URS

Civil Engineering Services

SUMTER COUNTY TURKEY CREEK WATERSHED PLAN

SUMTER COUNTY · 1800 · 1868 · SOUTH CAROLINA

Sumter
UNCOMMON PATRIOTISM

CHARLESTON

SUMTER COUNTY

TURKEY CREEK WATERSHED PLAN

PREPARED FOR

SUMTER COUNTY
13 EAST CANAL STREET
SUMTER, SOUTH CAROLINA 29150

PREPARED BY

URS CORPORATION
4016 SALT POINTE PARKWAY, SUITE 200
NORTH CHARLESTON, SOUTH CAROLINA 29405

OCTOBER 2013

TABLE OF CONTENTS

TABLES

FIGURES

APPENDICES

EXECUTIVE SUMMARY

The Turkey Creek Watershed Plan has been developed to assist Sumter County and the City of Sumter to implement structural and non-structural best management practices (BMPs) to improve water quality within Turkey Creek. 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 Turkey Creek, and subsequently the Pocotaligo River.

Turkey Creek is a mixed-use watershed that flows through the City of Sumter and Sumter County before draining into the Pocotaligo River approximately one-half mile south of the City of Sumter. The Turkey Creek watershed collects stormwater runoff from roads and neighborhoods in the City of Sumter, and surrounding portions of Sumter County. The upper reaches of the watershed are highly developed with a large concentration of residential, commercial and industrial development. The lower reaches of the watershed consists of scattered residential developments and agricultural activities. The agricultural activities are primarily row crops, with very little livestock activity in the watershed. Future goals of the County, according to their comprehensive plan, have the development of the entire watershed shifting toward a low-density residential area. This will allow the County to implement water quality improvement strategies through design ordinances and development guidelines to improve water quality within the watershed. The watershed is a high priority for both Sumter County and the City of Sumter.

In order to define structural and non-structural BMPs for implementation, the City and County evaluated water quality at several locations within the watershed. Since only two (2) monitoring stations were 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 eight (8) sub-watersheds and evaluated for pollutant loading. The results of this monitoring and modeling assessment indicated that five of the sub-watersheds are currently meeting SCDHEC water quality standards. The loadings observed within the watershed are consistent with the estimated load reduction requirements outlined in the existing TMDL document. However, in order to evaluate the success of each of the proposed implementation projects through water quality monitoring, success of the Watershed Plan and implementation goals is specifically based on meeting SCDHEC concentrations for bacteria and not a percentage reduction.

The City and County jointly performed detailed site assessments for potential locations for site-specific projects. Pollutant loading estimations and filed verification indicated that a high percentage of the pollutant loading was concentrated in the upper limits of the Turkey Creek watershed, which encompasses an approximate 50/50 split between the City and County jurisdictions. This pollutant loading then travels through the watershed as a slug of pollutant load due to certain flow constriction areas located at East Liberty Street and Fulton Street. Pollutant concentrations do not significantly increase or decrease as flow travels through the watershed past these two points. This indicates that there is neither significant dilution nor addition of substation pollutants through the lower reaches of the watershed.

Given the high concentration of pollutant loading in the upper reaches of the watershed, it was determined that the watershed plan should address these areas to provide the most cost-effective approach to meeting water quality standards for the entire watershed. Field investigation and discussions with City and County staff identified three major waters quality improvement project areas in the upper reaches of the watershed. These projects encompass:

- The installation of a major constructed wetland complex on a current vacant parcel along E. Calhoun Street
- Installation of treatment train complex of constructed wetland and infiltration on a County-owned industrial parcel along E. Fulton Street
- Construction of a treatment complex within city-owned Eastwood Park
- Retrofit of an existing pond along Snake Creek in the lower reaches of the watershed.

The implementation of these projects will be supplemented with stream restoration activities at each location. The stream restoration will provide additional treatment capacity through the reestablishment of vegetated buffers and a stabilization of the ecological habitat within Turkey Creek and its tributaries.

Additional water quality treatment activities will take place outside of these areas; these implementation practices include retrofitting existing roadside ditches with enhanced infiltration swales, stream restoration and buffer enhancement 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 and County as part of their ongoing stormwater maintenance activities. This watershed plan addresses water quality concerns within the Turkey Creek watershed to the maximum extent practicable given the limitations on Turkey Creek itself. Turkey Creek is considered a flood control canal and maintenance and operation of the Creek itself is regulated by an agreement between the City, County and the US Army Corps of Engineers (USACE). This prevents the City and County from reestablishing full buffers along the creek or significantly altering the creek itself. This limits full ecological redevelopment of the creek directly, but through the implementation of the proposed projects and supplementation stream restoration and retrofit activities, it is the City and County's goal to improve the water quality to meet SCDHEC standards.

Overall, the proposed site-specific implementation projects identified in this Watershed Plan meets approximately 52% of the pollution reduction goal. While this does not seem significant to meet water quality standards, it is anticipated, through preliminary field investigation and historic water quality monitoring activities that the pollutant removal efficiencies will actually be quite higher than estimated in this document. One significant aspect of this plan is the E. Calhoun project, which has been identified to reduce pollutant loading and reduce a significant flooding problem within the City. This project will improve the drainage patterns within the eastern portion of the City and reduce the amount of standing water within this residential area, which has been identified as an on-going historic problem and a potential source of bacterial loading from standing water and subsequent SSOs during rainfall events. Additionally, stream restoration and buffer treatment removal efficiencies cannot be accurately quantified due to several factors including location, drainage area and ecological condition of the streams themselves.

This plan provides the most comprehensive approach to meeting water quality standards to the MEP. Through the identification of the restoration sites included herein, the City and County believe that the implementation of these water quality projects, along with a focused outreach effort to reduce residential pollution and illegal dumping, which is a significant concern within the watershed, will ultimately improve water quality to meet the pollutant loading standards set forth by SCDHEC.

Section 1

BACKGROUND

Turkey Creek is a primarily urban stream that flows through the City of Sumter and Sumter County before draining into the Pocotaligo River approximately one-half mile south of the City of Sumter. The Turkey Creek watershed collects stormwater runoff from roads and neighborhoods in the City of Sumter, and surrounding portions of Sumter County. The watershed is a high priority for both Sumter County and the City of Sumter.

In September 2005, SCDHEC developed a Total Maximum Daily Load (TMDL) to protect and restore the Turkey Creek watershed from impairment due to fecal coliform bacteria. The TMDL goals were based on sampling data collected for fecal coliform bacteria at two SCDHEC Water Quality Monitoring Stations on Turkey Creek (PD-098 and PD-040).

The City of Sumter and Sumter County were granted coverage under the revised NPDES General Permit for Small Municipal Separate Storm Sewer Systems (MS4s) in September 2007. The City and County each developed and implemented a Stormwater Management Plan to protect and maintain the water quality within its jurisdiction.

In November 2012, Sumter County was awarded a §319 grant from SCDHEC to develop a watershed-based plan for the Turkey Creek Watershed, including the PD-098 and PD-040 Water Quality Monitoring stations.

The EPA approved revisions to South Carolina regulations in February 2013 changing the bacterial indicator species in freshwaters from fecal coliform bacteria to *E. coli*. New TMDLs for fecal coliform and *E. coli* were developed for the Turkey Creek watershed and public noticed in June 2013.

1.1 PREVIOUS WORK IN THE WATERSHED:

Both Sumter County and the City of Sumter have completed inspections of all stormwater outfalls within their jurisdiction that contribute to Turkey Creek. Follow-up inspections were conducted on any suspected non-stormwater discharges to eliminate illicit discharges.

Local citizens were targeted, through MS4 education and outreach programs, to encourage proper disposal of pet waste in an effort to reduce fecal coliform concentrations in stormwater runoff.

The City annually performs vegetation and sediment maintenance in the sections of Turkey Creek within its jurisdiction, and it has completed several sanitary sewer rehabilitation projects within the Turkey Creek watershed.

The County plans to include a water quality component in future flood control projects.

1.2 COOPERATING ORGANIZATIONS/STAKEHOLDERS:

The City of Sumter and Sumter County have developed this Watershed Plan as a cooperative effort. Where investigation and assessment was required, each entity provided the necessary investigation and information within their jurisdictional boundaries. The City and County have entered into a partnership to develop this comprehensive plan to establish water quality improvement activities that will benefit all residents of the Turkey Creek watershed. As such, the implementation of the projects identified herein will be undertaken as a joint venture in a manner that provides the most effective means of implementation to meet the water quality goals while providing the most economical approach to meeting these goals.

During the development of this Watershed Plan, City and County staff evaluated the potential for the inclusion of stakeholders within the watershed to be included as part of the overall evaluation and development of the management plan. However, the watershed is devoid of established civic groups and homeowners associations that were originally identified as potential stakeholders. Therefore, the final stakeholder group consists of City and County staff and members of the Sumter Stormwater Solutions Educational Consortium. Where water quality improvement project implementation are identified, the City and County are committed to including local residents on a project-by-project basis for their input on final design components and educational outreach activities and materials.

1.3 PROJECT STAFF EXPERTISE:

Sumter County and the City of Sumter each have full Stormwater Departments staffed with employees who are familiar with the portions of Turkey Creek watershed within their respective MS4 jurisdictions, including stormwater outfalls and water quality problems. The City and County have worked together over the last few years to better identify and quantify the sanitary and stormwater system infrastructure within the watershed. As part of this effort, the City has developed a comprehensive sanitary sewer map and identified and implemented rehabilitation projects within the watershed.

Section 2

WATERSHED CHARACTERIZATION

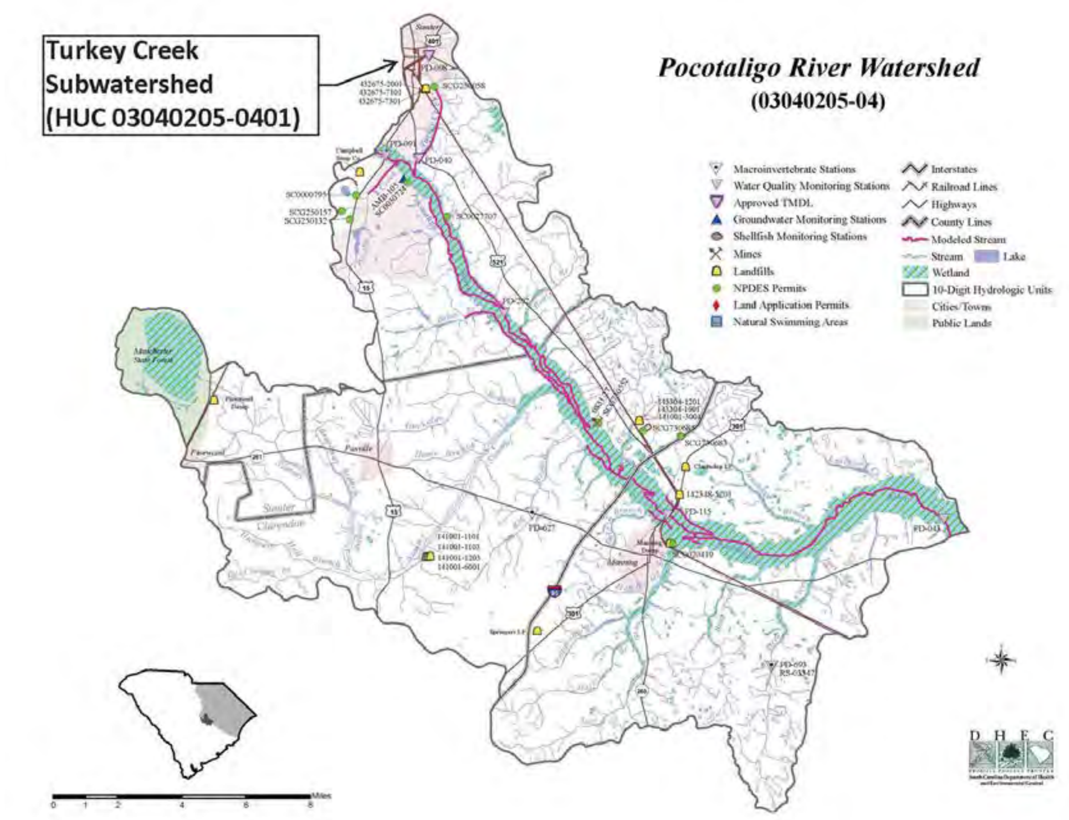
This section describes the natural features, land usage and other characteristics of the Turkey Creek Watershed.

2.1 PHYSICAL AND NATURAL FEATURES

2.1.1 Geography

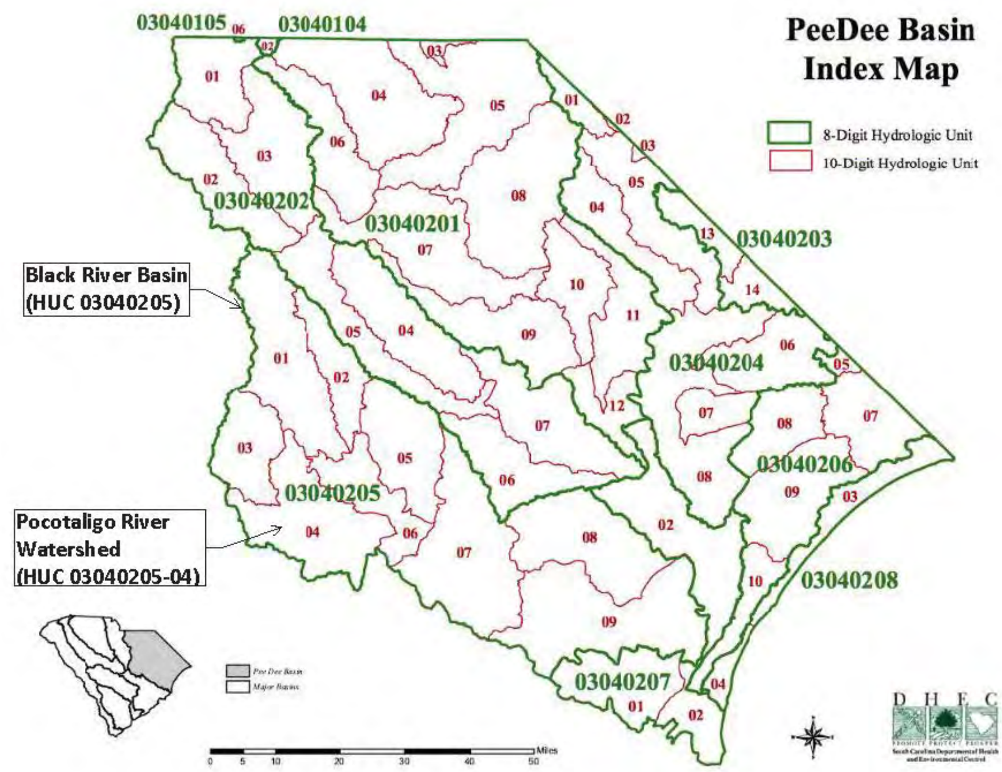
The Turkey Creek watershed (HUC 03040205-0401) is a 9.8 square mile watershed located near the northern boundary of the Pocotaligo River watershed (Figure 2-1).

Figure 2-1: Pocotaligo River Watershed



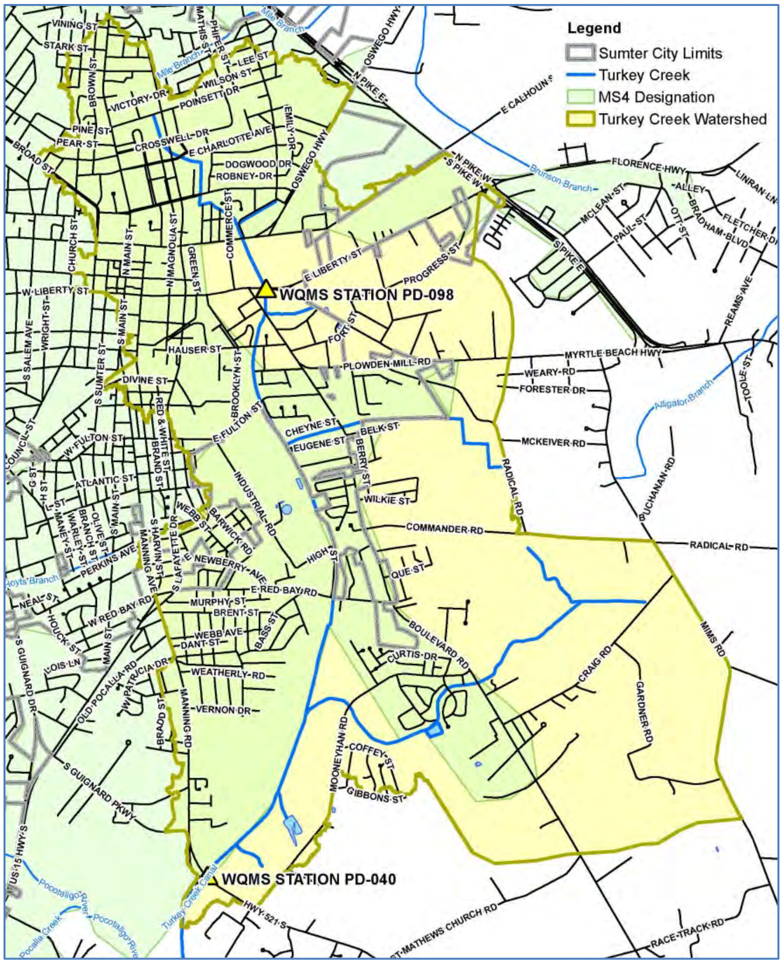
The Pocotaligo River watershed (HUC 03040205-04) is one of 9 watersheds of the Black River Basin (HUC 03040205), which in turn is part of the Pee Dee River Basin of northeastern South Carolina (Figure 2-2).

Figure 2-2: Pee Dee River Basin



Portions of the Turkey Creek watershed are located within the Sumter County MS4, the City of Sumter MS4, and the County of Sumter in South Carolina. The majority of the Turkey Creek watershed lies within the urbanized MS4 areas, as shown in Figure 2-3, below and Appendix A, Turkey Creek Watershed Location Map.

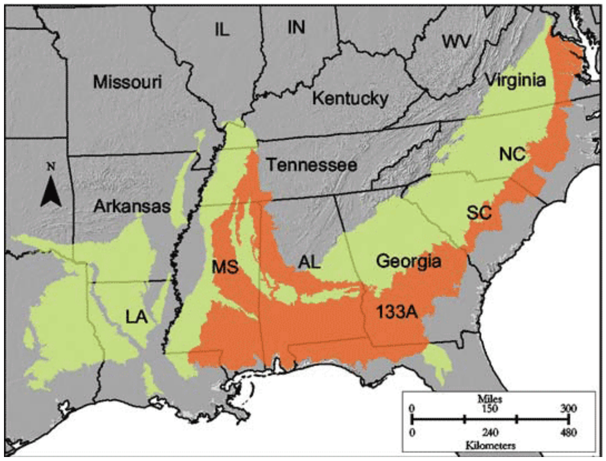
Figure 2-3: Turkey Creek Watershed Map



2.1.2 Geology

The Turkey Creek 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 Atlanta 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 Black River area indicates a normal yearly rainfall of approximately 48 inches. The highest seasonal rainfall occurred in the summer, averaging approximately 15 inches of rain. The average annual daily temperature was 63°F. Seasonal mean temperatures ranged from approximately 46°F in winter to 79°F in summer.

2.1.4 Hydrology

The headwaters of Turkey Creek begin in an urbanized area, with large volumes of urban runoff flowing into the Creek. Turkey Creek is the primary stormwater conveyance channel for much of the City and urbanized County. Downstream of the City, Turkey Creek is used for recreational purposes.

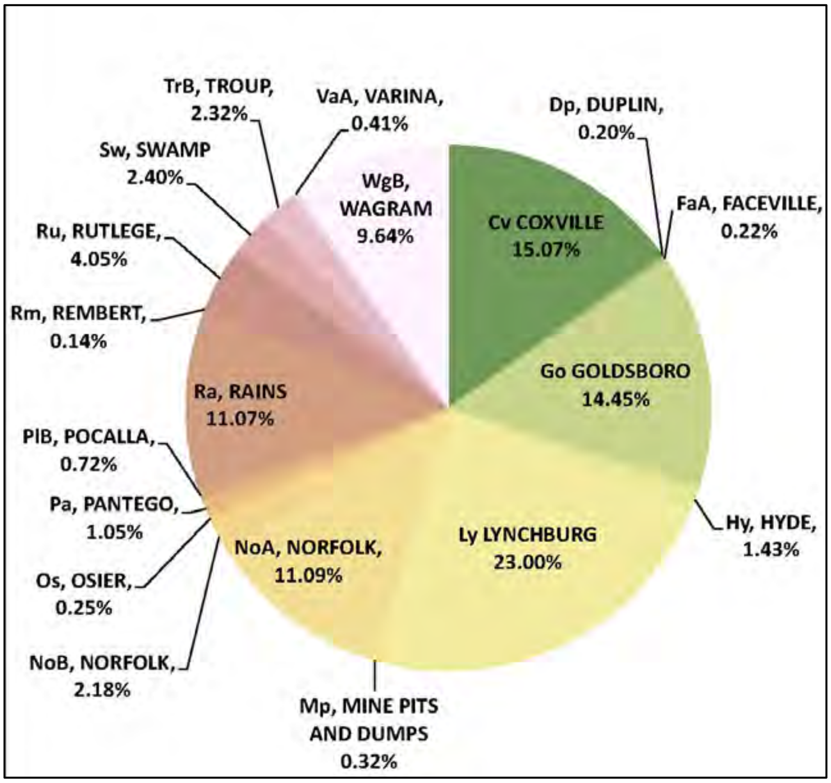
Turkey Creek is classified as a freshwater stream under the South Carolina water quality standards regulations, suitable for recreation, fishing, drinking water supply use, and industrial and agricultural uses. It is a blackwater system, with naturally low dissolved oxygen conditions.

The Turkey Creek watershed is divided into eight (8) separate drainage basins as shown in Appendix B, Sub-Watershed Map.

2.1.5 Soils

A wide range of soil types have been identified in the Turkey Creek Watershed, including Lynchburg, Coxville, Goldsboro, Norfolk and Rains (Figure 2-5, Appendix C, Soils Map).

Figure 2-5: Watershed Soil Types



The Lynchburg, Goldsboro and Rains soils, covering approximately 49% of the watershed, are moderately well to poorly drained soils on nearly level ridges and in shallow depressions. The Norfolk soils (13%) are deep, well drained soils, with loamy subsoil, on nearly level and gently sloping elevated uplands. The Coxville soils (15%) are deep, poorly drained soils, nearly level, in thick beds of clayey sediment.

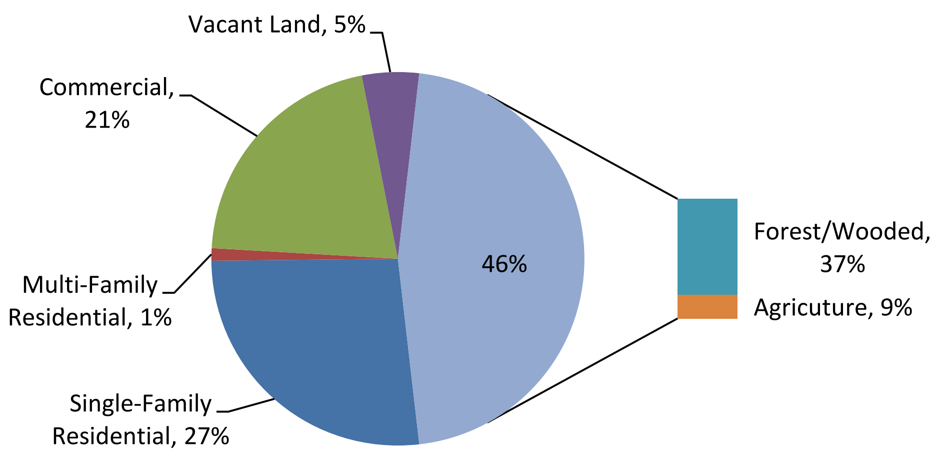
Soil erodibility in the Black River Basin ranges from 0.10 to 0.20 K value, suggesting that the soil is not highly prone to erosion from stormwater runoff. In general, clay soils have low K values (about 0.05 to 0.15) because the particles are resistant to detachment. Sandy soils also have low K values (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 moderate 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 Turkey Creek watershed extends from the City of Sumter urbanized area outward through rural areas of Sumter County. The divergent land uses are reflected in n Figure 2-6 below, and Appendix D, Existing Land Use Map. Approximately 46% of the watershed is comprised of Forest/Wooded and Agriculture land uses. The remainder of the watershed is primarily Residential (28%) and Commercial (21%).

