URS

Civil Engineering Services

CHARLESTON

CITY OF FLORENCE GULLY BRANCH WATERSHED PLAN

City of Florence South Carolina

CITY OF FLORENCE
GULLY BRANCH WATERSHED PLAN

PREPARED FOR

CITY OF FLORENCE
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FLORENCE, SOUTH CAROLINA 29501

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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, as part of that establishment, the TMDL did not specifically define causes of impairment or potential solutions to the pollution problem. This watershed plan, funded through an EPA 319 Grant by SCDHEC, picks up where the TMDL ended and establishes 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. 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.

Section 1

BACKGROUND/PLANNING PROCESS

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, SCDHEC developed a Total Maximum Daily Load (TMDL) for fecal coliform bacteria based on data collected at SCDHEC's Water Quality Monitoring Station 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. The potential sources of fecal coliform 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 NPDES General Permit for Small MS4s (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 a 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 criteria for fecal coliform and *E. coli* for primary contact recreational uses in Gully Branch.

1.1 CITY OF FLORENCE MS4 STORMWATER MANAGEMENT PROGRAM

As part of its 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 F, Gully Branch – Outfalls. Over the past 15 years, 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.

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.

Over the last five years, the City has made 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 to govern land use and development. The watershed encompasses one of the oldest development corridors in the City, and thus, the need for stormwater retrofitting and upgrades within the watershed are vitally important.

1.2 COOPERATING ORGANIZATIONS/STAKEHOLDERS

Stakeholders will play an important role in the overall development and implementation of the Gully Branch Watershed Plan. Stakeholders will provide input, local knowledge and recommendations for how the watershed plan should be utilized within certain neighborhoods and portions of the City to both 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 past and current projects, including installation of pet waste removal stations and bioretention areas within the Timrod Park recreation area. Plans are currently in development for stream restoration in Timrod Park.

Stakeholders with which the City has developed a working relationship include:

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

While, in many instances, agriculture is identified as a key contributor of bacteria loading within watersheds, the urban nature of this watershed, along with the perceived absence of agricultural activities, precludes the need for coordination with the Natural Resource Conservation Service (NRCS) or the local conservation district.

1.3 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. They have been intimately involved with assessment and project implementation within the watershed. Staff has been involved with performing a sanitary sewer assessment within the watershed, and the City has provided staff time for oversight and construction of bioretention areas within the watershed limits.

Section 2

WATERSHED CHARACTERIZATION

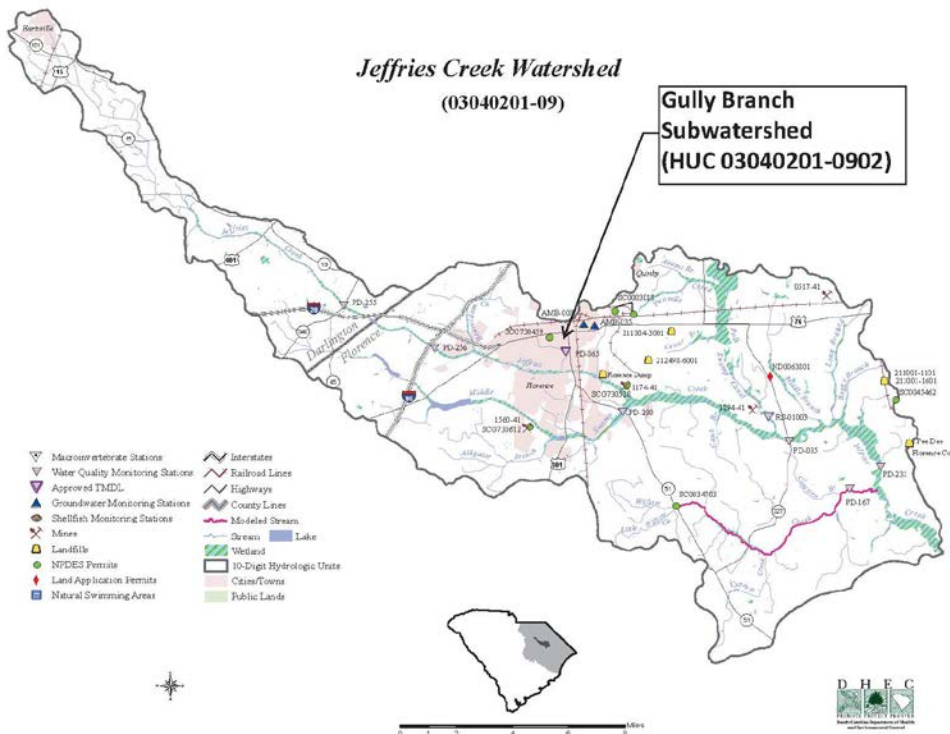
This section describes the natural characteristics and land usage of the Gully Branch watershed.

2.1 PHYSICAL AND NATURAL FEATURES

2.1.1 Geography

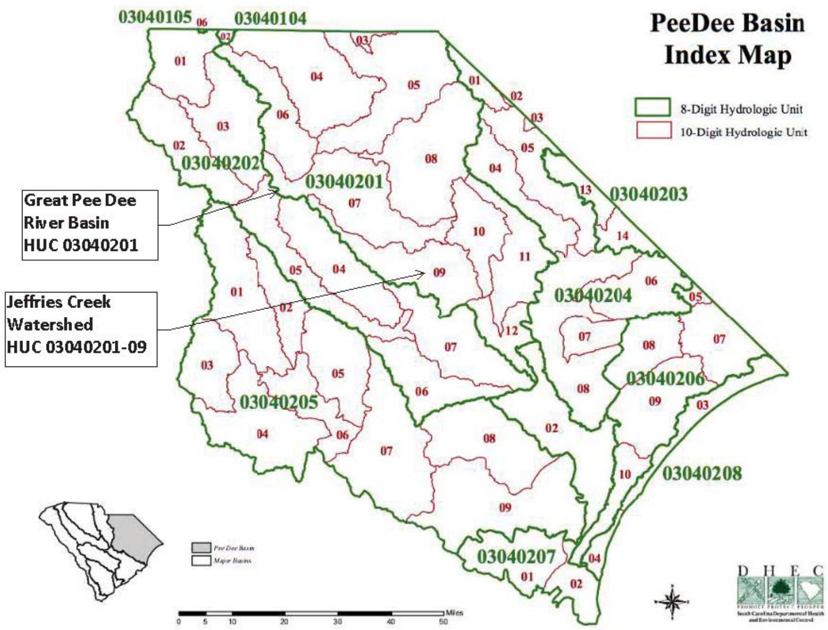
The Gully Branch watershed (HUC 03040201-0902) is a 2.1 square mile watershed located near the northern boundary of the Jeffries Creek watershed in the City of Florence (Figure 2-1).

Figure 2-1: Jeffries Creek Watershed



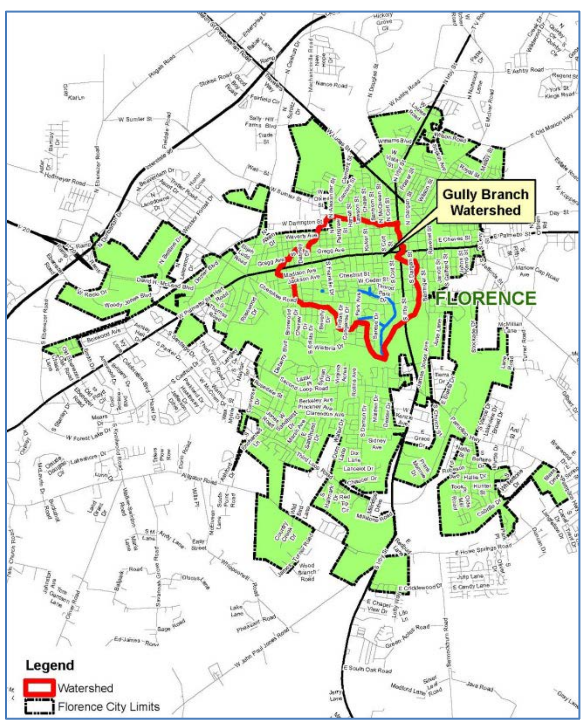
The Jeffries Creek watershed (HUC 03040201-09) is one of 22 watersheds of the Great Pee Dee River Basin (HUC 03040201), which in turn is part of the Pee Dee River Basin of northeastern South Carolina (Figure 2-2).

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 A.

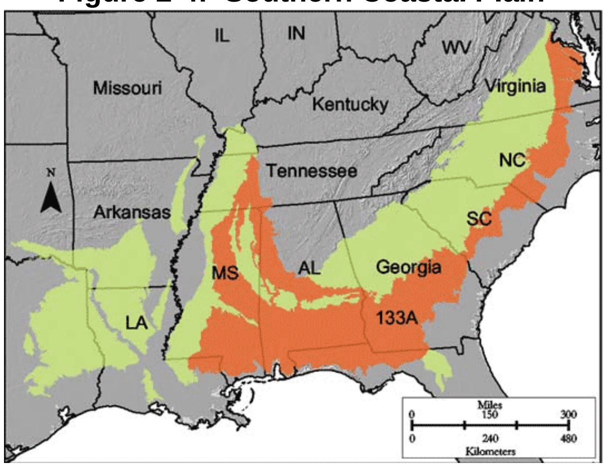
Figure 2-3: Gully Branch Watershed



2.1.2 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 below, is bordered on the west and north by the fall line, which marks the western and northern extent of the unconsolidated Coastal Plain sediments. To the east and south of the fall line, rivers and streams draining the Appalachians deposited a thick wedge of silt, sand and gravel as delta deposits in the Atlantic Ocean during the Jurassic and Cretaceous periods. Subsequent uplift of the Coastal Plain and the rise and fall of sea level throughout its geologic history resulted in cycles of erosion and deposition as the area was exposed and submerged numerous times. The Coastal Plain is underlain by layers of sand, unconsolidated clay, silt, gravel and carbonates.

Figure 2-4: Southern Coastal Plain



2.1.3 Climate

Minimum precipitation in the Southern Coastal Plain occurs in autumn. In the eastern part of the area, including South Carolina, the maximum precipitation falls during midsummer, typically occurring as high-intensity, convective thunderstorms; however, moderate-intensity tropical storms can produce large amounts of rainfall during the winter.

Rainfall data compiled from National Weather Service Stations in the Great Pee Dee River area indicates a normal yearly rainfall of approximately 49 inches. The highest seasonal rainfall occurs in the summer, averaging approximately 16 inches of rain. The average annual daily temperature is 63°F. Seasonal mean temperatures range from approximately 46°F in winter to 79°F in summer.

2.1.4 Hydrology

Gully Branch is classified as a freshwater (FW) stream under the South Carolina water quality standards regulations, suitable for recreation, fishing, drinking water supply use, and industrial and agricultural uses. Most of the spring-fed flow in Gully Branch is routed through underground pipes; however, the stream flows through a natural streambed beginning at the Timrod Park recreation area.

2.1.5 Soils

The predominant soils within the Gully Branch Watershed are of the Coxville-Norfolk association (93%), as shown in Appendix B, Gully Branch Watershed Soils Map.

The Coxville series consists of deep, poorly drained, nearly level soils on uplands. Norfolk soils are deep, well-drained soils, with loamy subsoil, nearly level and gently sloping elevated uplands.

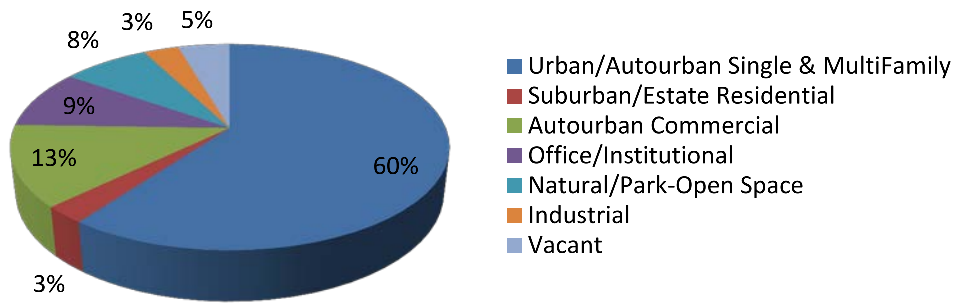
Soil erodibility in the Pee Dee River Basin ranges from 0.10 to 0.28 K value, suggesting that the soil is not highly prone to erosion from stormwater runoff. In general, clay soils have low K values (about 0.05 to 0.15) because the particles are resistant to detachment. Sandy soils, also have low K values (about 0.05 to 0.20) because they have high infiltration rates resulting in low runoff, and although 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. Soil particles in silt soils are easily detached, sediment is easily transported, and silt soils readily crust producing high runoff rates and amounts.

2.2 LAND USE AND POPULATION CHARACTERISTICS

2.2.1 Land Use and Land Cover Data

The existing 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 Autourban Commercial, which includes commercial uses along main corridors, shopping centers and two large medical centers. Office and Institutional land use comprises 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 attached as Appendix C.

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



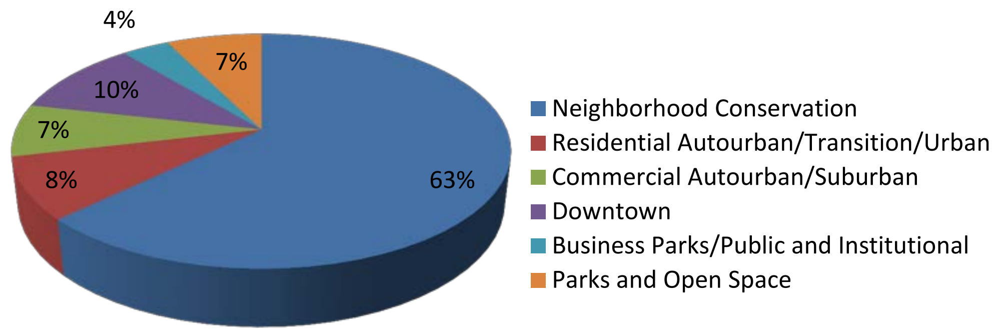
The neighborhoods within the watershed are older, established neighborhoods, and are pedestrian-friendly. The Timrod Park recreation area, churches, restaurants, and other public amenities are within walking distance.

