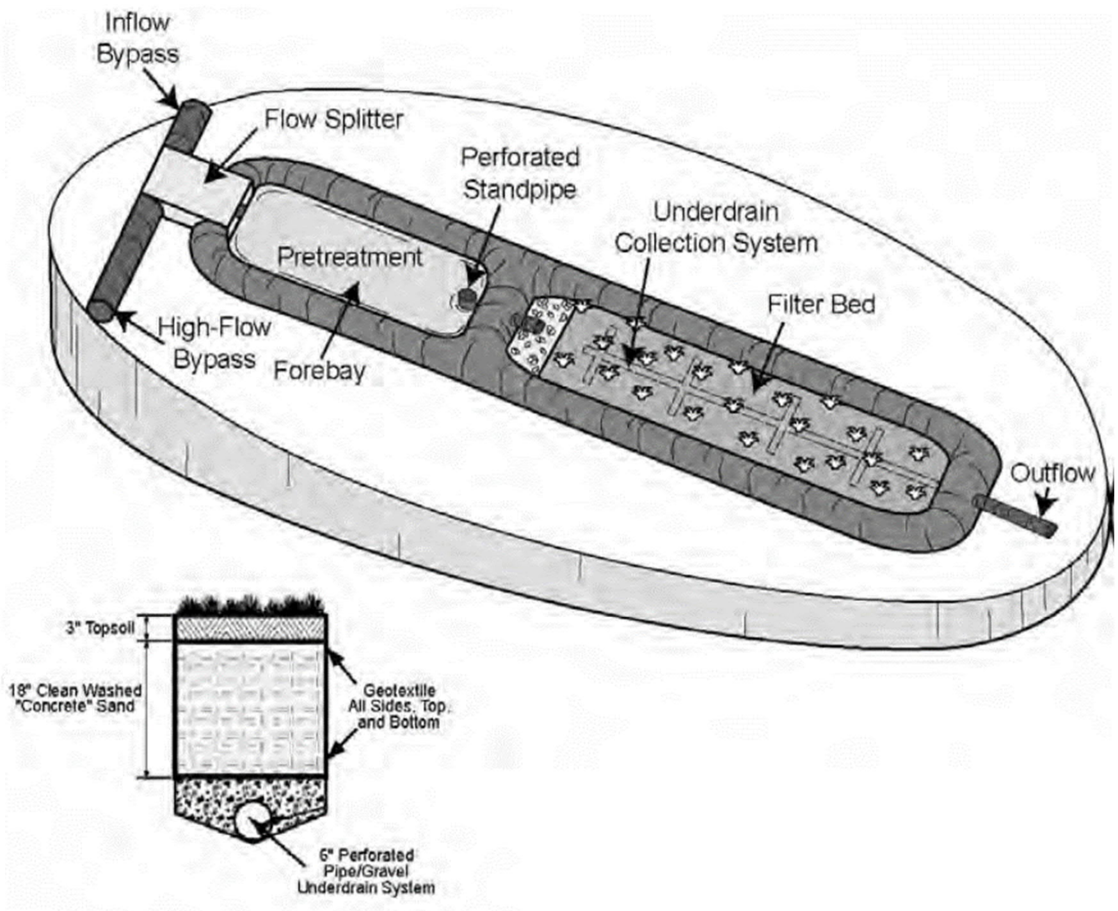

Figure 4-11. Example Surface Sand Filter Design

Figure 4-12. Surface Sand Filter

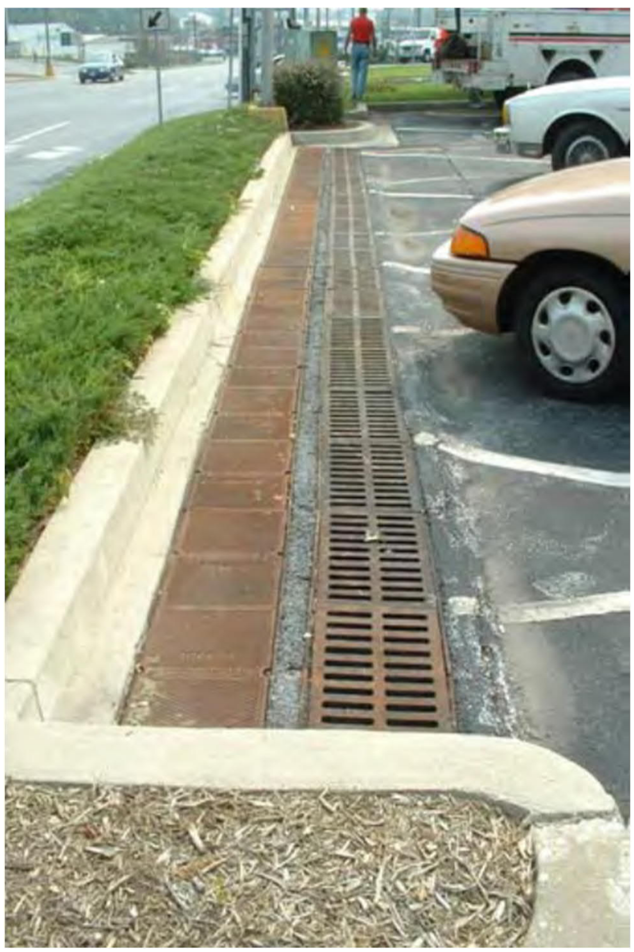

Figure 4-13. Perimeter Sand Filter

4.2.7 *Open Channel*

Description: Open channels (**Figure 4-14** and **Figure 4-15**) are a variant of the swale, and are primarily designed to convey stormwater through a stable conduit. Vegetated open channels can be used as part of a runoff conveyance system to provide pretreatment. The vegetation lining the channel filters stormwater runoff and reduces flow velocities.

Bacteria Removal: Studies show that open channels provide negative removal efficiencies for bacteria, with a -25 % median removal efficiency.

Area Requirements: Grass-lined open channels should generally be used to treat small drainage areas of less than 5 acres.

Advantages:

- Open channels can partially infiltrate runoff from small storm events if the underlying soils are pervious.
- Grass-lined open channels are less expensive than curb and gutter systems.

Disadvantages:

- Grass-lined open channels have the potential for bottom erosion and resuspension of sediment.
- Clogging with sediment and debris reduces the effectiveness of grass-lined open channels.

General Maintenance:

- Inspect channels after every rainfall until vegetation is established.
- Standard maintenance as needed: mow, remove litter and perform spot vegetation repair to maintain a dense and vigorous growth, periodically clean vegetation and soil buildup in curb cuts.

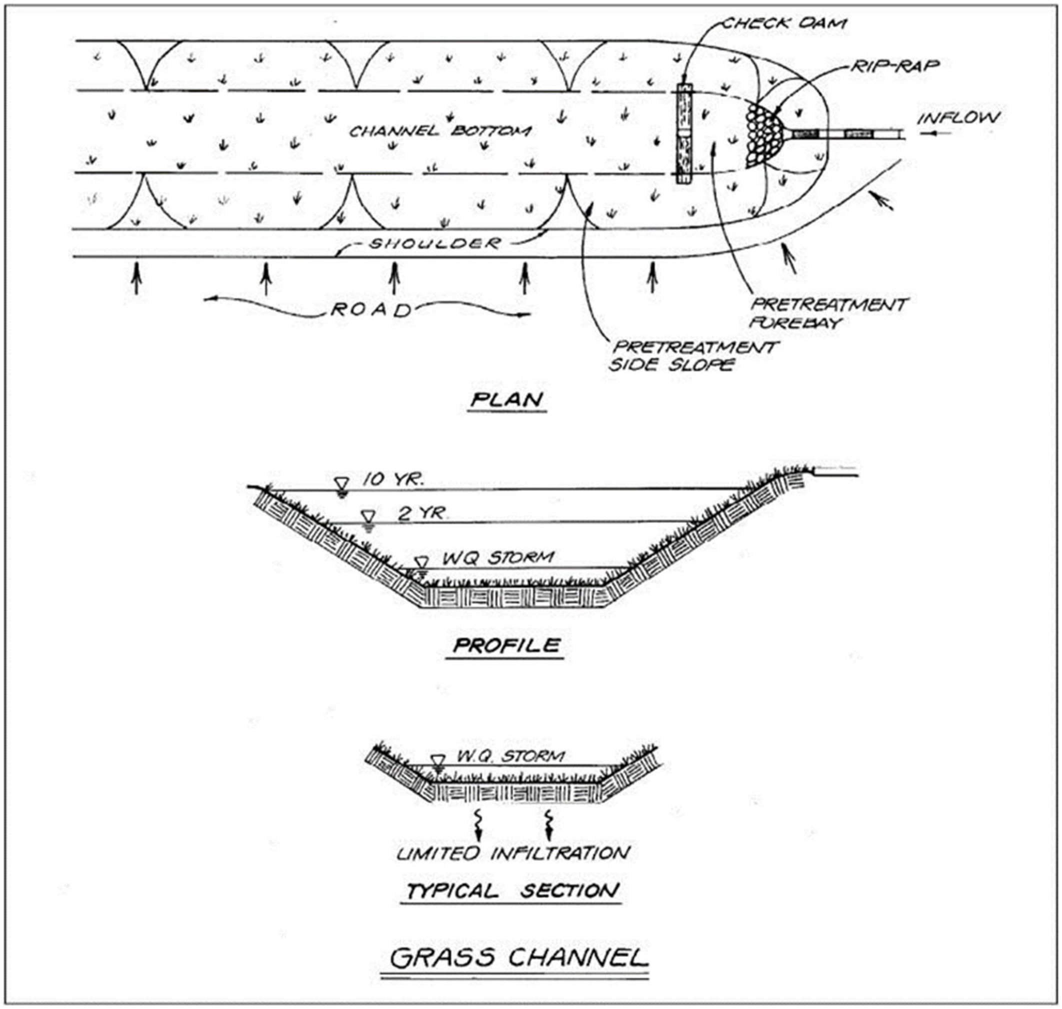

Figure 4-14. Example Grass-Lined Open Channel Design

Figure 4-15. Grass-Lined Open Channel

4.2.8 Grass Filter Strip

Description: Grass filter strips (**Figure 4-16** and **Figure 4-17**) are uniformly graded strips of grass designed to treat sheet flow from adjacent surfaces. Stormwater runoff flows evenly over the grass filter strip, reducing runoff velocities and allowing for the capture of sediment and infiltration of stormwater into the soil. Grass filter strips are ideal for use as pretreatment for another structural stormwater control.

Bacterial Removal: Grass filter strips generally exhibit low removal efficiencies for bacteria, with studies indicating a mean removal efficiency of 6% for fecal coliform. Removal efficiencies may be greater where infiltration into the soil is high and a long flow path is provided over the grass filter strip.

Area Requirements: The maximum contributing drainage area for a grass filter strip is one (1) acre of impervious surface for every 580 ft. of length. The surface area required for a grass filter strip is 5% to 15% of the contributing drainage area.

Advantages:

- Grass filter strips are useful as part of the runoff conveyance system to provide pretreatment.
- Grass filter strips can provide groundwater recharge.
- Construction costs are low.

Disadvantages:

- • Grass filter strips have large land requirements.
- • Grass filter strips have not been shown to have high pollutant removal.

General Maintenance:

- Standard maintenance as required: mow grass to maintain a 2 to 4-inch height (frequent), remove sediment buildup (infrequent).
- Annual maintenance: inspect pea gravel diaphragm for clogging, remove sediment, inspect vegetation for rills and gullies, seed or sod bare areas (replace with alternative species if required).