Figure 2-6: Turkey Creek Existing Land Use



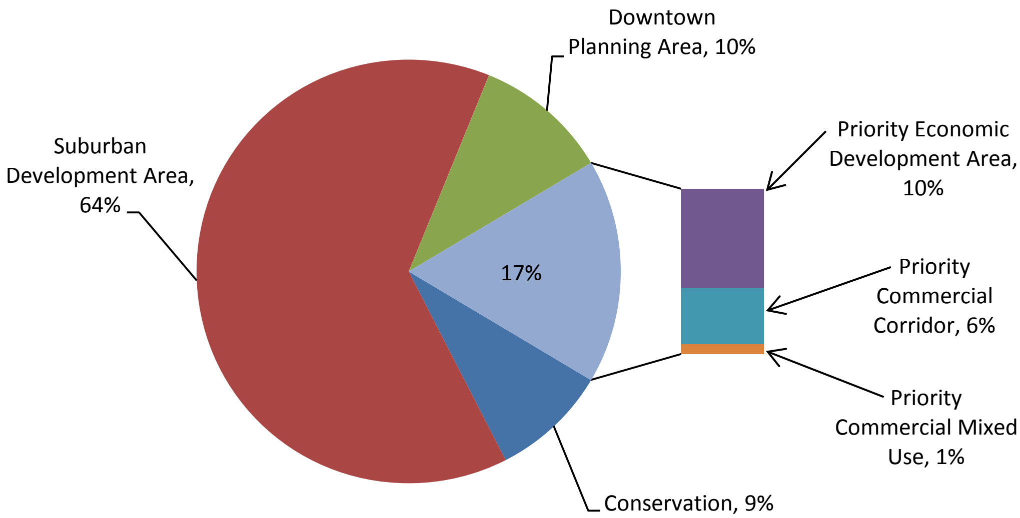
Within the 6,280-acre Turkey Creek watershed, approximately 31 acres are owned by Sumter County and 174 acres are owned by the City of Sumter. See Appendix E, Local Government Owned Parcels Map.

2.2.2 Future Growth and Land Use Changes

The Sumter 2030 Comprehensive Plan predicts that over the near term, the City and County will experience slow, even, flat growth. Most of the growth is expected to the north and west of the City of Sumter, toward Shaw Air Force Base, rather than east toward I-95.

Figure 2-7, below, is a breakdown of future land use for the Turkey Creek watershed based on the 2030 Comprehensive Plan. Approximately 64% of the Turkey Creek watershed is placed in the future land use category for Suburban Development to encourage mixed use at medium densities in these areas. Priority Investment Areas are identified in the Comprehensive Plan in an effort to better identify, direct and concentrate new development opportunities to these areas. Immediately adjacent to Turkey Creek, the majority of the land is designated as Conservation Planning Area, which demonstrates the County/City commitment to protecting and restoring Turkey Creek. Appendix F, Future Land Use Map, shows 2030 Comprehensive Plan future land uses for the Turkey Creek watershed.

Figure 2-7: Turkey Creek Future Land Use



2.2.3 Demographics

Sumter County has a total population of 107,456. The City of Sumter, with a population of 40,524, makes up 38% of the County's population. The City and County share similar demographics as shown in Figures 2-8 and 2-9 below.

The racial makeup of the City and County are nearly split between African American and White. By gender, the City/County is approximately 48% male and 52% female. The population breakdown by age shows 26% under the age of 18, and 14% age 65 or older. The remaining 61% of the population is between 18 and 64 years old, the typical working age range. The median household income for the City of Sumter is $37,409; however, for the County overall, the median household income is $40,542.

Figure 2-8: City of Sumter Demographics

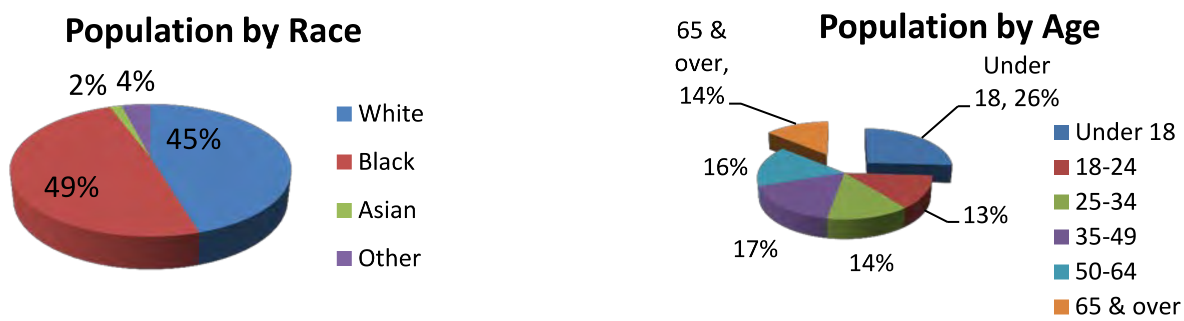
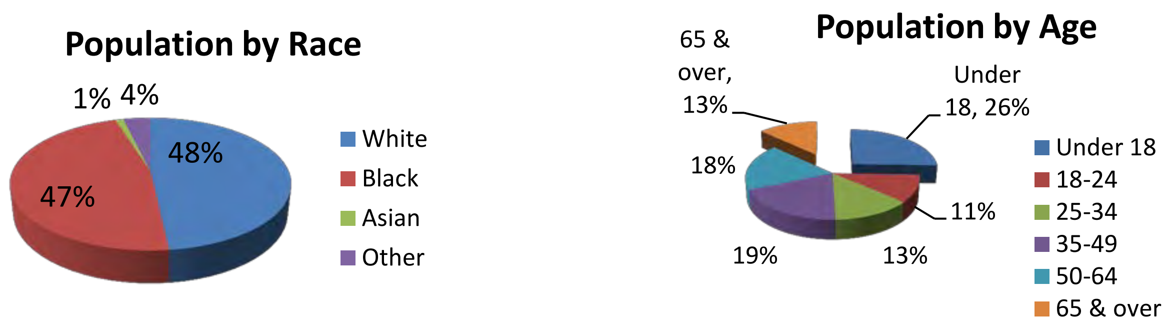


Figure 2-9: Sumter County Demographics



2.3 WATERBODY AND WATERSHED CONDITIONS

2.3.1 Water Quality Standards

Turkey Creek is designated as freshwater 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 percent of samples collected and analyzed for fecal coliform bacteria exceeded 400 cfu/100 mL.

In June 2012, *Escherichia coli* (*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 Total Maximum Daily Load (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. TMDLs for fecal coliform and *E. coli* have been established for the Turkey Creek watershed.

2.3.2 Water Quality Monitoring Stations

The Turkey Creek watershed is monitored by SCDHEC at two Water Quality Monitoring (WQM) Stations, PD-098 and PD-040, on Turkey Creek.

Both WQM Station PD-098 and PD-040 exceeded the Water Quality Standard (WQS) of 400 cfu/100 mL for fecal coliform bacteria in samples collected from 1998 through 2002. At PD-098, 6 of 9 samples (67%) exceeded the WQS, and at PD-040, 6 of 8 samples (75%) exceeded the WQS. The WQM stations were placed on the 2004 §303(d) list for impairment due to fecal coliform exceedances.

WQM Station PD-040 is also listed on the 2012 §303(d) list for Fish Consumption due to mercury contamination and for impairment of Aquatic Life Use due to dissolved oxygen excursions and exceedances of the aquatic life criterion for ammonia.

2.3.2.1 PD-098 Turkey Creek at Liberty Street in Sumter above Santee Print Works

Water Quality Monitoring (WQM) Station PD-098, located in Turkey Creek at Liberty Street, monitors the upper reaches of the Turkey Creek watershed, a total of approximately 4.5 miles of stream reach. The watershed of PD-098 covers a 1,204-acre drainage area that flows into Turkey Creek and its tributaries from near the intersection of Lee Street and Colonial Drive. A portion of the urbanized area of the City of Sumter is contained within the watershed. The predominant land uses are Open Space Development (27%) and Low Intensity Development (24%). The majority of the watershed is comprised of developed lands (68.5%). There are no active animal feeding operations (AFOs). The estimated median flow rate is very low, at 1.1 cfs, and ranging from 0 to 8.3 cfs. Monitoring data at this station appears to indicate an association between increased fecal coliform loading and surface runoff related to rainfall.

2.3.2.2 PD-040 Turkey Creek at US 521

Water Quality Monitoring (WQM) Station PD-040 is located downstream of PD-098 in Turkey Creek at U.S. Route 521 in the City of Sumter, Sumter County. The watershed of PD-040 contains approximately 4,303 acres and 17.5 miles of stream reach. The predominant land uses are Woody Wetlands (26%) and Open Space Development (20%). Approximately 43% of the watershed is comprised of developed lands. The estimated medium flow rate is 3.7 cfs, ranging from 0.2 to 27.8 cfs. Monitoring data shows that fecal coliform exceedances at PD-040 occurred under both wet and dry conditions. PD-040 drains into the Pocotaligo River approximately 0.5 miles south of the City of Sumter, within the limits of Sumter County.

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 TMDLs for fecal coliform bacteria for WQM Stations PD-098 and PD-040 on Turkey Creek.

2.3.4 Pocotaligo River and Tributaries TMDL

In 2012, the State of South Carolina replaced fecal coliform bacteria with *E. coli* as the bacterial indicator species for fresh waters. In June 2013, SCDHEC issued the Total Maximum Daily Load Document for the Pocotaligo River and Tributaries (2013 TMDL Document), which includes revised TMDLs for Turkey Creek WQM Stations PD-098 and PD-040. In addition to addressing fecal coliform bacteria impairments, the 2013 TMDL document includes TMDLs for *E. coli* based on conversions of fecal coliform data and the new numeric recreational standards for *E. coli*. Future TMDLs will be calculated based on actual *E. coli* data once sufficient data are collected from impaired stations.

2.3.5 TMDL Goals for Turkey Creek

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 94% at PD-098 and 75% at PD-040 to restore and maintain the water quality in Turkey Creek.

Additional monitoring data collected since the date of the Report, indicates that fecal coliform bacteria continue to be exceeded at both PD-098 and PD-040.

The 2013 TMDL Document revised the TMDL goals for PD-098 and PD-040 based on monitoring data collected from 1999 through 2008. For purposes of implementation of the current recreational use standard, the 2013 TMDL Document also includes converted *E. coli* TMDLs for these stations. The revised percent reduction goal for fecal coliform bacteria and *E. coli* at PD-098 is 81% based on stream flows during moist conditions. Downstream at PD-040, the revised percent reduction goal is 88% based on stream flows during mid-range conditions. Table 2-1 shows the September 2005 and Revised May 2013 percent reductions for each station.

Table 2-1: TMDL Percent Reduction Goals

Turkey Creek Water Quality Monitoring Station	Percent Reduction September 2005	Revised Percent Reduction May 2013
PD-098	94%	81%
PD-040	75%	88%

2.4 POLLUTANT SOURCES

Fecal coliform bacteria and *E. coli*, both coliform bacteria, live in the intestines of warm-blooded animals. Although generally not harmful, these coliform bacteria may indicate the presence of disease-carrying organisms, which live in the same environment as the coliform bacteria. Water samples with high concentrations of fecal coliform or *E. coli* bacteria are indicators of recent human or animal waste contamination.

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 Turkey Creek Watershed. However, portions of the Turkey Creek watershed are within the designated MS4 urbanized areas of the City of Sumter and Sumter County, and the SCDOT MS4. 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 Sumter-Pocotaligo WWTP collection system, located partially within the PD-040 and PD-098 drainage basins, reported SSOs in 2002. Three of the SSOs discharged to ditches or canals draining to Turkey Creek.

There are three permitted landfill facilities and one minor industrial wastewater discharger in the Turkey Creek watershed.

2.4.2 Non-Point Sources

Potential nonpoint sources of fecal coliform within the Turkey Creek watershed include wildlife, agricultural activities and domesticated animals, land application fields, urban runoff, failing On Site Wastewater Disposal (OSWD) systems, and pets.

The fecal coliform contribution from wildlife and farm animals is expected to be minor, with an estimated deer density of 15 to 30 deer per square mile and an estimated 72 head of cattle in the watershed.

The density of OSWDs for the PD-040 watershed is 11 per 100 acres, which is considered excessive and a potentially significant source of fecal coliform loading. Upstream at PD-098, the OSWD density is only 3 per 100 acres. More than 95% of OSWD's are septic systems. 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. Fecal coliform loading from failing OSWD systems can enter streams in stormwater runoff or through groundwater springs and seeps.

In urban areas, domestic pets are the primary source of *E. coli* and other fecal coliform bacteria. The estimated daily dog waste produced in Sumter County is 5.2 tons per day. PD-040 and PD-098 occupy a small portion of the acreage in Sumter County, however pet populations are higher in urbanized areas and can be a significant source of fecal coliform loading.

Because of SSOs and high OSWD system density, human sources likely play a major role in fecal coliform loadings in the Turkey Creek watershed. The PD-040 watershed is regarded as one of the most degraded watersheds according to the 2005 Technical report. Due to the similarity in land use and the proximity of PD-098, the upstream reaches of Turkey Creek may be contributing to the fecal coliform exceedances at PD-040.

Section 3

WATERSHED ANALYSIS

This section describes the components of the watershed analysis for Turkey Creek, and the major findings.

3.1 WATERSHED MANAGEMENT GOALS

The Turkey Creek watershed is currently threatened by impairment from fecal coliform and *E. coli* bacteria. *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, the presence of fecal coliform or *E. coli* in surface waters is an indication of recent human or animal waste contamination and the quantity of disease-causing organisms potentially present. The State of South Carolina recently replaced fecal coliform bacteria with *E. coli* as the bacterial indicator for predicting the presence of pathogens in South Carolina fresh waters. The State of State's Water Quality Standards (WQS), effective June 22, 2012 include maximum levels of *E. coli* bacteria.

The goal of the Turkey Creek Watershed Plan is to identify current and potential threats to water quality within the Turkey Creek watershed, including areas beyond the MS4 boundaries. The Sumter County Stormwater Department and the City of Sumter Stormwater Department will utilize the results of the watershed analysis to identify the locations and types of Best Management Practices and other projects that will be the most effective in reducing fecal coliform and *E. coli* loading in Turkey Creek. The City and County each will be responsible for implementation of projects within its own jurisdiction. Projects will be prioritized and implemented according to funding availability.

3.2 DETAILED WATERSHED ASSESSMENT

3.2.1 Subwatershed Assessment

The Turkey Creek watershed consists of eight (8) primary drainage basins, hereby referred to as SW-1 through SW-8.

SW-1 consists primarily of residential and commercial development and is located almost entirely within the City limits of Sumter. This watershed has historically been a source of high fecal coliform levels and potential sources include illegal dumping, leaking sanitary sewer systems and pet waste. This watershed includes the entirety of drainage to PD-098. Investigation of this watershed indicated the presence of a high amount of stagnant water in drainage ditches and swales, which could be contributing to the propagation of bacterial growth within the watershed. This watershed was also identified as being an area of high flood concern by the City, with a significant number of older slab homes that become inundated during rainfall events. The source of this flooding was determined to be two-fold. First, the drainage network within the area of the watershed is insufficient to adequately drain significant storm events. Secondly, all drainage through this watershed drains through a railroad culvert along East Liberty Street. During runoff events, the drainage from the City bottlenecks at this culvert and causes backwater up into the residential neighborhood. This can lead to concentration of bacteria in the system as a result of inundation of the storm sewer system through this area. Resulting water quality evaluation indicated that this watershed is the prime source of bacterial loading within the entire Turkey Creek watershed.

SW-2 and SW-3 are primarily a mix of commercial and residential development. The side tributaries have somewhat adequate drainage to convey flows through Turkey Creek, and flooding impacts are rather limited in this watershed. Water quality evaluation of this watershed identified sanitary sewer as the primary disposal mechanism in the watershed. Historic sanitary sewer leakage had been identified within the watershed. However, at the time of this evaluation, no active leakage or seepage was observed. It was determined that the primary source of fecal coliform loading within these watersheds were animal waste, illegal dumping and periodic sanitary sewer overflows.

SW-4, SW-5, SW-7 and SW-8 are along the lower reaches of the Turkey Creek watershed. The majority of the landuse within these watersheds is agriculture and residential development. The agricultural activities are primarily row crops, and bacterial loading from these activities is considered minimal. Historically, some of these areas have been used as reuse areas for manure respreading, but activities have been complete in accordance with State regulations. Septic systems with these watersheds, based on field investigation, appeared to be functioning property and not contributing significant pollutant loading to Turkey Creek. Water quality investigation reflected the field assessment, identifying these watersheds as having very low bacterial input into the system.

SW-06 is primarily a residential watershed with a mix of sanitary sewer and septic disposal systems. Evaluation of this watershed indicated that the water quality is of good quality and little bacterial input is seen from this portion of the watershed. Additionally, this watershed has high buffer quality and the development is set back from the banks of Turkey Creek more so than any of the upstream watersheds. Water quality assessment indicated the presence of low bacteria levels and it was determined that the potential loading form this watershed s primarily from illegal dumping and animal (wildlife and pet) contributions.

3.2.2 Reach Assessment

Forty-five stream reach segments within the Turkey Creek watershed were defined and evaluated using the Unified Stream Assessment Reach Level Assessment Form. Eleven (11) of the reaches are located on Turkey Creek, and the remaining 34 reaches are located on tributaries of Turkey Creek.

Each reach was assigned a score for Stream Condition based on in-stream habitat, vegetative protection, bank erosion and floodplain connection. A Buffer & Floodplain Condition score was also assigned based on an evaluation of the vegetated buffer width, floodplain vegetation, floodplain habitat and floodplain encroachment. The two scores were combined for a Total Survey Reach Score, and each stream reach received ratings ranging from Optimal to Poor, as shown in Table 3-1, below.

Table 3-1: Stream Reach Scoring Criteria

Stream Reach Rating	Stream Condition Score	Buffer & Floodplain Condition Score	Total Score
Optimal	61 - 80	61 - 80	121 - 160
Suboptimal	41 - 60	41 - 60	81 - 120
Marginal	21 - 40	21 - 40	41 - 80
Poor	0 - 20	0 - 20	0 - 40

Appendices G, H and I are color-coded reach maps indicating the In-stream Condition, Buffer/Floodplain Condition and Total Survey Reach.

As part of the reach assessment, the left and right bank of each reach, facing downstream, was evaluated to determine the major land usage for that section. The Reach Identification Numbers and adjacent land uses are shown on Appendix J, Existing Land Use Reach Map.

3.2.2.1 Reaches of Turkey Creek

The eleven Turkey Creek reaches are shown in Table 3-2 below. These reaches were evaluated for stream health and buffer and floodplain condition.

Stream condition reflects the relative health of the stream itself. This includes the stability of the stream bank, suitable habitat within the stream and the absence or presence of significant sediment deposition within the stream. This is an important indicator with respect to stream health in that the presence of biological activity can aid in the treatment and removal of bacteria within the stream reach. However, the presence of erosion and sediment reduces the habitat for these microorganisms and reduces the pollutant removal capacity of the stream.

Buffer and floodplain condition reflects the diversity and width of the overall floodplain area of the stream. Good buffer width and vegetation growth is critical in filtering harmful pollutants prior to discharge into the stream system. Where poor buffers are present, there is little ability to naturally filter runoff and bacteria can enter the stream system with very little treatment. Additionally, connectivity to an active floodplain allows for water to be spread over a wider area that can be naturally treated by adjacent wetlands and vegetation within the floodplain.

Four (4) of the reaches are rated as Marginal. This indicates that the reaches are not providing optimal water quality benefits within the watershed from both a stream condition and buffer treatment capacity. From this evaluation, it was determined that these four stream reaches would be good candidates to receive stream restoration practices and buffer enhancement to increase the overall natural treatment capacity of the system.

Table 3-2: Turkey Creek Reach Assessment

REACH ID	DESCRIPTION	Stream Condition Subtotal	Buffer & Floodplain Condition Subtotal	Total Score
21	Turkey Creek 1	37	41	78
24	Turkey Creek 2	47	50	97
26	Turkey Creek 3	44	36	80
27	Turkey Creek 4	62	49	111
28	Turkey Creek 5	43	40	83
30	Turkey Creek 6	50	45	95
31	Turkey Creek 7	31	24	55
32	Turkey Creek 8	49	42	91
43	Turkey Creek 9	33	33	66
44	Turkey Creek 10	36	49	85
45	Turkey Creek 11	43	47	90

The land usage on the left bank of Turkey Creek differs greatly from that on the right bank. Figure 2-4 below shows that major land uses for the left bank of Turkey Creek are Single Family Residential (45%), Forest (27%) and Vacant Land (18%). However, as shown in Figure 2-5, the land use on the right bank is split nearly evenly between Commercial, Vacant Land and Forest, with less than 10% of the area used for Single Family Residential.

Figure 3-1: Major Land Use Types – Left Bank Reaches

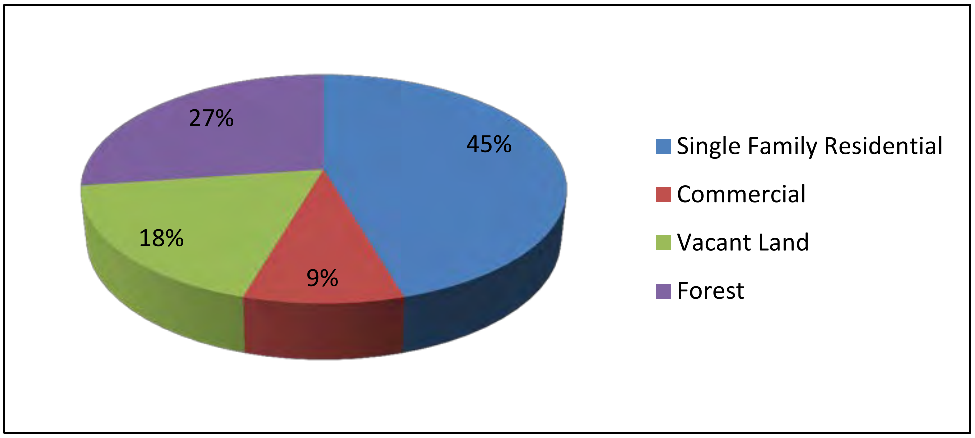
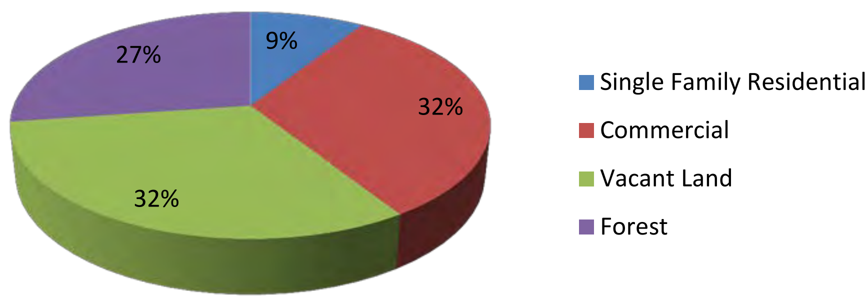


Figure 3-2: Major Land Use Types – Right Bank Reaches



Appendix K, Future Land Use Reach Map, shows the future land use of the reaches of Turkey Creek and its tributaries. The majority of the reaches of Turkey Creek are located within designated Conservation Planning Areas, whereas the future land use areas for the tributaries are more varied. The purpose of designated conservation areas is to protect and preserve environmentally sensitive natural resources including floodplains, streams, wetlands, water bodies and established natural recreational areas from encroachment due to residential, industrial or commercial development.