Approximately 12 acres within the watershed are owned by the City. See Appendix D, City Owned Property Location Map.

2.2.2 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 of Florence Comprehensive Plan, updated in 2010, 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 (Autourban, 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 E, Future Land Use Location Map, shows the proposed land use areas based on the updated Comprehensive Plan.

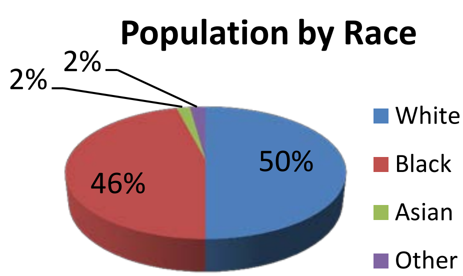
Figure 2-6: Gully Branch Future Land Use (2010 Comprehensive Plan)

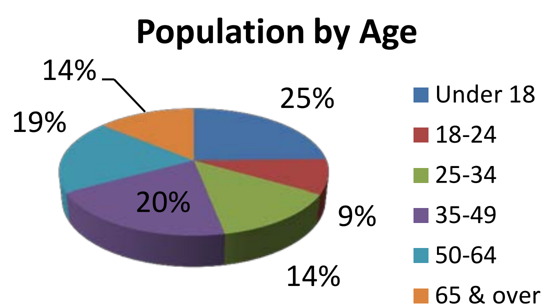


2.2.3 Demographics

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: City of Florence Demographics





2.3 WATERBODY AND WATERSHED CONDITIONS

2.3.1 Water Quality Standards

Gully Branch is designated a freshwater (FW) stream as defined under 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 freshwaters 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 freshwaters as an indicator of potential health risks for individuals exposed to recreational waters. Until recently, 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 freshwater recreational standards in the State of 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. Most strains of *E. coli* are harmless, and are an important part of a healthy intestinal tract. However, *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 fresh waters.

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 126/100 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 349/100 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 water quality standards, and for which 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 water quality standards. A TMDL for fecal coliform has been established for the Gully Branch watershed.

2.3.2 Water Quality Monitoring Station

The Gully Branch watershed is monitored by SCDHEC at Water Quality Monitoring Station (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 Water Quality Standard (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.

2.3.3 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.

2.3.4 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. Future TMDLs will be calculated based on *E. coli* data. 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* water quality standards in freshwaters, 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, (Figure 2-8). *E. coli* percent reduction goals are assumed to be the same as fecal coliform percent reduction goals due to the lack of sampling data for *E. coli*.

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

$$Ratio = \frac{349}{400} = 0.8725$$

$$\frac{E.coli\ MPN}{100\ mL} = 0.8725\ x\ \left(\frac{Fecal\ Coliform\ cfu}{100\ mL}\right)$$

2.4 POLLUTANT SOURCES

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

2.4.1 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) 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 urbanized area.

Stormwater runoff from MS4 areas can contain high fecal coliform and *E. coli* bacteria concentrations due to leaking sewers, sanitary sewer overflows (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.

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.

2.4.2 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 adjacent groundwater. The contaminated groundwater may reach the water table that serves as the base flow for Gully Branch. Although bacteria contamination from the sanitary sewer is not visible, and specific problem areas have not been identified, the potential for impairment of Gully Branch due to leaking sewers must be addressed. 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.

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 have potential 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.

Because of SSOs and leaking sewers, human sources likely play a major role in bacteria loadings in the Gully Branch watershed. It is also likely that domestic pets are an additional source of bacteria in this urban environment.

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.

Section 3

WATERSHED ANALYSIS

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

3.1 WATERSHED PLAN GOALS

The Gully Branch watershed is currently threatened by impairment from fecal coliform. Fecal coliform are non-disease causing bacteria commonly used as an indicator organism in water quality monitoring. The number of fecal coliform bacteria present in a stream or lake is an indicator of the amount of disease-causing organisms likely present. The State of South Carolina has established Water Quality Standards (WQS), which include maximum levels of fecal coliform bacteria. The goals of the Gully Branch Watershed Plan are to protect the natural resources within the Gully Branch watershed by identifying and mitigating stormwater pollution that could compromise the water quality of Gully Branch and impact the community's use and enjoyment of the area, including the Timrod Park recreation area located along its banks.

The City's Public Works Department will utilize the results from the Plan Development project to identify the locations and types of Best Management Practices (BMPs) and other projects that will be effective in reducing bacteria loading in Gully Branch.

The goals of the Watershed Plan are to protect and restore the natural resources of Gully Branch, and to educate the public about watersheds and stormwater treatment. Successful management of the watershed will increase the level of enjoyment and livability for residents and visitors to the area. The project will also have positive impacts downstream in the Jeffries Creek watershed.

Timrod Park recreation area is an ideal location for educating the public about watersheds and stormwater treatment through public outreach.

3.2 DETAILED WATERSHED ASSESSMENT

The headwaters of the Gully Branch watershed consist of an extensive network of previously piped stream channels and drainage networks. Since these headwater areas are piped, fecal coliform sources in these areas are likely limited to stormwater runoff associated with pet waste, illicit connections to the stormwater system and sanitary sewer SSOs.

This piped system becomes daylighted 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; one is a culvert inlet along Spruce Street between Graham Street and Timrod Park Drive, the second is the headwaters of Gully Branch, which originate approximately 600 feet upstream of the park and enters the park under Park Ave. Runoff and base stream flow through the park discharges 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. The flow and velocity of stormwater runoff was determined for each of the drainage basins.

Figure 3-1: Gully Branch Drainage Basins

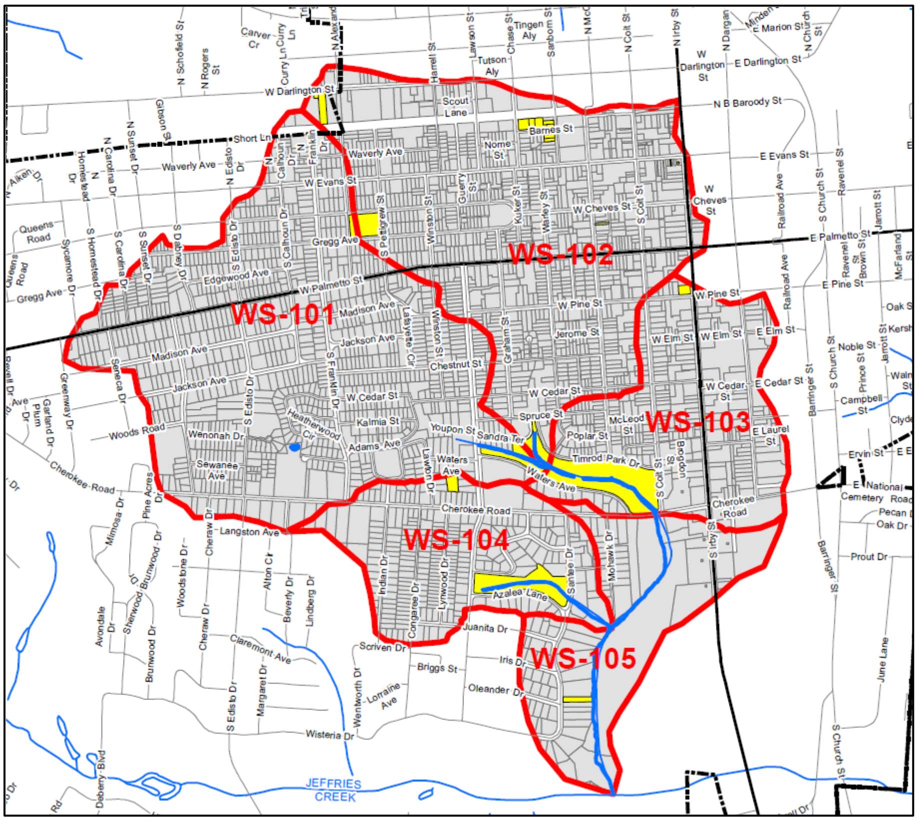


Table 3-1: Drainage Basin Areas

Drainage Area	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**	**100.0%**

Appendix G shows the location of five proposed water monitoring stations.

3.2.1 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. See Appendix F, Gully Branch – Outfalls. Dry weather screenings are performed a minimum of 72 hours after the most recent rainfall event. The condition of all inlets and outlets was also assessed.

During the course of outfall investigations associated with the NPDES Phase II MS4 permit requirements, the City has identified and eliminated two illicit discharges since 2009. Neither of these discharges was identified as being potential contributors of fecal coliform or *E. coli*, and was eliminated upon discovery. Subsequent dry weather screening activities have not identified any illicit discharges, cross connections or illegal dumping. However, it is acknowledged that there is a potential for sanitary sewer leakage due to the age of the infrastructure in this watershed. The City has upgraded portions of the system, and will continue to maintain and improve the system as part of on-going system upgrades. This should somewhat mitigate the potential for leakage in the future.

3.2.2 Drainage Basin Land Use

WS-101, with 462 acres, comprises 34% of the Gully Branch watershed and is the largest of the five (5) sub-watershed areas. The area is mostly Auto-Urban. Additionally, several public institutions are located within the area.

WS-102 is 397 acres, and includes a mixture of land use types, including Auto-Urban, Office and Industrial areas.

WS-103 is 187 acres, and contains a mixture of land use. The majority of Timrod Park is in this sub-watershed.

WS-104 is 153 acres, and is mostly Auto-Urban, with Park/Open Space surrounding an unnamed stream in Lucas Park.

WS-105 is 145 acres with land use nearly equally balanced between Urban and Natural/Parks/Open Space.

3.2.3 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.

A hydraulic analysis was performed for the watershed to determine peak runoff from each of the sub-watersheds. 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.

Figure 3-2: Existing and Future Flow to Outfall at Jeffries Creek

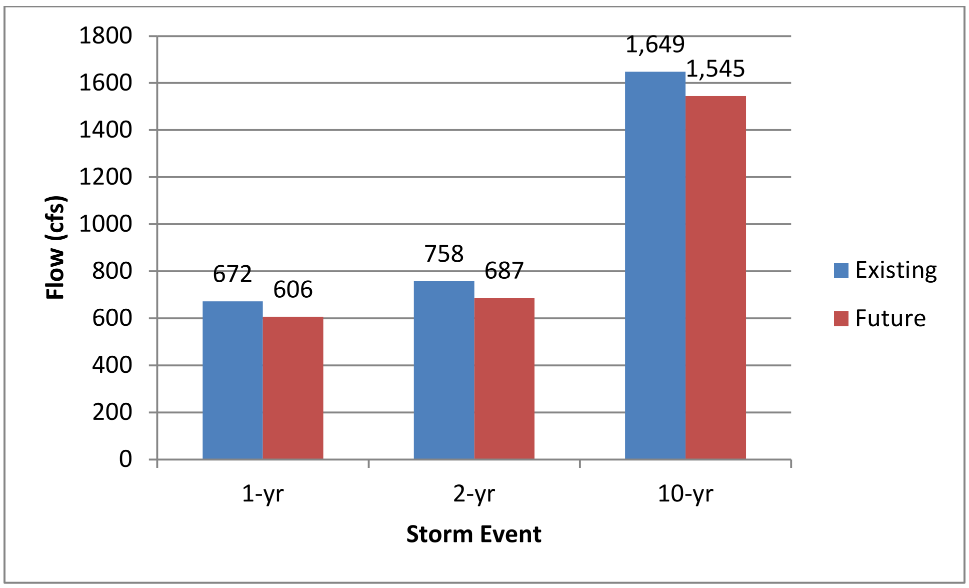


Table 3-2: Storm flow analysis

Station	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

3.2.4 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 is expected at WS03 – Spruce Avenue, in Basin WS-102, which has mixed land use.

Table 3-3: Theoretical Pollutant Loading

Station	Loading Rank	Average Loading
WS01 - Timrod Park	3	High
WS02 - Timrod Park	2	High
WS03 - Spruce Avenue	5	Very Low
WS04 - Waters Avenue	1	Very High
WS05 - Azalea Drive	4	Low

3.3 WATER QUALITY ANALYSIS

3.3.1 TMDL Findings (SCDHEC Technical Report Number: 029-05)

The TMDL for Gully Branch (Gulley Branch), SCDHEC Water Quality Monitoring (WQM) station PD-065, was published in September 2005 establishing the pollutant load reduction goals for the Gully Branch watershed. According to the report, the watershed of WQM station PD-065 contains 1,055 acres within the City of Florence. The estimated median flow rate is 1.5 cfs at this WQM station, and ranges from 0.3 to 4.8 cfs. Approximately 82% of the total area containing houses, businesses, and ancillary development, another 17% being forest and pastures and row crops covering less than 1% combined.

For the period examined (1994 to 2001) there were numerous days in which fecal coliform concentrations exceeded the WQS. A summary of these monitoring results can be seen in

Table 3-4. The authors of the TMDL determined that there is no apparent relationship between rainfall and fecal coliform exceedances.

Table 3-4: Fecal Coliform Bacteria Observed from 1998 through 2002. (Courtesy SCDHEC Technical Report Number: 029-05)

Station	Total Number of Samples	Maximum Concentration cfu/100 ml	Total Number of Samples > 400 cfu/100 ml	Percentage of Samples > 400 cfu/100 ml
PD-065	33	12,000	24	73%

Water samples collected at WQM station PD-065 were collected from 1998 through 2000. Table 3-4 shows that 73% of the water samples collected at PD-065 were above the maximum daily fecal coliform WQS of 400 cfu/100 ml.

A requirement of the TMDL is to identify potential sources of pollutant loading within the watershed. Two non-continuous point sources were identified within the Gully Branch watershed; 1) the City of Florence MS4 and 2) the City of Florence WWTP (SC0045462) sanitary sewer network. The WWTP reported 32 SSOs between March 2, 1999 and April 6, 2005, with five of SSOs reportedly affecting a waterbody. The largest SSO to reach a waterbody was 450,000 gallons on December 28, 2004. Authors of the TMDL state that SSOs or leaking sewers are contributing to the fecal coliform exceedances.