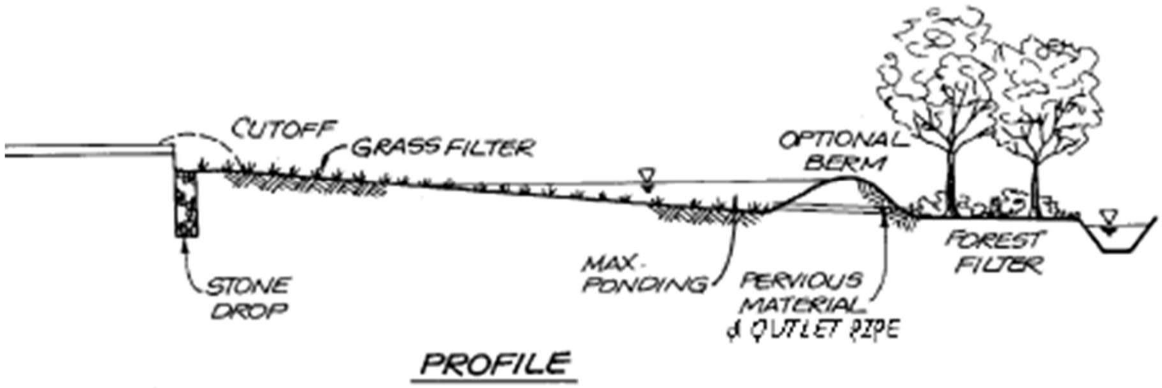

Figure 4-16. Example Grass Filter Strip Design

Figure 4-17. Grass Filter Pretreatment for an Infiltration Trench

4.2.9 Swales

Description: Swales (**Figure 4-18**) are vegetated open channels designed to utilize the stormwater conveyance system to treat and attenuate stormwater runoff. As stormwater runoff flows along the swale it is slowed by vegetation, allowing for sedimentation and infiltration. Swales are useful as part of a treatment train and are often used as pretreatment for other controls.

Bacterial Removal: Studies show that grassed swales generally have low or even negative removal efficiencies for bacteria. Data collected for swales show a mean removal efficiency of 25% for fecal coliform and 65% for *E. coli*.

Area Requirements: The maximum drainage area for a swale is 5 acres, and the surface area required for a swale is 5% to 15% of the contributing drainage area.

Advantages:

- Swales promote infiltration and may provide groundwater recharge

Disadvantages:

- Swales have low effectiveness in reducing bacteria and may export bacteria under certain circumstances (e.g., resuspension of sediment).

General Maintenance:

- Standard maintenance as required: mow grass to maintain a 3 to 4-inch height (frequent), remove sediment buildup (infrequent).
- Annual maintenance: inspect pea gravel diaphragm for clogging; remove accumulated trash and debris, inspect and control erosion problems, inspect grass on side slopes for rills and gullies, replace grass with alternative species if required.

Figure 4-18. Grassed Swale

4.2.10 Enhanced Dry Swales

Description: Enhanced dry swales (**Figure 4-19** and **Figure 4-20**) are vegetated open channels specifically designed to attenuate and treat stormwater runoff within cells formed by check dams or other means. The limited slopes and vegetation slow the flow of stormwater and allow particulates to settle. Stormwater infiltrates into a filter bed of prepared soil overlaying an underdrain system. Larger stormwater volumes are conveyed to a discharge point, and stormwater treated by the soil bed flows into an underdrain, which conveys treated stormwater back to the storm drain. Enhanced dry swales promote slowing, cleansing and infiltration of stormwater.

Bacteria Removal: Pollutants are removed through settling and filtering by vegetation and soils. Removal rates for bacteria range from 10 to 60%.

Area Requirements: Enhanced dry swales are generally designed for a contributing drainage area of 5 acres or less. The surface area required for an enhanced swale is 5% to 15% of the contributing drainage area. Adequate upstream pretreatment such as sediment forebay must be provided to reduce sediment loads to the swale and prevent clogging.

Advantages:

- Enhanced swales combine stormwater treatment with runoff conveyance.
- Enhanced swales provide groundwater recharge and reduce runoff volumes and velocities.
- Installation is less costly than curb and gutter storm drain systems.

Disadvantages:

- Bacteria removal is unreliable, and enhanced swales may export bacteria under certain circumstances (e.g., resuspension of sediment).
- Enhanced dry swales may not be suitable for areas of seasonably high water tables.

General Maintenance:

- Standard maintenance as required: mow grass to maintain a 4 to 6-inch height (frequent); remove sediment buildup (infrequent).
- Annual maintenance: inspect pea gravel diaphragm for clogging; remove accumulated trash and debris from the forebay and channel; inspect and control erosion problems; inspect grass on side slopes for rills and gullies; replace grass with alternative species if required.

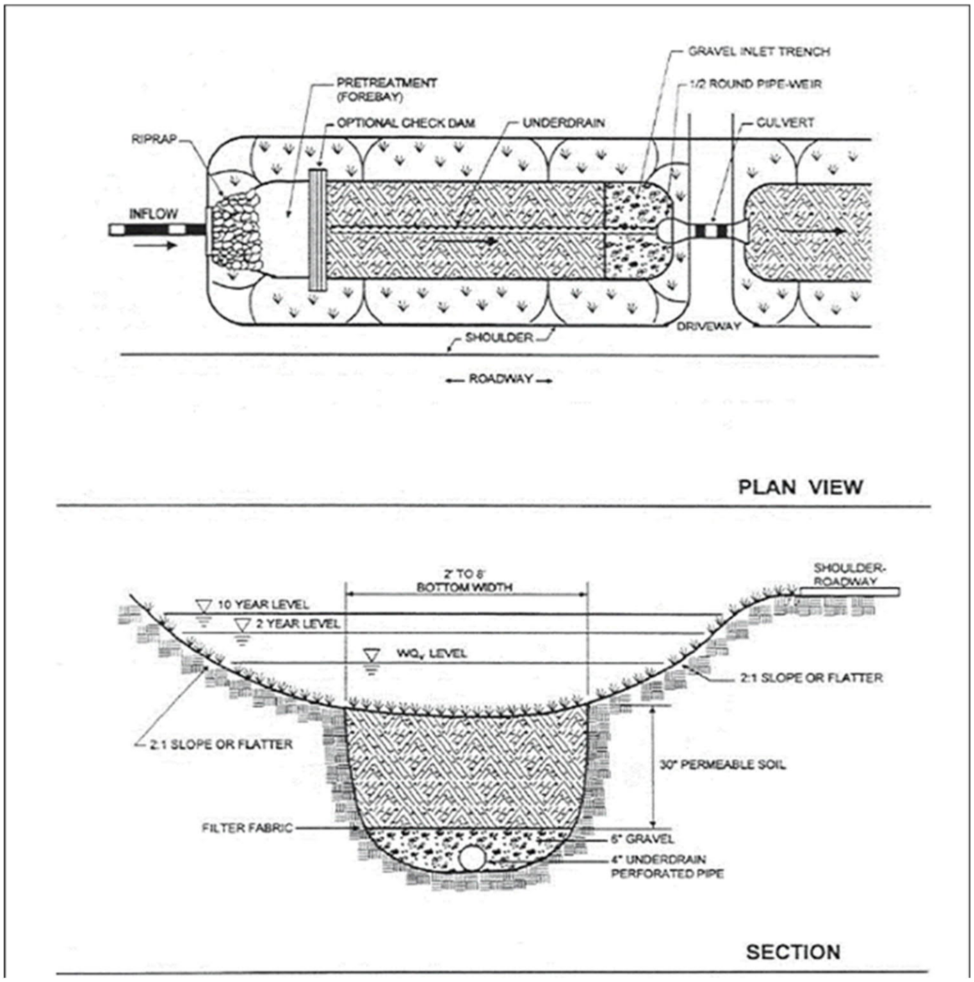

Figure 4-19, Example Enhanced Dry Swale Design

Figure 4-20. Enhanced Dry Swale

4.2.11 Proprietary Devices

Description: Many types of proprietary stormwater structural controls are commercially available for stormwater treatment, including hydrodynamic devices and filtration systems.

Hydrodynamic devices capture sediment from stormwater by encouraging rapid sedimentation through the swirling action of water moving through the device.

Filtration systems are typically dual-chambered and consist of a pretreatment settling basin and a filter bed filled with sand or other media. They may utilize standardized cartridges placed in vaults and proprietary filters.

Bacteria Removal: Performance of proprietary devices should be evaluated based on the unit treatment process.

The measured effectiveness for bacteria removal was 39% to 86% in a study of a hydrodynamic device manufactured by Vortechs.

A filtration device manufactured by Filtrexx claims a removal rate of 73% for E. coli, and up to 99% with the addition of a bacterial agent.

Advantages:

- Proprietary devices are useful on small sites and areas with limited space.
- The devices can be used in combination with other BMPs to enhance bacteria removal.

Disadvantages:

- There is limited performance data and no consensus regarding optimum media design, required contact time and expected removal rates.
- Proprietary devices are often more costly than other options.
- Maintenance requirements may be high.

4.2.12 Tree Planter Boxes

Description: Tree planter boxes or tree box filters (**Figure 4-21** and **Figure 4-22**) are mini-bioretention cells installed beneath trees. Runoff is cleaned by vegetation and soil before entering the stormwater catch basin through an underdrain. Engineered soils can be utilized to provide higher infiltration rates. Non-proprietary sand/compost blends can be designed for rates of up to 10 inches per hour. Specialized commercial media can provide infiltration rates up to 100 inches per hour.

Bacteria Removal: Tree filters have a high degree of stormwater pollutant removal capacity, utilizing physical, biological and chemical remediation functions. For bacteria, the reported removal rate is greater than 85%.

Advantages:

- Tree planter boxes fit into any landscape scheme, enhancing the urban landscape and reducing urban heat island effects.
- They can be planted with typical landscape plants (shrubs, ornamental grasses, trees and flowers).
- They provide low impact development (LID) benefits similar to conventional bioretention.

Disadvantages:

- Individual tree planter boxes hold a relatively small volume of stormwater.

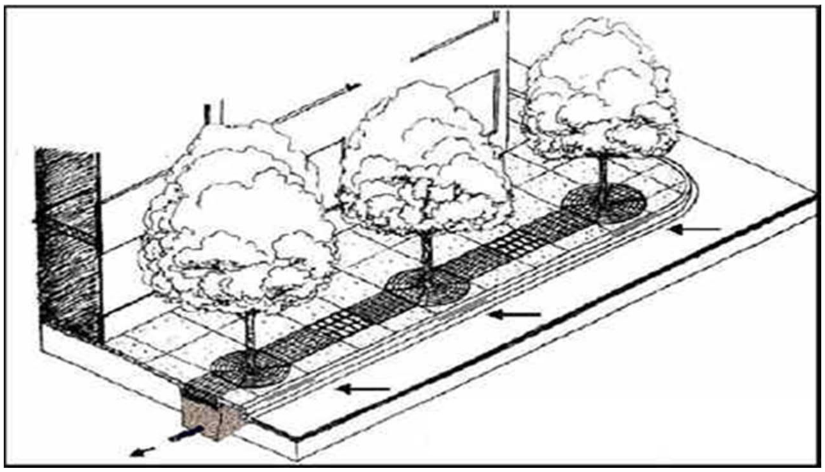

Figure 4-21. Example Manufactured Tree Planter Box Design

Figure 4-22. Tree Planter Box

4.3 SUMMARY OF BEST MANAGEMENT PRACTICES (BMPS) FOR FECAL COLIFORM AND E. COLI REMOVAL

No single stormwater BMP will be applicable for all situations. The BMP selection process considers numerous factors, including size of the drainage area, and the surface area required for the BMP. **Appendix H** is a summary of the removal efficiency of the BMPs discussed in this section, including the drainage area requirements for each BMP and the required surface area as a percent of the contributing drainage area.