3.2.2.2 Reaches of Tributaries of Turkey Creek

Thirty-four tributary reaches were defined and evaluated for the stream conditions addressed above. The reaches are shown in Table 3-3 below. Two (2) of the reaches are rated as Optimal, and twenty-one (21) are Marginal. Four (4) of the reaches received a rating of Poor for Buffer & Floodplain Condition. The twenty-one stream reaches that are marginal have been identified for stream restoration to increase their overall natural treatment abilities for pollutants within the watershed.

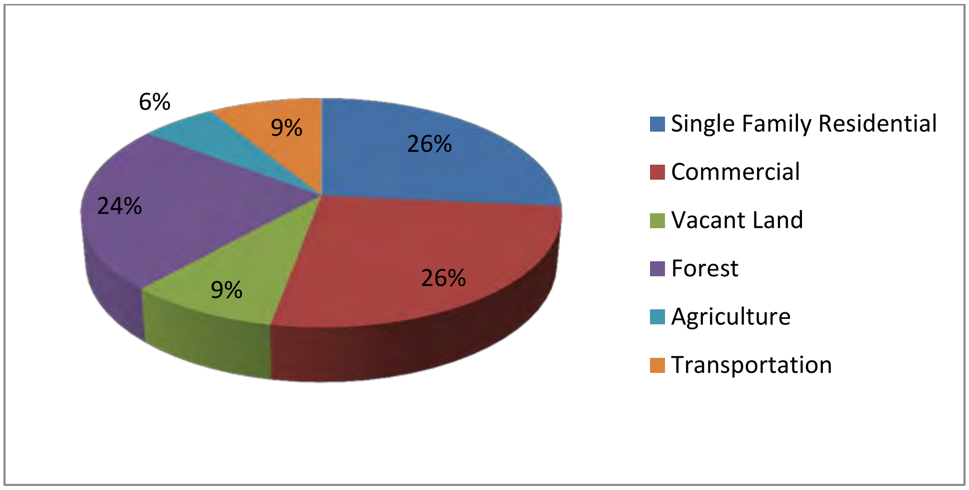
Table 3-3: Reach Assessment for Tributaries

REACH ID	DESCRIPTION	Stream Condition Subtotal	Buffer & Floodplain Condition Subtotal	Total Score
01	Crosswell Orphanage Ditch	41	34	75
02	Crosswell to Lafayette	42	28	70
03	Charlotte to Loring	42	22	64
04	Lafayette to Loring	26	37	63
05	Commerce to Calhoun	62	8	70
06	D" Ancona Drive	38	39	77

REACH ID	DESCRIPTION	Stream Condition Subtotal	Buffer & Floodplain Condition Subtotal	Total Score
07	Main Channel, Calhoun to Commerce Ditch	42	23	65
08	Commerce St Ditch	42	29	71
09	Main Channel, Commerce Ditch to CSX	49	32	81
10	Ditch paralleling North of Railroad from Liberty	45	41	86
11	Ditch from behind C & C Recycling	41	29	70
12	CSX to Hwy 76	41	22	63
13	76 to Boulevard	41	22	63
14	Ditch behind Eastwood Pk	42	18	60
15	Boulevard to Houser	34	17	51
16	Houser to Fulton	48	28	76
17	Ditch opposite Hannah St	55	66	121
18	Drainage ditch from Brooklyn St	50	59	109
19	Ditch behind Dyer factory	58	66	124
20	Fulton St.	31	35	66
22	Industrial Blvd.	48	50	98
23	Ditch paralleling Eugene	50	42	92
25	Hodge	45	51	96
29	High St.	57	35	92
33	Reaves St.	44	28	72
34	Trash Ditch	25	32	57
35	Railroad	44	22	77
36	Curtis 3	48	51	99
37	Curtis 2	48	19	67
38	Curtis 1	42	24	66
39	Snake Cr 4 Mooneyham to Turkey Creek	48	52	100
40	Snake Cr 3 RR to Mooneyham	48	57	105
41	Snake Cr 2 Montana to RR	46	37	83
42	Snake @ Blvd to Montana	39	38	77

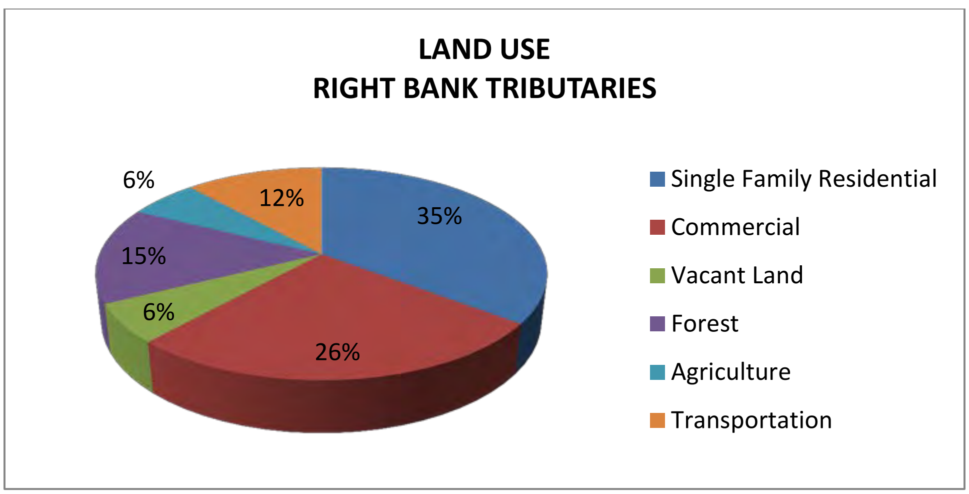
Figure 3-3, below, shows that major land uses on the left banks of the tributaries are a combination of Single Family Residential (26%), Commercial (26%), and Forest (24%), with the remainder as Agriculture, Transportation and Vacant Land. Land usage for the right banks is 35% Single Family Residential. The right banks also have Commercial land use of 26%, with the remainder as Vacant Land, Forest and Agriculture, as shown in Figure 3-4.

Figure 3-3: Major Land Use Types – Left Bank Tributary Reaches



As shown in Appendix K, Future Land Use Reach Map, the reaches of the Turkey Creek tributaries lie within various land use types. The longest reaches, in the southeastern portion of the watershed, are within the designated Suburban Development Area. These areas are intended for mixed use development at medium densities, including residential, commercial and recreational and employment uses, with new development to be served by public utilities.

Figure 3-4: Major Land Use Types – Right Bank Tributary Reaches



3.3 WATER QUALITY ANALYSIS

The approved TMDL for Turkey Creek and the Pocotaligo River provides load reduction requirements for the Turkey Creek watershed based on samples collected at SCDHEC WQM stations PD-098 and PD-040 between the years 1999 and 2008. Since this is a limited data set, a goal of the County was to collect and analyze water quality samples throughout the Turkey Creek watershed prior to and following the development of the Turkey Creek Watershed Plan so that existing conditions can be compared to future changes as the watershed plan is implemented.

The County has collected grab samples from three (3) locations along Turkey Creek since February 2012. The Falls near Fulton Street is located nearest the headwaters of Turkey Creek at the junction of drainage areas two, three and four; the Power Line near Red Bay is located in drainage area six; and the Highway 521 Bridge station is located at the watershed outlet at the intersection of Turkey Creek and US Highway 521 South near SCDHEC WQM station PD-040.

In total, samples were collected on fifty-one (51) separate days between February 15, 2012 and September 5, 2013. A map of the sampling locations is included in Appendix N, Water Quality Monitoring Stations Location Map. Event Mean Concentration (EMC) values were then calculated as the average of these sampling results for each station. The results of these monitoring efforts are summarized in Table 3-4. EMC results at each of the three monitoring locations exceed the SCDHEC standard of 400 cfu/100mL. Unfortunately, due to that fact that Turkey Creek flows through the center of the watershed receiving lateral inflow from all sides the results from these sampling efforts cannot be directly attributed to one particular drainage basin. However, it appears that the majority of the pollutant loading is attributable to drainage areas upstream of The Falls monitoring station.

Table 3-4: Sumter County Fecal Coliform Sampling Results (cfu/100mL)

Date of Sample	The Falls Near Fulton Street	Power Line Near Red Bay	Highway 521 Bridge
02/15/12	---	1	---
03/06/12	250	---	---
03/08/12	---	---	70
03/19/12	995	170	50
04/02/12	500	350	30
04/12/12	60	90	10
04/16/12	30	120	40
04/19/12	140	60	10
04/24/12	340	1500	50
04/26/12	160	60	10
05/01/12	170	110	30
05/03/12	240	420	150
05/08/12	160	400	140
05/14/12	4400	6600	8400
05/30/12	4600	7200	4100
06/04/12	8000	2000	50
06/11/12	42000	40000	10000

Date of Sample	The Falls Near Fulton Street	Power Line Near Red Bay	Highway 521 Bridge
11/15/12	4600	9600	440
02/12/13	2420	2420	2420
02/13/13	1300	981	1300
02/14/13	291	262	291
02/22/13	0	100	0
02/25/13	100	100	0
02/26/13	1870	1810	100
02/27/13	690	687	2420
02/28/13	388	91	185
03/12/13	1554	2420	173
03/13/13	89	37	2420
03/19/13	249	388	---
03/20/13	617	102	326
03/25/13	1120	1204	1340
04/01/13	980	3730	134
04/02/13	156	215	1987
04/04/13	30	91	35
04/05/13	1047	771	1554
04/29/13	11060	7890	11120
05/20/13	691	22820	43520
06/06/13	215	2130	2460
06/07/13	13960	11620	5830
06/10/13	1120	1554	970
06/11/13	2230	1690	3090
07/01/13	12960	12230	8800
07/02/13	8620	---	---
07/03/13	15000	4640	2720
07/04/13	---	2230	---
07/05/13	---	---	1610
07/12/13	7490	16500	8820
08/16/13	15150	---	---
08/17/13	---	10810	---
08/18/13	---	---	4880
09/05/13	411	---	---
EMC	**3743**	**4050**	**3072**

Pollutant loading measured at the Falls near Fulton Street can be associated with SW-1, SW-2 and a portion of SW-3. Therefore, this EMC value was used for computing the annual pollutant loading for these three sub-watersheds.

The calculated EMC value increases as Turkey Creek flows from The Falls to the Power Line monitoring station, indicating that additional pollutant loading can be attributed to the sub-watersheds downstream of The Falls. Assuming that no degradation of the pollutant loading occurs between The Falls and the Power Line, then the difference in EMC values of these two stations is the EMC attributable to the drainage areas contributing to the Power Line station, but not contributing to pollutant loading at The Falls. Therefore, an EMC of 307 cfu/100mL is assumed to be the EMC for SW-4, SW-5 and SW-6.

This approach does not work for estimating pollutant loads in SW-7 and SW-8 because the EMC decreases as Turkey Creek flows from the Power Line to the Highway 521 Bridge, indicating that some treatment, or degradation of the bacteria, is being provided as the runoff flows through Turkey Creek. Additional, but sparse, sampling efforts were conducted throughout the County including sampling at the outfall of Snake Creek (Outfall # 8110457), a tributary to Turkey Creek which drains SW-7. The EMC for Snake Creek was calculated from three (3) samples collected in February 2013 as shown in Table 3-5. This EMC value was used to estimate the annual pollutant loading for SW-7 and SW-8.

Table 3-5: Sumter County Fecal Coliform Sampling Results for Snake Creek (Outfall #8110457) (cfu/100mL)

Date of Sample	Snake Creek (Outfall # 8110457)
02/13/13	143
02/26/13	750
02/27/13	136
EMC	**343**

Using these EMC results the County was then able to develop annual pollutant load estimates for fecal coliform within the Turkey Creek 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 Turkey Creek watershed in Table 3-6, and the total estimated annual load for fecal coliform in Turkey Creek is 4.09E+14 lb/yr. 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 Turkey Creek 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 in Turkey Creek

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 (%)
1	1508.22	3743	1.54E+11	2.33E+14	2.08E+14	89.3%
2	173.59	3743	1.54E+11	2.68E+13	2.39E+13	89.3%
3	631.74	3743	1.56E+11	9.84E+13	8.79E+13	89.3%
4	830.50	307	1.21E+10	1.01E+13	Meets Standard	Meets Standard
5	444.41	307	1.21E+10	5.37E+12	Meets Standard	Meets Standard
6	507.26	307	1.22E+10	6.20E+12	Meets Standard	Meets Standard
7	1729.09	343	1.33E+10	2.29E+13	Meets Standard	Meets Standard
8	454.78	343	1.32E+10	6.02E+12	Meets Standard	Meets Standard
Turkey Creek Total Estimated Annual Load				**4.09E+14**	**3.08E+14**	**75.5**

3.4 WATERSHED RESTORATION FIELDWORK AND PRIORITIZATION

The Turkey Creek watershed is an urban watershed that crosses the jurisdictional boundary between the City of Sumter and the Sumter County. Numerous City-owned and County-owned properties were identified and investigated as potential stormwater management sites for water quality treatment. Following is a list of sites reviewed for this project:

3.4.1 County-owned Sites:

1. Industrial Road and Fulton Street. This is a 16.92-acre former industrial site, located in SW-3. The property is overgrown and in various stages of succession with deteriorating asphalt parking lots and concrete foundations. The existing stormwater network runs near the property boundaries. The site is bordered on the north side by a stormwater ditch running directly to Turkey Creek. On the east, the parcel abuts a privately owned undeveloped parcel located on the west bank of Turkey Creek. The size, elevations, proximity to Turkey Creek and overall nature of the site make it an ideal location for a constructed wetland to treat stormwater runoff from a large portion of SW-3. The County could also explore a partnership with nearby industries or Lemira Elementary School to promote the site for public education and outreach about watershed management and stormwater treatment.

2. Beaver Pond at Snake Creek. Beaver Pond is a former settlement pond adjacent to Snake Creek in SW-7. The existing pond is approximately 200' by 300'. Because Snake Creek has the potential for significant hydrologic impact of Turkey Creek, this location would be an ideal site for a stormwater retrofit. The two vacant lots adjacent to the pond could be acquired for installation of additional BMPs or as a park to showcase the site for public awareness and education on stormwater management.

3. Mooneyham Road and Oklahoma Street. The County owns three (3) single residential lots on Mooneyham Road, and one (1) on Oklahoma Street, a few blocks from Snake Creek, in SW-7. The lots are undeveloped and are disconnected from each other. Due to the small size of the lots and their location, these sites are not considered potential sites for installation of BMPs.

4. Montana Drive and Wyoming Drive. The County owns two adjacent single-lot properties at Montana Drive and Wyoming Drive, both with frontage on Snake Creek in SW-7. The lots are at a public corner and school bus stop. However, the property is wooded, and is not considered a potential BMP site. Vandalism in and around this area is also a concern.

5. County Firehouse. The County Firehouse site is located on Highway 521 at Weatherly Rd, in SW-7. The Firehouse is a high visibility site, and would provide opportunities for education and outreach on stormwater management. However, the property is limited for use as a BMP site due to its small size and location of existing facilities.

3.4.2 City-owned Sites:

1. Brooklyn Street Parcel. This property is a heavily wooded 11-acre tract of land on the west bank of Turkey Creek in SW-3. The thick riparian vegetation provides water quality protection by filtering runoff and groundwater before it enters Turkey Creek. Protection of this property through a conservation easement would maintain the buffer in its natural state in perpetuity, thereby maintaining the water quality of Turkey Creek to help meet the goals of the Turkey Creek Watershed Plan. The conservation easement would also serve to preserve the area as an urban wildlife habitat.

2. Eastwood Park. Eastwood Park is a 9-acre public park with playground located at Eastwood Drive and Boulevard Road. The Park is located in SW-2. A stormwater ditch runs along the northern boundary of the Park. Stormwater enters the ditch from a stormwater pipe on the northeast side of the Park and exits through a stormwater pipe at the northwestern corner of the Park. The ditch also collects runoff from stormwater pipes connected to the adjacent parking lot to the north. Runoff from areas south of the Park also drain to the ditch via a channel that bisects Eastwood Park from the south on Eastwood Drive, intersecting with the main drainage ditch at the northern edge of the Park. The stormwater ditch network flows to Turkey Creek just outside of the northwestern corner of the Park. Multiple sites within the Park have been identified for stormwater BMPs. These BMPs would provide water quality treatment for the drainage currently routed through the Park, and have the added benefit of enhancing the aesthetic features of the Park. Furthermore, public areas such as parks provide prime opportunities for educational kiosks to highlight this project.

3. East Calhoun Street Extension. Two privately-owned parcels situated at the northeastern City/County boundary were identified as a potential location for a major stormwater treatment facility proposed to treat much of the stormwater runoff from SW-1. The adjoining parcels stretch from US Highway 401 (Oswego Highway) to the East Calhoun Street Extension, and encompass a total of 136 acres. The proposed BMP site would ultimately drain to Turkey Creek at Calhoun Street. By treating and managing stormwater flow from SW-1, this project would also minimize the occurrence of streamflow backups at the railroad trestle that crosses Turkey Creek downstream of East Calhoun Street.

4. Turkey Creek from East Calhoun Street to Liberty Street. The banks of Turkey Creek in this area of SW-1 are generally devoid of riparian vegetation. This reach of Turkey Creek has been identified for a potential streambank restoration project to enhance water quality treatment and improve aesthetics.

5. Crosswell Park. Crosswell Park is located at Lafayette Drive & Crosswell Drive, near the headwaters of Turkey Creek in SW-1. This is a small, well-utilized public park with playground, situated adjacent to Crosswell Drive Elementary School. While the Park offers an excellent opportunity for placement of educational kiosks, the elevation is higher than the surrounding terrain, and a stormwater BMP is not viable at this location.

Other County-owned and City-owned properties were identified, but were determined to be less suitable for the initial phases of the watershed plan. These sites may be reconsidered during later phases of plan implementation.

Section 4

MANAGEMENT STRATEGIES

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

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

Bacteria can be inactivated or removed through multiple mechanisms including sorption, sedimentation, filtration, predation and UV light. Best Management Practices (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 re-suspended 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

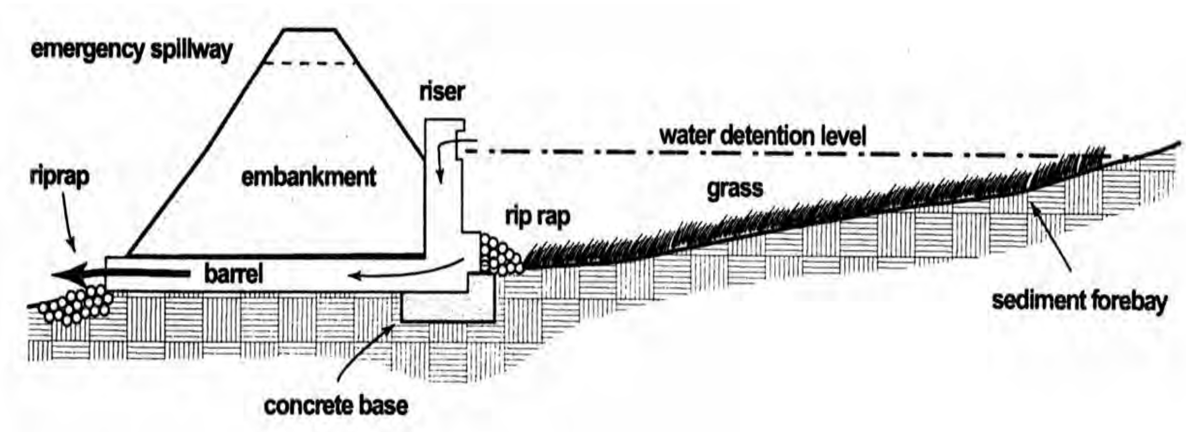


Figure 4-2: Detention (Dry) Pond

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.
  - o Every 5 to 7 years: Remove sediment from forebay.
  - o 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

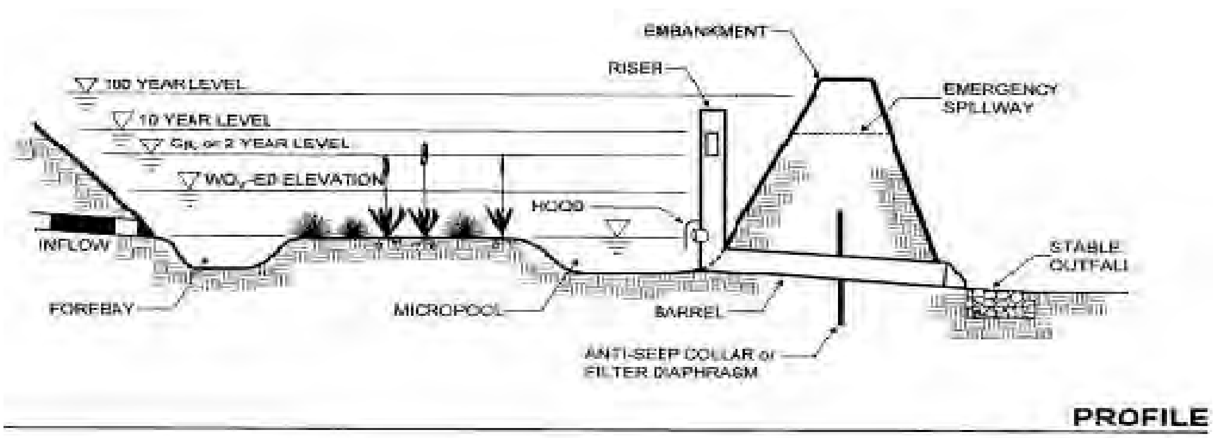


Figure 4-4: Retention (Wet) Pond

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 of 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 the second growing season, replace wetland vegetation to maintain at least 50% surface area 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

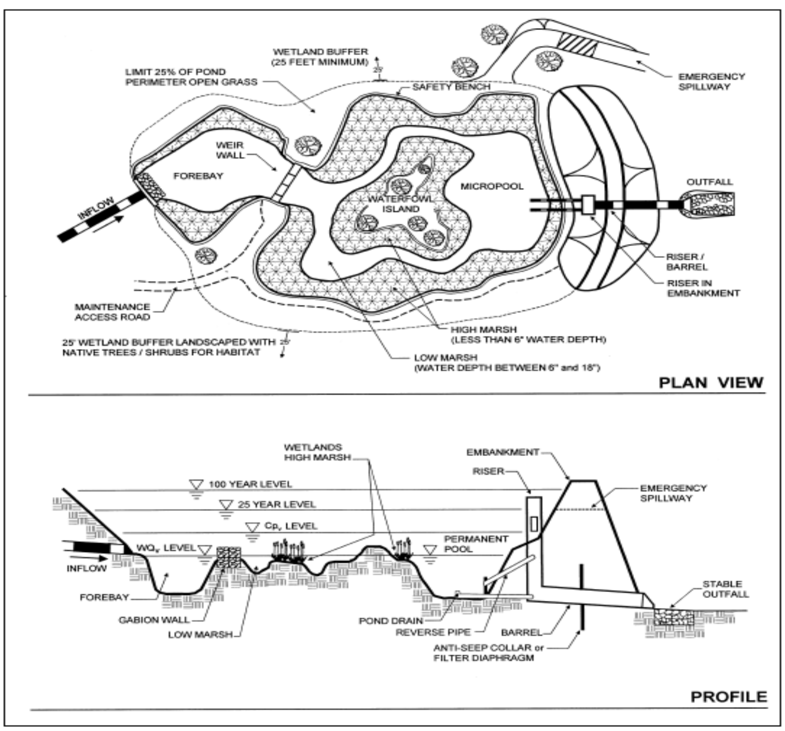


Figure 4-6: Constructed Wetland

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 along with 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