Nonpoint sources are another major contributor of fecal coliform loading within the Gully Branch watershed. The deer density within the watershed ranges between 15 and 30 per acre. The PD-065 watershed contains no known cattle, and there are no AFOs or AFO land application areas. This watershed contains 43 OSWD systems with an average density of four per 100 acres, which could be significant. Nonpoint fecal coliform sources associated with MS4s are expected and include human sources of fecal coliform, including leaking sewers and SSOs, as well as domesticated pets.

3.3.2 City of Florence Fecal Coliform Sampling

As noted in the TMDL for Gully Branch the City has experienced fecal coliform loading from SSOs and leaking sewers in the past. Also, the City continues actively working to identify and repair these discharges when they occur. Due to changes in the watershed since 2005, the 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, Monitoring Station Location Map. Event Mean Concentration (EMC) values were then calculated as the average of these four (4) sampling results. The results of these monitoring efforts are summarized in Table 3-5. EMC results at four of the five monitoring locations exceed the SCDHEC standard of 400 cfu/100mL.

Table 3-5: City of Florence Fecal Coliform Sampling Results (#/100mL)

Date of Sample	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**

Using these EMC results, the City was then able to develop annual pollutant load estimates for fecal coliform within the Gully Branch watershed. The annual load is a function of land use, rainfall and EMC concentration. The estimated annual load for fecal coliform is listed for each drainage basin within the Gully Branch watershed in Table 3-6, 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/100mL. These annual loads are used to develop the implementation plan, contained herein, 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 3-6: Estimated Annual Pollutant Loads

Drainage Basin	Land Area (acres)	EMC	Annual Load (lb/ac/yr)	Annual Load (lb/yr)	Reduction Required to Meet SCDHEC Standard (lb/yr)	Reduction Required to Meet SCDHEC Standard (%)
WS-101	463.60	2408	8.76E+10	4.06E+13	3.39E+13	83%
WS-102	396.37	2675	1.00E+11	3.97E+13	3.38E+13	85%
WS-103	187.44	1	3.75E+07	7.02E+09	Meets Standard	Meets Standard
WS-104	153.13	7255	2.61E+11	4.00E+13	3.78E+13	94%
WS-105	145.32	534	1.92E+10	2.79E+12	7.00E+11	25%
Gully Branch Total Estimated Annual Load				**1.23E+14**		

3.4 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 scant 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 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.

2. Barnes Street Complex. This is another property 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.

3. Vacant Property adjacent to Gully Branch. This City-owned property 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. Located in the upper reaches of the Gully Branch underground network, Maple Park 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. Although the contributing drainage area at Maple Park is small, the proximity to the Maple Park Community Center and the attraction of area residents to the ballfields provides an ideal opportunity for promoting education and awareness of stormwater pollution.

5. Lucas Park. Lucas Park 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 are potential BMP sites.

6. Timrod Park. Timrod Park 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.

Section 4

WATERSHED MANAGEMENT STRATEGIES

4.1 BEST MANAGEMENT PRACTICES (BMPs) 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.

4.1.1 Detention (Dry) Pond:

Description: Dry Detention Ponds 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

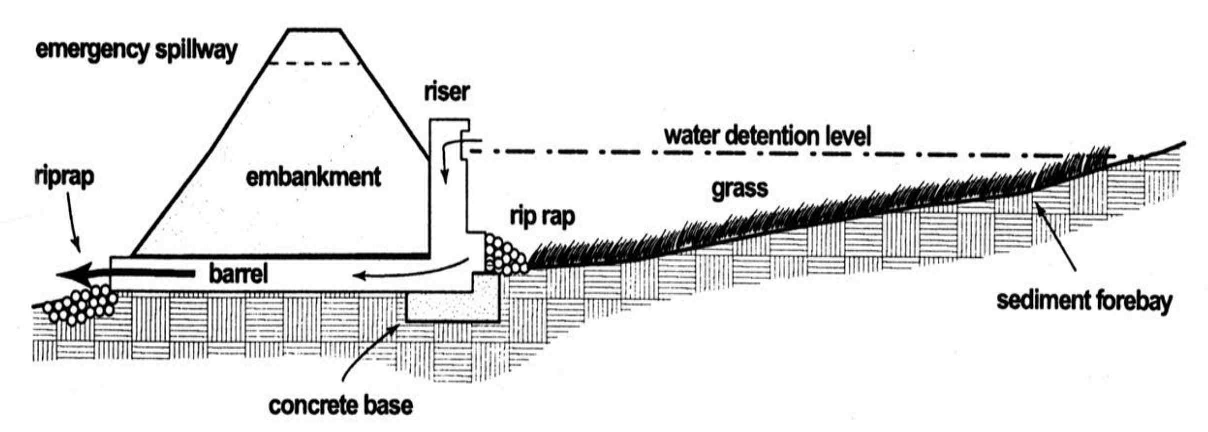


Figure 4-2: Detention (Dry) Pond

4.1.2 Retention (Wet) Pond:

Description: Retention (Wet) ponds 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 Profile

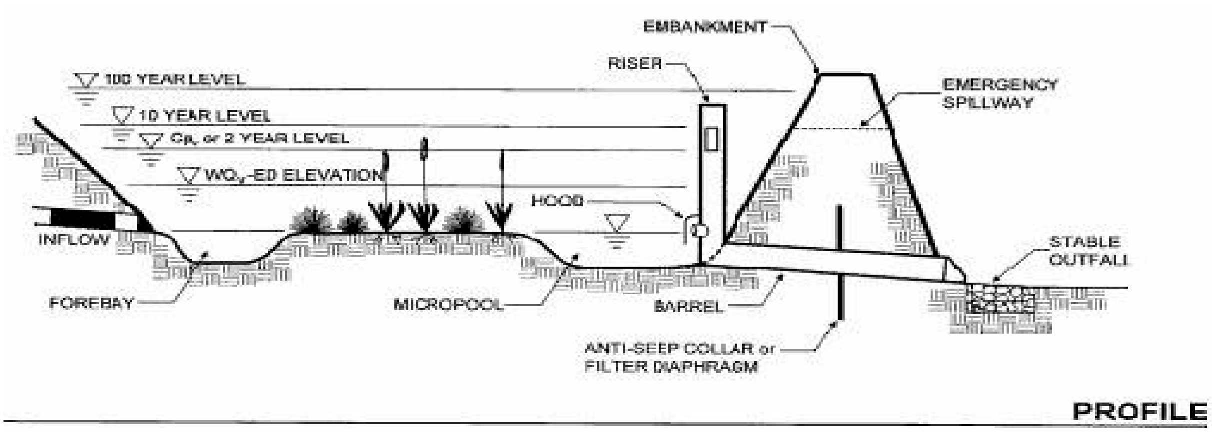


Figure 4-4: Retention (Wet) Pond

4.1.3 Constructed Wetlands:

Description: Constructed wetlands 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

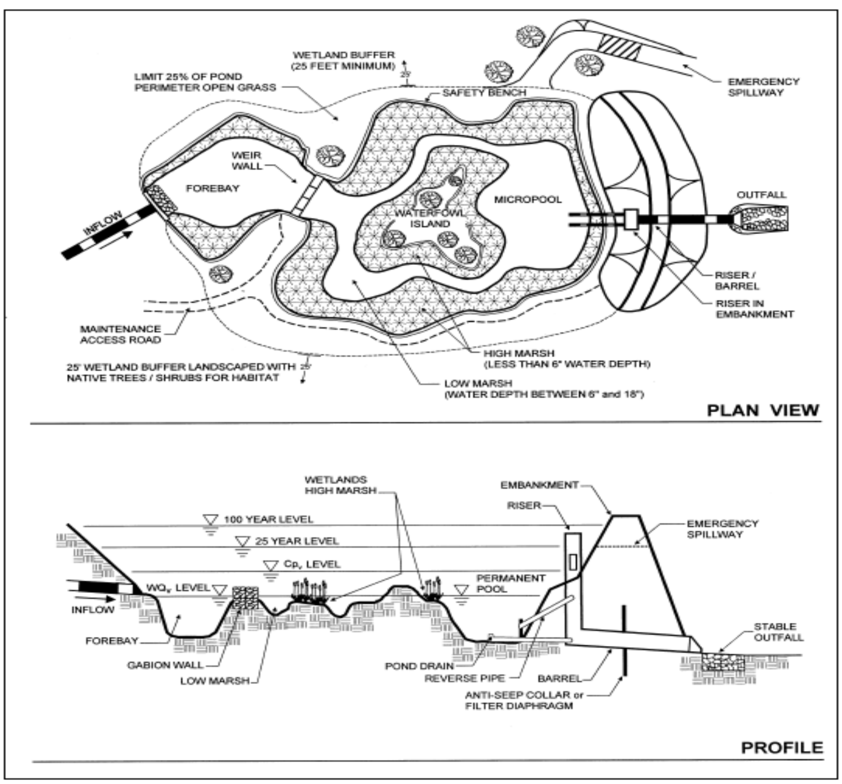


Figure 4-6: Constructed Wetland

4.1.4 Bioretention:

Description: Bioretention systems 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 helps 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. Data from monitoring studies is limited; however, 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.

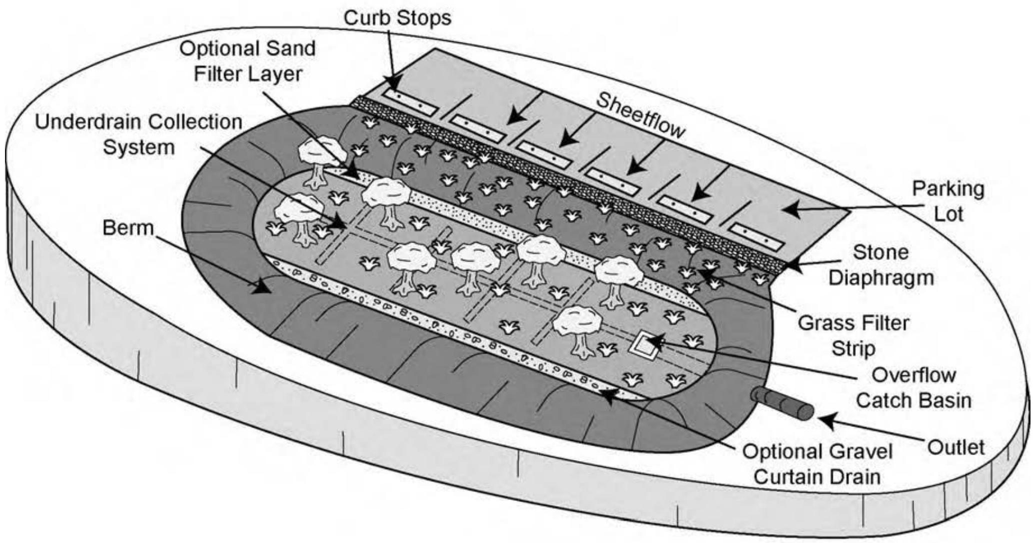
Disadvantages:

- 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



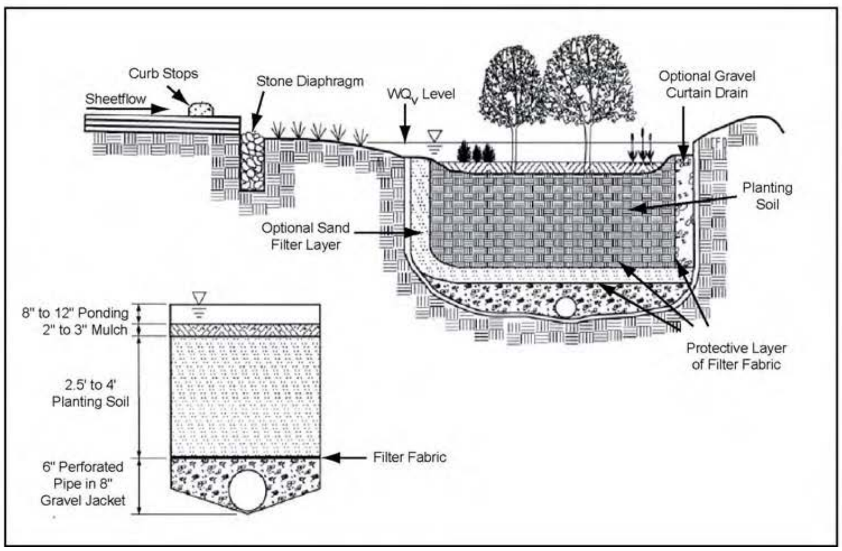


Figure 4-8: Bioretention in a Parking Lot Turnaround

4.1.5 Infiltration:

Description: Infiltration systems 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.

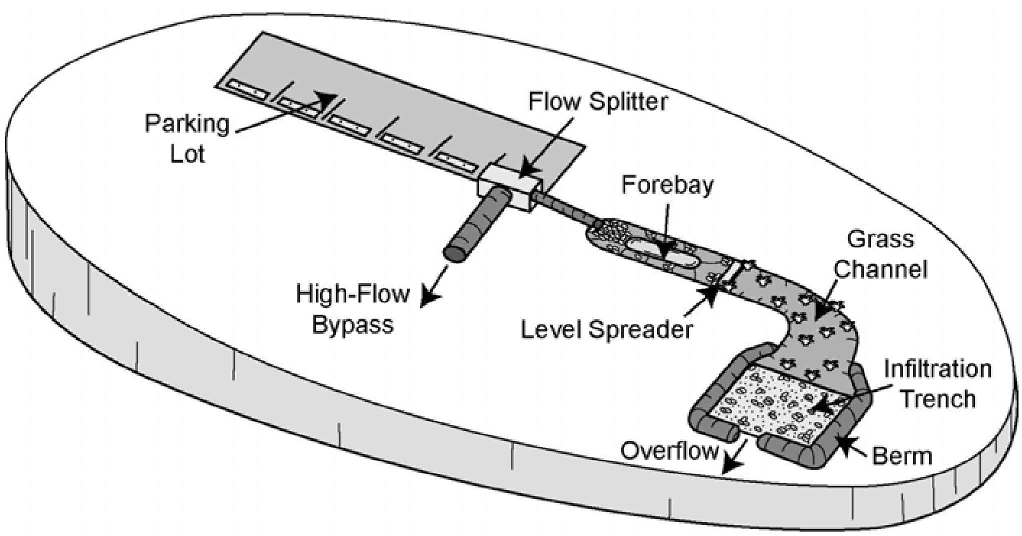
Disadvantages:

- 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: Total rehabilitation.