4.4 LOW IMPACT DEVELOPMENT

Since most of the watershed is completely built-out and developed, the potential for implementing green development and site design concerning larger common plan development is rather limited. The City is currently in the process of integrating green infrastructure and LID practices into their revised City ordinances. These revisions should provide opportunities for redevelopment within the watershed to take a more proactive stance with respect to fecal coliform and *E. coli* bacteria removal. All redevelopment sites, including commercial and residential, within the watershed should implement green infrastructure as part of their stormwater controls. The BMPs outlined in this watershed plan should be evaluated for feasibility in each of the redevelopment sites within the watershed. When redevelopment projects are proposed, the City will conduct water quality monitoring in accordance with this watershed plan to determine the potential contribution of the site to water quality concerns.

4.5 ENFORCEMENT OF EXISTING RULES

The Gully Branch community in large part is self-policing. When sediment buildup and trash in and around stormwater drains prevents efficient drainage of runoff into the conveyance system, members of the community actively report these problem areas to the City. To further aid these efforts, the City is developing a reporting form to facilitate community reports.

4.6 OUTREACH AND EDUCATION

The City has been very active in communicating with the neighborhoods within the watershed through community meetings and the development of the UDO Advisory Board, which includes representatives from various communities throughout the watershed and the City. Through these meetings, the City staff has not only gained a broader knowledge with regards to development issues within the watershed, but also pollutant and erosion concerns of the residential community.

The City also receives assistance from Carolina Clear to educate and involve the public in waterway protection and pollution prevention. Carolina Clear, developed by Clemson University, uses a comprehensive approach to inform and educate communities about water quality, water quantity, and the cumulative effects of stormwater. Carolina Clear uses numerous types of media and other means, such as workshops and presentations, to educate, inform, and encourage community involvement in stormwater pollution prevention. Information on the Florence Darlington Stormwater Consortium is available to the public on the Carolina Clear website at https://www.clemson.edu/extension/carolinaclear/regional-consortiums/fdsc/index.html.

As part of the watershed plan, information signage will be included for all projects within the limits of the public parks identified herein. This will allow for visual information to be disseminated to the public with regards to the importance of fecal coliform and *E. coli* bacteria removal. Signage will be presented to the stakeholders for review prior to implementation. Since the stakeholders have a vested interest in these projects due to the proximity to the residential neighborhoods, it will be important to include them in the decision-making process with regards to how information is presented and how this signage will be integrated into the natural layout of the parks.

Where additional projects are implemented outside of the limits of the City-owned parcels, the City will implement a public awareness campaign for the projects that includes the distribution of printed informational fliers, inclusion of project information on the City's website and in print media, and educational distribution on the City's television public access channel.

While the overall reduction in pollutant loading associated with educational outreach activities cannot be quantified as part of this plan, the ability to educate and change behaviors can have a significant impact within the community. The long-term water quality monitoring plan associated with this watershed project will monitor the water quality and may be able to provide conclusive results with regards to educational impact in the future.

IMPLEMENTATION PLAN

05

5. IMPLEMENTATION PLAN

5.1 INTRODUCTION

The section describes a number of BMPs that were recommended or implemented in the Gully Branch Watershed. This section also includes BMPs in Timrod Park and Lucas Park were implemented and BMPs are recommended for Maple Park and other areas of the City.

5.2 IMPLEMENTED PROJECTS

The City completed construction of best management practices (BMPs) to alleviate erosion and sediment transport, and thereby reducing the counts of fecal coliform and E. coli in the Gully Branch Watershed. The City constructed six (6) BMPs in each two (2) public parks: Timrod Park and Lucas Park.

5.2.1 Timrod Park

Timrod Park is one of the multi-functional facilities for the City. The six (6) BMPs installed in the park were two (2) infiltration trenches, three (3) tree planter boxes, and restoring and stabilizing the right bank of Gully Branch. The infiltration trench near Park Avenue has three (3) components: an energy dissipating forebay at the upstream edge, an energy dissipation riprap lined swale that is underlain with a geotextile fabric, and bank stabilization with permanent turf reinforcing mat. The second infiltration trench near the tennis courts has two separate underdrain systems and a berm in the south-side of the trench to ensure runoff is captured. The three (3) tree planter boxes are performing well with one (1) exceeding expectations since it was installed in conjunction with a riprap forebay to dissipate energy and collect debris. The last BMP constructed in Timrod Park was the stream restoration on the right bank of Gully Branch. To aid in stabilizing the stream bank, two (2) rock vanes were added to dissipate the energy and reduce sediment transport.

5.2.2 Lucas Park

Lucas Park is an older park within the City that has undergone restoration and revitalization as part of a City rehabilitation project. As part of the project, six (6) BMPs were installed to alleviate the drainage problems within the park. Three (3) bioretention cells were constructed in a tiered system connected by underdrains. The last of the tiered bioretention cell has an overflow swale that directs water to a yard inlet. The park was regraded to direct any overland flow that was not captured by the tiered bioretention area towards a fourth bioretention cell downstream to allow for infiltration of the first flush before being discharged into the existing drainage system. An enhanced swale with check dams was installed above the tiered bioretention system to promote more infiltration and to lower the peak discharge. Lateral drains were installed downstream of the tiered bioretention system to reduce the consistent saturation of the area and promote infiltration before the stormwater was discharged into the existing drainage system. A proposed treatment forebay, a type of constructed wetland, for the lower end of Lucas Park was not installed. The City was not able to obtain the easement necessary for the installation of the treatment forebay BMP.

5.3 IMPLEMENTED PROJECT ANALYSIS

5.3.1 Timrod Park

The reduction goal from Timrod Park BMP implementation was 1.45%. Currently with the limited data set, the general reduction of the Timrod Park BMP implementation is 64%. Although the BMPs at Timrod Park are exceeding expectations, additional implementation needs to be completed to fully realize the pollutant reduction goals of the Gully Branch Watershed Plan.

5.3.2 Lucas Park

The reduction goal from Lucas Park BMP implementation was 66%. The general pollutant reduction is estimated to be 55%. Post construction data of the BMPs show a significant effect of pollutant removal. The enhanced swale was not included in the estimated pollutant reduction because post construction monitoring data was not available. Additional pre-treatment prior to discharge to the storm drainage system should further enhanced the removal efficiency of the system.

5.4 PREVIOUSLY RECOMMENDED PROJECTS

This section includes projects that were previously recommended to the City to be implemented in the Gully Branch Watershed. Due to various reasons, such as funding, these projects were not constructed, and they are not recommended for the upcoming permit cycle. The projects remain in this plan to document that they were recommended previously, and are available if the City would like to pursue them in the future.

5.4.1 Maple Park

1. **Bioretention Area**

   A bioretention area is proposed for Maple Park. The BMP would be located near the existing storm drain. Stormwater for much of the Park would drain to the bioretention area, receiving treatment through infiltration and evapotranspiration. Excess stormwater would flow into an underdrain system and into the existing stormwater pipes.

Figure 5-1. Potential Location of a Bioretention Cell

2. **Tree Planter Box**

   Tree boxes are proposed for each of the four street corners at Maple Park.

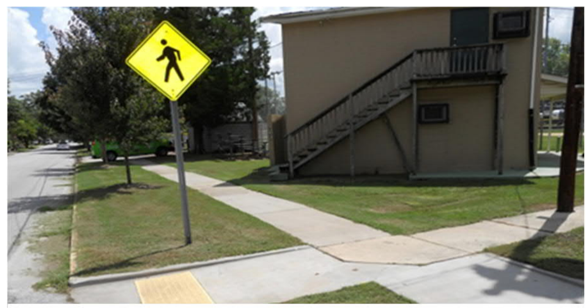

Figure 5-2. Potential Location of Tree Planter Boxes

Maple Park is a one-block site surrounded by paved streets with curb and gutter. Runoff from the ball fields drains to a drop inlet located near the playground near the center of the park. Additionally, runoff from the site, which reaches the street, flows in the gutter to one of four catch basins located at each corner of the site.

Table 5-1 list the five BMPs recommended at the site along with the estimated pollutant load, pollutant removal, and percent load reduction based on the EMC for WS-102 and the contributing drainage area for each BMP. Four tree planter boxes are recommended in Maple Park, one at each corner catch basin, and a bioretention cell should be installed above or adjacent to the existing catch basin near the playground. It is estimated that these five elements will remove approximately 2.86E+11 lb/yr of fecal coliform reducing the overall load in WS-102 by 0.50%. Though this number seems small, it is believed that the educational opportunities will greatly enhance other non-structural BMP elements of the watershed plan.

Table 5-1. Estimated Analysis of Recommended BMPS for Maple Park

BMP No.	BMP Type	Drainage Area (acres)	Estimated Load (lb/yr)	Estimated Pollutant Removed (lb/yr)	Estimated Load Reduction (%)
1	Tree Planter Box	0.25	2.51E+10	2.13E+10	0.05
2	Tree Planter Box	0.25	2.51E+10	2.13E+10	0.05
3	Tree Planter Box	0.25	2.51E+10	2.13E+10	0.05
4	Tree Planter Box	0.25	2.51E+10	2.13E+10	0.05
5	Bioretention Cell	3	3.01E+11	1.20E+11	0.30
Cumulative Total		4	4.014E+11	2.05E+11	0.50

Construction of the proposed BMP implementation projects will require a significant capital investment within the Gully Branch watershed. Important costs that must be considered include planning, permitting, design, construction and operation and maintenance costs for each of the individual proposed BMP projects. The many factors that must be considered when preparing a cost estimate (costs of land, varying site conditions, material and labor costs, weather variation, etc.) along with a lack of available historical data make it difficult to accurately estimate the costs of installation for these various practices. Estimated capital costs for the BMPs recommended for Maple Park are listed in **Table 5-2**.

Table 5-2. 2013 Cost Estimate for Maple Park BMP Implementation

BMP	Number of Each	Unit	Unit Cost ($)	Extended Cost ($)
Bioretention Cell	1	Acre	20,000	20,000
Tree Planter Boxes	4	No.	10,000	40,000
			Total	60,000

5.5 RECOMMENDED PROJECTS

These are the projects that are recommended for the year 2020 and the next permit cycle. This section includes a description of recommended projects, project analysis, and project cost estimates.

5.5.1 Rehabilitation and Maintenance of existing BMPs in Timrod and Lucas Parks

Structural BMPs age and require maintenance beyond the typical monthly or annual maintenance. Existing structural BMPs that need maintenance and rehabilitation are:

Bioretention Cells

Bioretention cells accumulate sediment and eventually the bowl portion of the BMP will be filled in and clog the engineered media. The recommendation is to remove the excess and clogged media, reshape the bowl of the bioretention cell, and replace with fresh media and mulch. Another recommendation is to remove the metal guards surrounding the bioretention cells. The metal guards prohibit stormwater runoff from entering the cell unless the runoff depth is over 1 inch. This stormwater runoff is not treated because the runoff is bypassing the bioretention cell.

Infiltration Trenches

Infiltration trenches can lose infiltration capacity over time from excess sediment and soil compaction. It is recommended that the infiltration trenches are tested to determine the infiltration rate and capacity. If the infiltration rates are not optimal, the infiltration trenches will need to be rehabilitated by excavating the media and filter fabric. Any accumulated sediment would be stripped from the trench bottom. The trench bottom would be scarified/tilled and filled using new media and filter fabric.