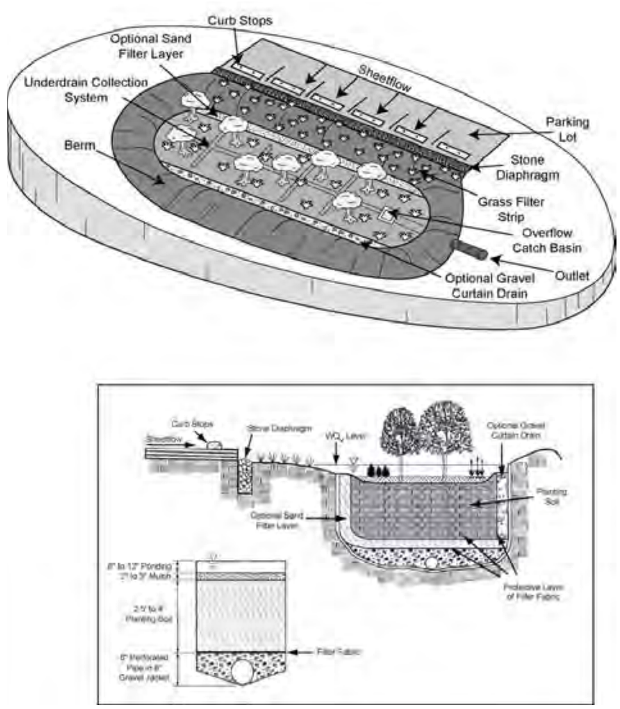


Figure 4-8: Bioretention in a Parking Lot Turnaround

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:

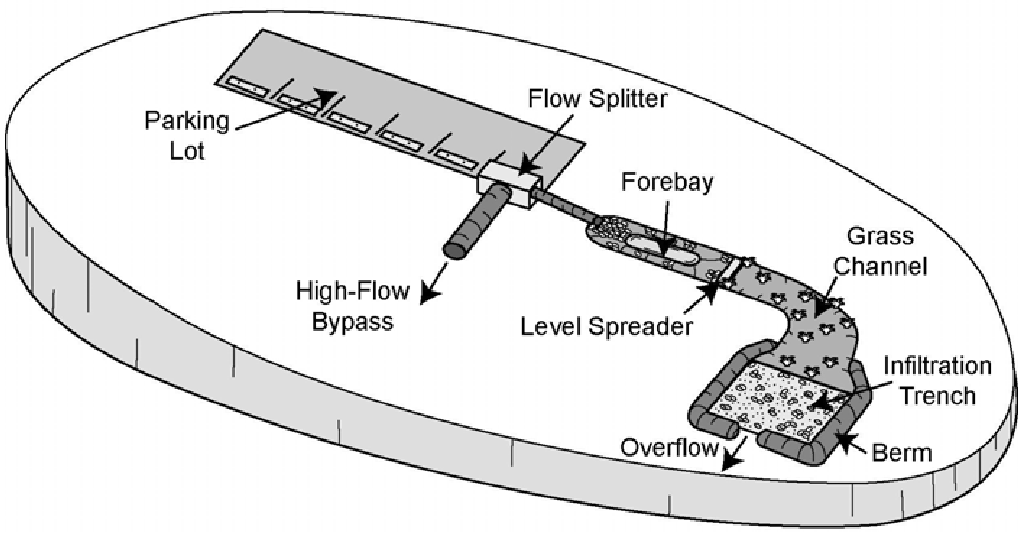
- Significant setbacks may be required from wells, leach fields, and surface waters, etc.

- 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



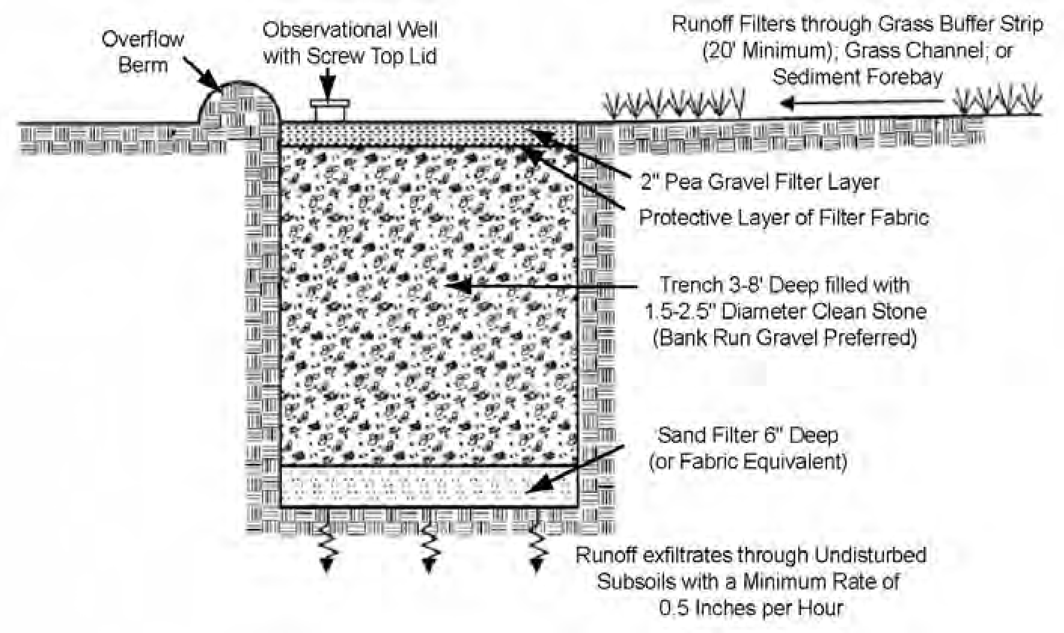


Figure 4-10: Infiltration Trench

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

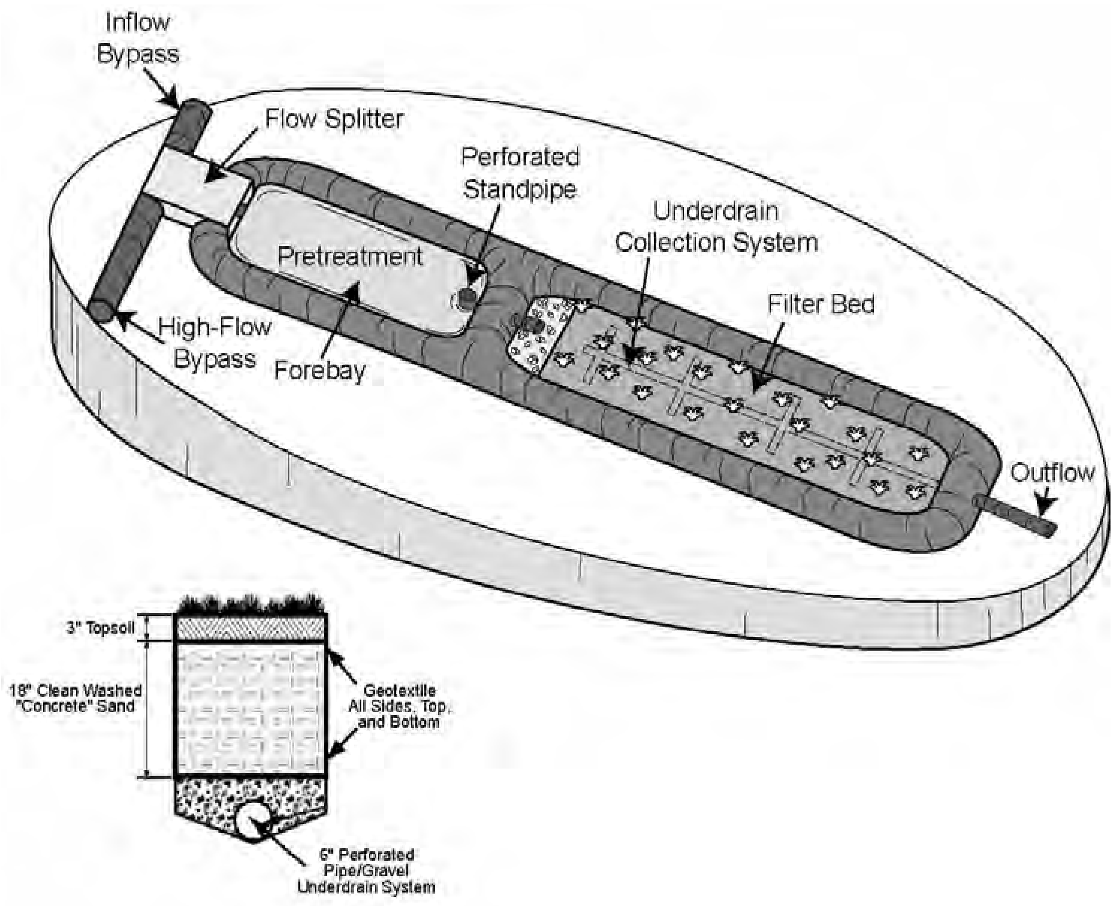


Figure 4-12: Surface Sand Filter

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

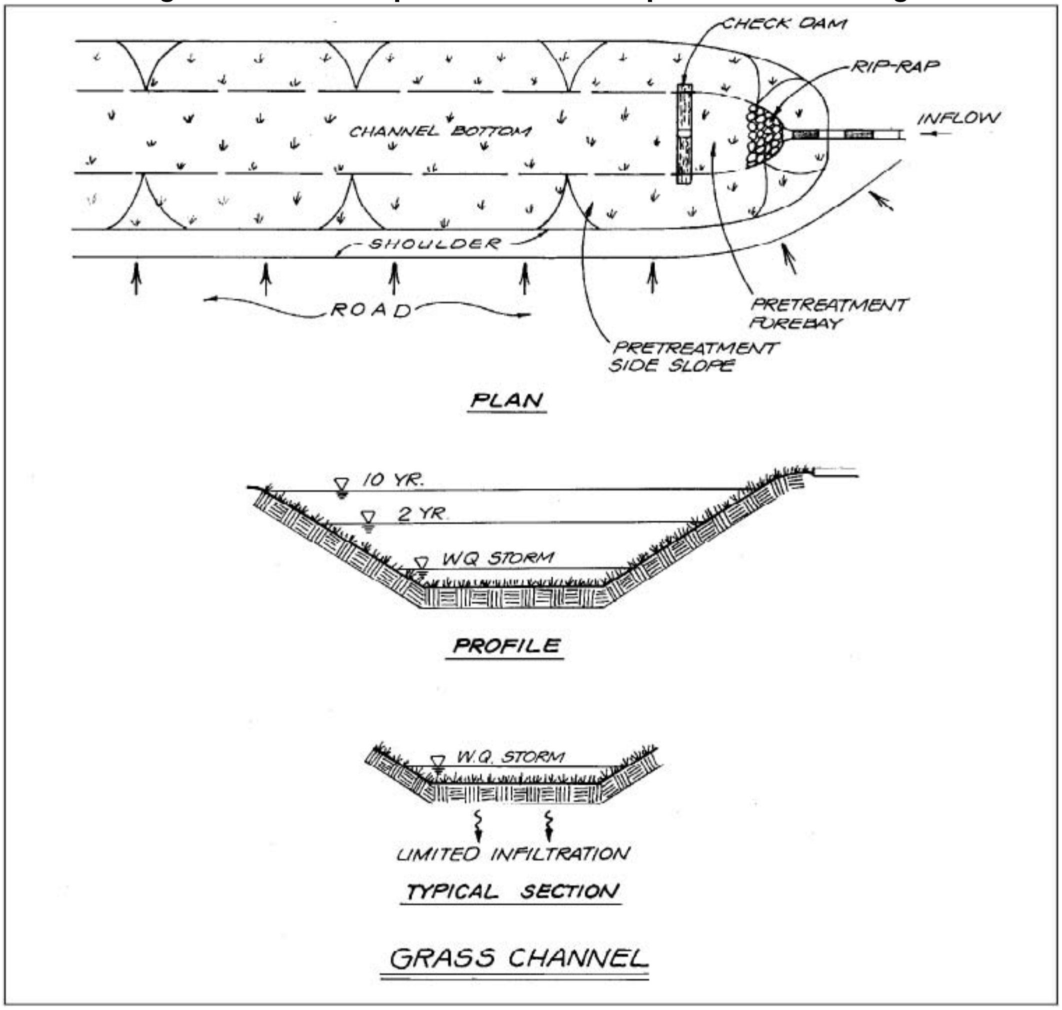


Figure 4-15: Grass-Lined Open Channel

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

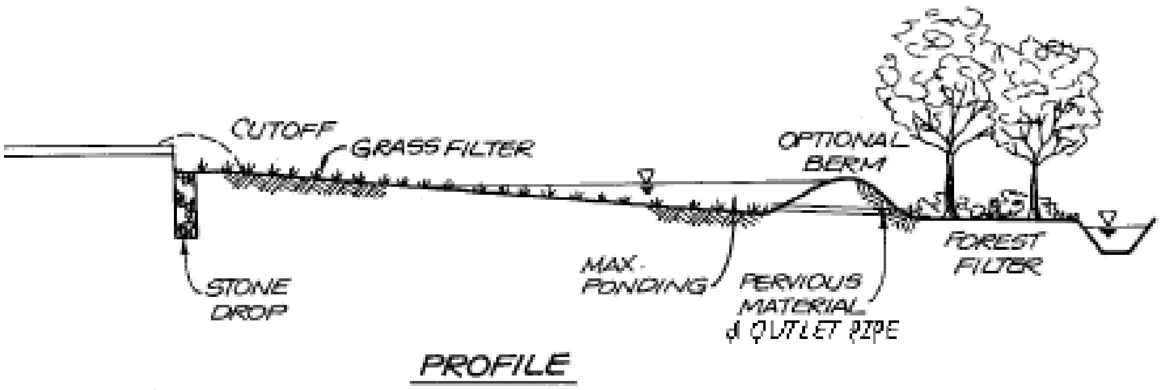


Figure 4-17: Example Grass Filter Pretreatment for an Infiltration Trench

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 into the underlying soils. Swales are useful as part of a treatment train and are often used as pretreatment for other structural 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

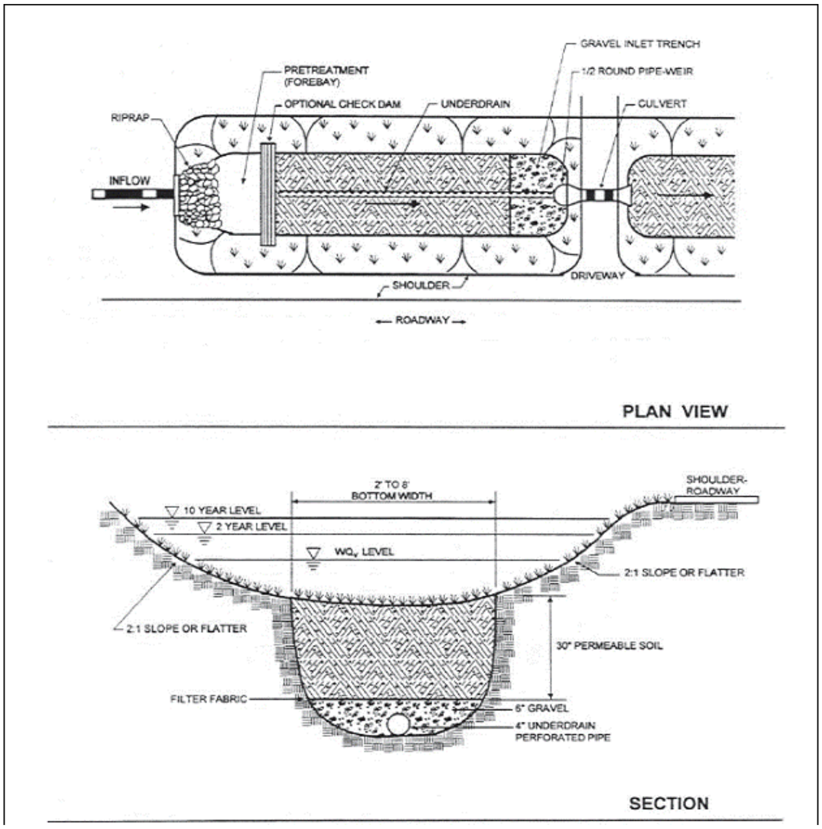


Figure 4-20: Enhanced Dry Swale

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 Box Filter Design

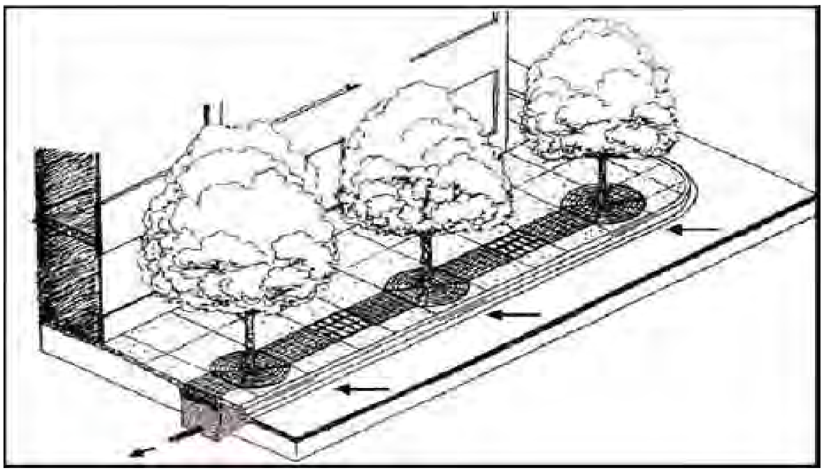


Figure 4-22: Tree Box Filter

4.2 BMP SUMMARY OF BEST MANAGEMENT PRACTICES 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 M 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

The City and County of Sumter currently have established stormwater utilities. As part of providing credits for the utilities, BMP retrofits that utilize established practices for bacterial removal will be given higher credit with respect to reducing the overall utility fee, once the credit systems have been finalized. Additionally, as performance standards are established for water quality as part of the MS4 Permit requirements, the City and County will identify Turkey Creek as a priority area and place additional construction and design requirements. These design requirements will be identified as part of on-going ordinance revisions. The BMPs outlined in this watershed plan should be evaluated for feasibility in each of the development and redevelopment sites within the watershed. When development or redevelopment projects are proposed, the City and County 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 community has a significant problem with illegal trash dumping along some of the rural thoroughfares in the watershed. While steps have been taken as part of the existing stormwater program, the City and County will place a renewed focus on this watershed and increase educational awareness to the impact of illegal dumping. This program will require significant educational outreach activities and increased enforcement of the existing regulations. As part of the establishment of this plan, the County and City intend to develop educational outreach messages to target fishermen and rural residents, all of whom have a direct stake in the health of Turkey Creek. Turkey Creek is a source of fish, both recreational and sustenance, to some members of the community. It is imperative to provide outreach to these individuals.

4.5 OUTREACH AND EDUCATION

In addition to direct outreach mentioned above, both Sumter County and the City of Sumter receive 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 Sumter

County and the City of Sumter Stormwater Consortium, Sumter Stormwater Solutions, is available to the public on the Carolina Clear website at:

http://www.clemson.edu/public/carolinaclear/consortiums/sumter_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 to 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 County-owned or City-owned parcels, the County/City will implement a public awareness campaign for the projects that includes the distribution of printed informational fliers, inclusion of project information on the County or City website and in print media, and educational distribution on the local 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.

4.6 WATERSHED RESTORATION STRATEGIES

The Turkey Creek Watershed Plan is designed to protect the natural resources within the Turkey Creek watershed from fecal coliform and *E. coli* impairment by identifying and mitigating stormwater pollution that could compromise the water quality of Turkey Creek.

A significant portion of the fecal coliform and *E. coli* pollutant loading in Turkey Creek is believed to originate within the Sumter city limits in the northern section of SW-1. All stormwater drainage from this sub-watershed enters Turkey Creek before passing through a single culvert near the intersection of West Liberty Street and the CSX railroad track. The storm drainage network in this mostly residential area consists mainly of open and piped storm sewers for street drainage. This area is near fully developed and provides few opportunities for BMP implementation sites within neighborhoods. Therefore, sites on the periphery of development should be considered where there is potential to divert stormwater flows for treatment before discharging to Turkey Creek.

Results of sampling efforts indicate that bacteria accumulate north of the railroad tracks during dry periods and are then flushed through the lower reaches of Turkey Creek by peak flows of significant storm events. Providing offline treatment of stormwater before it enters this portion of Turkey Creek should reduce fecal coliform and *E. coli* counts below SCDHEC limits throughout the watershed. Through preliminary fieldwork, the City and County have identified four (4) sites for construction of BMPs designed to reduce the levels of fecal coliform and *E. coli* in Turkey Creek along with several sites for linear streambank restoration projects.

Three (3) of these sites will be utilized for constructed wetlands and the fourth site would be a detention pond retrofit project. Two (2) unnamed parcels located between US Highway 401 (Oswego Highway) and East Calhoun Street Extension, Eastwood Park and an abandoned industrial site at East Fulton Street and Industrial Road, have been identified as potential constructed wetland sites, and an abandoned waste treatment pond adjacent to Snake Creek has been identified for potential pond retrofits for stormwater treatment.

Educational kiosks with interpretive signs highlighting the features of the BMP will be installed at each location. Each project will include public meetings throughout the planning and construction process. This will not only provide the public with education on the importance of improved water quality but will provide the communities with ownership of the project. This will help increase the long-term viability of each of the proposed projects.

4.7 RECOMMENDED PROJECTS

4.7.1 East Calhoun Street Extension (SW-1)

The East Calhoun Street Extension site, see Appendix L Exhibit A and B, consists of two (2) large, wooded and vacant, privately-held tracts of land totaling 136 acres located between US Highway 401 (Oswego Highway) and East Calhoun Street Extension just to the east of SW-1. The County has expressed interest in purchasing this site and constructing a large wetland to treat stormwater flows in the upper reaches of Turkey Creek. This constructed wetland would serve as the Phase I of a multi-year, multi-phase, project to re-direct storm drainage from within the City limits through the proposed wetland complex for treatment before discharging to the Turkey Creek canal near its intersection with East Calhoun Street, see Appendix L Exhibit A. In conjunction with the constructed wetland project, the stream restoration from Calhoun Street to East Liberty will be completed as discussed in Section 4.7.5.

Phase II of this implementation project will include stormwater retrofits of existing storm drainage infrastructure to divert runoff from nearby urbanized areas through the wetland complex before draining to Turkey Creek, see Appendix L Exhibit B. This phase will not only be a retrofit of existing storm drainage piping and infrastructure, but it will also include upgrades of existing open drainage to enhanced dry swale facilities further increasing the pollutant removal efficiency within this watershed. A summary of estimated pollutant reductions for the complete implementation of this site is provided in Table 4-1.