Figure 4-9: Example Infiltration Design



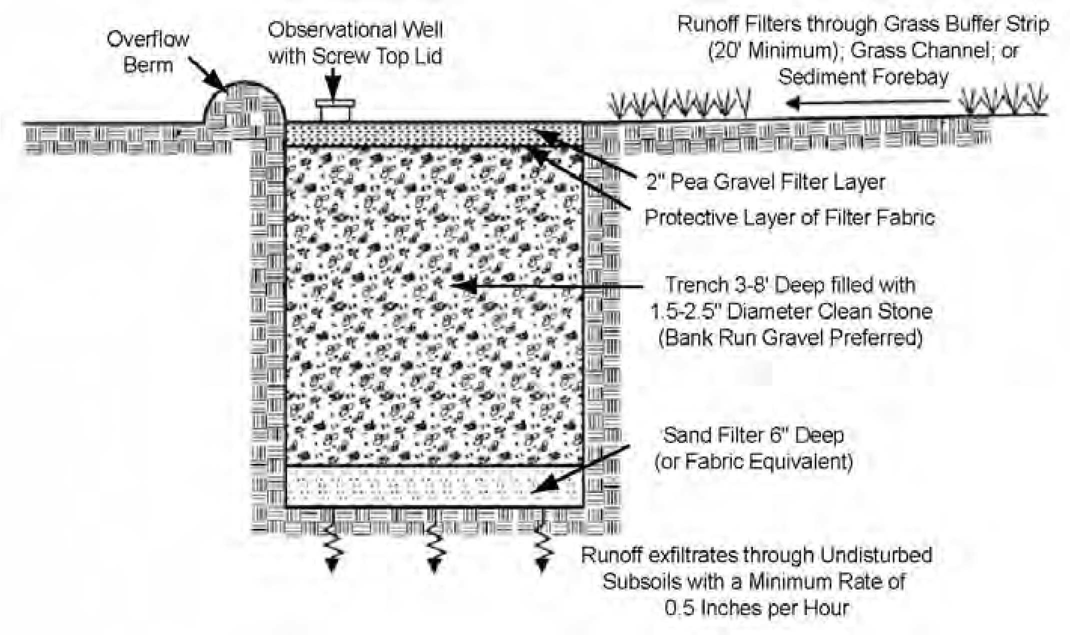


Figure 4-10: Infiltration Trench

4.1.6 Filtering:

Description: Filtration practices 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

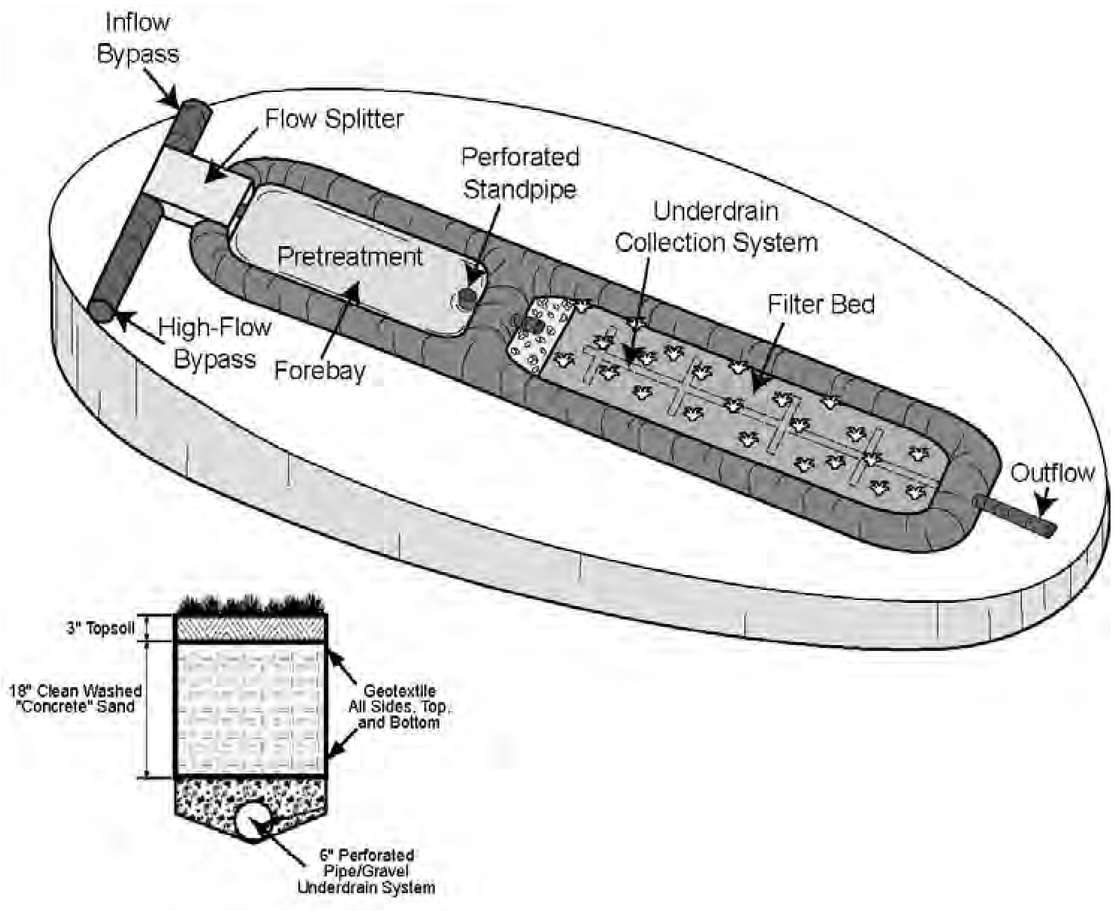


Figure 4-12: Surface Sand Filter

Figure 4-13: Perimeter Sand Filter

4.1.7 Open Channel:

Description: Open channels 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 median removal efficiency of -25%.

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

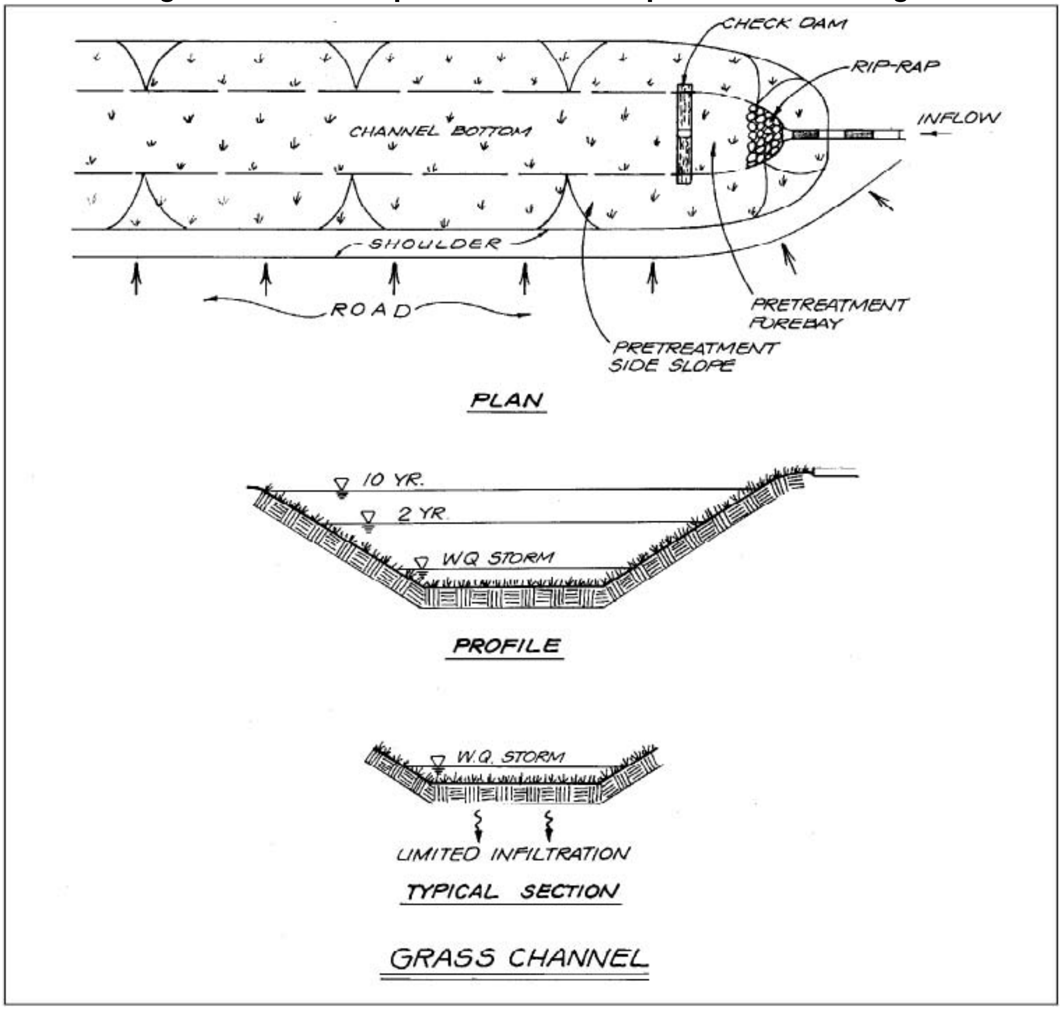


Figure 4-15: Grass-Lined Open Channel

4.1.8 Grass Filter Strip:

Description: Grass filter strips 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, replacing with alternative species if required.

Figure 4-16: Example Grass Filter Strip Design

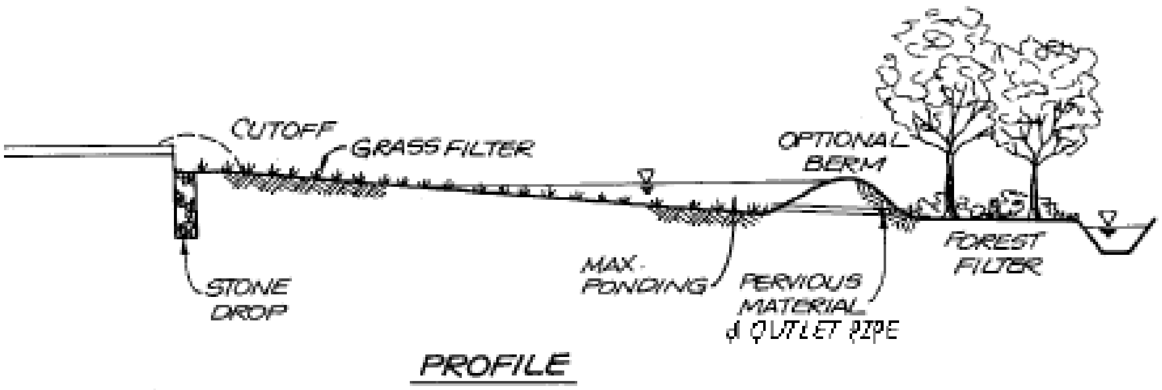


Figure 4-17: Example Grass Filter Pretreatment for an Infiltration Trench

4.1.9 Swales:

Description: Swales 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

4.1.10 Enhanced Dry Swales:

Description: Enhanced dry swales 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

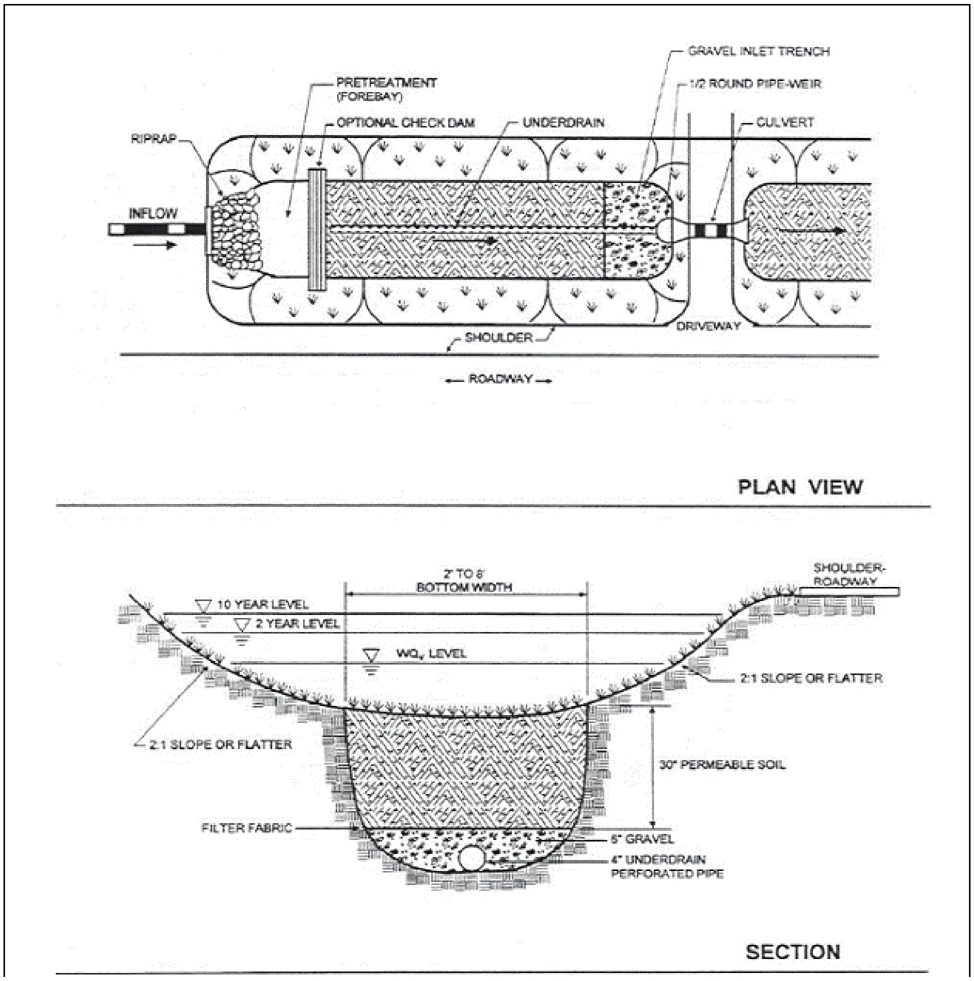


Figure 4-20: Enhanced Dry Swale

4.1.11 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.