Tree Planter Boxes

Tree Planter Boxes can accumulate sediment within the box to a height equivalent to the overflow pipe. The recommendation is to excavate the excess sediment and scarify/till the bottom of the tree planter box to promote infiltration into the soil. Trees can also outgrow the planter boxes. If the trees are too large, the recommendation is to relocate the existing trees in the planter boxes and plant new, appropriately sized trees in the tree planter boxes. It is also recommended to stabilize the soil surrounding the overflow pipe, so the pipe does not break and potentially clog.

Dog Waste Stations

Dog waste stations have been vandalized in the parks, and need repair.

5.5.2 Streambank Stabilization in Timrod Park

The streambanks in Timrod Park are eroding, which affect other BMPs in the area, such as the tree planter boxes. It is recommended to regrade and stabilize the streambanks with vegetation. In addition to bank stabilization, stream restoration practices should be utilized to stabilize the streambed and provide additional protection of the stream banks. This would include site-specific practices such as the installation of instream structures or augmenting the riffle-pool sequence and meander pattern of Gully Branch. Since the City does not want citizens or animals to enter into the stream at Timrod Park, it is recommended that aesthetically pleasing vegetation that reaches a maximum height of 2.5 feet be used to deter the citizens and animals from entering the stream.

5.5.3 Sanitary Sewer Network Assessment

Gully Branch Watershed is primarily an urban environment, and the majority, if not all, of the buildings are connected to the sanitary sewer network. The TMDL states that the probable source of *E. coli* in the watershed is from SSOs and exfiltration from the sanitary sewer network. The City has planned to begin assessing the sanitary sewer network in 2022.

5.5.4 Clean Water Campaign

It is recommended that the City participate in a Clean Water Campaign. The campaign educates the citizens and businesses to protect the local waterways. Awareness is raised through a variety of educational resources (pamphlets and kiosks), a website, and stenciling stormwater inlets with "Keep it Clean, Drains to Stream." An example program from the Metropolitan North Georgia Water Planning District can be found at:

https://cleanwatercampaign.org/protect-our-water/

5.6 RECOMMENDED PROJECTS ANALYSIS

5.6.1 Rehabilitation and Maintenance of existing BMPs in Timrod and Lucas Parks

During the lifespan of a structural BMP, the removal efficiencies decrease. The rehabilitation and maintenance proposed will restore the BMPs to the original removal efficiencies.

5.6.2 Streambank Stabilization in Timrod Park

Regrading and stabilizing the streambanks, stabilizing the streambed, and establishing a riparian buffer in Timrod Park will provide the stream a vegetative buffer that has the potential to remove and/or attenuate pollutant removal, including *E.coli,* from stormwater runoff directly entering the stream. Studies have been completed documenting *E. coli* and bacterial removal efficiencies ranging from 70-99% (Klapproth and Johnson 2009; Tate et al 2006; Tate et al 2004). The removal efficiencies are dependent on slope and width of the vegetative buffer.

5.6.3 Sanitary Sewer Network Assessment

If leaks are found during the assessment, 100% of *E. coli* will be removed once the City repairs the sanitary sewer network.

5.6.4 Clean Water Campaign

Educational resources do not have a direct effect on the reduction of *E. coli*. Through raising the awareness of clean stormwater, reduction can be achieved through the practice of daily activities of the citizens and businesses.

5.7 COST ESTIMATES

5.7.1 Rehabilitation and Maintenance of existing BMPs in Timrod and Lucas Parks

The costs estimate for the rehabilitation and maintenance of existing BMPs in Timrod and Lucas Parks is located in **Table 5-3**.

Table 5-3. Unit cost for rehabilitation and maintenance of existing BMPs

BMP	Unit	Number	Unit Cost ($)	Total Cost
Bioretention Cell	No	6	20,000	120,000
Tree Planter Boxes	No.	3	10,000	30,000
Infiltration Trench	No.	3	10,000	30,000
Dog Waste Stations	No.	As Needed	1,000	As Needed

5.7.2 Streambank Stabilization in Timrod Park

Costs associated with streambank stabilization will be prepared based off the future field investigation per the direction of the City.

5.7.3 Sanitary Sewer Network Assessment

The estimate of the City-wide sanitary sewer network assessment is $10-20 million.

5.7.4 Clean Water Campaign

The Clean Water Campaign costs would include building and maintaining a website, educational materials and construction of any new kiosks, and the time and materials that are associated with the stenciling of inlets that drains to nearby receiving waters.

5.8 MILESTONE IMPLENTATION SCHEDULE

The schedule of implementation will be variable, based on funding sources and the ability to acquire property and approval of the retrofits. This plan provides an overall goal for implementation, but several key factors, including grant cycles, the economy, and design development timelines, may influence the ability to implement the plan as recommended. In addition, the schedule should be revisited annually to determine the practicality of the schedule and revisions based on changes to the overall plan.

The implementation schedule is based on the BMPs proposed for the three (3) city-owned properties since 2013. If the City should determine that the proposed plan is not feasible, the schedule may be adjusted based on revised treatment areas. However, to achieve the full goals of the City and stakeholders, every effort should be made to implement as much of the proposed plan as possible.

There are approximately 1,030 acres that can be treated through the implementation of BMPs proposed in this plan. Additional treatment will be provided by retrofitting existing stormwater drainage ditch and catch basin facilities utilizing enhanced infiltration swales and vegetated filter boxes throughout the watershed. If funding sources become available for additional work, the projects identified in this plan should be completed as soon as possible. Milestones are located in **Table 5-4**, **Table 5-5**, and **Table 5-6**.

Table 5-4. Milestones – Education and Outreach

Activity	Projected Start Date	Projected End Date	Status
Campaign to neighborhood groups and the public	2013	2014	Completed
Conduct a minimum of three meetings in first year	2013	2014	Completed
Investigate and pursue willing landowners for buffer preservation and restoration	2013	2014	Completed
Conduct outreach meetings prior to final design of each proposed project	2014	2016	Completed
Conduct outreach meetings following construction of each proposed project	2014	2016	Completed
Conduct education and outreach to public	2017	2022	In Progress
Clean Water Campaign	2020	--	

Table 5-5. Milestones – Recommended Projects

Activity	Projected Start Date	Projected End Date	Status
Repair and Retrofit Sanitary Sewer Network	2013	2022	In progress
Minimum of 2 Initial Projects Complete in the first year. These should be highly visible and include informational signage	2013	2014	Completed
Timrod Park			
• Preliminary investigation for final site locations and sizing of BMPs	2013	2014	Completed
• Design of BMPs proposed to treat surface runoff 100% complete	2013	2014	Completed
• Construction of BMPS	2014	2016	Completed
• All preliminary investigation of proposed BMPS complete	2014	2016	Completed
• Verification and Selection of remaining BMPS	2014	2016	Completed
• Rehabilitation and Maintenance of Existing BMPs	2020	2022	
• Streambank Stabilization	2020	2022	
Lucas Park			
• Verification and BMP selection for a minimum of 30% of BMPS	2013	2014	Completed
• All preliminary investigation of proposed BMPS complete	2014	2016	Completed
• Verification and Selection of remaining BMPS	2014	2016	Completed
• Design and construction projects complete	2017	2019	Completed
Maple Park			
• Verification and BMP selection for a minimum of 30% of BMPS	2013	2014	Completed
• Construction of BMPs	2014	2016	On Hold
• All preliminary investigation of proposed BMPS complete	2014	2016	On Hold
• Verification and Selection of remaining BMPS	2014	2016	On Hold
Identify additional BMP implementation opportunities not identified in Watershed Plan. Should be based on Phase I and II Sampling	2017	2019	In Progress
Construction of all BMP projects Complete	2019	2022	In Progress
Re-evaluate management priorities	2019	2022	In Progress

Table 5-6. Milestones – Sampling

Activity	Projected Start Date	Projected End Date	Complete/ In Progress
Baseline Monitoring at current sample locations (Phase I Sampling)	2013	2022	In Progress
BMP Performance Monitoring (Phase II Sampling)	2014	2022	In Progress

5.9 PROJECT SUMMARY

Twelve BMPs were implemented in Timrod Park and Lucas Park. The pollutants in Timrod Park were reduced by 64%, and the pollutants in Lucas Park were reduced by 55%. The implementation strategies represent significant strides in meeting the overall water quality goals for Gully Branch, most notably in subwatersheds WS-101, WS-102, WS-103, and WS-104.

Additional projects were recommended to reduce the pollutant loading to meet water quality standards. These projects include maintaining/rehabilitating implemented projects, stabilizing stream banks, an assessment of the sanitary sewer network, and providing outreach opportunities and educational information to the public through a Clean Water Campaign.

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STREAM AND WATERSHED MONITORING

06

6. STREAM AND WATERSHED MONITORING

6.1 INTRODUCTION

The City's Quality Monitoring Plan for Jeffries Creek currently collects data at Gully Branch and Cherokee Road (GB01US). Additional ambient water quality monitoring for fecal coliform and *E. coli* in the Gully Branch Watershed must be conducted to characterize water quality conditions in Gully Branch and to monitor BMP progress and long-term water quality trends.

This section describes the procedures and methods for creating an ambient water quality monitoring program using consistent and objective monitoring, sampling, and analytical methods and consistent data quality assurance protocols. The sampling plan will document conditions both prior to BMP installation and after BMP implementation to evaluate the overall effectiveness of the BMPs in protecting water quality in Gully Branch.

6.2 SAMPLING PLAN

Water quality monitoring stations will be located within the Gully Branch watershed based on identification and implementation of BMPs. Prior to installation of the selected BMPs, water quality monitoring will be conducted to establish baseline concentrations for fecal coliform and *E. Coli* at each proposed BMP location (Phase I Sampling). Additional water quality monitoring will be performed after BMP installation to monitor BMP performance and determine compliance with WQS (Phase II Sampling).

Sampling will be conducted during dry weather conditions to determine the ambient in-stream water quality of Gully Branch under minimal dilution conditions.

6.2.1 Baseline Monitoring (Phase I Sampling)

Once a project site is selected and a BMP is identified for stormwater treatment, a sampling location will be established downstream of the proposed BMP stormwater outfall for baseline monitoring. The duration of Phase I Sampling is two sampling events for each implemented project.

6.2.2 BMP Performance Monitoring (Phase II Sampling)

Phase II sampling to monitor BMP performance will begin after installation of each BMP. The Phase II sampling location is identical to the Phase I sampling location. The duration of Phase II Sampling is quarterly sampling for one year from the completion of each project.

6.2.3 Monitoring Team

The Gully Branch Watershed Monitoring Team includes all personnel involved in logistical support, sample collection, traffic control, and safety during monitoring. A Sampling Team will be assigned to each BMP. Each Sampling Team consists of a Sampling Team Leader and Sampling Team Crew composed of two (2) Crew Members. The Sampling Team Leader is responsible for coordinating schedules and logistics associated with monitoring. The Sampling Team Crew is responsible for ensuring that all required equipment is ready for field operation. The Field Sampling Equipment Checklist is attached as **Appendix I**. They are also responsible for performing the monitoring preparation and field monitoring activities, including recording required data on the Field Data Sheet, completing the Chain of Custody Form (**Appendix J**), storing and delivering samples to the lab and cleanup and storage of field monitoring equipment. Any member of the Sampling Team may recommend canceling monitoring if health or safety of the Team could be imperiled due to site conditions or extreme weather.

6.2.4 Laboratory

The Laboratory responsible for analyzing the water samples collected under the Gully Branch Watershed Monitoring Plan will designate a Laboratory Supervisor at its discretion. The Laboratory Supervisor will provide analytical support to this project and is responsible for ensuring that laboratory analyses are performed in accordance with appropriate laboratory protocols and quality control criteria.

6.2.5 Project Quality Assurance/Quality Control Manager

The Project Quality Assurance/Quality Control (QA/QC) Manager is responsible for coordinating with the analytical Laboratory, ensuring conformance with data quality objectives, overseeing data validation and managing project quality assurance and quality control. The project QA/QC manager will be designated by the City stormwater manager.