Table 4-1: Estimated Load Reductions for E Calhoun Street Extension (SW-1)

BMP Type	*Drainage Area (acres)*	*Estimated Load (lb/yr)*	*Estimated Pollutant Removed (lb/yr)*	*Estimated Load Reduction (%)*
Enhanced Dry Swales	[519.5]	8.02E+13	3.21E+13	31.2
Constructed Wetland	666.5	[7.08E+13]	6.89E+13	50.7
Cumulative Totals	**666.5**	**1.03E+14**	**8.52E+13**	**82.8**

4.7.2 Eastwood Park (SW-2)

Eastwood Park, see Appendix L Exhibit C, is a nine (9) acre City-owned public park located parallel to Eastwood Drive between US Highway 378 (Myrtle Beach Highway) and Boulevard Road in SW-2. Two large drainage canals traverse the park collecting runoff from adjoining parcels. One bisects the park from south to north and one parallels the northern boundary of the park before discharging directly to Turkey Creek.

Several BMPs are recommended for this site including a constructed wetland, infiltration practices, and streambank restoration. The constructed wetland would begin near the confluence of the two (2) drainage canals extending westward towards the outfall to Turkey Creek. The existing drainage canals would be re-aligned to enter the wetland forebay and streambank restoration would be utilized to improve the condition of the drainage canals. Additionally, infiltration trenches would be utilized along the northern boundary of the park where storm drainage enters the canal through several small conduits that drain parking areas and roofs from the adjacent warehouse facility.

Table 4-2: Estimated Load Reductions for Eastwood Park (SW-2)

BMP No.	BMP Type	Drainage Area (acres)	Estimated Load (lb/yr)	Estimated Pollutant Removed (lb/yr)	Estimated Load Reduction (%)
1	Constructed Wetland	28.48	4.39E+12	3.30E+12	62.7
2	Infiltration Trench	5.58	8.61E+11	8.18E+11	15.6
	Cumulative Totals	**34.06**	**5.25E+12**	**4.11E+12**	**78.3**

4.7.3 East Fulton Street Site (SW-3)

The East Fulton Street site is a County-owned parcel located at the intersection of East Fulton Street and Industrial Road in SW-3. The site, shown in Appendix L Exhibit D, is vacant and mostly covered with asphalt and concrete parking areas and foundations. This site would require a significant amount of demolition; however, several large stormwater drainage pipes bypass near or through the property boundaries before discharging directly into Turkey Creek.

A constructed wetland is proposed for this site and could be incorporated into a park or walking trail for adjacent industry employees. Additionally, the existing drainage canal located in the East Fulton Street right-of-way at the northern extents of the site should be retrofit as an infiltration or bioswale complex. The existing canal should be filled in with filter media to treat stormwater flows before they enter Turkey Creek. It may be necessary to include drop inlets and conduits to provide adequate street drainage; however, the complex should be configured to store and treat first flush runoff events. Stream restoration will be completed for the lower section of the drainage channel downstream of the installation of the bioswale complex. This will reestablish a healthy stream system at the confluence with Turkey Creek.

Table 4-3: Estimated Load Reductions for E Fulton Street Site (SW-3)

BMP No.	BMP Type	Drainage Area (acres)	Estimated Load (lb/yr)	Estimated Pollutant Removed (lb/yr)	Estimated Load Reduction (%)
1	Constructed Wetlands	148.86	2.33E+13	1.98E+13	66.6
2	Infiltration Trench	1.00	1.56E+11	1.48E+11	0.6
	Cumulative Totals	**149.86**	**2.33E+13**	**1.57E+13**	**67.2**

4.7.4 Beaver Pond at Snake Creek (SW-7)

The Beaver Pond at Snake Creek, see Appendix L Exhibit E, is an abandoned waste treatment pond located in SW-7 between Boulevard Road and Turkey Creek. The pond was identified by County personnel as a potential candidate for retrofit since it discharges to Snake Creek, a tributary of Turkey Creek. Retrofitting of the detention pond could allow storm runoff from nearby neighborhoods to be re-routed to the pond for treatment prior to entering Turkey Creek. The headwaters of this system, prior to discharge into the pond, will be restored with a stable stream channel and vegetated buffer.

Table 4-4: Estimated Pollutant Reductions for Snake Creek Pond (SW-7)

BMP Type	Drainage Area (acres)	Estimated Load (lb/yr)	Estimated Pollutant Removed (lb/yr)	Estimated Load Reduction (%)
Wet Pond (Retention)	894.49	1.19E+13	8.78E+12	74

4.7.5 Stream Restoration Projects

In order to reestablish an overall improvement in water quality throughout the Turkey Creek watershed, stream restoration will be a critical component to natural water quality treatment. As discussed in Section 3.2.2 significant portions of the watershed have stream impairments from a stability, habitat and buffer standpoint. Stream restoration activities will include bank stabilization and buffer reestablishment.

Since Turkey Creek exists as a primary flood control project that was established and regulated by the USACE, coordination of restoration activities on Turkey Creek will need to have a high level of coordination. As part of this watershed project, buffers along Turkey Creek will be reestablished by increasing the overall vegetation length within the buffer areas. While the USACE requirements prohibit the establishment of large woody vegetation within the buffer easement of the creek, current maintenance practices will be modified to allow for a tall stand of vegetation year round. Currently, the vegetation is removed to the ground by City and County crews at the end of each growing season. This project proposes to allow this vegetation to grow to a maximum height of two feet. This will not preclude the utilization of the Creek as a flood control practice and will provide additional filtering benefits along Turkey Creek. This buffer reestablishment would be no cost to the City or County and would only require a modification to the clearing practices currently utilized.

Additionally, full stream restoration and bank stabilization is proposed on Turkey Creek and its tributaries upstream of the CSX rail line north of E. Liberty Street. This will reestablish ecological habitat within the most impaired sections of the Creek and should improve the natural treatment capacity of the system. This will also provide a healthy stream environment at the outfall of the Calhoun Street project. Additional stream restoration will occur as part of the Fulton Street and Snake Creek projects. Ultimately, the project will include buffer reestablishment and restoration practices on all tributaries of Turkey Creek. However, these three areas have been identified as the first stream restoration projects to be implemented as they are in close proximately to major water quality improvement projects in the watershed and will serve as supplemental treatment activities for these projects.

4.7.6 Urban Retrofit Projects

Though the BMPs selected for use in SW-1, SW-2 and SW-3 provide significant pollutant load reductions within their associated drainage areas, a significant portion of these sub-watersheds, greater than 50% of the land area in each sub-watershed, remains untreated due to many factors including topography and existing development. Table 4-5 lists the respective treated and untreated drainage areas for SW-1, SW-2 and SW-3.

Table 4-5: Treated and Untreated Drainage Areas

Sub-Watershed	Total Area (acres)	Treated Area (acres)	Treated Area (%)	Untreated Area (acres)	Untreated Area (%)
1	1508.22	666.45	44.19	841.77	55.81
2	173.59	34.06	19.62	139.53	80.38
3	631.74	149.86	23.72	481.88	76.28

Additional stormwater treatment is necessary in the untreated portions of the watershed to meet water quality standards. Therefore, two (2) urban retrofit strategies are proposed for areas where large stormwater treatment BMPs are not practical. These strategies are present as alternatives for future implementation. Based on water quality assessment and sampling results, it may be necessary to implement these strategies as long-term alternatives. The implementation of projects identified in Sections 4.7.1 through 4.7.4 will be implemented and monitored to determine the actual load reduction requirements to achieve full water quality standards. These alternatives are presented as long-term options to supplement the major implementation projects identified herein and will be implemented on a case by case basis as more water quality monitoring data becomes available as part of the long-term water quality monitoring program.

The first strategy is to retrofit existing stormwater catch basins with tree planter boxes in commercial districts with existing curb and gutter infrastructure. These devices provide an aesthetic appeal in the downtown district as well as a high pollutant removal efficiency of 85%. Tree planter boxes are proposed throughout SW-1, SW-2 and SW-3 to supplement the water quality improvement projects.

The second strategy is to retrofit existing open drainage canals to enhanced dry swales. These facilities also provide an aesthetic appeal in the urbanized areas as well as moderate pollutant removal efficiency. The potential to install significant lengths of dry swales exists throughout SW-1, SW-2 and SW-3. However, these projects are dependent on right-of-way acquisition and total length, and water quality impact will be determined once the final need for these retrofits has been established following the implementation of the priority projects identified within this plan.

4.8 PROJECT SUMMARY

A total of four (4) sites for large BMP implementation projects are proposed for the Turkey Creek Watershed along with several stream restoration and urban stormwater retrofit projects. The combined pollutant reduction of full implementation of this plan is shown in Table 4-6. As shown in the table, SW-4, SW-5, SW-6, SW-7 and SW-8 are currently meeting SCDHEC standards for fecal coliform. Therefore, BMP implementation is primarily focused in SW-1, SW-2 and SW-3. The proposed implementation projects in this plan reduce fecal coliform loading by approximately 2.10E+14 lb/yr in Turkey Creek. This pollutant load reduction is not reflective of potential reduction associated with stream restoration activities. Because stream restoration removal efficiencies are dependent on a variety of factors including sedimentation, plant growth and biological repopulation, the final water quality impacts of the stream restoration will be quantified through water quality monitoring activities. As seen in the table, these implementation strategies provide an estimated 51.5% reduction in annual pollutant loads, helping to meet the overall water quality goals for Turkey Creek. The total annual load reductions in each drainage basin and the corresponding additional reduction requirements to meet the SCDHEC standard throughout the watershed are listed in Table 4-6.

Table 4-6: Pollutant Reduction Summary for Turkey Creek

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 (%)
1	2.33E+14	2.08E+14	89.3%	1.38E+14	59.34%	29.98%
2	2.68E+13	2.39E+13	89.3%	1.31E+13	48.74%	40.58%
3	9.84E+13	8.79E+13	89.3%	5.03E+13	51.16%	38.15%
4	1.01E+13	Meets Standard	Meets Standard	---	---	Meets Standard
5	5.37E+12	Meets Standard	Meets Standard	---	---	Meets Standard
6	6.20E+12	Meets Standard	Meets Standard	---	---	Meets Standard
7	2.29E+13	Meets Standard	Meets Standard	8.78E+12	38.28%	Meets Standard
8	6.02E+12	Meets Standard	Meets Standard	---	---	Meets Standard
Total Annual Pollutant Load Reduction in Watershed				**2.10E+14**	**51.5%**	

As stated previously, two (2) water quality monitoring locations are listed in the TMDL document for Turkey Creek, PD-098 and PD-040. Therefore, it is important to note how actions taken as a part of this plan translate to the requirements of that document, though the overall goal of the watershed plan is simply to meet SCDHEC water quality standards throughout the watershed. Table 4-7 and Table 4-8, summarize the estimated load reductions at each of these stations based on the implementation projects proposed in this document. PD-098 lies within the boundaries of SW-1; therefore, the East Calhoun Street site is the only large proposed BMP that will influence water quality at this monitoring station.

Table 4-7: Pollutant Reduction Summary for PD-098

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 (%)
PD-098	**2.33E+14**	**2.08E+14**	**89.3%**	---	---
1	2.33E+14	2.08E+14	89.3%	1.38E+14	59.3
			Cumulative Load Reduction	**1.38E+14**	**59.3**
			Additional Load Reduction to Meet Standard	**1.23E+14**	**30.0**

Table 4-8: Pollutant Reduction Summary for PD-040

Drainage Basin	Annual Load (lb/yr)	Reduction Required to Meet SCDHEC Standard (lb/yr)	Reduction Required to Meet SCDHEC Standard (%)	Proposed Projects: Annual Load Reduction (lb/yr)	Proposed Projects: Annual Load Reduction (%)
PD-040	**4.09E+14**	**3.08E+14**	**75.5**	---	---
1	2.33E+14	2.08E+14	89.3	1.38E+14	33.8
2	2.68E+13	2.39E+13	89.3	1.31E+13	3.2
3	9.84E+13	8.79E+13	89.3	5.03E+13	12.3
4	1.01E+13	Meets Standard	Meets Standard	---	---
5	5.37E+12	Meets Standard	Meets Standard	---	---
6	6.20E+12	Meets Standard	Meets Standard	---	---
7	2.29E+13	Meets Standard	Meets Standard	8.78E+12	2.2
8	6.02E+12	Meets Standard	Meets Standard	---	---
			Cumulative Load Reduction for Proposed Projects	**1.71E+14**	**51.5**
			Additional Load Reduction to Meet Standard	**1.37E+14**	**24.0**

PD-040 is located at the outlet of the Turkey Creek Watershed and receives drainage from the entire watershed. Table 4-8 lists the complete summary of proposed projects in Turkey Creek along with the estimated load reductions and additional reduction requirements to meet water quality standards throughout the watershed

4.9 COST ESTIMATES

Construction of the proposed BMP implementation projects will require a significant capital investment within the Turkey Creek 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, including the costs of land, varying site conditions, material and labor costs, weather variation, and others, 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 4-9.

Table 4-9: Estimated Capital Cost Per Land Acre Treated for New BMP Implementation

BMP Type	Capital Costs	Unit
Constructed Wetlands	$ 20,000.00	Acre
Wet Pond (Retention)	$ 30,000.00	Each
Infiltration Trench	$ 200.00	l.f.
Grass Filter Strip	$ 100.00	l.f.
Tree Planter Boxes	$ 10,000.00	Each
Enhanced Dry Swale	$ 150.00	l.f.
Stream Restoration	$ 150.00	l.f.

A cost estimate was prepared for each of the sites selected for implementation projects using the capital cost estimates provided in Table 4-9 using the named BMPs from Section 4.1 above. Implementation of the two (2) proposed projects in Phase I and II for the East Calhoun Street site, Table 4-10, is estimated near $4.46 million. Enhanced dry swales will convey stormwater from the retrofit area to the constructed wetland at the East Calhoun Street site. Therefore, the wetland must be sized to treat storm flow from the entire contributing area. The drainage area for the constructed wetland listed in Table 4-10 is inclusive of the drainage area of the enhanced dry swales in the SW-1 retrofit area, see Appendix L, Exhibits B. Costs to remove and replace existing infrastructure necessary to re-direct stormwater flows from the retrofit area to the East Calhoun Street Extension site are not included in this estimate. In addition, the cost provided for retrofitting existing open drainage to enhanced dry swales is the complete cost of implementation. These projects can be completed as budget allows over an extended period of time. The estimate provided herein is extremely conservative, particularly with respect to the installation of the constructed wetland. The existing site is conducive to construction practices that could limit clearing and grading. This estimate is based on typical construction costs associated with constructed wetland construction on vacant land and final site evaluation will determine final construction costs for the project.

Table 4-10: Cost Estimate for East Calhoun Street BMP Implementation

BMP	Total	Unit	Unit Cost	Extended Cost
Enhanced Dry Swales	22,000	l.f.	$150.00	$3,300,000.00
Constructed Wetland	58	Acres	$20,000.00	$1,160.000.00
			TOTAL	**$ 4,460,000.00**

Improvements in Eastwood Park include the construction of a constructed wetland, infiltration trenches, and approximately 600 linear feet of stream, or canal, relocation and restoration. Cost estimates for BMP implementation in Eastwood Park are provided in Table 4-11.

Table 4-11: Cost Estimate for Eastwood Park BMP Implementation

BMP	Total	Unit	Unit Cost	Extended Cost
Constructed Wetland	1.3	Acres	$ 20,000.00	$ 26,000.00
Infiltration Trench	950	l.f.	$ 200.00	$ 190,000.00
BMP	Total	Unit	Unit Cost	Extended Cost
Streambank Relocation/Restoration	600	l.f.	$ 150.00	$ 90,000.00
			TOTAL	**$ 306,000.00**

Proposed BMPs for the site located at East Fulton Street and Industrial Road include the construction of a large wetland complex and the retrofit of an existing street drainage canal to either an infiltration or a bioswale facility. Costs estimates for the implementation of these BMPs are provided in Table 4-12. A significant amount of demolition may be required on the site to remove existing foundations, loading facilities and impervious parking areas before the wetland complex can be constructed; however, the extent of demolition will be dependent on the final design of the site and these costs are not included in this estimate.

Table 4-12: Cost Estimate for E Fulton Street BMP Implementation

BMP	Total	Unit	Unit Cost	Extended Cost
Constructed Wetlands	8	Acres	$ 20,000.00	$ 160,000.00
Infiltration Trench	750	l.f.	$ 200.00	$ 150,000.00
			TOTAL	**$ 310,000.00**

The Beaver Pond, an abandoned waste treatment pond, is to be retrofitted to treat stormwater in SW-7. Estimated costs for the proposed retrofit project are provided in Table 4-13.

Table 4-13: Cost Estimate for Beaver Pond at Snake Creek BMP Implementation

BMP	Total	Unit	Unit Cost	Extended Cost
Wet Pond (Retention)	1	Each	$30,000.00	$ 30,000.00
			TOTAL	**$ 30,000.00**

The estimated costs for proposed stream restoration activities for the three areas discussed in Section 4.7.5 are provided in Table 4-14.

Table 4-14: Cost Estimate for Proposed Stream Restoration Projects

BMP	Total	Unit	Unit Cost	Extended Cost
Calhoun Street	2,000	l.f.	$ 150.00	$ 300,000.00
Fulton Street	500	l.f.	$ 150.00	$ 75,000.00
Snake Creek	500	l.f.	$ 150.00	$ 75,000.00
			TOTAL	**$ 450,000.00**

The total estimated implementation costs for each of the BMP practices identified in this plan are summarized by location in Table 4-15. East Calhoun Street Extension has the highest cost of implementation followed by Eastwood Park with the Beaver Pond at Snake Creek restoration representing the lowest cost project. The individual stream restoration projects can be done as stand-alone, or in conjunction with their associated water quality improvement projects. The total cost for implementation is estimated to be **$ 5.56 million**.

Table 4-15: Overall Implementation Costs

Location		Cost Estimate
East Calhoun Street Extension		$ 4,460,000.00
Eastwood Park		$ 306,000.00
Fulton Street		$ 310,000.00
Beaver Pond at Snake Creek		$ 30,000.00
Stream Restoration Projects		$ 450,000.00
	Total	**$ 5,556,000.00**

4.10 MILESTONE IMPLEMENTATION SCHEDULE

The schedule of implementation will be variable, based on funding sources and the ability to acquire property and obtain approval for the proposed 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 four (4) Sumter County properties described in the plan above (priority projects) along with the stream restoration and urban retrofit projects. If the County 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 County, City and other stakeholders, every effort should be made to implement as much of the proposed plan as possible.

From data presented in Section 4.7, there are approximately 1,745 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 tree planter boxes throughout the upper reaches of the watershed and through various stream restoration projects. 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:

- Conduct education and outreach.
- 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.
- Preliminary investigation for a minimum of 30% of the proposed BMPs.
- Verification and BMP selection for a minimum of 30% of the BMPs.
- Preliminary (60%) design, including detailed cost estimate, of Snake Creek complete to facilitate funding opportunities.
- A minimum of two "pilot" projects constructed in Year 1. These could be stream restoration, tree planter boxes or enhanced dry swales. The purpose of these projects is to provide education with respect to the watershed and provide the public with an overall goal and plan for the watershed restoration.

Years 2-4:

- Continue education and outreach.
- Continue baseline monitoring (Phase I Sampling) at water quality monitoring locations.
- Investigate and pursue riparian buffer preservation and restoration opportunities.
- Preliminary (60%) design, including detailed cost estimate, of East Calhoun Street, East Fulton Street and Eastwood Park complete to facilitate funding opportunities.
- Complete construction of Snake Branch retrofit.
- Begin construction of one of the above projects based on funding availability.

- 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:

- Construction of a minimum of 25% of additional proposed stream restoration and urban retrofit projects complete.
- Complete construction of two of the four priority projects.
- Continue education and outreach.
- Continue Phase I and II water quality monitoring.
- Identification of additional BMP implementation opportunities not identified in this plan.
- Re-evaluate management priorities and begin next phase.

Years 7-10:

- Continue education and outreach.
- Continue Phase I and II water quality monitoring.
- Construction of a minimum of 50% of proposed stream restoration and urban retrofit projects complete.
- Complete construction of all priority projects.
- Identification of additional BMP implementation opportunities not identified in this plan.
- Re-evaluate management priorities and identify additional projects as necessary.

Years 11-15:

- Continue education and outreach.
- Construction of all of proposed stream restoration and urban retrofit projects complete.
- Continue Phase I and II monitoring on all major tributaries and Turkey Creek.
- Implement all priority projects to meet water quality standards. Verify standard attainment through final monitoring activities.

Section 5

STREAM AND WATERSHED MONITORING

SCDHEC currently collects data from Turkey Creek at two WQM stations, PD-098 at Liberty Street and PD-040 at U.S. Route 521. Additional ambient water quality monitoring for fecal coliform and *E. coli* in the Turkey Creek Watershed must be conducted to characterize water quality conditions in Turkey Creek 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 Turkey Creek.

5.1 SAMPLING PLAN

Water quality monitoring stations will be located within the Turkey Creek 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 Turkey Creek under minimal dilution conditions.

5.1.1 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.

5.1.2 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.

5.1.3 Monitoring Team

The Turkey Creek 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. The Sampling Team consists of a Sampling Team Leader and

Sampling Team Crew composed of two (2) Crew Members per crew. 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 O. 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.

5.1.4 Laboratory

The Laboratory responsible for analyzing the water samples collected under the Turkey Creek 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.

5.1.5 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 County Stormwater Manager.

5.2 DATA GENERATION AND ACQUISITION

This section details the strategy for monitoring Turkey Creek 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.

5.2.1 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.

5.2.2 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.

5.2.3 Rainfall Events

The Turkey Creek Watershed Sampling Plan is designed to monitor ambient water quality. Rainfall events can impact 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 Sumter County Public Works facility, as shown on the Water Quality Monitoring Stations Location Map (Appendix N). 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.

5.2.4 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.

5.2.5 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.

5.2.6 Monitoring Duration and Frequency

The monitoring frequency for the Turkey Creek 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.

5.2.7 Sample Set

The sample set is designed to enable the County/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 Turkey Creek. The sample set will consist of two individual 500 ml samples. These samples will be collected at the monitoring station as concurrent grab samples.

5.2.8 Sample Collection Technique

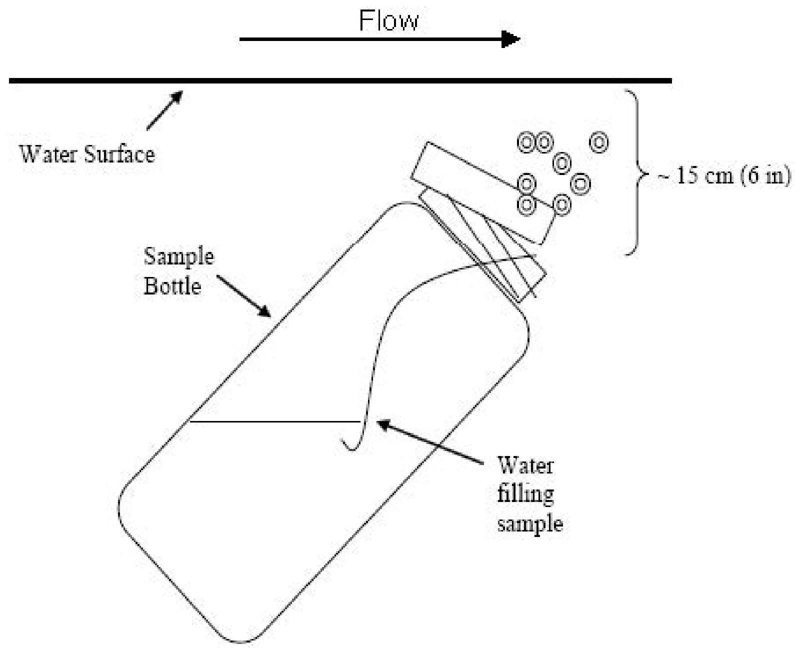
Proper technique, equipment and sample preservation are especially critical factors for collecting bacteriological samples to obtain valid test results.

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 5-1: 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 P)
   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 Q)
   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.