4.1.12 Tree Planter Boxes:

Description: Tree planter boxes or tree box filters 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 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

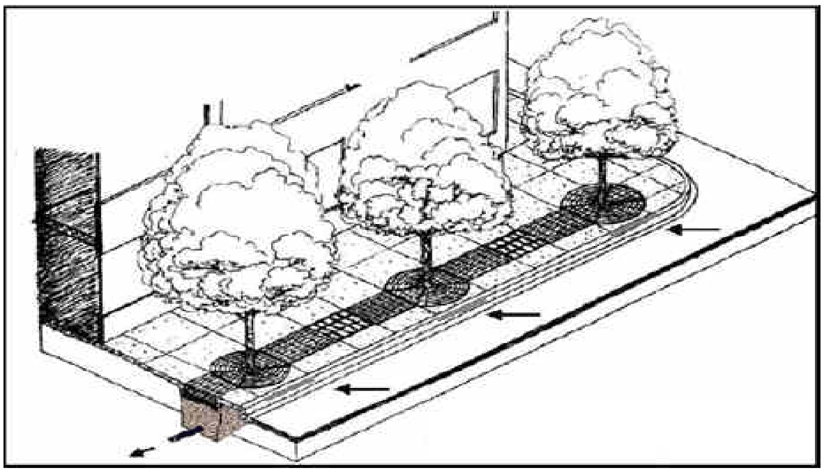


Figure 4-22: Tree Planter Box

4.2 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 takes into account numerous factors, including size of the drainage area, and the surface area required for the BMP. Appendix I 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.

4.3 BETTER SITE DESIGN / 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. However, the City of Florence 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.

4.4 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.

4.5 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 http://www.clemson.edu/public/carolinaclear/consortiums/flodar_home/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.

Section 5

PROPOSED IMPLEMENTATION PLAN

5.1 RECOMMENDED IMPLEMENTATION PROJECTS

The Gully Branch Watershed Plan is designed to protect the natural resources within the Gully Branch watershed from fecal coliform impairment by identifying and mitigating stormwater pollution that could compromise the water quality of Gully Branch. Through preliminary fieldwork, the City has identified three sites for construction of BMPs designed to reduce the levels of fecal coliform and *E. coli* in Gully Branch. Educational kiosks with interpretive signs highlighting the features of the BMP will be installed at each location.

1. Timrod Park.

   a. Infiltration Trenches. Two (2) sites have been identified for the installation of infiltration trenches (see Appendix H, Exhibit A). Infiltration trenches capture and temporarily store stormwater runoff, allowing infiltration into the underlying soil and fecal coliform removal. Geoweb pathways upslope of the infiltration trenches will reduce the volume and velocity of stormwater runoff.

   b. Bioretention Areas. Two (2) sites are proposed for bioretention areas (see Appendix H, Exhibit A). Underdrains will drain treated stormwater to Gully Branch. In addition to stormwater infiltration and fecal coliform removal, bioretention areas are planted with selected adapted or native plants that provide evapotranspiration.

c. Stormwater Wetland.
A stormwater wetland is proposed at the confluence of the two branches near the western end of Timrod Park (see Appendix H, Exhibit A). This wetland will provide treatment for most of the stormwater generated in drainage areas WS-101 and WS-102.

d. Tree Planter Boxes. Two (2) locations have been identified for installation of tree boxes. These are catch basins which capture runoff from the parking area and discharge directly to Gully Branch.

e. Proprietary Devices. One (1) location has been identified for installation of proprietary devices.

f. Land Acquisiton. A land parcel currently sits undeveloped upstream of Spruce St. The City will investigate the feasibility of acquiring this parcel. Construction on the parcel includes a constructed wetland and bioretention complex to provide water quality treatment and peak runoff attenuation. At the time of the development of this report, the potential of acquisition and overall cost for this parcel has not been determined. Therefore, this parcel is considered a future project and not included in the pollutant removal capacity of the overall development of the Timrod Park area.

2. Lucas Park.

   a. Bioretention Areas. One site has been identified for the installation of bioretention areas with under drains. (Appendix H, Exhibit B).

   b. Sand Filter. A sand filter is proposed near Camellia Circle to capture and treat stormwater runoff from the street. The project would consist of a sand filter and retaining wall with weepholes constructed to intercept and treat runoff from Camellia Circle into Lucas Park.

   c. Riparian Improvements. Shrubs and other vegetation are proposed to be planted in the sloped areas of the Park off W. Azalea Lane. The vegetation will help prevent erosion and trap sediments and pollutants, including fecal coliform and *E. coli*, from entering the stormwater drains in the Park.

d. Treatment Forebay. A treatment forebay is proposed for the streamflow exiting the underground system on the opposite side of Santee Drive. The existing headwall would be removed, and the streambed excavated and restored up to the right-of-way of Santee Drive, where a new headwall would be constructed. The treatment forebay would be designed to allow sediment from runoff to settle out, and provide additional stormwater treatment form wetland vegetation planted on benches along the streambank. The wetland/forebay would also provide aesthetic and wildlife benefits for the area.

3. Maple Park.

a. Bioretention Area. A bioretention area is proposed for Maple Park (see Appendix H, Exhibit C). 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.

b. Tree Planter Box. Tree boxes are proposed for each of the four street corners at Maple Park (see Appendix H, Exhibit C).

5.2 RECOMMENDED PROJECTS ANALYSIS

Near complete development, mostly residential, within the Gully Branch watershed makes the implementation of large structural stormwater quality BMPs infeasible in many areas. Therefore, city owned properties including parks and public facilities are the strongest candidates for implementation sites. The City of Florence has completed an assessment of all city-owned properties and has selected three primary locations, Maple Park, Timrod Park and Lucas Park, as potential BMP implementation sites. The following sections describe each of these locations along with possible BMPs for implementation.

5.2.1 Timrod Park (WS-101, 102, 103)

Timrod Park is unique in that it lies at the junction of three sub-watersheds, WS-101, WS-102, and WS-103. A significant portion of the overall estimated pollutant load, 65%, comes from these three sub-watersheds. Therefore, implementation projects within Timrod Park are considered high priority. Table 5-1 and Table 5-2 list the eleven BMPs selected for implementation in Timrod Park along with the estimated pollutant load, pollutant removal, and percent load reduction based on the appropriate EMC for WS-101, WS-102, or WS-103 and the contributing drainage area for each BMP. Locations of proposed BMPs are shown in Appendix H, Exhibit A.

Table 5-1 describes BMPs selected for the upper reaches of the park at and above the confluence of Gully Branch's two major tributaries, both of which daylight at the park. Upstream of the park these tributaries are entirely enclosed within the storm sewer network. First, infiltration trenches are proposed along the banks of the western branch where it becomes daylighted near Park Avenue. Infiltration trenches are recommended here to reduce erosion and treat high velocity runoff believed to contribute a significant amount of sediment loading to Gully Branch. Second, improvement of the riparian buffer, along with possible re-daylighting, of a portion of the northern tributary to Gully Branch is proposed. If this were to occur, the streambank would be restored and a grass filter strip, or buffer area, should be included to prevent sediments from entering this new portion of the stream. Finally, a constructed wetland is proposed at the confluence of these two tributaries to treat the entire runoff contribution from WS-101 and WS-102. Though it will require approval from the US Army Corps of Engineers, this is recommended as the most feasible option to actualize significant fecal coliform loading reductions attributed to these watersheds. These three practices alone could reduce the fecal coliform loading from these two sub-watersheds by 5.78E+13 lb/yr, or 72.29% of the total fecal coliform loading.

Table 5-1: Recommended BMPs for Timrod Park WS-101 and WS-102

WS Unit	BMP No.	BMP Type	Drainage Area (acres)	Estimated Load (lb/yr)	Estimated Pollutant Removed (lb/yr)	Estimated Load Reduction (%)
101	1	Infiltration Trench	3	2.63E+11	2.50E+11	0.61%
102	2	Grass Filter Strip	3	3.01E+11	1.80E+10	0.05%
101,102	3	Constructed Wetland	854	8.59E+13	5.75E+13	71.63%
		Cumulative Totals	**860**		**5.78E+13**	**72.29%**

Table 5-2 lists the BMPs for the portion of Timrod Park contained within WS-103. Unlike, the BMPs listed in Table 5-1, these BMPs will focus on treating stormwater runoff from within the park and adjacent properties. In addition, WS-103 is currently meeting SCDHEC standards for fecal coliform at monitoring station WS02. BMPs listed in Table 5-2 will, however, aid in the overall reduction of fecal coliform contributions to Gully Branch and may offset reductions required in other sub-watersheds. Bioretention areas, tree planter boxes, and infiltration BMPs are recommended for the areas around the picnic, amphitheater, and tennis court areas to treat surface runoff as it approaches Gully Branch from the north. These BMPs will complement the existing bioretention areas located at the southeast corner of the site. Additionally, streambank restoration and the addition of grass filter strips, or stream buffers, is recommended along the streambank where erosion and the addition of riprap have removed vegetation. Combined, the implementation of these BMPs could reduce pollutant loads in WS-103 by 1.89E+08 lb/yr, for a fecal coliform load reduction of 2.69% in WS-103.

Table 5-2: Recommended BMPs for Timrod Park WS-103

WS Unit	BMP No.	BMP Type	Drainage Area (acres)	Estimated Load (lb/yr)	Estimated Pollutant Removed (lb/yr)	Estimated Load Reduction (%)
103	4	Bioretention Cell	1.5	5.62E+07	2.25E+07	0.32%
	5	Grass Filter Strip	1	3.75E+07	2.25E+06	0.03%
	6	Infiltration Trench	1	3.75E+07	3.56E+07	0.51%
	7	Tree Planter Box	0.25	9.36E+06	7.96E+06	0.11%
	8	Tree Planter Box	0.25	9.36E+06	7.96E+06	0.11%
	9	Tree Planter Box	0.25	9.36E+06	7.96E+06	0.11%
	10	Bioretention Cell	5	1.87E+08	7.49E+07	1.07%
	11	Existing Bioretention Cells	1	7.49E+07	3.00E+07	0.43%
		Cumulative Totals	**10.25**		**1.89E+08**	**2.69%**

5.2.2 Lucas Park (WS-104)

The locations of the BMPs proposed for Lucas Park are shown in Appendix H, Exhibit B. A Bioretention Cell is recommended in the far western portion of the site where the canopy allows adequate sunlight for plants, which are an important component of the BMP. A sand filter is proposed for the northern boundary of Lucas Park along Camelia Circle to treat runoff entering the park from the street. This filter would be incorporated into a tiered retaining wall type-landscaping feature. Along the opposite, south, side of the park, riparian improvements including shrubs and other vegetative groundcover is recommended to filter runoff entering the park from W. Azalea Lane. Finally, a constructed wetland, or treatment forebay, is proposed at the eastern side of Santee Drive adjacent to the roadway where the tributary daylights. This location provides the greatest opportunity for water quality improvement within the drainage area. Estimated pollutant removal rates and percent load reductions are listed in Table 5-3 for each of the BMPs described herein. Cumulative load reductions of 2.72E+13 lb/yr are anticipated resulting in an overall pollutant reduction of 67.94% for WS-104.

Table 5-3: Recommended BMPs for Lucas Park

BMP No.	BMP Type	Drainage Area (acres)	Estimated Load (lb/yr)	Estimated Pollutant Removed (lb/yr)	Estimated Load Reduction (%)
1	Bioretention Cell	5	1.31E+12	5.23E+11	1.31%
2	Sand Filter	5	1.31E+12	5.23E+11	1.31%
3	Grass Filter Strip	5	1.31E+12	7.84E+10	0.20%
4	Constructed Wetland	138	3.89E+13	2.61E+13	65.12%
	Cumulative Totals	**153**		**2.72E+13**	**67.94%**

5.2.3 Maple Park (WS-102)

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 5-4: 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 Totals	**4**		**2.05E+11**	**0.50%**

Table 5-4 list the five BMPs selected for implementation 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. The locations for BMP implementation can be seen in Appendix H, Exhibit C. 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.

5.3 COST ESTIMATES

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 chosen for implementation in this report are listed in Table 5-5.

Table 5-5: Estimated Capital Costs Per Land Acre Treated for New BMP Implementation

BMP Type	Capital Costs	Unit
Bioretention Cell	$ 20,000.00	Ea
Constructed Wetlands	$ 25,000.00	Ea
Constructed Forebay	$50,000.00	Ea
Grass Filter Strip	$ 100.00	l.f.
Infiltration Trench (w/drain)	$ 300.00	l.f.
Sand Filter (w/drain)	$ 500.00	l.f.
Tree Planter Boxes	$ 10,000.00	Ea

A cost estimate was prepared for each of the parks selected as implementation sites using the capital cost estimates provided in Table 5-5 for the named BMPs from Section 4.2 above. Implementation for the 10 proposed projects within Timrod Park provide substantial treatment for runoff from WS-101 and WS-102 and the infiltration trenches that would provide filtration for runoff form the neighborhoods adjacent to Timrod Park.

Table 5-6 shows a total preliminary cost estimate near $300,000. A significant portion of the capital cost would be for the constructed wetland that would provide substantial treatment for runoff from WS-101 and WS-102 and the infiltration trenches that would provide filtration for runoff form the neighborhoods adjacent to Timrod Park.