6.3 DATA GENERATION AND ACQUISITION

This section details the strategy for monitoring Gully Branch for fecal coliform and *E. coli*, including the monitoring locations and frequency, and the specific methods for collecting and storing samples for laboratory analysis. All methodology herein complies with applicable American Society for Testing and Materials (ASTM) standards for water quality sampling and testing.

6.3.1 Location

The monitoring sites will be located based on BMP locations. The sampling method employed at these sites will be either a bridge dip or streambank sample, dependent on the location.

6.3.2 Sampling Equipment

Sampling equipment will consist of sterile 500 ml glass or polyethylene bottles. A swing sampler, extendable to 12 feet, will be used to collect samples from the streambank or bridge. Samples will be preserved in a cooler with tight-fitting lid.

6.3.3 Precipitation Events

The Gully Branch Watershed Sampling Plan is designed to monitor ambient water quality. Precipitation events can influence the results of the data; therefore, each sampling event must be preceded by at least 72 hours (3 days) with no previous measurable precipitation. Precipitation will be monitored and recorded at a rain gauge located at the WWTP, at 1000 Stockade Drive, as shown on the Monitoring Station Location Map (**Appendix G**). The Sampling Team Leader will review the precipitation log and schedule the sampling events a minimum of 72 hours (3 days) following a measurable rainfall. Sampling events shall be rescheduled at the next available opportunity as required due to rainfall or adverse weather conditions.

6.3.4 Adverse Weather Conditions

When adverse weather conditions prevent collection of samples as scheduled, samples will be collected at the next available opportunity. Adverse weather conditions are those that are dangerous or create inaccessibility, such as local flooding, high winds, electrical storms, or situations that otherwise make sampling impractical, such as drought or extended frozen conditions.

6.3.5 Preparation for Sampling

Prior to the scheduled sampling date, the Sampling Team Leader will prepare for sampling as follows:

1. Prepare Mode (7 days prior to sampling event):
   a. Order bottles from lab and alert lab of possible monitoring activities (if possible keep a supply of bottles on hand)
   b. Assemble field equipment
   c. Identify Sampling Team Members and arrange schedules for field activities
   d. Arrange vehicle(s) for monitoring activities
   e. Inspect all sample locations, assess site conditions for potential problems.
2. Ready Mode (1 day prior to sampling event):
   a. Check bottle inventory against station check list
   b. Confirm Sampling Team Members schedules for field activities
   c. Label bottles

d. Initiate Chain of Custody procedure
e. Check field boxes for supplies
f. Ensure a sufficient amount of ice for sampling and sample transport

3. Sampling Team Leader Decision Mode:
    a. Confirm no measurable precipitation recorded for the preceding 72 hours
    b. Confirm no adverse weather conditions
4. Sampling Team Go Mode:
    a. Mobilize Sampling Team
    b. Place ice in coolers
5. Sampling Team No-Go Mode:
    a. Inventory, clean, organize and prepare sampling equipment for next scheduled sampling event.

6.3.6 Monitoring Duration and Frequency

The monitoring frequency for the Gully Branch Watershed Monitoring Plan will be project based. Monitoring will be undertaken for each proposed project prior to project implementation. Samples shall be taken downstream of each project site a minimum of twice prior to BMP implementation. Once BMPs have been implemented, downstream sampling shall be taken on a quarterly basis for the duration of one year.

6.3.7 Sample Set

The sample set is designed to enable the City to monitor fecal coliform and *E. coli* concentrations at each BMP to determine the effectiveness of the BMP in protecting the water quality in Gully Branch. The sample set will consist of two individual 500 mL samples. These samples will be collected at the monitoring station as concurrent grab samples.

6.3.8 Sample Collection Technique

Safety

To minimize safety risks, use the buddy system when conducting water quality sampling or performing any other type of work on or near open water.

Sample Collection

The procedures recommended below are from the USGS National Field Manual for the Collection of Water-Quality Data (https://water.usgs.gov/owq/FieldManual/chapter4/pdf/Chap4_v2.pdf).

There are key procedures to eliminate the potential for contamination such as wearing appropriate gloves and avoid hand contact with the sample and avoiding any surface. Proper technique, equipment and sample preservation are especially critical factors for collecting bacteriological samples to obtain valid test results.

The samples will be collected by manual “grab” sampling as follows:

1. Container Preparation and Labeling

    a. Prepare 500 mL sample containers. Reused sample containers and all glassware must be rinsed and sterilized at 121°C for 15 minutes using an autoclave before sampling. Sample bottles should have tape over the cap or a marking to indicate that they have been sterilized. Sample bottles shall be clearly marked.

    b. Sample bottles shall be clearly labeled with the following information:

        i. Monitoring Station ID:

        ii. Sample Date:

        iii. Sample Time:

        iv. Sample Number: INITIAL or DUPLICATE

        v. Sampling Team Member’s Initials:

2. Safety

    a. Wear appropriate personal protective equipment, including a high-visibility safety vest, when operating near vehicular traffic.

    b. Place traffic cones, if appropriate, to direct traffic away from the area of operation.

    c. Use best judgment when sampling during high flows. Do not monitor during adverse weather conditions as defined in Paragraph 5.2.4 above, or if sampling cannot be carried out in a reasonably safe manner.

    d. Before sampling from bridges, follow all safety precautions and ensure risk of injury is negligible. Be wary of passing traffic. Never lean over bridge rails unless you are firmly anchored to the ground or the bridge with good hand/foot holds.

3. Direct Sampling Surface Water

    a. Remove stopper/cap from container just before sampling. Be careful not to contaminate the cap, neck, or the inside of the bottle with your fingers, wind-blown particles, or dripping water from your clothes, body, or overhanging structures.

    b. Place yourself facing away from the streambank or bridge.

    c. Hold the container near its base, reach out in front of yourself as far as possible, and plunge it (mouth down) below the surface to a depth of 6 inches or more if the sediments will not be disturbed.

    d. Keep the bottle submerged long enough for the container to fill (**Figure 6-1**).

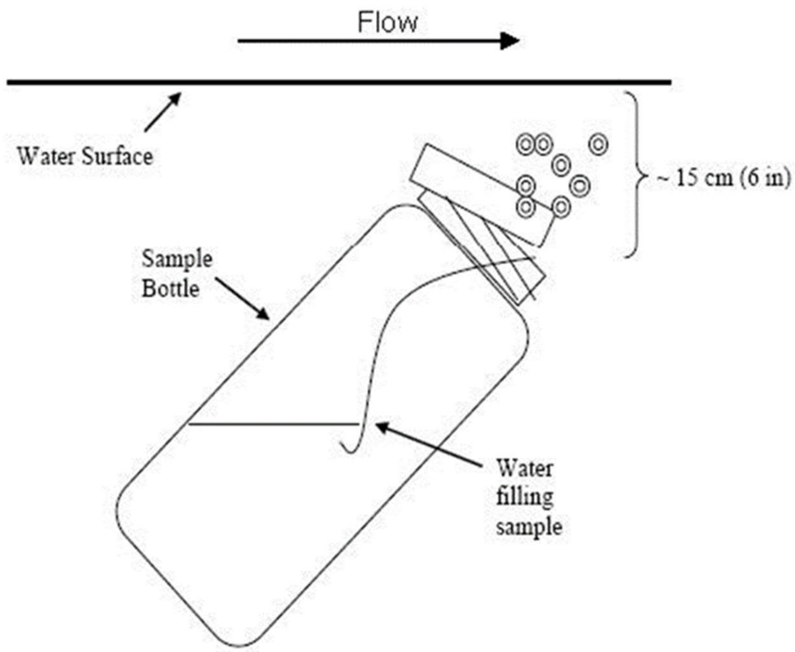

Figure 6-1. Grab Sample Collection

e. If an extension pole is used from a bridge or streambank, securely attach the sample container (with its cap in place) to the holder with the clamps or bands. Remove the container cap being careful not to contaminate the container and follow the above procedure.

f. Tip out some of the water to allow for air space needed for proper mixing at the lab. Securely replace the cap of the container being careful not to touch the inside of the cap.

g. Rinse any large amount of dirt or debris from the outside of the container after securing the cap.

4. Sampling from a bridge

a. Pick a spot on the downstream side of the bridge over the middle of the channel.

b. Clear any loose debris from the bridge railing and make sure the path from the railing to the water's surface is clear of obstructions.

c. Attach sterilized bottle to the swing sampler and secure carefully.

d. Remove cap just before lowering the sampler with bottle.

e. Lower the sampler in such a manner so as not to contaminate the open bottle with dirt or dripping water.

f. When approaching the water surface, drop the sampler quickly through the surface to avoid the micro-layer to a depth of 6 inches or more unless contact will be made with the substrate.

g. Keep the bottle submerged long enough for the container to fill.

h. Pull up the sampler and bottle, being careful not to contaminate the sample with dirt or water from the bridge or other sources of contamination.

i. Tip out some of the water to allow for air space needed for proper mixing at the lab. Securely replace the cap of the container being careful not to touch the inside of the cap.

j. Rinse any large amount of dirt or debris from the outside of the container once the cap is secure.

5. Sample Storage

a. After collecting the sample, immediately review the sample tag to ensure accurate location and analytical information. Record the time the sample was collected on the tag and enter relevant data into the Field Data Sheet using waterproof ink.

b. Immediately place labeled sample bottle on ice in a cooler with a tight-fitting lid. Use only enough ice to maintain the required preservation temperature of 4°C or less.

6. Field Data Sheet (**Appendix K**)

a. Sampling Information. Complete the Field Data Sheet for each sample collected.

b. Rainfall History. Record the date of last measurable precipitation preceding the sampling event and enter the information on the Field Data Sheet.

7. Chain of Custody (**Appendix J**)

a. Immediately following sample collection, complete the Chain of Custody form for the samples collected from each monitoring station.

b. Upon delivery to the Lab, sign the Chain of Custody form to relinquish the samples to the Lab.

8. Sample Delivery

a. Return the Field Data Sheet, Chain of Custody Form and the samples to the Laboratory or to a previously designated drop-off point as soon as possible.

b. Samples must be analyzed within 6 hours of collection.

6.3.9 Analytical Methods

Analysis of all samples will be conducted by a SCDHEC lab certified for fecal coliform and E. coli analysis.

The analytical method for measuring fecal coliform is the membrane filter (MF) procedure, SM9222D, 18th Edition. The membrane filter technique is highly reproducible, can be used to test relatively large volumes of sample, and yields numerical results more rapidly than the multiple-tube procedure.

The analytical method utilized for measuring E. coli will be either E. coli (MF) (EPA Method 1603 or m ColiBlue24®) or E. coli (MPN) (SM 9223B Colilert®/Colilert-18®).

6.4 QUALITY ASSURANCE AND QUALITY CONTROL

The QA/QC program provides a process for ensuring the reliability of the measured data in order to meet the objectives of the stormwater quality monitoring program. The data must be of documented quality to be scientifically and legally defensible.

The primary data quality objective of the Gully Branch Watershed Monitoring Plan is to measure the concentrations of fecal coliform and *E. coli* bacteria and other specified field parameters at the Gully Branch monitoring stations. The results will be used to determine the ambient water quality before and after BMP installation and WQS compliance.

6.4.1 *Field Quality Assurance/Quality Control*

QA for the field monitoring activities covered under this plan will be achieved through documentation of the following:

1. Consistent adherence to monitoring protocols identified within the Sampling Plan.
2. A determination of whether the project objectives and data quality objectives have been met for a specific set of data and information at the time of reporting.
3. Training of all field personnel on the monitoring components contained in the Sampling Plan.