5.2.9 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, 18^{th} 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®).

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

5.3.1 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.

5.3.2 Laboratory Quality Control

The Laboratory responsible for sample analysis will be identified by Sumter County upon project initiation. 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 R 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.

5.4 DATA MANAGEMENT AND REPORTING

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

5.4.1 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 R. 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.

5.4.2 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.

5.4.3 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

5.4.4 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 6

REFERENCES

- 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. (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. (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

- USDA Natural Resources Conservation Service, 133A – Southern Coastal Plain, http://www.mo15.nrcs.usda.gov/technical/MLRAs/mlra_133a.html (July 11, 2013)

- South Carolina Regulation 61-68, Water Classifications & Standards, effective June 22, 2112

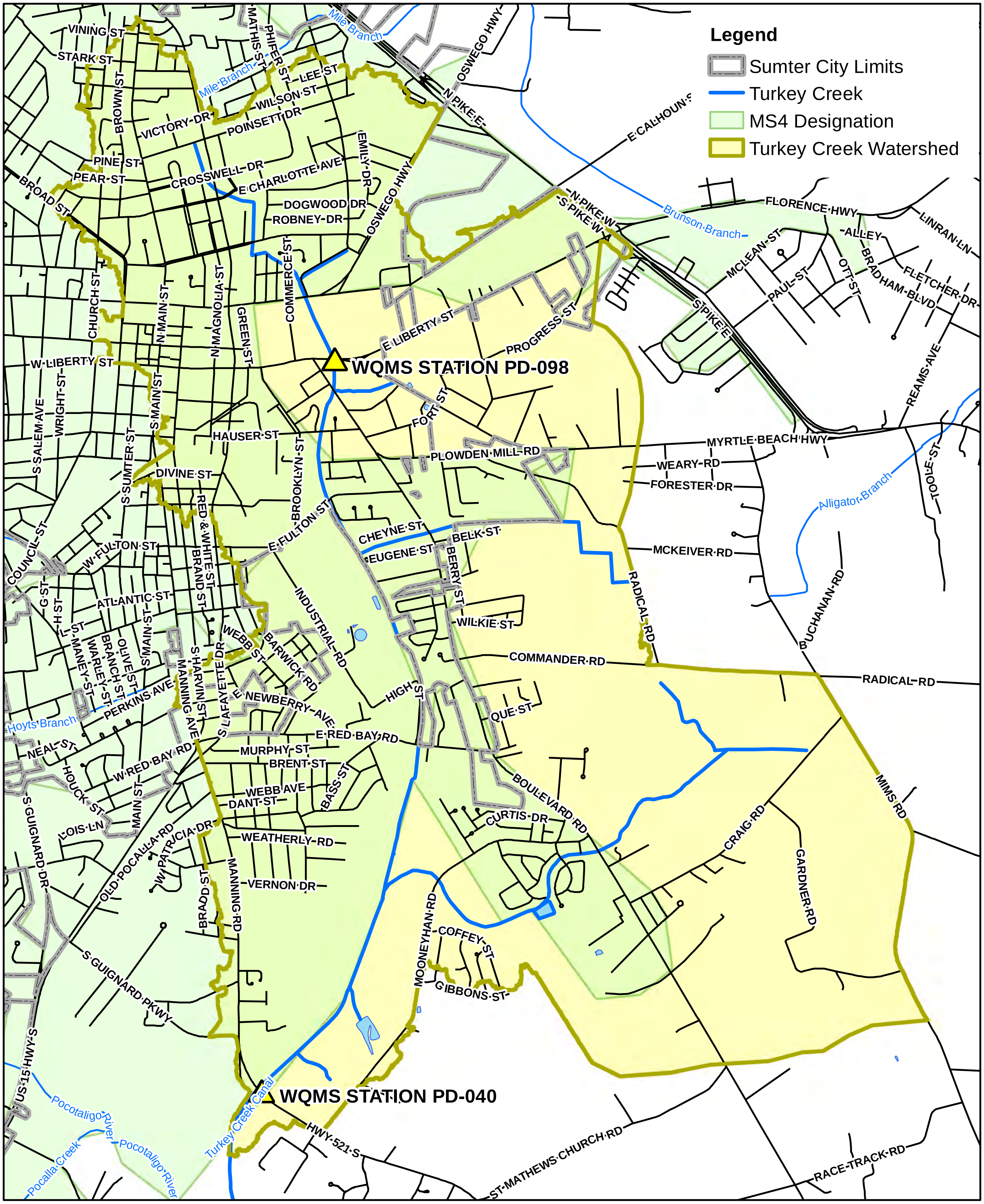
- Sumter 2030 Comprehensive Plan, http://www.sumtersc.gov/comprehensive-plan.aspx (July 29, 2013)

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

Turkey Creek Watershed
Location Map



File:G\46422560_Sumter_319GrantFunding
\Maps\Location_Map.mxd
Date: August 13, 2013
Author: LCS

URS

N

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

1 inch = 0.6 miles

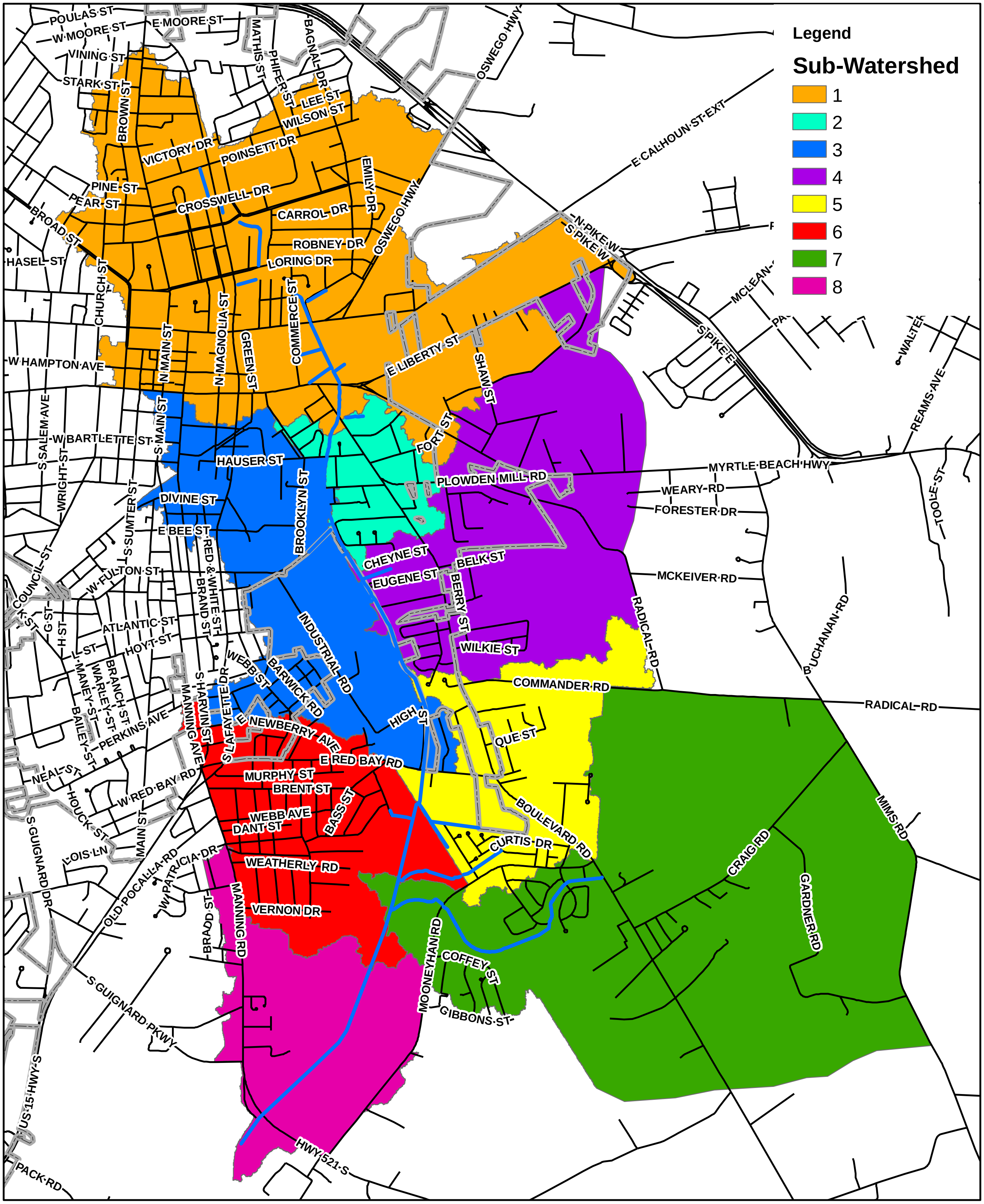
0 0.5 1 Miles

City of Sumter/Sumter County

Turkey Creek Watershed Location Map

APPENDIX B

Turkey Creek Watershed
Sub-Watershed Map



File:G\46422560_Sumter_319GrantFunding
\Maps\Watershed.mxd
Date:July 22, 2013
Author: LCS

URS

N

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

1 inch = 0.6 miles

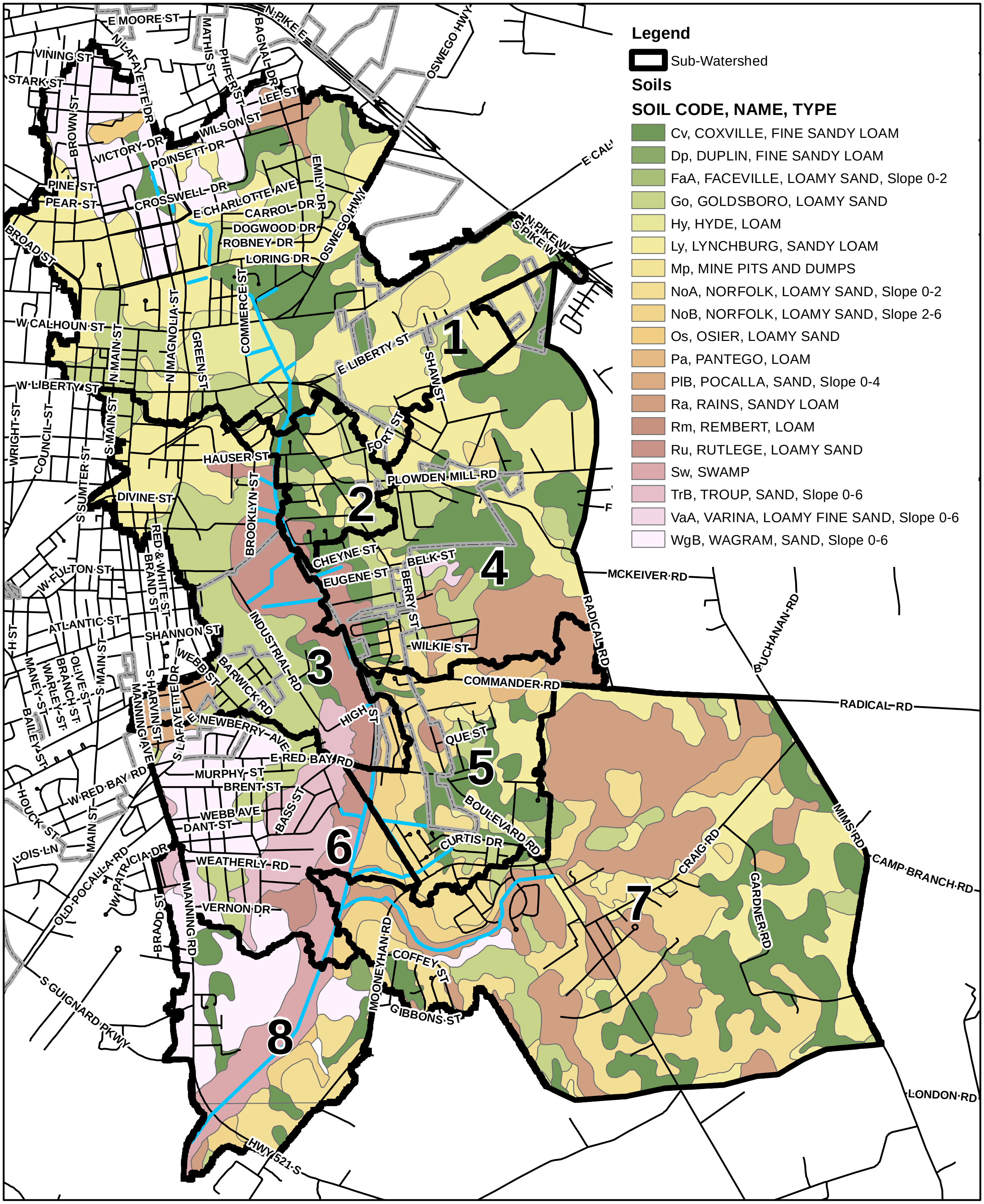
0 0.5 1 Miles

Sumter County

Turkey Creek Watershed Sub-Watershed Map

APPENDIX C

Turkey Creek Watershed Soils Map



File:G\46422560_Sumter_319GrantFunding
\Maps\Soils.mxd
Date:July 22, 2013
Author: LCS

URS

N

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

1 inch = 0.6 miles

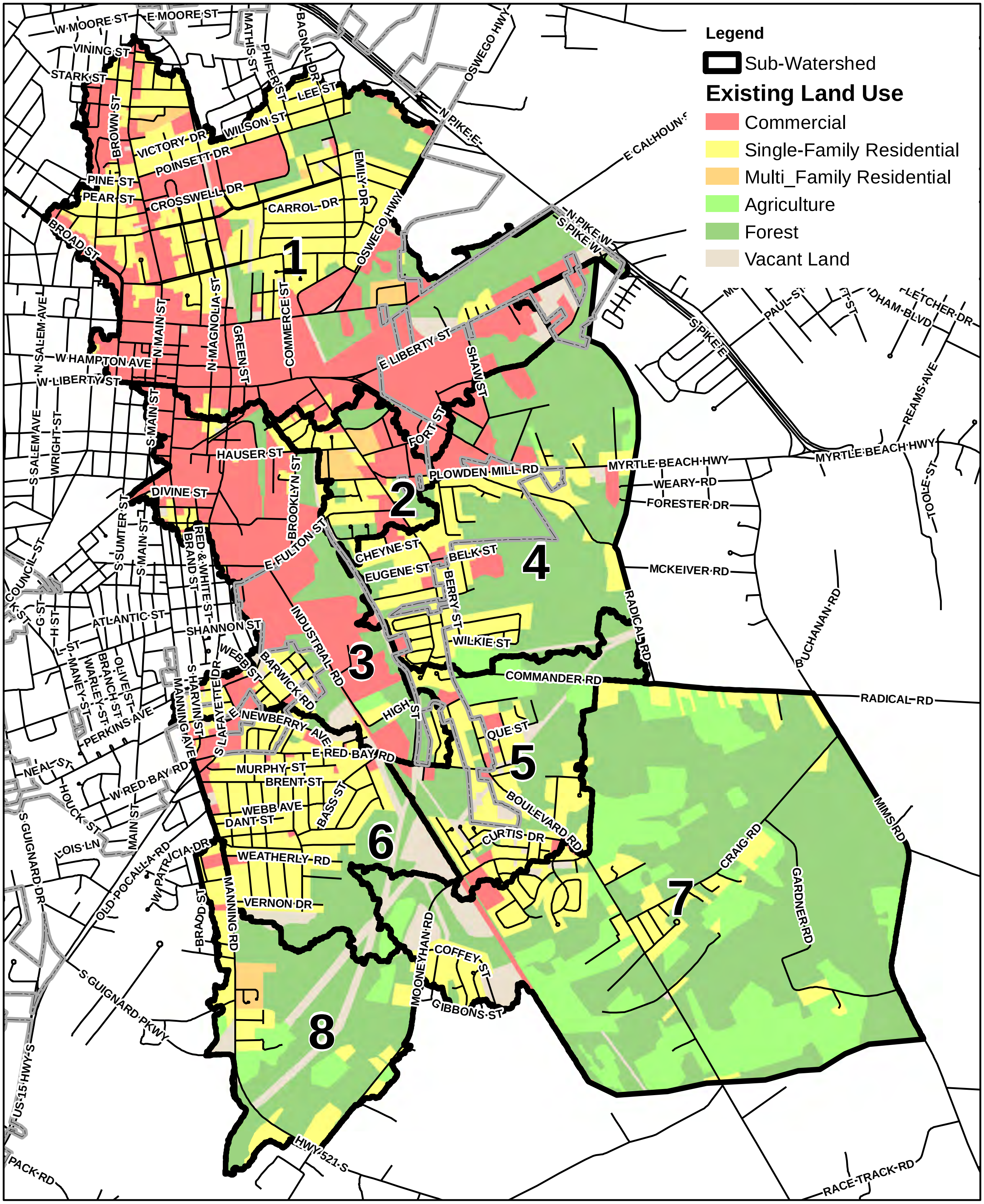
0 0.5 1 Miles

Sumter County

Turkey Creek Watershed Soils Map

APPENDIX D

Turkey Creek Watershed
Existing Land Use Map



File:G\46422560_Sumter_319GrantFunding
\Maps\LandUse.mxd
DateAugust 13, 2013
Author: LCS

URS

N

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

1 inch = 0.6 miles

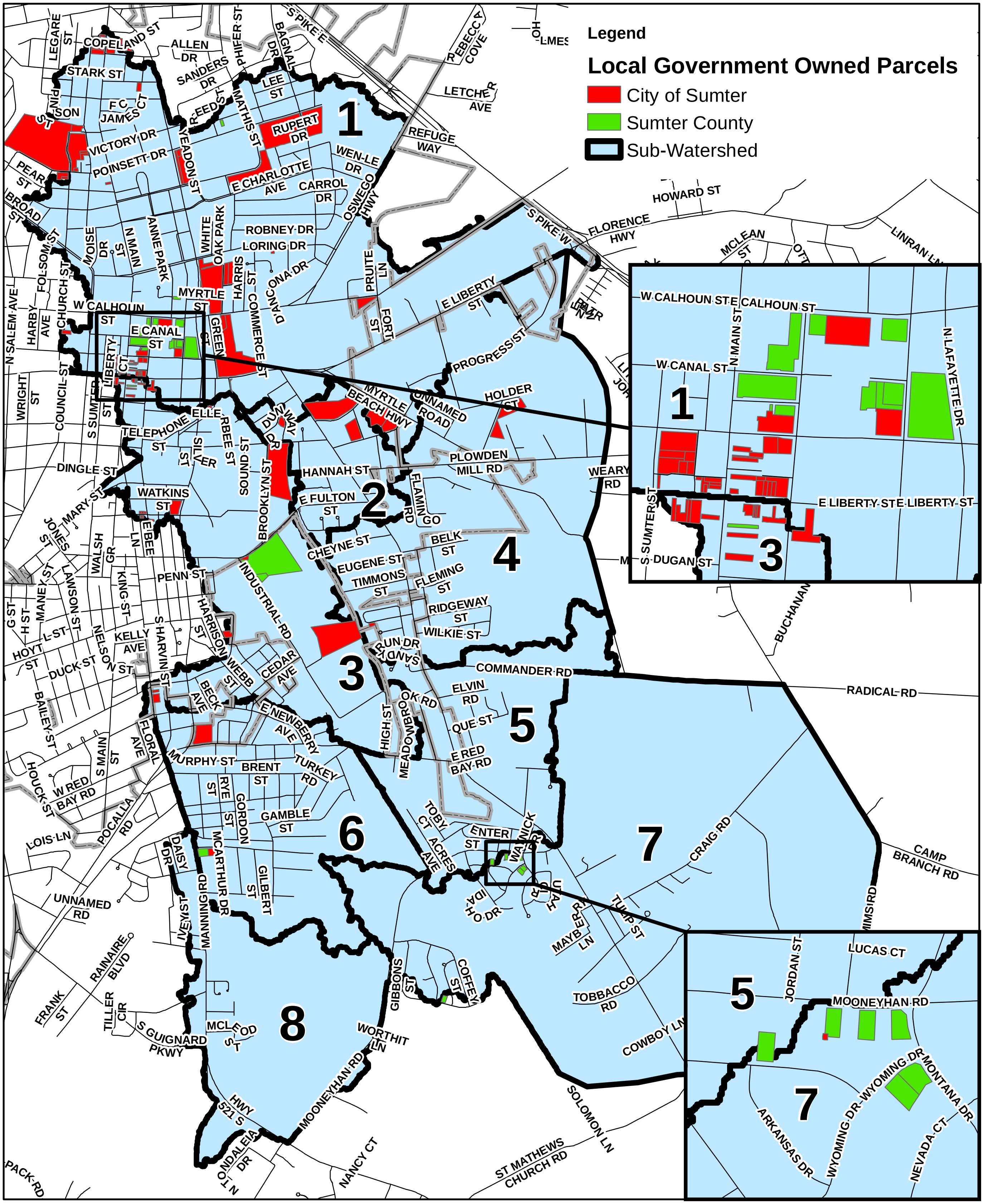
0 0.5 1 Miles

Sumter County

Turkey Creek Watershed
Existing Land Use Map

APPENDIX E

Turkey Creek Watershed
Local Government Owned Parcels Map



File:G\46422560_Sumter_319GrantFunding
\Maps\LocalGovProp.mxd
Date:July 22, 2013
Author: LCS

URS

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

1 inch = 0.6 miles

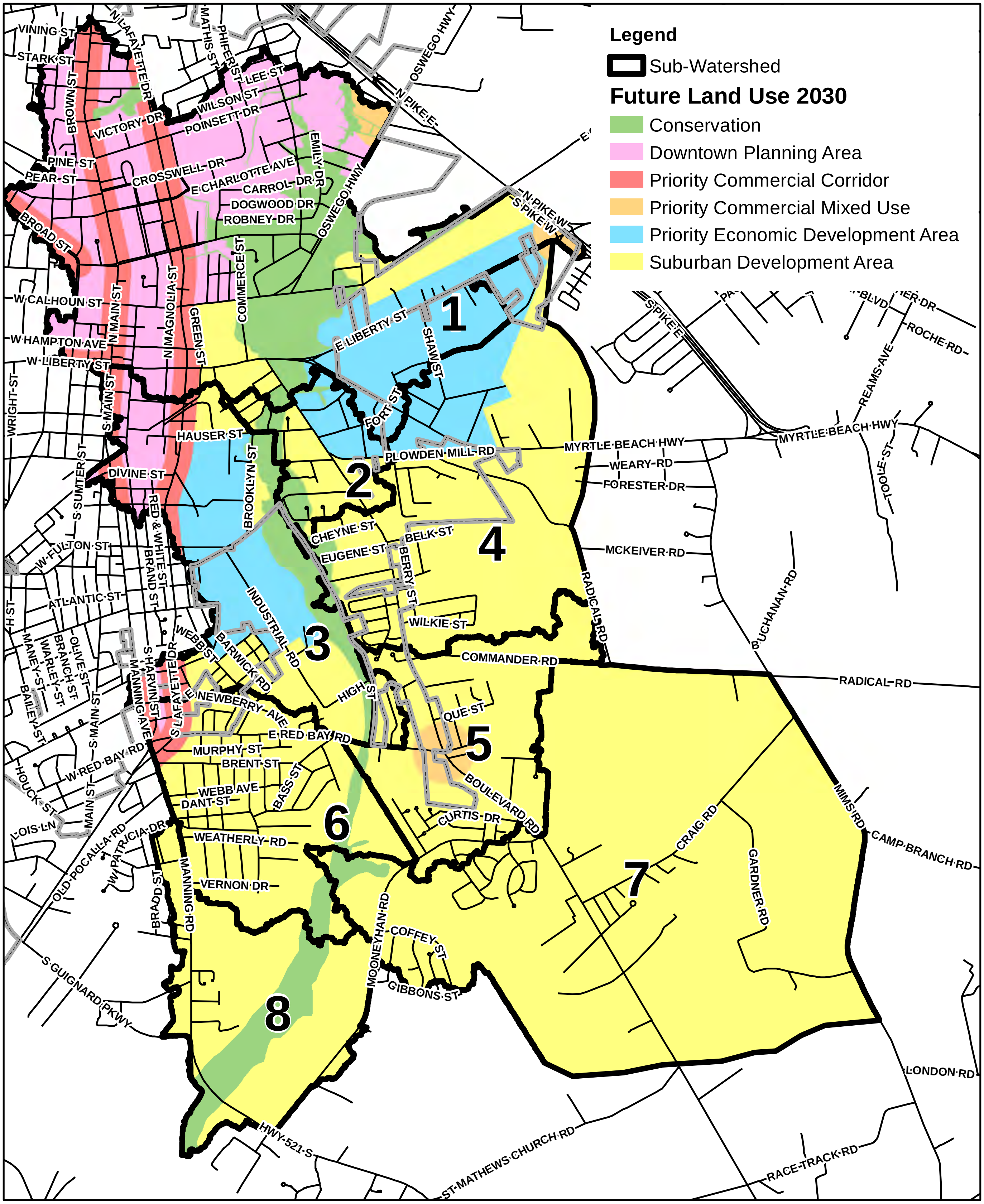
0 0.5 1 Miles

Sumter County

Turkey Creek Watershed Local Government Owned Parcels Map

APPENDIX F

Turkey Creek Watershed
Future Land Use Map
(through 2030)