Table 5-6: Cost Estimate for Timrod Park BMP Implementation

BMP	Total	Unit	Unit Cost ($)	Extended Cost
Bioretention Cell	1	Ea	20,000.00	20,000.00
Constructed Wetlands	3	Ea	25,000.00	75,000.00
Grass Filter Strip	250	l.f.	100.00	25,000.00
Infiltration Trench	500	l.f.	300.00	150,000.00
Tree Planter Boxes	3	No.	10,000.00	30,000.00
			Total	**$ 300,000.00**

Table 5-7 provides a cost estimate for each of the four (4) BMP projects selected for implementation in Lucas Park. These projects are estimated to cost around $250,000 with just 25% of the estimate designated for the constructed wetland (treatment forebay) proposed for the eastern side of Santee Drive.

Table 5-7: Cost Estimate for Lucas Park BMP Implementation

BMP	Total	Unit	Unit Cost ($)		Extended Cost
Bioretention Cell (two tier)	2	Ea	20,000.00		40,000.00
Constructed Forebay	1	Ea	50,000.00		50,000.00
Grass Filter Strip	350	l.f.	100.00		35,000.00
Sand Filter	250	l.f.	500.00		125,000.00
			Total	**$**	**250,000.00**

Maple Park has the fewest number of BMP types selected for implementation along with the lowest budget. Table 5-8 shows the proposed budget for Maple Park with a total estimated cost of around $60,000. This includes the installation of one (1) bioretention cell and four (4) standard tree planter boxes.

Table 5-8: Cost Estimate for Maple Park BMP Implementation

BMP	Total	Unit	Unit Cost ($)		Extended Cost
Bioretention Cell	1	Acre	20,000.00		20,000.00
Tree Planter Boxes	4	No.	10,000.00		40,000.00
			Total	**$**	**60,000.00**

The total estimated implementation costs for each of the BMP practices identified in this plan are summarized by location in Table 5-9. Timrod Park has the highest cost of implementation followed by Lucas Park with BMP installation improvements and Maple Park with the lowest overall cost estimate. The total cost for implementation is estimated to be **$ 610,000.00**.

Table 5-9: Overall Implementation Costs

Location		Cost Estimate
Timrod Park		300,000.00
Lucas Park		250,000.00
Maple Park		60,000.00
Total	**$**	**610,000.00**

5.4 MILESTONE IMPLEMENTATION 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 described above. 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.

From data presented in Section 5.1, 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. The minimum goals of the watershed plan should be as follows. If funding sources become available for additional work, the projects identified in this plan should be completed as soon as possible.

Year 1:

- Begin education and outreach campaign to neighborhood groups and the public. Conduct a minimum of three meetings in Year 1.
- Conduct baseline monitoring at current sampling locations. (Phase I Sampling)
- Continue to pursue repair and retrofit of sanitary sewer network.
- Investigate and pursue willing landowners for buffer preservation and restoration opportunities, particularly at the lower reaches of Lucas Park and properties downstream of Cherokee Rd along Gully Branch to the confluence with Jeffries Creek.
- Preliminary investigation for final site locations and sizing of the BMPs in Timrod Park.
- Verification and BMP selection for a minimum of 30% of the BMPs in Maple Park and Lucas Park.
- Design of BMPs proposed to treat surface runoff in Timrod Park 100% complete.
- A minimum of two initial projects constructed in year 1. These should be highly visible projects identified in this plan and shall include informational signage to coincide with the on-going educational outreach activities.

Years 2-4:

- Continue education and outreach. Conduct outreach meetings prior to final design and following construction of each proposed project.

- Continue baseline monitoring (Phase I Sampling) at water quality monitoring locations.
- Construction of proposed BMPs in Maple Park and Timrod Park completed.
- All preliminary investigation of proposed BMPs complete.
- Verification and selection of remaining proposed BMPs complete.
- Begin BMP Performance Monitoring (Phase II Sampling) of BMPs completed since plan implementation.

Years 5-7:

- Continue education and outreach.
- Continue Phase I and II water quality monitoring.
- Design and construction of Lucas Park BMP projects complete.
- Identify additional BMP implementation opportunities not identified in this plan. BMP identification should be based on results of Phase I and II water quality monitoring.

Years 7-10:

- Continue education and outreach.
- Construction of all proposed BMP projects and retrofits complete.
- Continue Phase I and II monitoring on all major tributaries and Gully Branch.
- Re-evaluate management priorities and implement additional projects identified in Years 5-7 to meet water quality standards.

5.5 PROJECT SUMMARY

Twenty BMP implementation projects are proposed for these three city-owned properties. The combined pollutant reduction of full implementation of this plan is shown in Table 5-10. The proposed implementation projects in this plan reduce fecal coliform loading by approximately 8.52E+13 lb/yr in Gully Branch. As seen in the table, these implementation strategies represent significant strides to meet the overall water quality goals for Gully Branch, most notably in sub-watersheds WS-101, WS-102, and WS-103. Based on these estimates an additional reduction of approximately 2.10E+13 lb/yr will be required through additional means to meet the SCDHEC standard throughout the watershed.

Table 5-10: Pollutant Reduction Summary for Gully Branch

Drainage Basin	Annual Load (lb/yr)	Reduction Required to Meet SCDHEC Standard (lb/yr)	Reduction Required to Meet SCDHEC Standard (%)	Annual Load Reduction (lb/yr)	Annual Load Reduction (%)	Additional Load Reduction Required to Meet Standard (%)
WS-101	4.06E+13	3.39E+13	83%	2.93E+13	72%	11%
WS-102	3.97E+13	3.38E+13	85%	2.87E+13	72%	13%
WS-103	7.02E+09	Meets Standard	Meets Standard	1.89E+08	3%	Meets Standard
WS-104	4.00E+13	3.78E+13	94%	2.72E+13	68%	26%
WS-105	2.79E+12	7.00E+11	25%	---	0%	25%

The additional pollutant removal requirements will be met through a series of water quality retrofit projects and installation of planted filter boxes throughout the watershed. As part of this plan, the Gully Branch watershed will continue to be a priority watershed within the City. As such, all development projects within the watershed will be subject to water quality improvement and pollutant load reduction. Additionally, the City will continue to inspect and monitor the existing sewer infrastructure in the watershed, as it has been identified as part of this watershed plan as a potential source of bacterial contamination. While field investigation did not indicate identifiable sources of sanitary sewer leakage, it is acknowledged as a potential source and will be monitored. The educational activities outlined in this plan represent a significant increase in targeted neighborhood outreach associated with retrofit installation. In this way, the residents of the community can work hand-in-hand with the City to improve water quality throughout the Gully Branch watershed.

Section 6

STREAM AND WATERSHED MONITORING

The City of Florence Water 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.

6.1 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 Water Quality Standards (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.

6.1.1 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.

6.1.2 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.

6.1.3 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 J. 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, 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.

6.1.4 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.

6.1.5 Project QA/QC Manager

The Project 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.

6.2 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 ASTM standards for water quality sampling and testing.

6.2.1 Location

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

6.2.2 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.

6.2.3 Rainfall Events

The Gully Branch Watershed Sampling Plan is designed to monitor ambient water quality. Rainfall 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 rainfall. Precipitation will be monitored and recorded at a rainfall gauge located at the WWMF, 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.

6.2.4 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.

6.2.5 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

On the day of the scheduled sampling event, the Sampling Team Leader will make a Go/No-Go decision on monitoring based on a review of the required sampling conditions:

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
   c. (See Section 5.2.8, Sample Collection Technique)

5. Sampling Team No-Go Mode:
   a. Inventory, clean, organize and prepare sampling equipment for next scheduled sampling event.

6.2.6 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.

6.2.7 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.

6.2.8 Sample Collection Technique

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

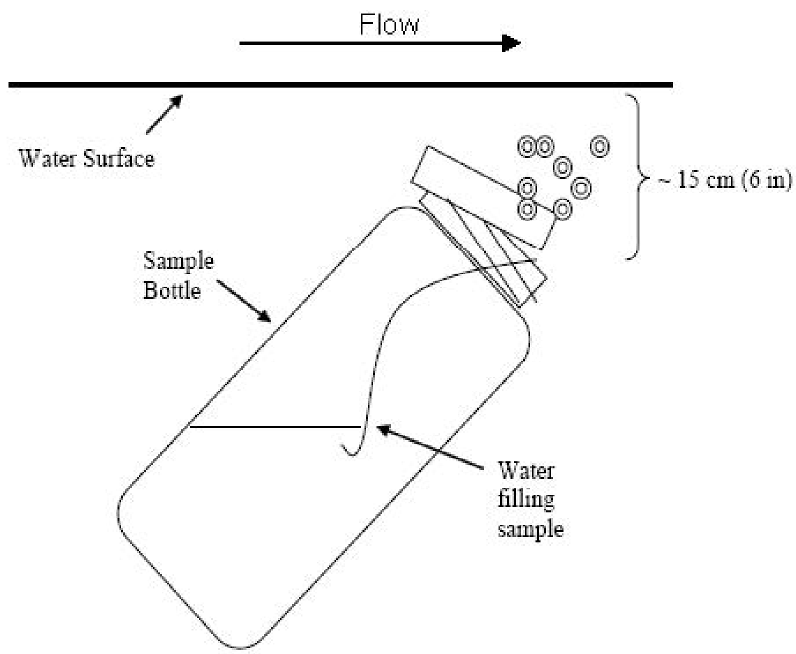
a. Remove stopper/cap from container just before sampling. Be careful not to contaminate the cap, neck, or the inside of the bottle with your fingers, wind-blown particles, or dripping water from your clothes, body, or overhanging structures.

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: 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 L)
   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

   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. Samples must be analyzed within 6 hours of collection.

6.2.9 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®).

6.3 QUALITY ASSURANCE AND QUALITY CONTROL

The Quality Assurance/Quality Control 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.

6.3.1 Field Quality Assurance/Quality Control

Quality assurance 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.

6.3.2 Laboratory 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 herein, including the Laboratory's Standard Operating Procedures for Fecal Coliform and *E. coli*. The SOP for each of Fecal Coliform and *E. coli* shall be added as Appendix M in this document.
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.

6.4 DATA MANAGEMENT AND REPORTING

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

6.4.1 Data Validation

The Laboratory will be responsible for data verification at the lab, and will follow applicable laboratory Quality Control measures as outlined in the SOPs in Appendix M. 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 and Chain of Custody Forms 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.

6.4.2 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.

6.4.3 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

6.4.4 Data Analysis

The sample concentration and time since rainfall for each sampling event will be entered into a spreadsheet by the Project QA/QC Manager, and will include the sample results from each Monitoring Station.

Section 7

REFERENCES

Watershed Planning References:

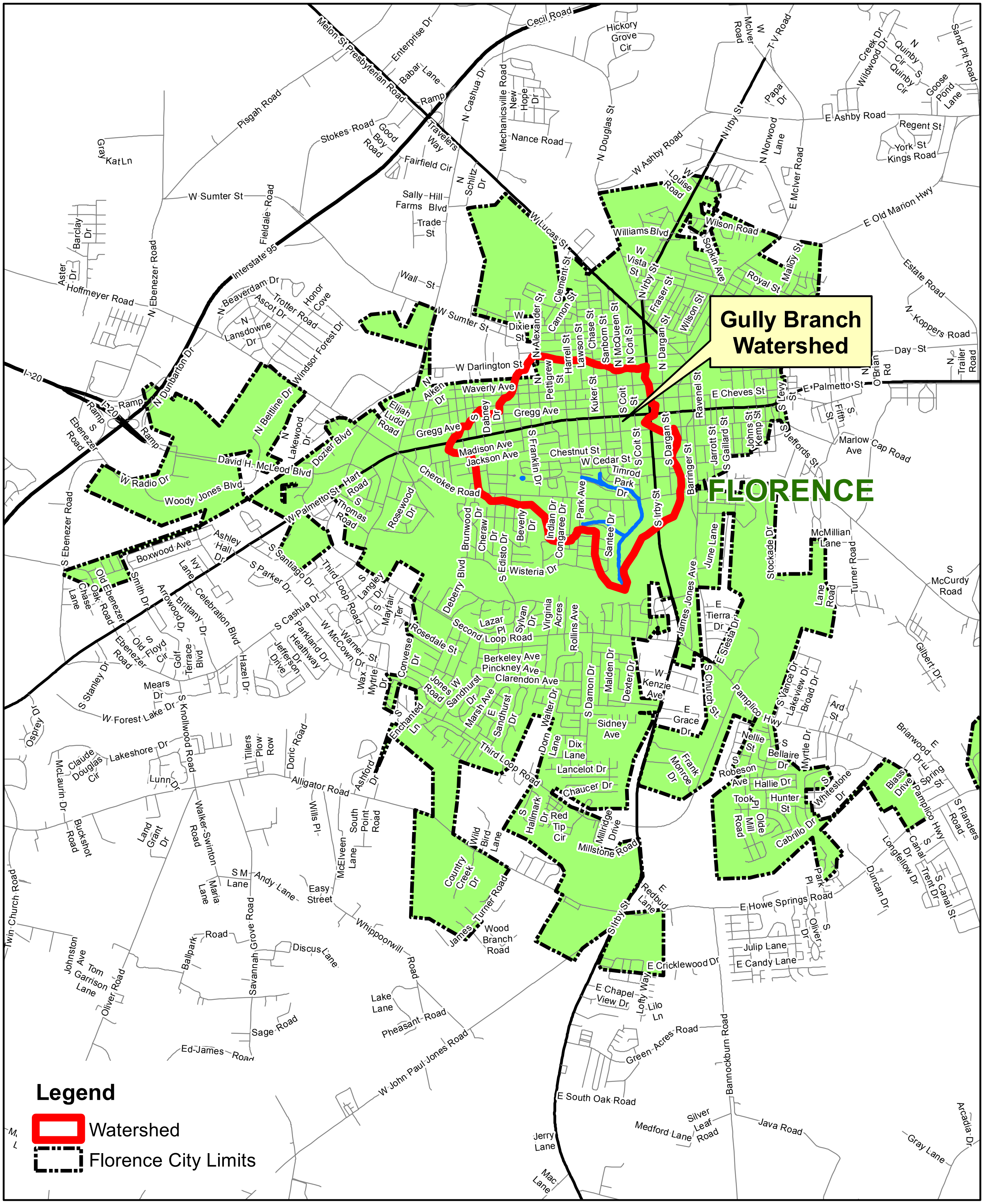
- City of Florence 2010 Comprehensive Plan (adopted February 14, 2011)
- South Carolina Department of Health and Environmental Control. (2005) Total Maximum Daily Loads for Fecal Coliform for Hills Creek, et al., of the Pee Dee River Basin, South Carolina, SCDHEC Technical Report Number: 029-05. http://www.scdhec.gov/environment/water/tmdl/docs/tmdl_peedee_fc.pdf
- South Carolina Department of Health and Environmental Control. (2007) Watershed Water Quality Assessment, Pee Dee River Basin. http://www.scdhec.gov/environment/water/shed/docs/pd-005-07.pdf
- South Carolina Department of Health and Environmental Control. (June 2013) Total Maximum Daily Load Document, Pocotaligo River and Tributaries*, Escherichia coli* Bacteria, Indicator for Pathogens. http://www.dhec.sc.gov/environment/water/tmdl/docs/Pocotaligo_Ecoli_ECOLI_TMDL_NODD.pdf
- U.S. Census Bureau, 2010 Census Data for City of Florence, South Carolina
- USDA Natural Resources Conservation Service, 133A – Southern Coastal Plain, July 11, 2013. http://www.mo15.nrcs.usda.gov/technical/MLRAs/mlra_133a.html