6.4.2 *Laboratory Quality Assurance/Quality Control*

The Laboratory responsible for sample analysis has been identified as the City's wastewater treatment plant. The Lab must follow the standard QA/QC requirements specified in standard analytical methods. Additionally, the Lab must meet the following minimum requirements:

1. Adhere to methods outlined in the Laboratory's Standard Operating Procedures (SOP) for Fecal Coliform and *E. coli*.
2. Deliver fax, hard copy, and electronic data within five (5) days of obtaining sample results.
3. Meet reporting requirements and turnaround times for deliverables.
4. Implement QA/QC requirements specified in standard analytical methods.
5. Allow laboratory and data audits to be performed, if deemed necessary.
6. Follow documentation and chain of custody procedures.

Changes in the laboratory procedures will not be permitted without written documentation of the intended change and the rationale. The Project QA/QC Manager must approve all changes in advance.

6.5 DATA MANAGEMENT AND REPORTING

The process for management and reporting of data is as follows:

6.5.1 *Data Validation*

The Laboratory will be responsible for data verification at the lab, and will follow applicable laboratory QC measures as outlined in the SOPs. Data verification will include review of the results by a second laboratory analyst provided by the Laboratory.

The Project QA/QC Manager will be responsible for reviewing all Field Data Sheets (**Appendix K**) and Chain of Custody Forms (**Appendix J**) to ensure that the correct samples have been provided to the laboratory for each sampled rainfall event. Should any discrepancies be detected during this review with regard to sampling methods, data, Chain of Custody, or field equipment, the sample will be discarded, and an additional sampling event will be scheduled.

6.5.2 *Data Verification*

The Project QA/QC Manager will record any problems noted by the Laboratory and Sampling Team, and examine the data and ensure that sample results match expected samples for the site. The Project QA/QC Manager will compare the data against historical data and determine if the data agrees with the project data. After these assessments, the Project QA/QC Manager will research the inconsistent data and/or documentation by contacting the Laboratory and Sampling Team to correct and/or explain inconsistencies. After all validation steps have been completed, the Project QA/QC Manager will prepare a report and incorporate the information into the report.

6.5.3 *Data Reporting*

A separate record will be generated by the Laboratory for each sample analysis, including key information such as Monitoring Station ID, sample date and time, Sampling Team Member, name of constituent (fecal coliform or *E. coli*), all results, units, detection limits, analytical methods used, name of the laboratory and any field notes. When reporting the laboratory results for each stormwater sample the following information will be provided:

1. Monitoring Station ID
2. Sample date and time
3. Sample number (or identification)
4. Sampling Team Member(s)
5. Constituent Analyzed (fecal coliform or E. coli)
6. Detection Limit and Reliability Limit of analytical procedure(s)
7. Sample Results with clearly specified units

6.5.4 *Summarizing Bacterial Sampling Results*

Bacteria samples can have large variations in the results, and averaging the results can skew the data. The geometric mean (**Equation 6-1**) is a calculation that dampens the effect of very high or low values. Therefore, when more than one bacteria sample is collected, instead of averaging the results, calculate the geometric mean of the results. The easiest way to calculate the geometric mean is to use the “geomean” function in Microsoft Excel.

Equation 6-1. Geometric Mean

$$Geometric\ Mean = \sqrt[n]{(x_1)(x_2)\ldots(x_n)}$$

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07

7. REFERENCES

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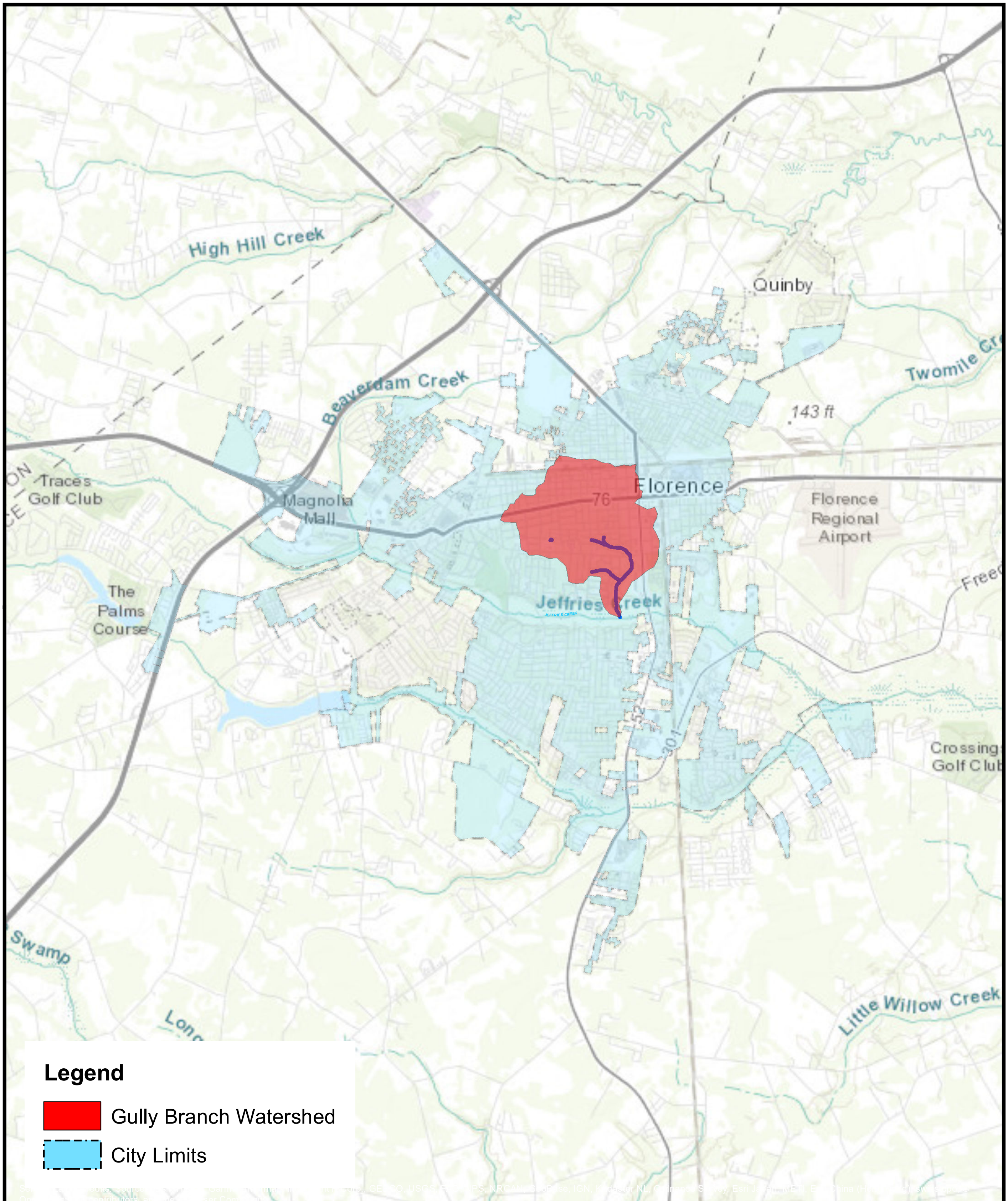
APPENDIX A. GULLY BRANCH – OUTFALLS

GULLY BRANCH - OUTFALLS

APPENDIX B. GULLY BRANK WATERSHED LOCATION MAP



Date: January 27, 2020
Author: JAP

AECOM

South Carolina State Plane, NAD 83
Zone 3900, International Feet

1 inch = 2 miles

0 0.25 0.5 1 1.5 2
Miles

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SOUTH CAROLINA

GULLY BRANCH WATERSHED
Location Map

AECOM
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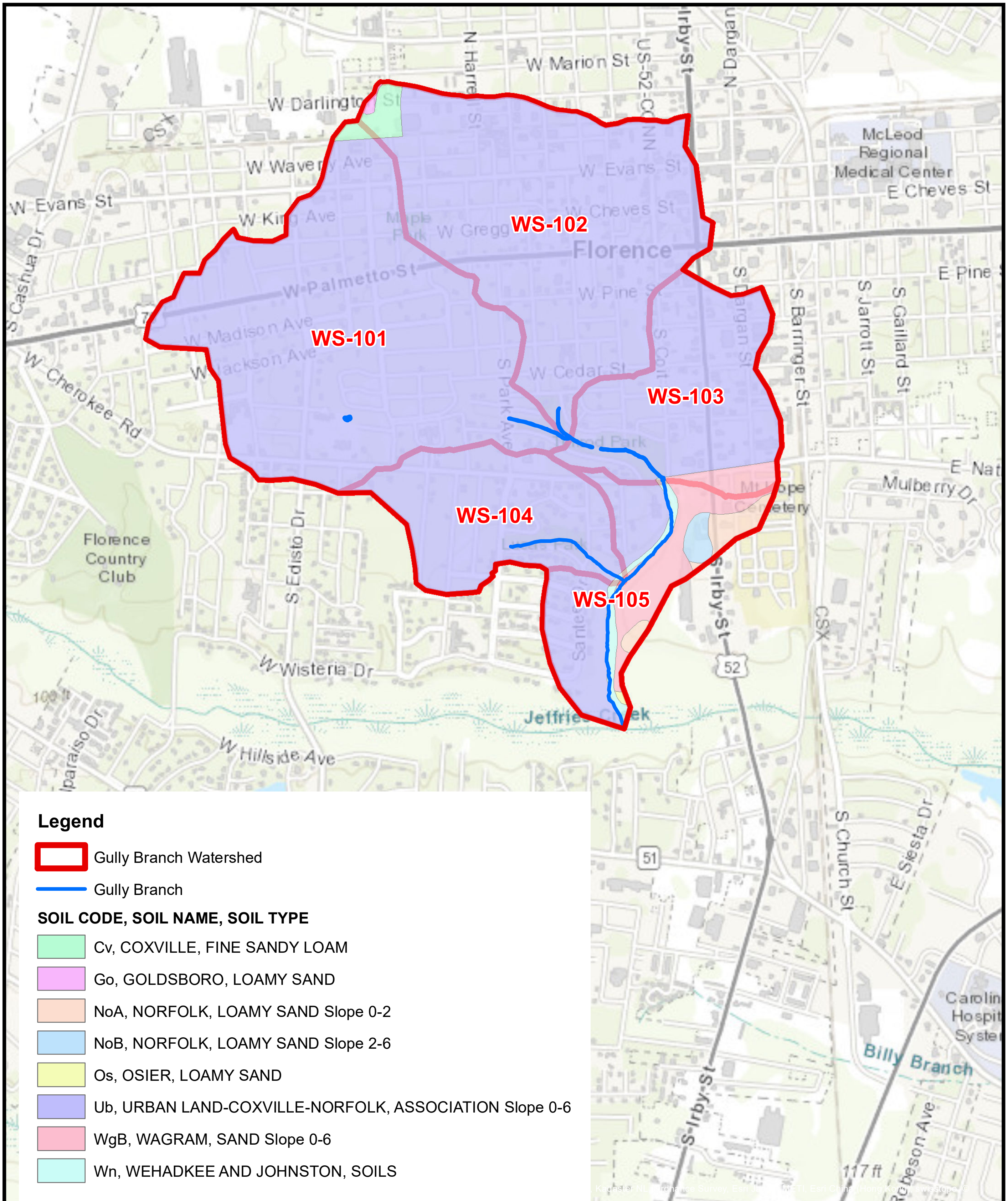
APPENDIX C. GULLY BRANCH WATERSHED SOILS MAP