File:G\46422560_Sumter_319GrantFunding \Maps\LandUse.mxd
Date: August 13, 2013
Author: LCS

URS

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

1 inch = 0.6 miles

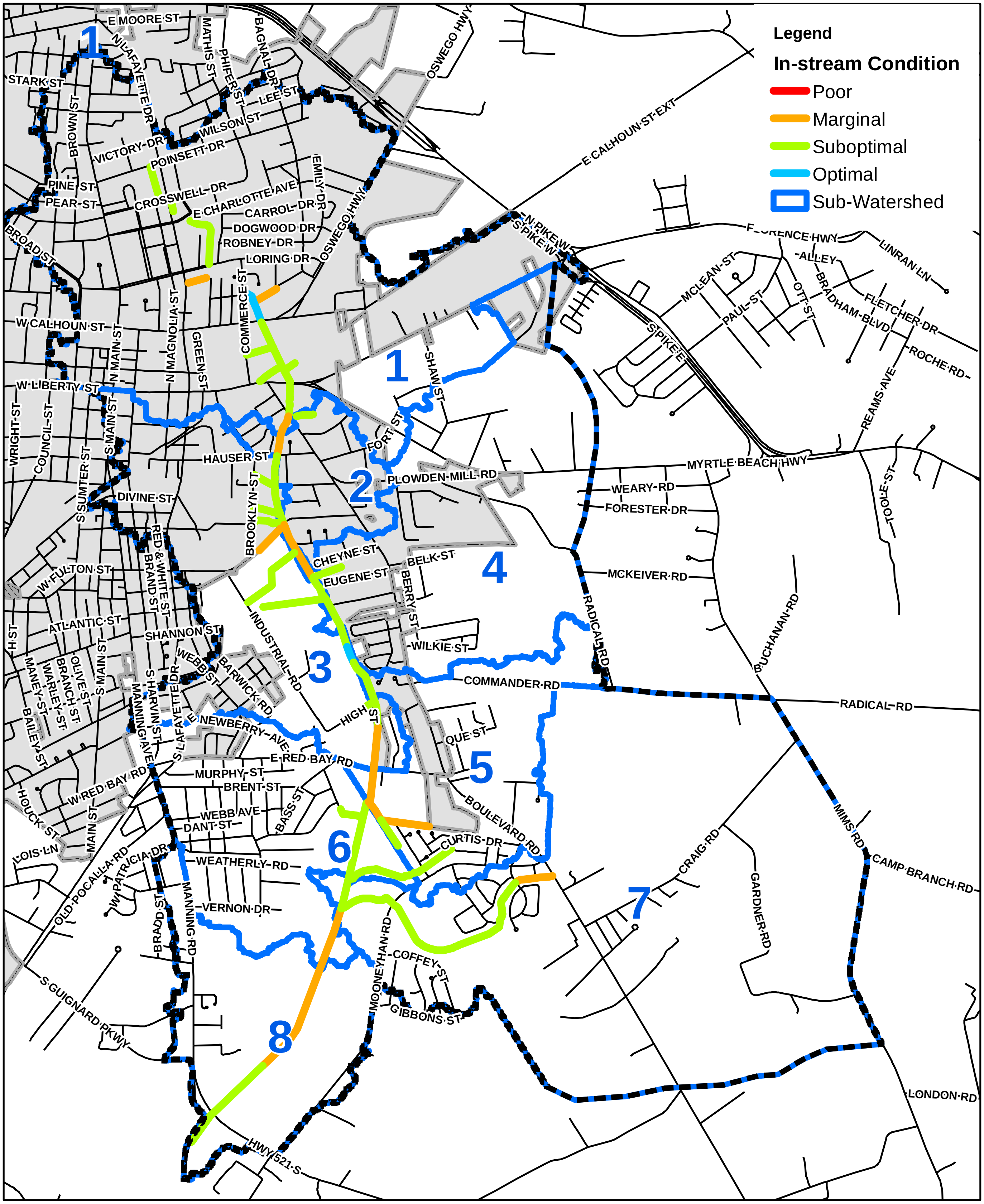
0 0.5 1 Miles

Sumter County

Turkey Creek Watershed Future Land Use Map (through 2030)

APPENDIX G

Turkey Creek Watershed
In-Stream Condition Map



File:G\46422560_Sumter_319GrantFunding\Maps\Soils.mxd
Date:July 22, 2013
Author: LCS

URS

N

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

1 inch = 0.6 miles

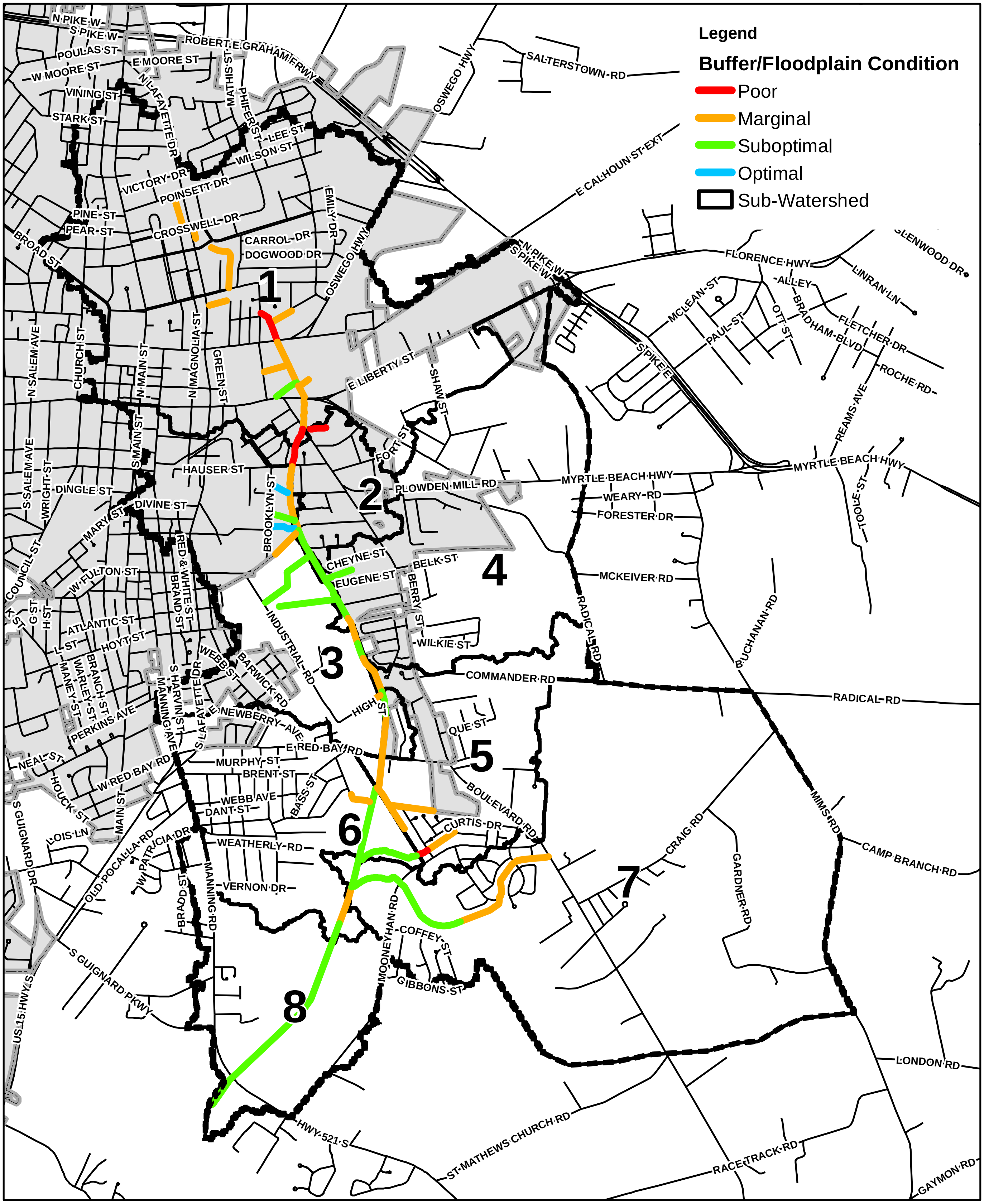
0 0.5 1 Miles

Sumter County

Turkey Creek Watershed
In-Stream Condition Map

APPENDIX H

Turkey Creek Watershed
Buffer/Floodplain Condition Map



File:G\46422560_Sumter_319GrantFunding
\Maps\Soils.mxd
Date:July 22, 2013
Author: LCS

URS

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

N

1 inch = 0.645246 miles

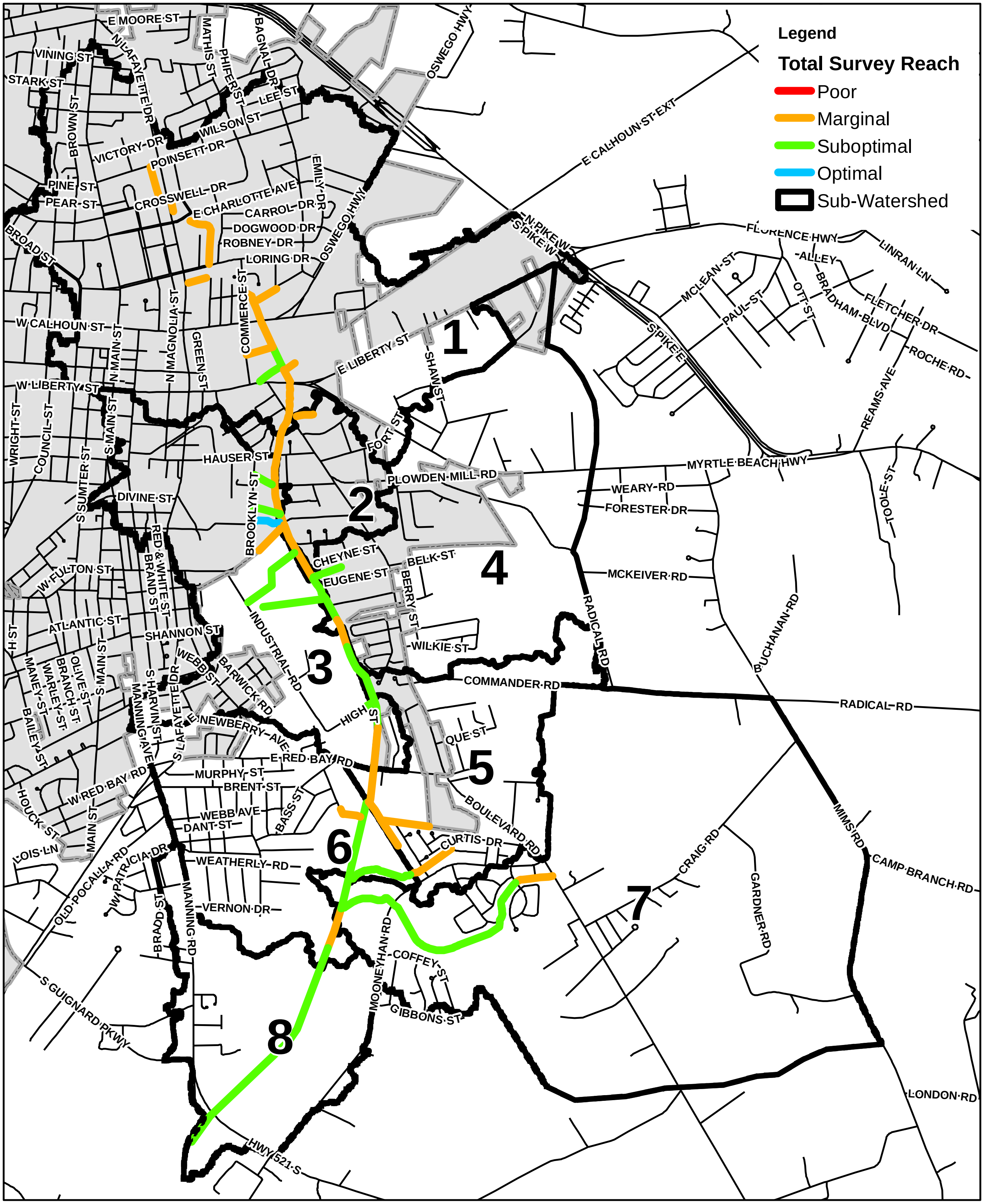
0 0.5 1 Miles

Sumter County

Turkey Creek Watershed Buffer/Floodplain Condition Map

APPENDIX I

Turkey Creek Watershed Total Survey Reach Map



File:G\46422560_Sumter_319GrantFunding
\Maps\Soils.mxd
Date:July 22, 2013
Author: LCS

URS

N

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

1 inch = 0.6 miles

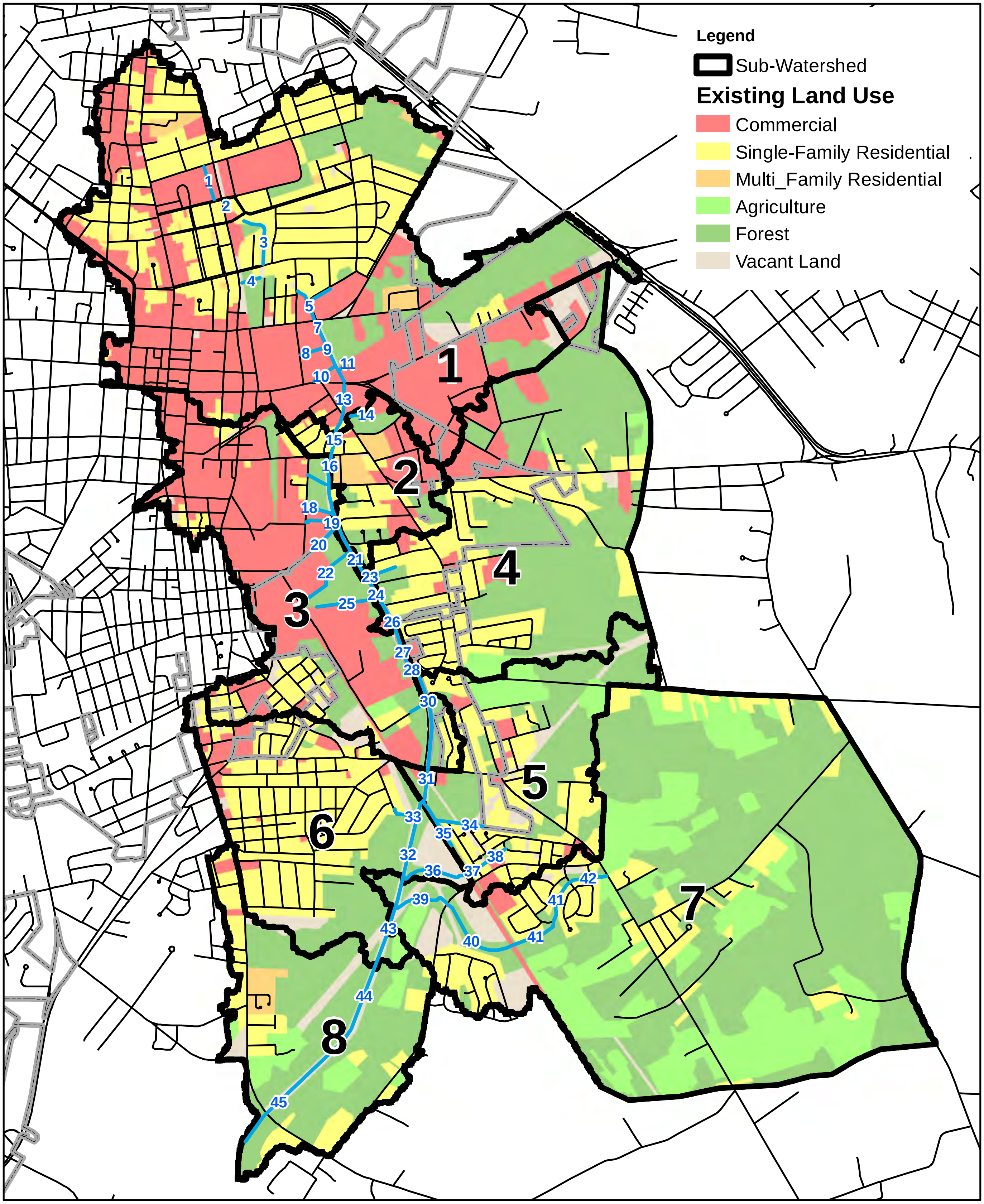
0 0.5 1
Miles

Sumter County

Turkey Creek Watershed
Total Survey Reach Map

APPENDIX J

Existing Land Use Reach Map



File:G\46422560_Sumter_319GrantFunding \Maps\Soils.mxd
Date:July 22, 2013
Author: LCS

URS

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

1 inch = 0.6 miles

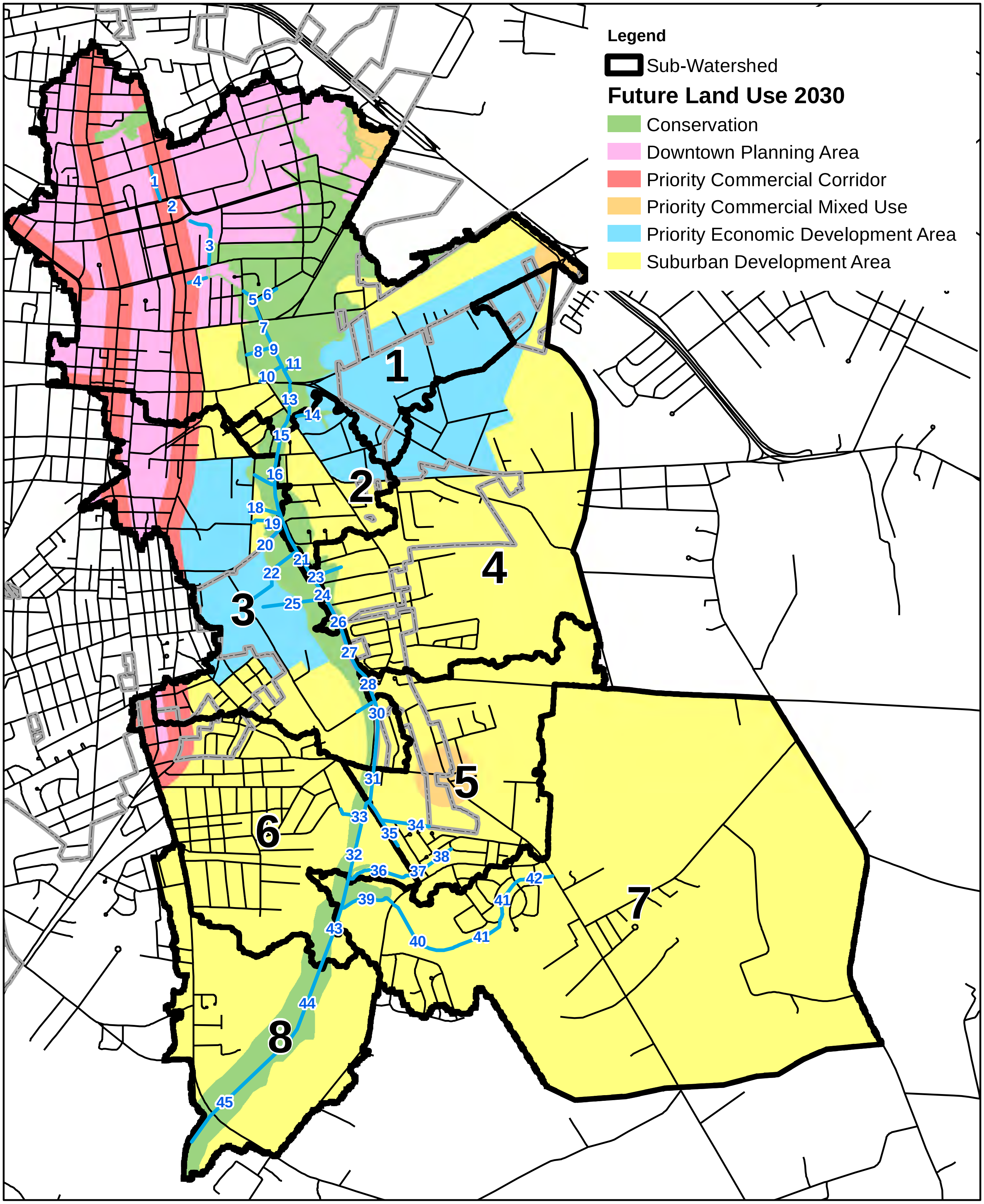
0 0.5 1 Miles

Sumter County

Existing Land Use Reach Map

APPENDIX K

Future Land Use Reach Map



File:G\46422560_Sumter_319GrantFunding
\Maps\Soils.mxd
Date:July 22, 2013
Author: LCS