Stormwater BMP References:

- BMP Summary Report prepared for San Antonio River Authority, James Miertschin & Associates, Inc., Sept. 2012.
- "Effectiveness of Best Management Practices for Bacteria Removal," June 2011, Emmons & Olivier Resources, Inc.
- EPA Stormwater Menu of BMPs.
- Filterra Bioretention Systems (March 2013), http://filterra.com/index.php/product/bacterra/.
- Georgia Stormwater Management Manual.
- International Stormwater Best Management Practices Database, Pollutant Category Summary: Fecal indicator Bacteria, December 2010, Wright Water Engineers, Inc. and Geosyntec Consultants, Inc.
- International Stormwater BMP Database, Water Environment Research Foundation, July 18, 2012, Geosyntec Consultants, Inc. and Wright Water Engineers, Inc.
- National Pollutant Removal Performance Database, Version 3, Sept. 2007, Center for Watershed Protection.
- South Carolina DHEC Storm Water Management BMP Handbook.
- Urban Stormwater Retrofit Practices Appendices, Center for Watershed Protection, Manual 3, Appendix D, www.cwp.org.

APPENDIX A

Gully Branch Watershed Location Map



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Date:March 18, 2013
Author: LCS

URS

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

1 inch = 6,000 feet

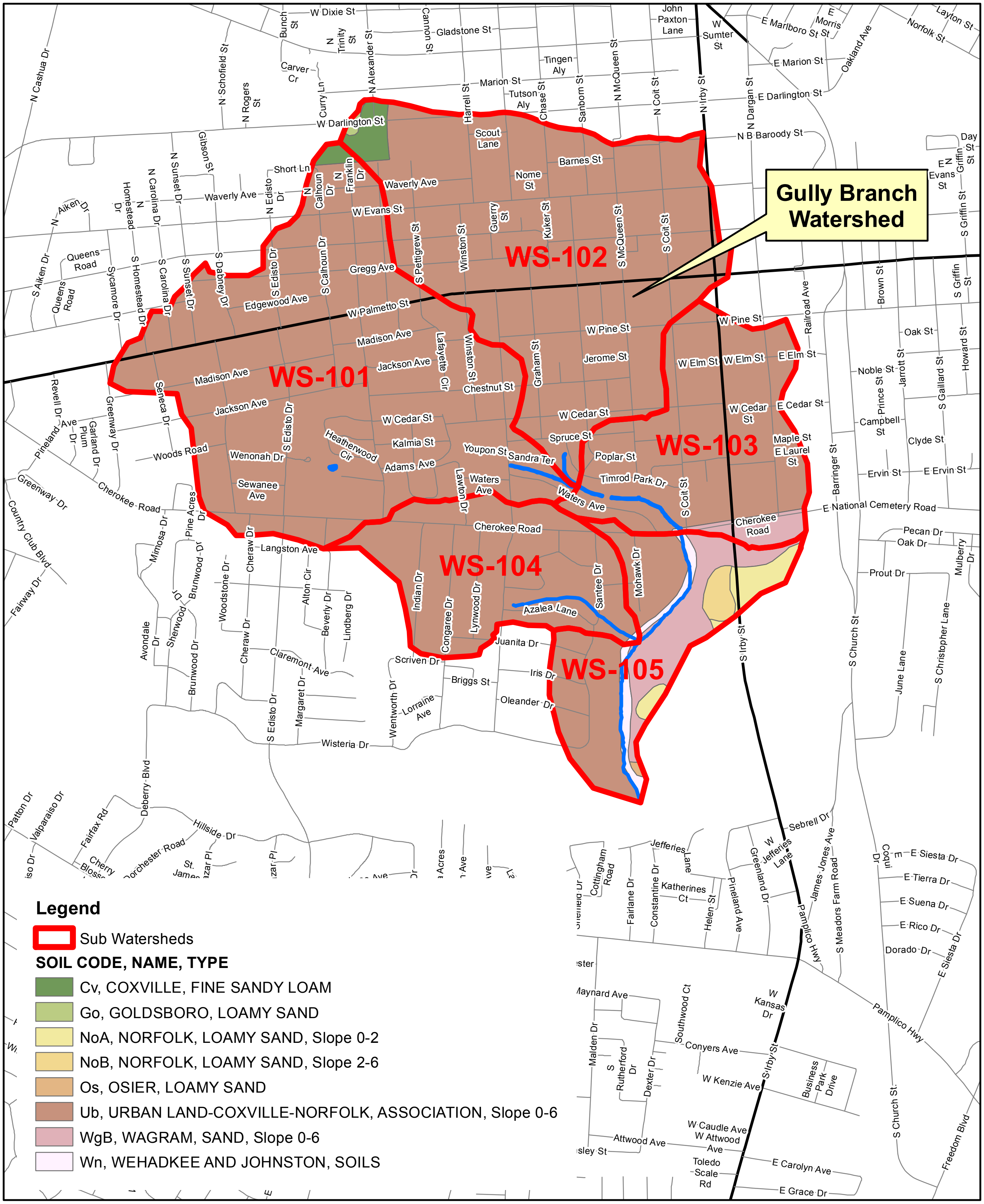
0 1,000 2,000 4,000
Feet

City of Florence

Gully Branch Watershed Location Map

APPENDIX B

Gully Branch Watershed Soils Map



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Date:July 9, 2013
Author: LCS

URS

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

N

1 inch = 2,000 feet

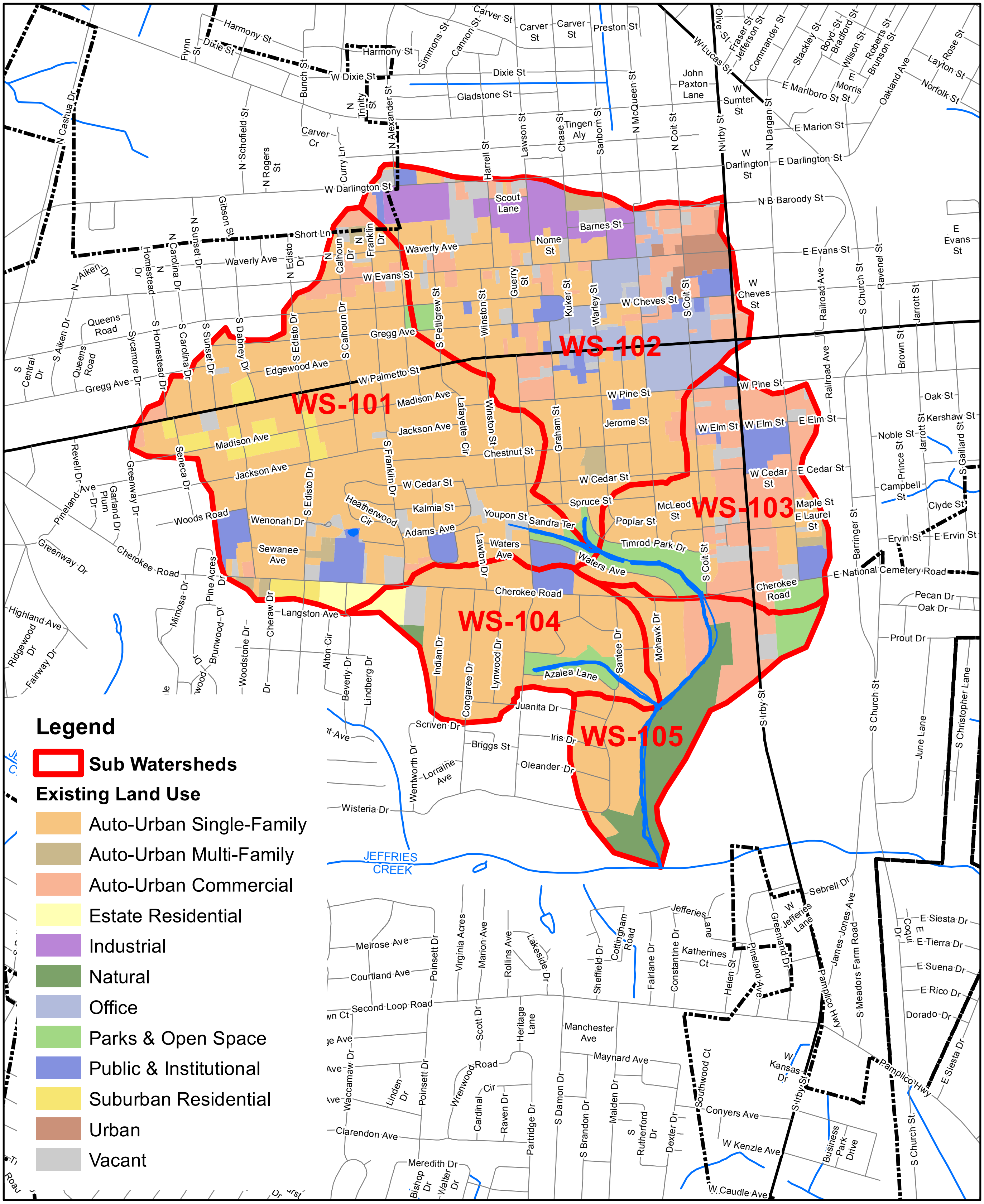
0 1,000 2,000 4,000 Feet

City of Florence

Gully Branch Watershed Soils Map

APPENDIX C

Existing Land Use Location Map



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Date:March 18, 2013
Author: LCS