Date: January 27, 2020
Author: JAP

AECOM

South Carolina State Plane, NAD 83
Zone 3900, International Feet

1 inch = 0.5 miles

0 0.25 0.5 0.75 1 Miles

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GULLY BRANCH WATERSHED
Soils Map

AECOM
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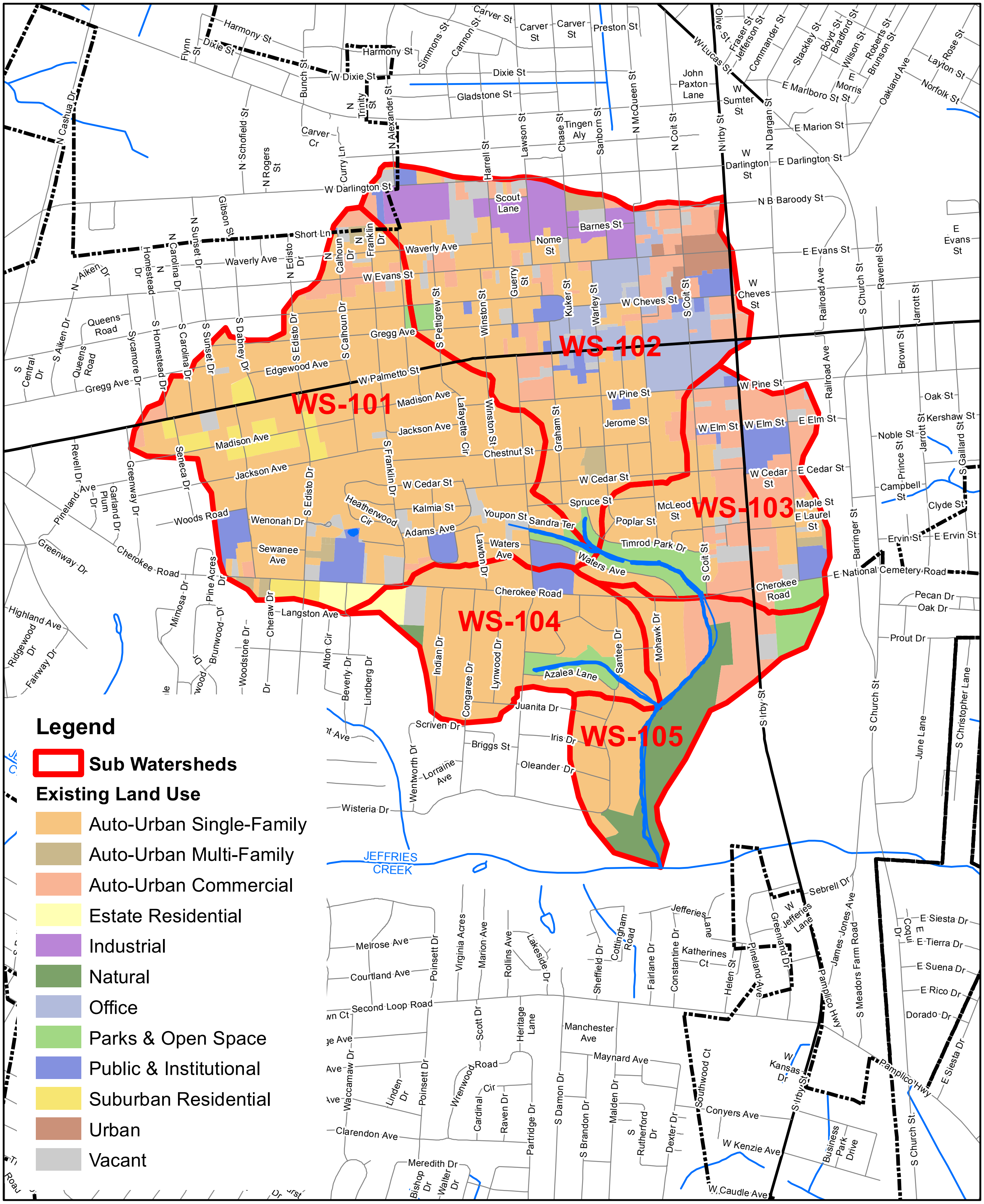
APPENDIX D. EXISTING LAND USE LOCATION MAP



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Date:March 18, 2013
Author: LCS

AECOM

South Carolina State Plane, NAD 83
Zone 3900, International Feet

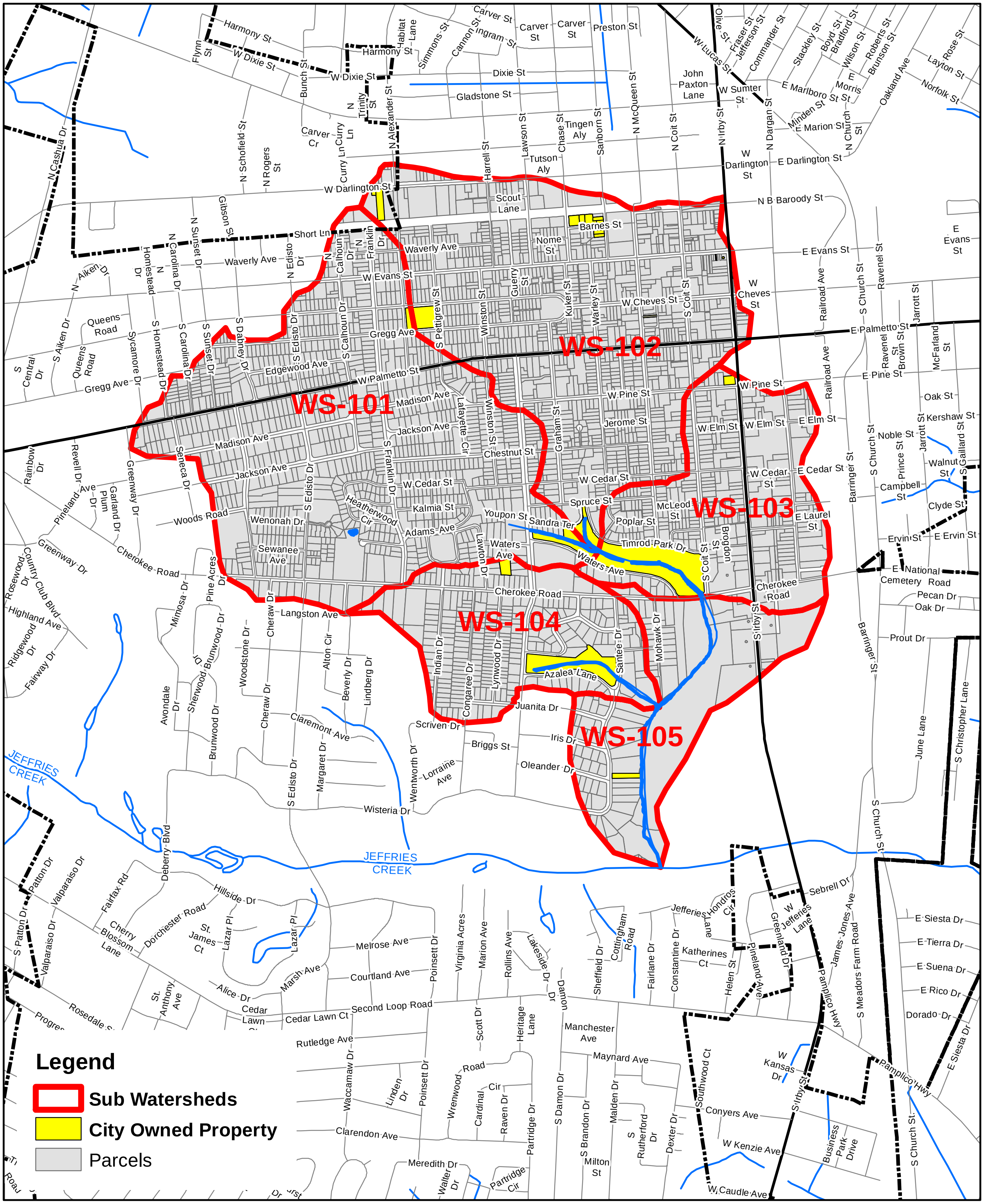
1 inch = 2,000 feet

0 1,000 2,000 4,000 Feet

City of Florence

Existing Land Use Location Map

APPENDIX E. CITY OWNED PROPERTY LOCATION MAP



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Date:March 18, 2013
Author: LCS

AECOM

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South Carolina State Plane, NAD 83
Zone 3900, International Feet

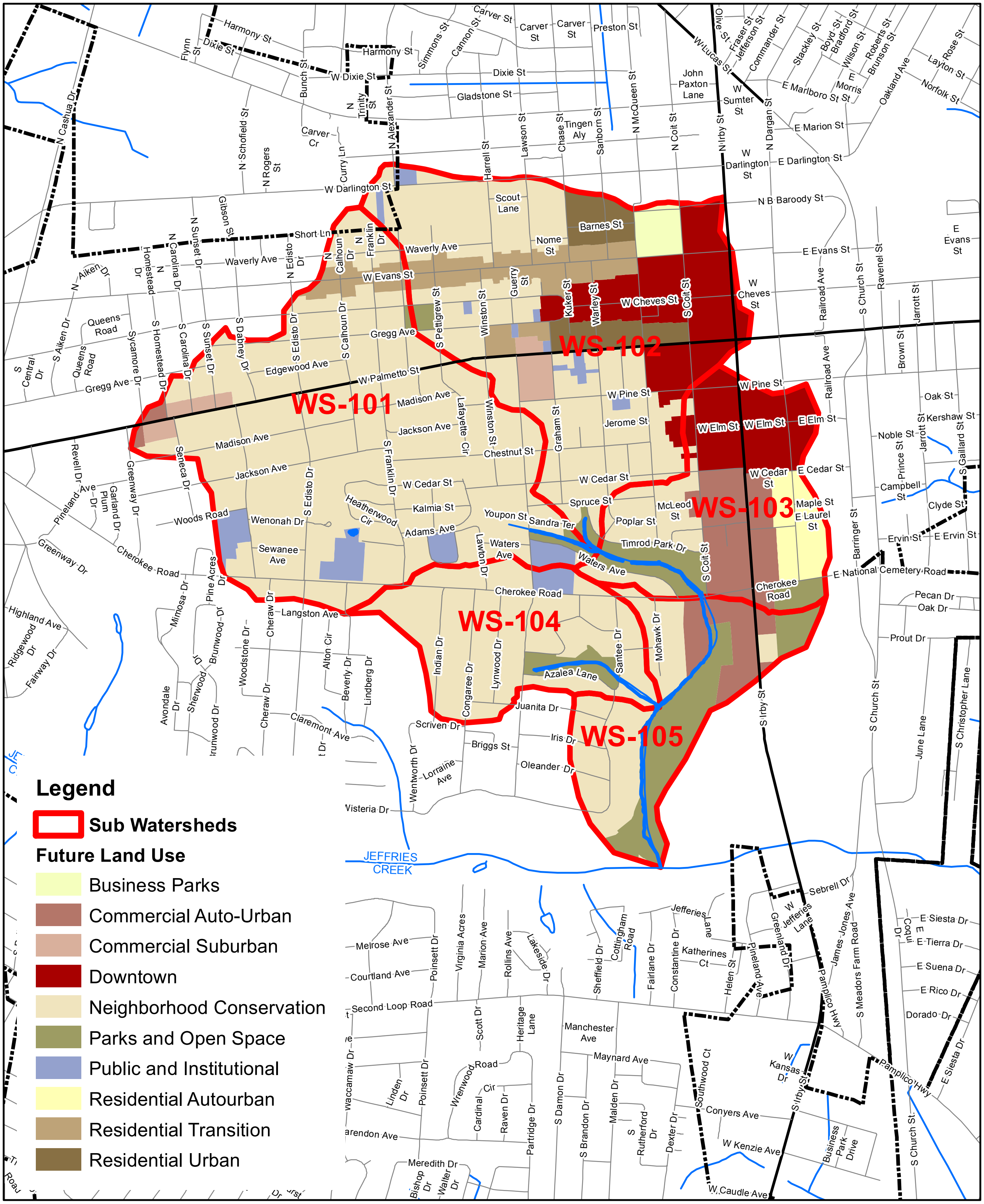
1 inch = 2,000 feet

0 1,000 2,000 4,000 Feet

City of Florence

City Owned Property Location Map

APPENDIX F. FUTURE LAND USE LOCATION MAP



File: \46422751_Florence\Maps\Maps\
Future_Land_Use.mxd
Date:March 18, 2013
Author: LCS