URS

N

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

1 inch = 0.6 miles

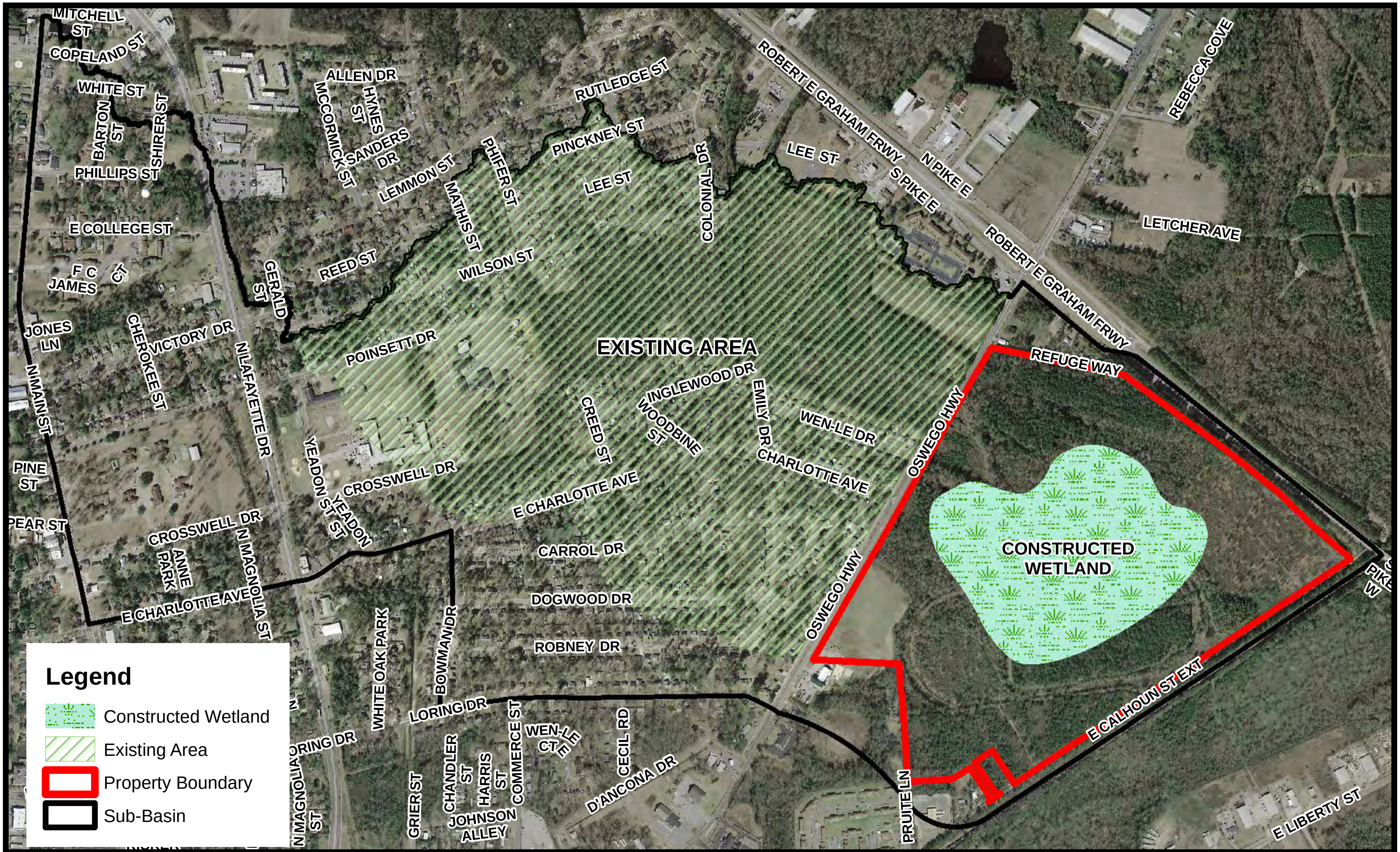
0 0.5 1 Miles

Sumter County

Future Land Use Reach Map

APPENDIX L

Recommended Projects Location Maps



0 500 1,000 2,000 Feet

1 inch = 1,000 feet

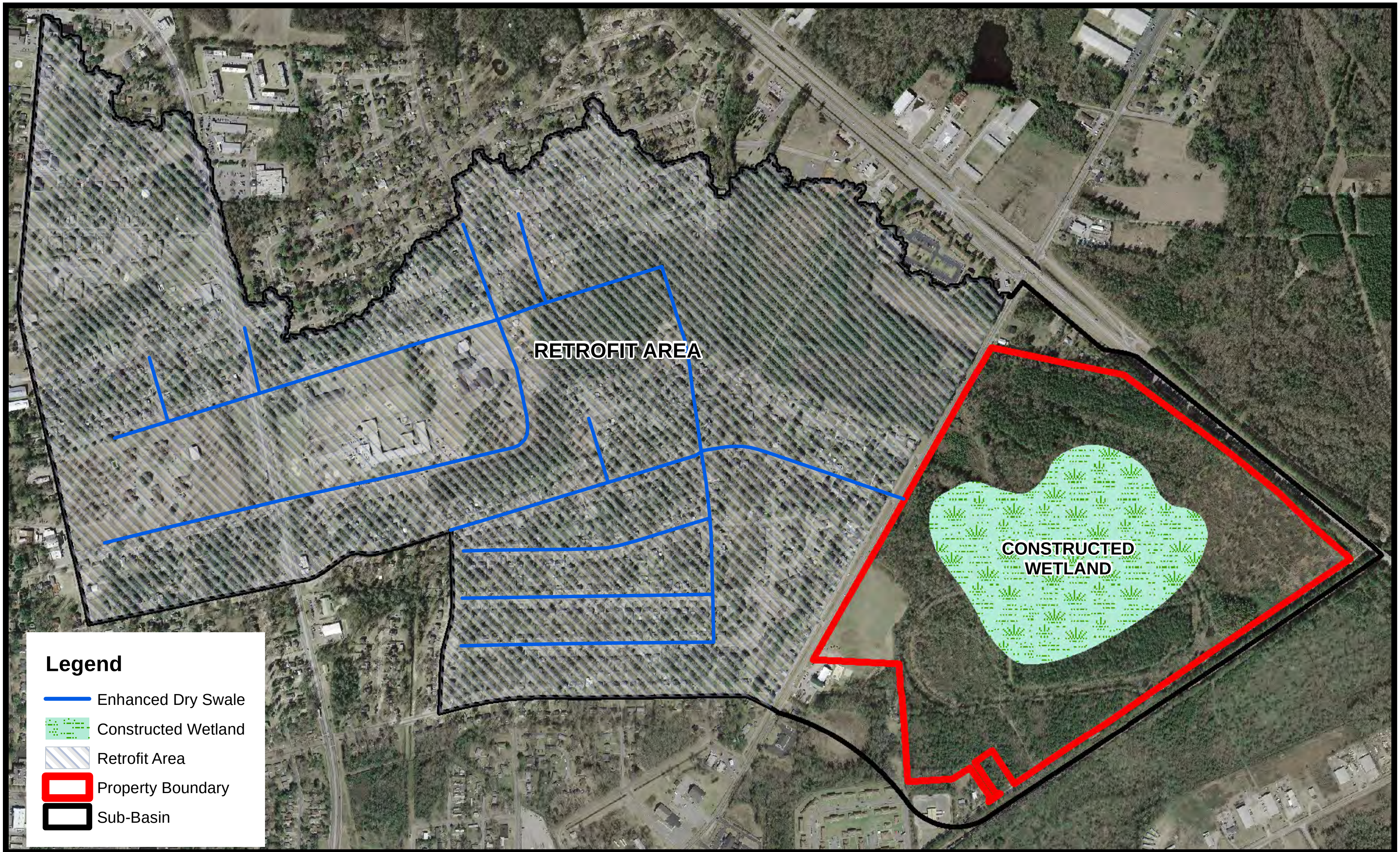
URS

EXHIBIT A
SUMTER COUNTY
Turkey Creek Watershed Plan
Sub-Basin 1

October 24, 2013

N

SUMTER COUNTY 1800 1899 SOUTH CAROLINA



0 500 1,000 2,000 Feet

1 inch = 1,000 feet

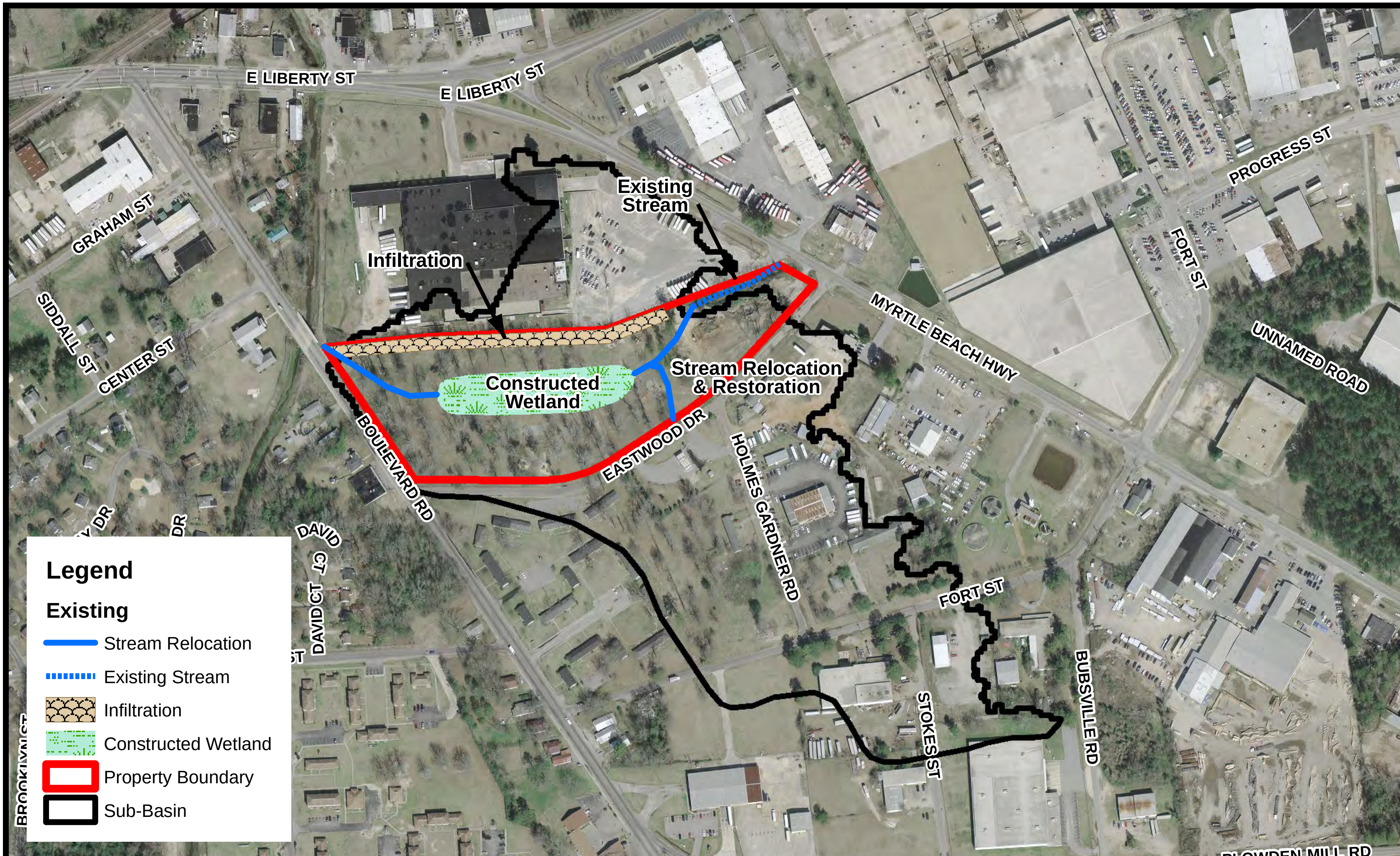
URS

EXHIBIT B
SUMTER COUNTY
Turkey Creek Watershed Plan
Sub-Basin 1

October 24, 2013

N

SUMTER COUNTY · 1800 · 1868 · SOUTH CAROLINA



0 200 400 800 Feet

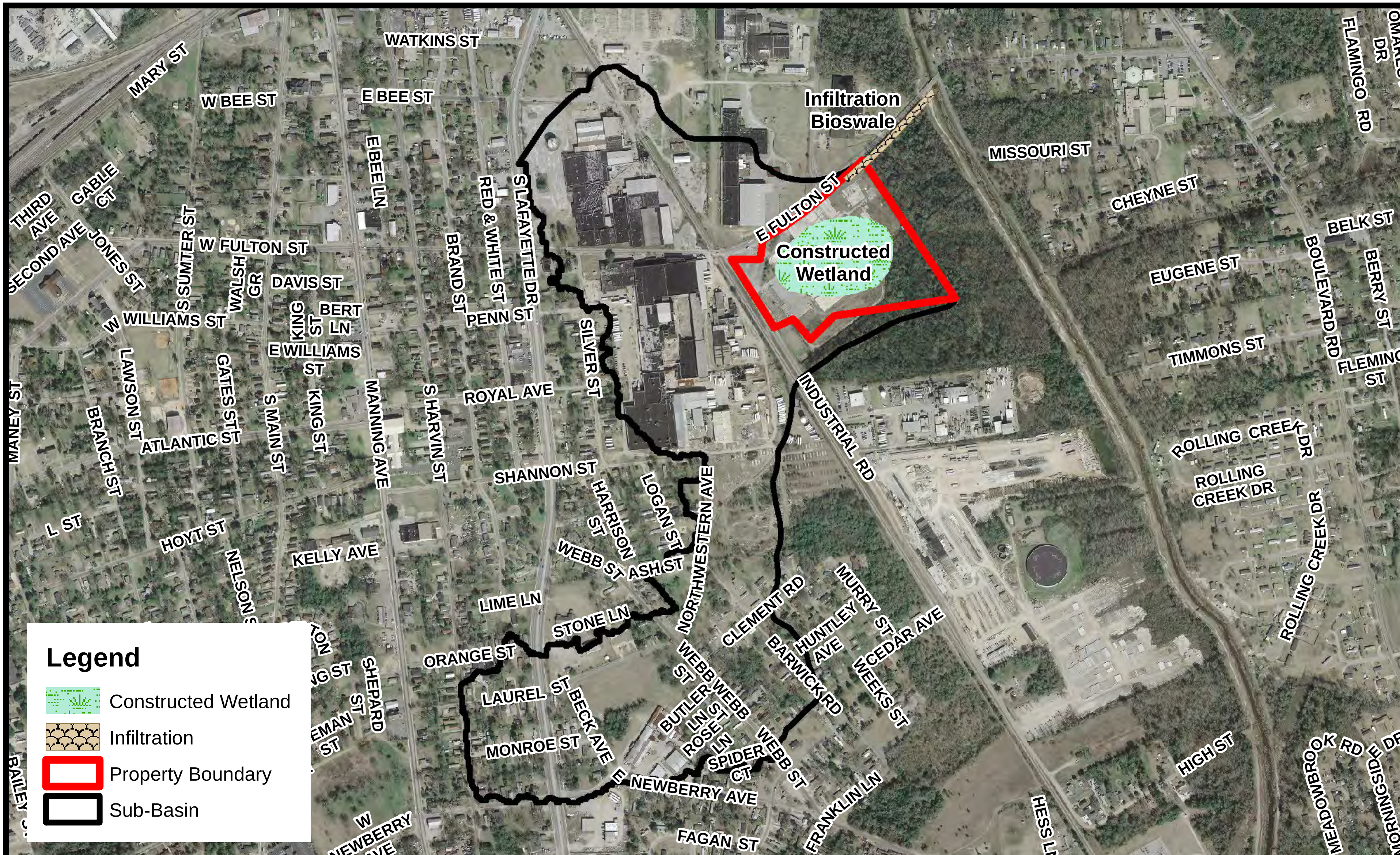
1 inch = 400 feet

URS

EXHIBIT C
SUMTER COUNTY
Turkey Creek Watershed Plan
Sub-Basin 2

October 24, 2013

N



0 450 900 1,800 Feet

1 inch = 900 feet

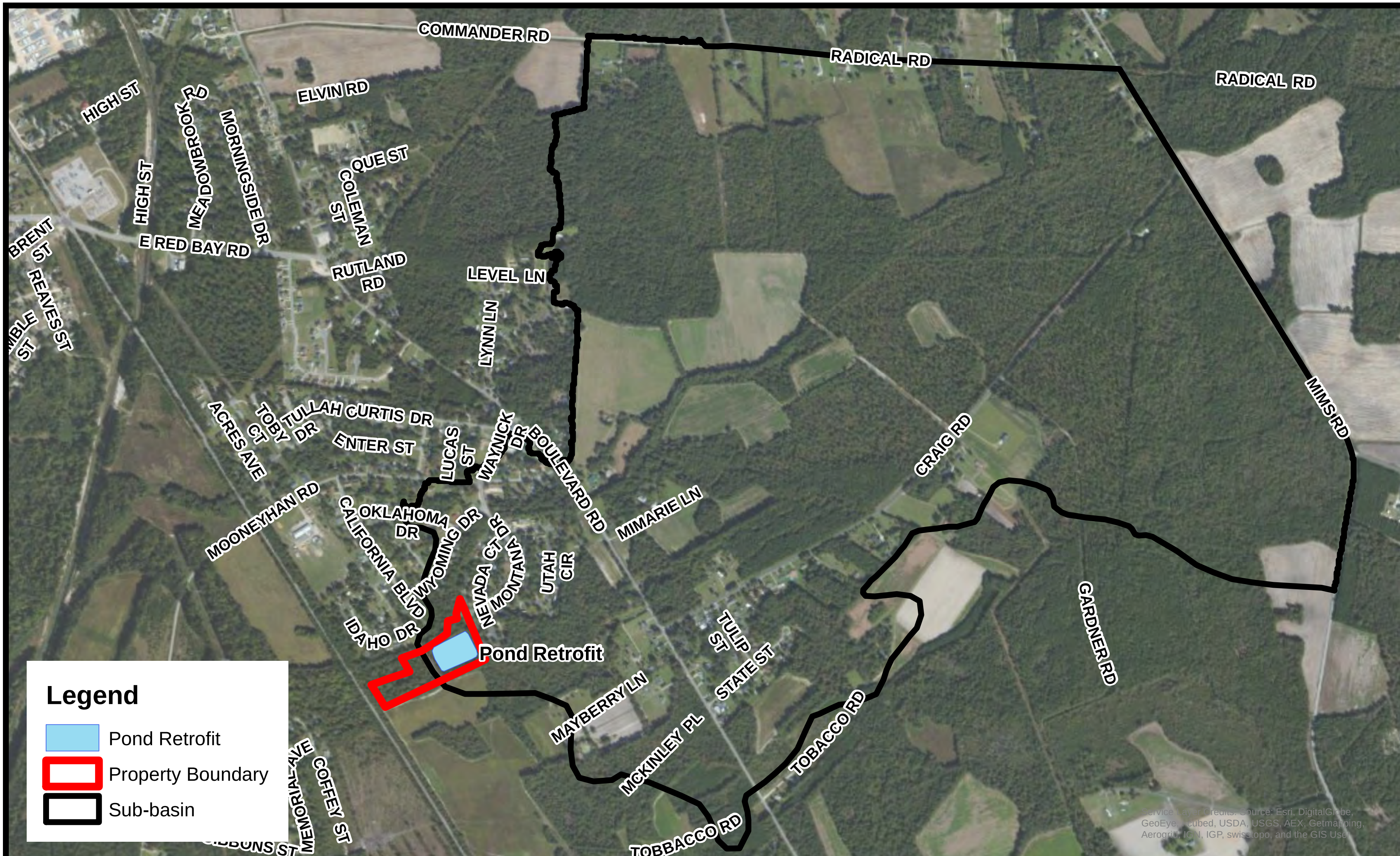
URS

EXHIBIT D
SUMTER COUNTY
Turkey Creek Watershed Plan
Sub-Basin 3

October 24, 2013

N

SUMTER COUNTY 1800 1998 SOUTH CAROLINA



URS

EXHIBIT E
SUMTER COUNTY
Turkey Creek Watershed Plan
Sub-Basin 7

October 24, 2013

N

SUMTER COUNTY · 1800 · 1998 · SOUTH CAROLINA

APPENDIX M

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

SUMTER COUNTY

TURKEY CREEK 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.

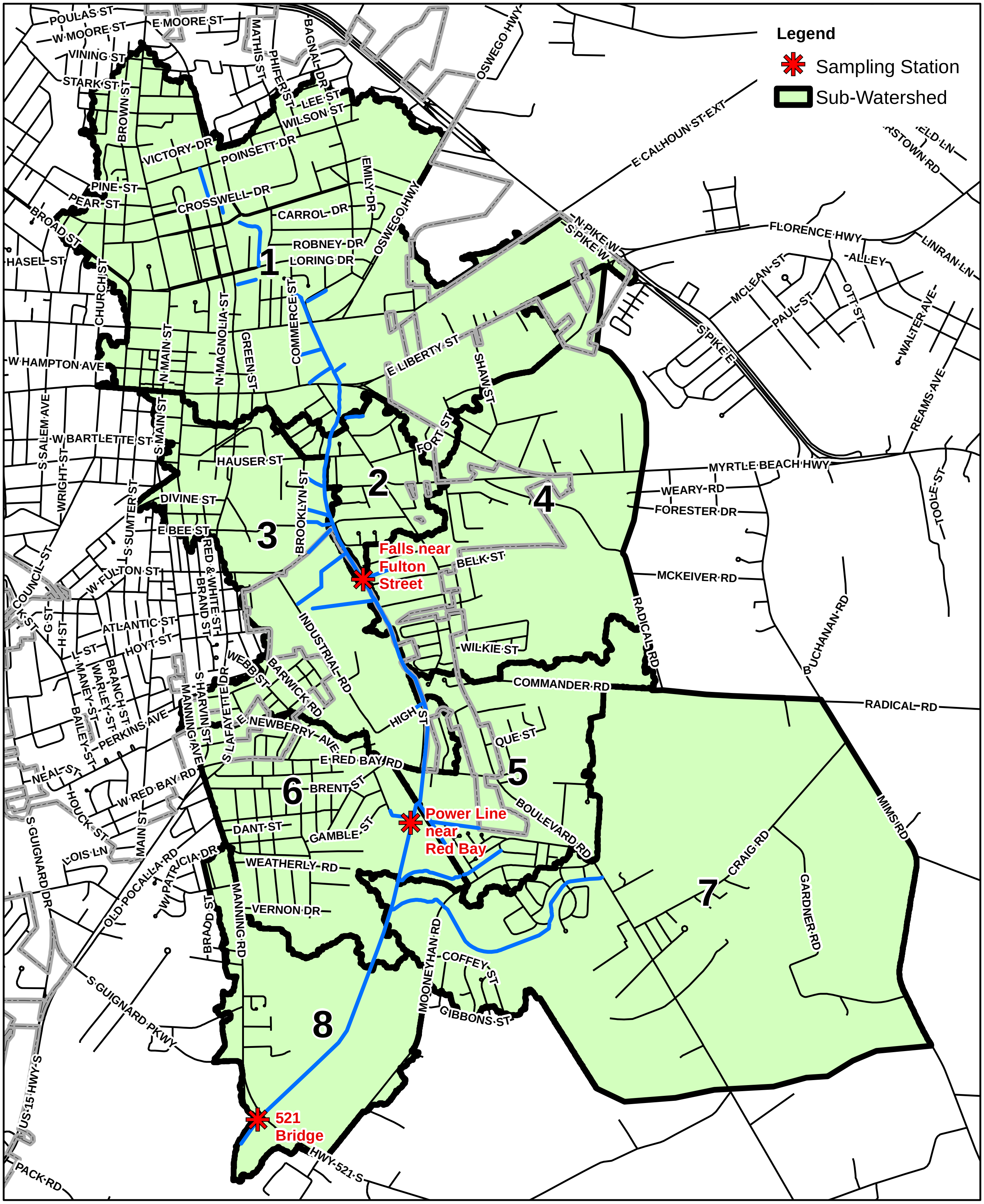
** Assumed based on results for filtering practices.

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 N

Water Quality Stations Location Map



File:G\46422560_Sumter_319GrantFunding
\Maps\Water_Quality_Monitoring_Stations.mxd
Date: October 29, 2013
Author: LCS

URS

N

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

1 inch = 0.6 miles

0 0.5 1 Miles

Sumter County

Water Quality Monitoring Stations Location Map

APPENDIX O

Field Sampling Equipment Checklist

SAMPLING EVENT # _______

FIELD SAMPLING EQUIPMENT CHECKLIST

Sumter County–Turkey Creek Watershed Plan
Turkey Creek 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 P

Water Quality Sampling Field Data Sheet

SAMPLING EVENT # _______

PHASE I - WATER QUALITY SAMPLING
FIELD DATA SHEET

Sumter County–Turkey Creek Watershed Plan
Turkey Creek 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				
	[Station ID] [Location]	[Station ID] [Location]	[Station ID] [Location]	[Station ID] [Location]	[Station ID] [Location]
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 Q

Chain of Custody Form

Sumter County–Turkey Creek Watershed Plan

Turkey Creek 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 R

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.]