URS

N

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

1 inch = 2,000 feet

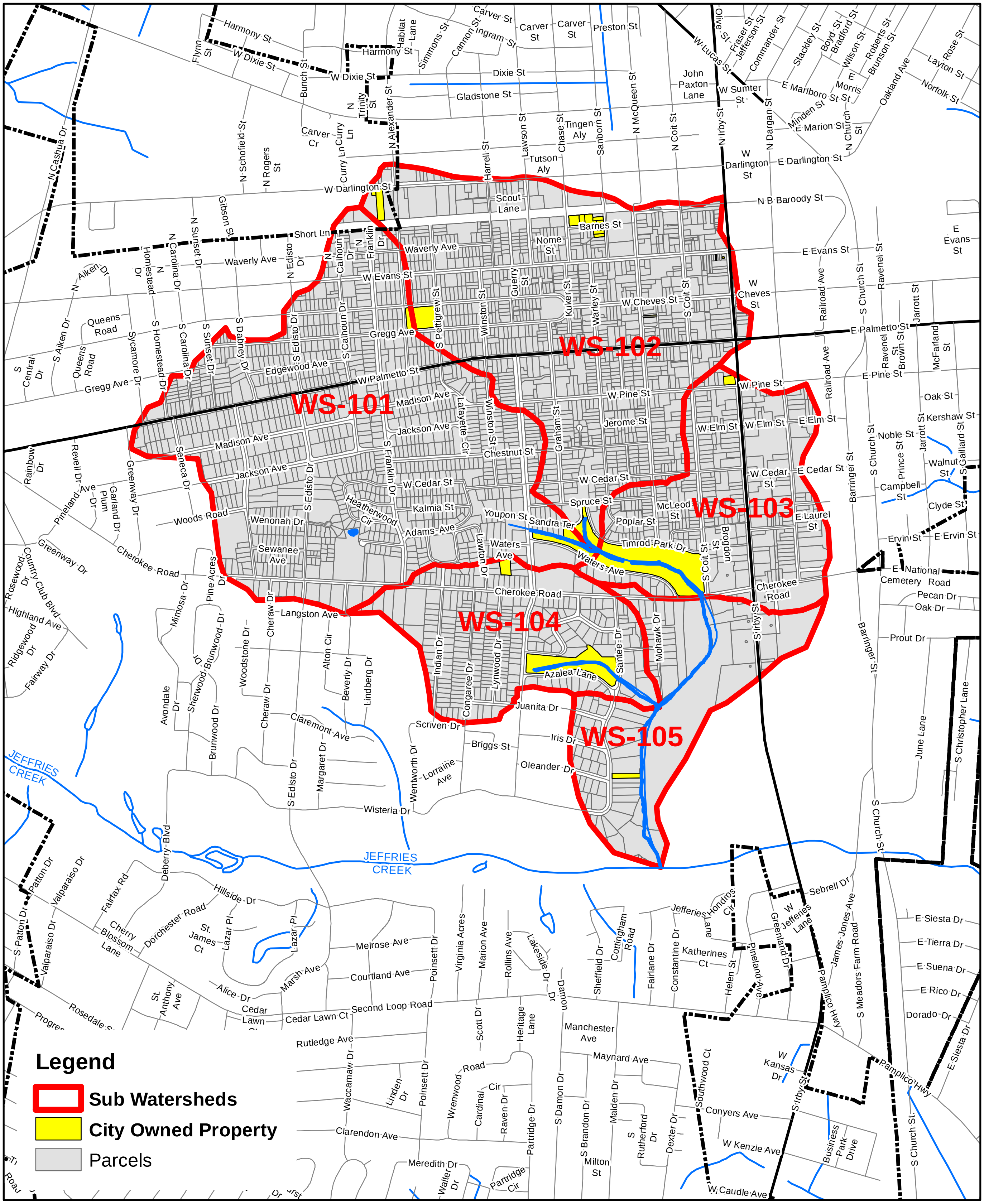
0 1,000 2,000 4,000 Feet

City of Florence

Existing Land Use Location Map

APPENDIX D

City Owned Property Location Map



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Author: LCS

URS

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

1 inch = 2,000 feet

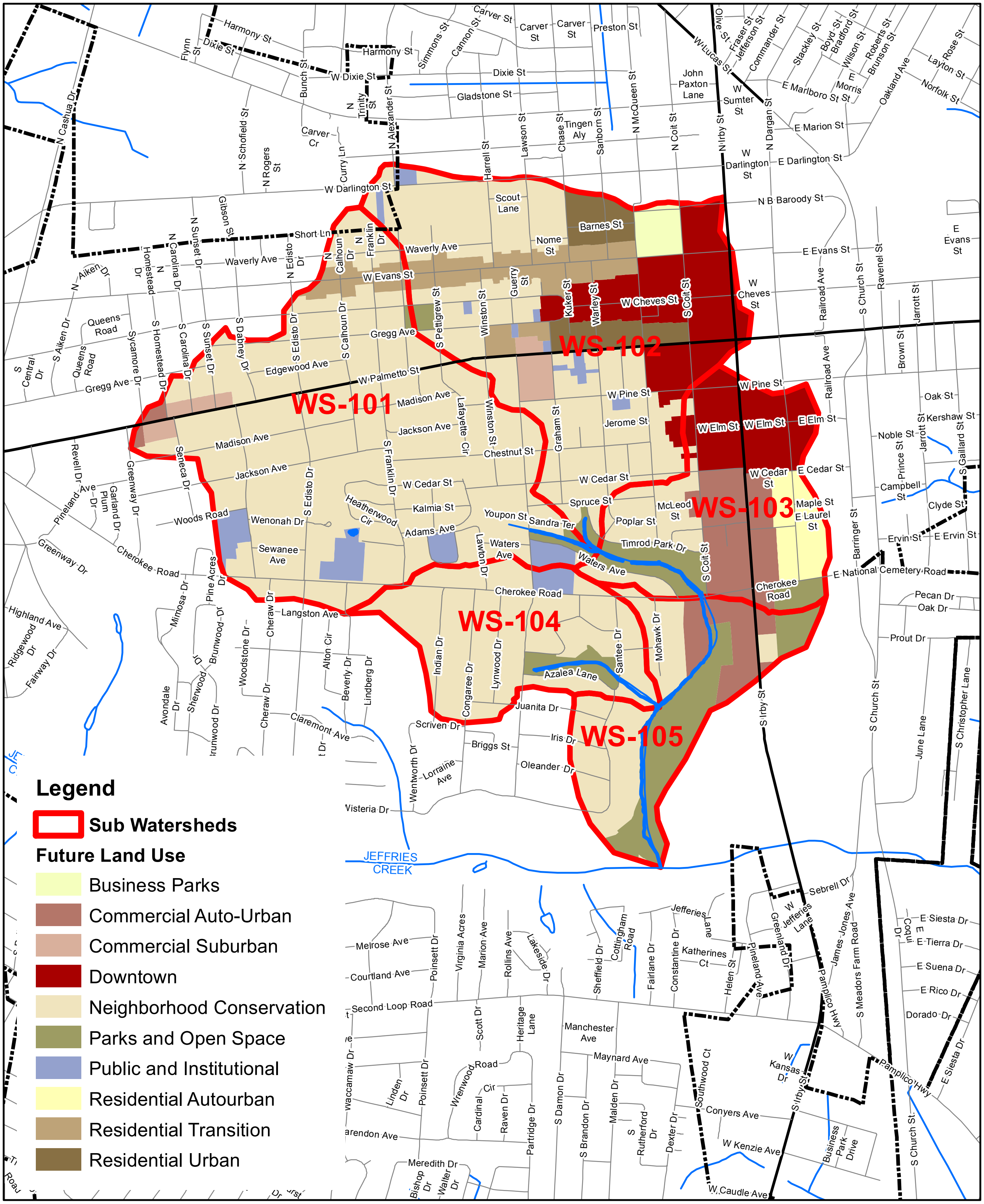
0 1,000 2,000 4,000 Feet

City of Florence

City Owned Property Location Map

APPENDIX E

Future Land Use Location Map



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Date:March 18, 2013
Author: LCS

URS

N

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

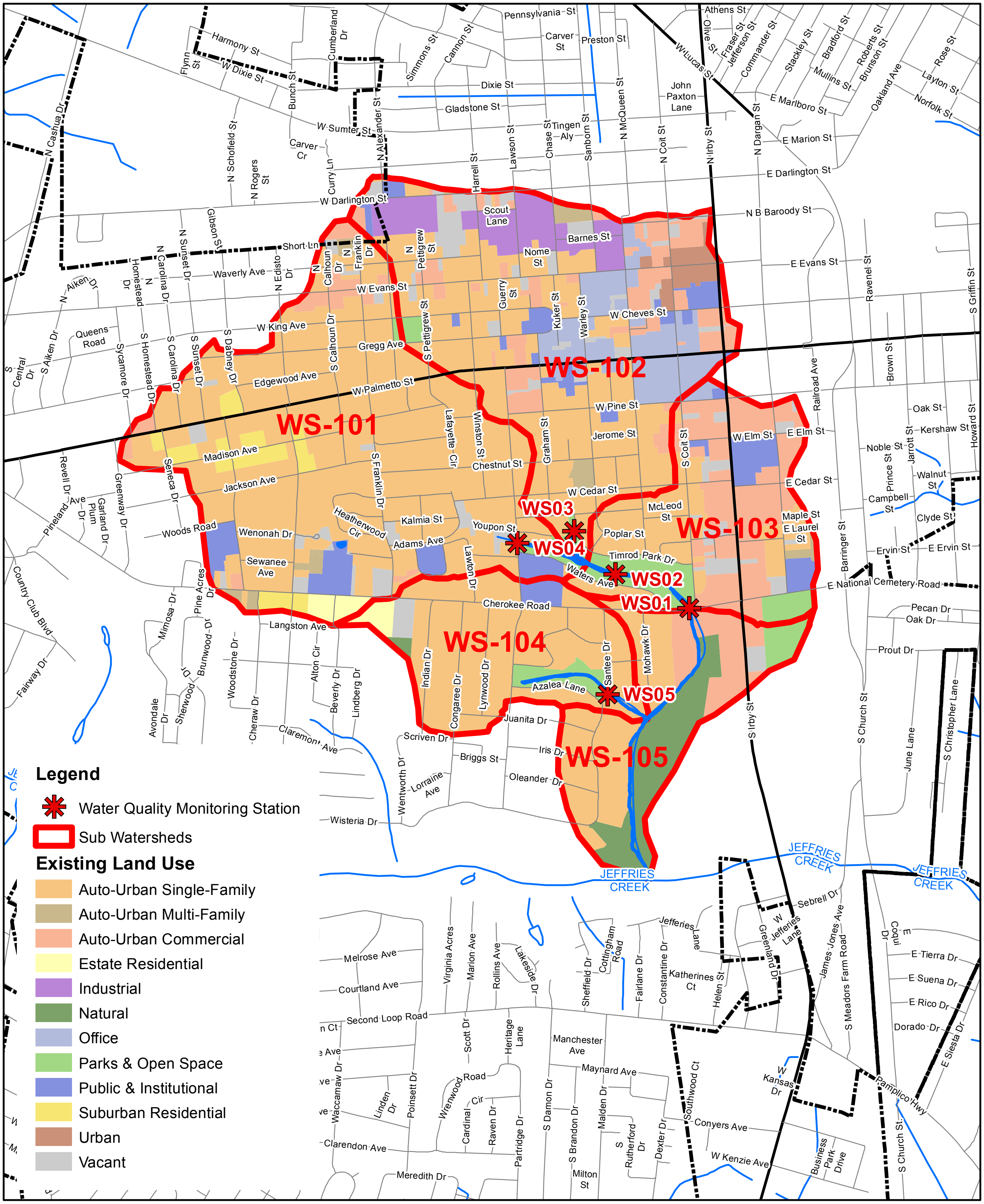
APPENDIX F

Gully Branch - Outfalls

GULLY BRANCH - OUTFALLS

APPENDIX G

Water Quality Monitoring Stations Location Map



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Existing_Land_Use.mxd
Date:October 8, 2013
Author: LCS

URS

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

1 inch = 2,000 feet

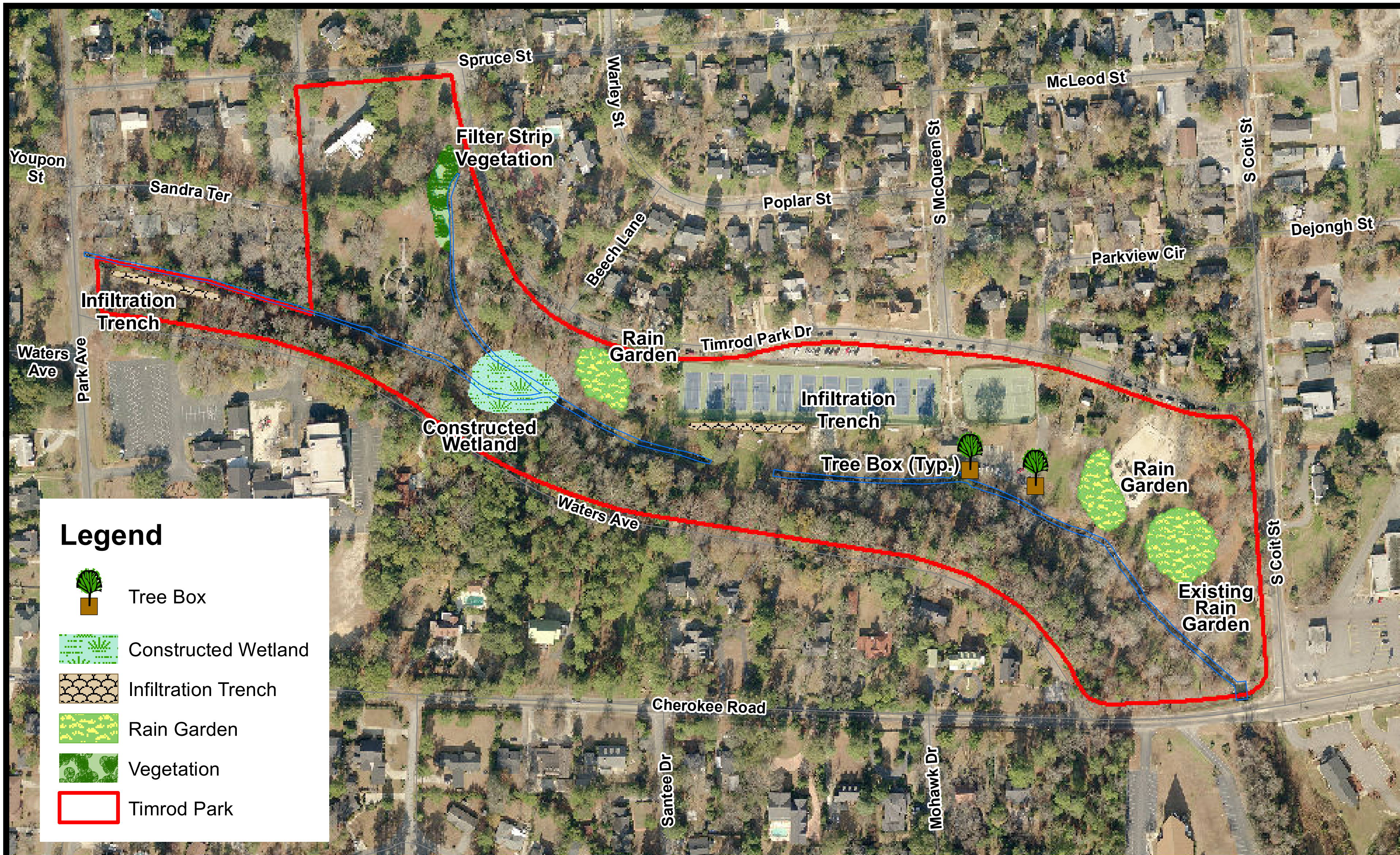
0 1,000 2,000 4,000 Feet

Gully Branch Watershed Plan

Water Quality Monitoring Stations Location Map

APPENDIX H

Recommended Projects Location Maps



0 150 300 600 Feet

URS

EXHIBIT A
CITY OF FLORENCE
Gully Branch Watershed Plan
Timrod Park

October 9, 2013

0 100 200 400 Feet

1 inch = 200 feet

URS

EXHIBIT B
CITY OF FLORENCE
Gully Branch Watershed Plan
Lucas Park

October 9, 2013

N

CITY OF FLORENCE S.C. JUSTICE TO ALL CHARTERED DEC. 24, A.D. 1890

0 50 100 200 Feet

1 inch = 100 feet

URS

EXHIBIT C
CITY OF FLORENCE
Gully Branch Watershed Plan
Maple Park

October 9, 2013

N

CITY OF FLORENCE S.C.
JUSTICE TO ALL
CHARTERED DEC. 24, A.D. 1890

APPENDIX I

Best Management Practices for Fecal Coliform and *E. coli* Removal

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 J

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 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: ___________

APPENDIX L

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 M

Laboratory Standard Operating Procedures

Fecal Coliform

E. coli

[SOP information to be provided by the water quality laboratory responsible for providing water quality data and testing.]