AECOM

South Carolina State Plane, NAD 83
Zone 3900, International Feet

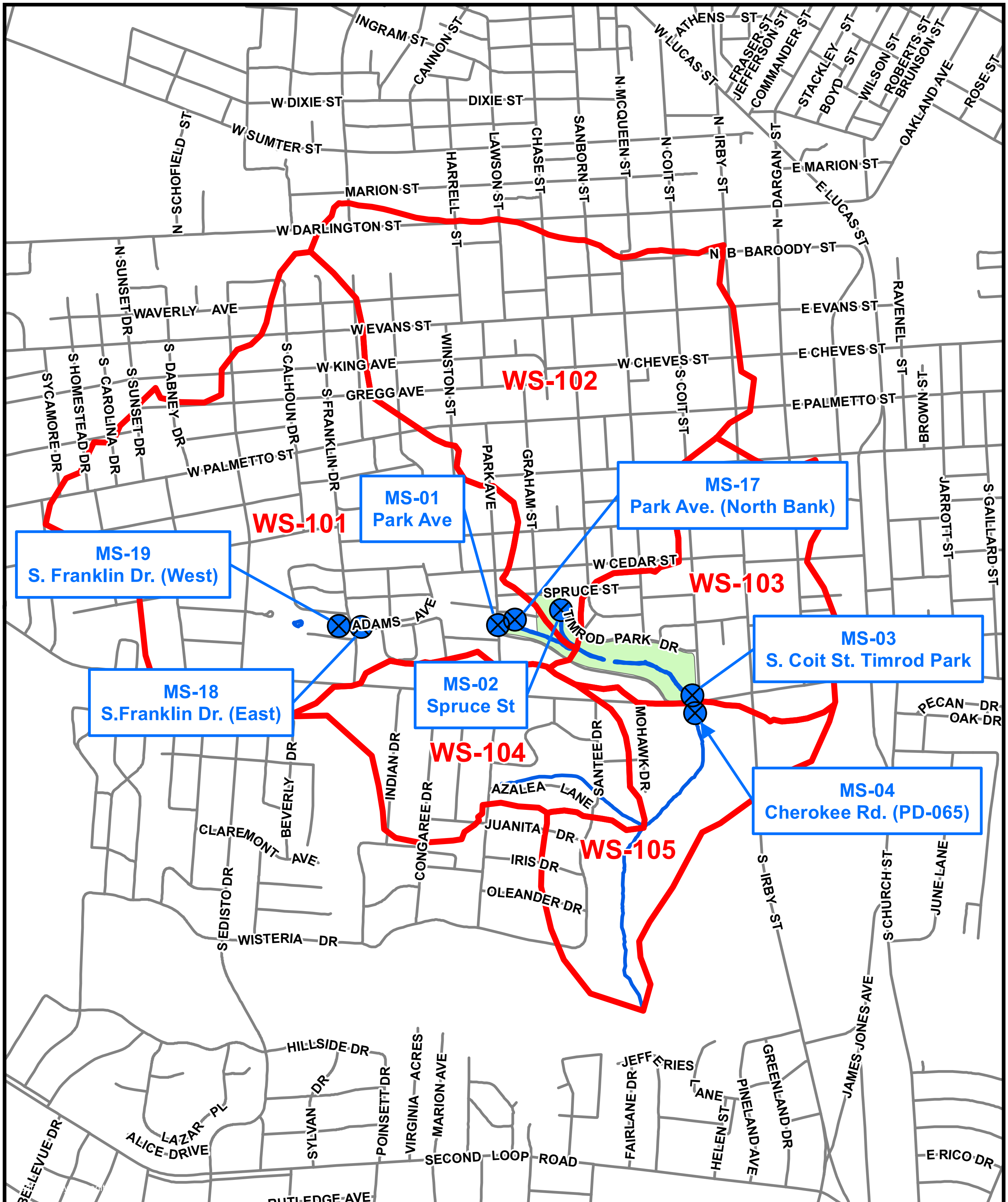
1 inch = 2,000 feet

0 1,000 2,000 4,000 Feet

City of Florence

Future Land Use Location Map

APPENDIX G. WATER QUALITY MONITORING STATION LOCATION



Date: January 21, 2019
Author: LCS

AECOM

South Carolina State Plane, NAD 83
Zone 3900, International Feet

1 inch = 0.4 miles

0 0.2 0.4 0.8 Miles

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GULLY BRANCH WATERSHED
Monitoring Stations

AECOM
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APPENDIX H. BEST PRACTICES FOR FECAL COLIFORM

CITY OF FLORENCE
GULLY BRANCH 319 GRANT
BEST MANAGEMENT PRACTICES FOR FECAL COLIFORM/E.COLI REMOVAL

Best Management Practice	Reference	Removal Efficiency (Percent)									City Property (Acres)	Required Drainage Area (Acres)	Required Surface Area (% Drainage Area)	Total Load	Final Load
		Bacteria			Fecal Coliform			E. Coli							
		No. Studies	Median	Range	*No. Studies*	Mean	Range	*No. Studies*	Mean	Range					
Detention (Dry) Pond	1	*2*	**88**	**78 – 97**								Min. 10	1 to 3%		
	2	*2*	**35**	**25 –50**											
	3				*13*	**38***		*3*	**79***						
Retention (Wet) Pond	1	*11*	**70**	**(-6) – 99**								Min. 25	1 to 3%		
	2	*46*	**70**	**50 – 95**											
	3				*11*	**74***		*4*	**93***						
Constructed Wetlands	1	*3*	**78**	**55 – 97**								Min. 25	3 to 5%		
	2	*3*	**60**	**40 – 85**											
	3				*5*	**67***		*3*	**21***						
Bioretention	2	*N/A***	**40**	**25 – 70**								Max. 5	5 to 10%		
	3							*3*	**58***						
Infiltration	2	*N/A***	**40**	**25 – 70**								Max. 10 (Basin) Max. 5 (Trench)	0 to 5%		
Filtering	1	*6*	**37**	**(-85) – 83**								Max. 2 to 5 (Sand Filter)	0 to 5% (Sand Filter)		
	2	*20*	**40**	**25 – 70**											
Open Channel	1	*3*	**(-25)**	**(-100) – (-25)**								Max. 5			
Grass Filter Strip	3				*2*	**6***						Max. 1 per 580 ft. length	5 to 15%		
Swales	2	*4*	**(-25)**	**(-65) – 25**								Max. 5	5 to 15%		
	3				*10*	**(-25)***		*5*	**(-65)***						
Enhanced Dry Swales	4			**10 – 60**								Max. 5	5 to 15%		
Proprietary															
Bacterra	5						**95 – 99**			**95 – 99**					
Vortechs	6			**39 – 86**											

* Percent Reduction based on Inlet Geomean and Outlet Geomean.

** Assumed based on results for filtering practices.

References:

1. National Pollutant Removal Performance Database, Version 3, Sept. 2007, Center for Watershed Protection.
2. Urban Stormwater Retrofit Practices Appendices, Center for Watershed Protection, Manual 3, Appendix D, www.cwp.org.
3. Categorical Summary of BMP Performance for Stormwater Bacteria Data Contained in the International Stormwater BMP Database, Water Environment Research Foundation, July 18, 2012, Geosyntec Consultants, Inc. and Wright Water Engineers, Inc.
4. South Carolina DHEC Storm Water Management BMP Handbook.
5. Filterra Bioretention Systems (March 2013), http://filterra.com/index.php/product/bacterra/
6. "Effectiveness of Best Management Practices for Bacteria Removal," June 2011, Emmons & Olivier Resources, Inc.

APPENDIX I. FIELD SAMPLING EQUIPMENT CHECKLIST

SAMPLING EVENT # _______

FIELD SAMPLING EQUIPMENT CHECKLIST

City of Florence Gully Branch Watershed Plan
Gully Branch Sampling Plan

Sampling Equipment:

- ☐ Two 500 ml sample bottles (glass or polyethylene) per sampling location
  - ☐ Sterilized
  - ☐ Pre-Labeled
- ☐ Extendable Swing Sampler in working order
- ☐ Cooler
- ☐ Ice sufficient to maintain preservation temperature of 4°C or less during sampling and transport

Documentation/Recordkeeping Supplies:

- ☐ Clipboard
- ☐ Waterproof pen
- ☐ Water Quality Sampling Field Data Sheet
- ☐ Chain of Custody Form

WQMP Sampling Locations:

- ☐ Monitoring Station Location Map
- ☐ Monitoring Station Location Descriptions

Safety Equipment:

- ☐ Latex Gloves
- ☐ High-visibility safety vest
- ☐ Traffic cones
- ☐ Rain gear as appropriate
- ☐ Hand sanitizer (optional)

Comments/Notes:
____
____

Sampling Crew Member: ___________________________________

Sampling Crew Team Leader: ___________________________________ Date: ___________

APPENDIX J. CHAIN OF CUSTODY FORM

City of Florence Gully Branch Watershed Plan

Gully Branch Sampling Plan

Chain of Custody (COC) Form for Lab

Chain of Custody No.	Project No./Title	Analyses	Project Point of Contact	Phone Number
			Scope of Work Document(s):	

Samples Preserved?	Yes*	No			
Date	Time	Relinquished by	Date	Time	Received by
Date	Time	Relinquished by	Date	Time	Received by
Date	Time	Relinquished by	Date	Time	Received by

Date	Time	Sample Identification	# of Containers	Destination Lab	Comments

* If yes, then note preservation in Comments section.

Date	Time	Sample Identification	# of Containers	Destination Lab	Comments

APPENDIX K. WATER QUALITY SAMPLING FIELD DATA SHEET

SAMPLING EVENT # _______

PHASE I - WATER QUALITY SAMPLING
FIELD DATA SHEET

City of Florence Gully Branch Watershed Plan
Gully Branch Sampling Plan

Form must be filled out and retained at the Public Works Facility as part of the monitoring record. Fill out the following table completely.

Date of Sample Set: ________________ Time of Initial grab sample: ______________

Date of most recent measurable precipitation: ___________ (use end of rainfall date) Greater than 72 hours YES / NO

	Monitoring Station ID				
	WS01	WS02	WS03	WS04	WS05
Time of Sample					
Two 500-milliliter samples collected for each sample set	Y / N	Y / N	Y / N	Y / N	Y / N
Bottles labeled with date and time	Y / N	Y / N	Y / N	Y / N	Y / N
Bottles labeled with sample location	Y / N	Y / N	Y / N	Y / N	Y / N
Samples put on ice after samples collected	Y / N	Y / N	Y / N	Y / N	Y / N
Samples immediately transferred to Lab?	Y / N		Time Delivered to Lab: ______		
COC form filled out and signed by field collector and Lab staff?	Y / N				

Comments/General Field observations: ____

____

Field Monitor Name: ______________________________ Field Monitor Signature: ____________________________ Date: ___________