Lower Caw Caw Swamp Watershed-Based Plan

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Prepared For

Prepared By

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Photographs on cover: (Right) stream at Turkey Hill Branch; (Left) wetland at Upper Caw Caw Swamp

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Commonly Used Acronyms

Abbreviation	Full Name
BMP	Best Management Practice
DPU	Department of Public Utilities
EPA	United States Environmental Protection Agency
FC	Fecal Coliform
GIS	Geographic Information System
MPN	Most Probable Number
SCDHEC	South Carolina Department of Health and Environmental Control
TMDL	Total Maximum Daily Load
WBP	Watershed-Based Plan

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This WBP could not have been possible without the grant funding provided by SCDHEC, and the support of many individuals. The main Project Team members are listed in Table 1.

Table 1: Lower Caw Caw Swamp WBP Project Team

Organization	Name	Title
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The Project Team would like to thank the following professionals and community stakeholders for their participation in focus group meetings, contributions to data collection, review of plan drafts, and input for recommendations to include in this report:

Table 2: Lower Caw Caw WBP Stakeholders and Focus Group Members

Organization	Name	Title
Orangeburg County	Richard Hall	*Community Development Director*
	Amanda Sievers	*Planning Director*
Orangeburg Soil & Water Conservation District	John Cuttino, Sr.	*Chairman*
	Lisa Rigden	*District Coordinator*
	Dianne Curlee	*Education Coordinator*
Edisto Riverkeeper	Hugo Krispyn	*Honorary Councilmember*
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	Frank Nemeth	*Watershed Manager*
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Longleaf Alliance	Lisa Lord	*Conservation Programs Director, Savannah River Clean Water Fund*
Congaree Land Trust	Mary Crockett	*Land Protection Director*

Executive Summary

Background Information

McCormick Taylor Inc. (MT) was contracted by the City of Orangeburg Department of Public Utilities (DPU) to develop a watershed-based plan (WBP) to identify and quantify sources of bacteria pollution and provide project recommendations within the Lower Caw Caw Swamp – North Fork Edisto River Watershed (HUC-12 030502030306). In this report, the watershed will be referred to as the Lower Caw Caw Swamp Watershed. This watershed is 14,227 acres and extends from the City of Orangeburg northeast across I-26 into Calhoun County. Both the Lower Caw Caw Swamp and North Fork Edisto River provide a critical source of drinking water for the City of Orangeburg, Orangeburg County, and Calhoun County. The City of Orangeburg utilizes the North Fork as its drinking water source, with its intake located within the Edisto Memorial Gardens.

This Watershed-Based Plan (WBP) for the Lower Caw Caw Swamp addresses key issues impacting source water protection and water quality issues within the watershed, which is currently under Total Maximum Daily Load (TMDL) requirements related to fecal coliform (FC) bacteria. The watershed faces problems typically associated with stormwater impacts resulting from agriculture and increasing development, such as stream erosion, water quality degradation, and loss of natural resources. The purpose of this WBP is to utilize the framework of the United States Environmental Protection Agency's (EPA) nine required elements to identify, quantify, and provide recommendations to reduce pollutants in the watershed. This WBP will also provide recommendations to measure and monitor progress and discuss funding needs and opportunities. Additionally, this plan will incorporate components that address climate change consideration, and the protection of public drinking water sources in the watershed.

The total population in this watershed is approximately 7,962. Currently, the major land cover types in the watershed are forest (50%), residential (29%), and commercial (9%). Other developed land uses include industrial (5%), and roadway (2%). The amount of impervious surfaces in the Lower Caw Caw Swamp Watershed is estimated to be 3,372 acres (24%) in total. At this level of imperviousness in a watershed, the stream health is predicted to be "impacted," as is discussed in Section 2.6.4 Existing Imperviousness.

Water Quality Modeling Results

The Watershed Treatment Model (WTM) was used to assess and quantify pollution in the watershed in three scenarios: current conditions, current conditions with recommendations, and future climate conditions. This spreadsheet tool was used to estimate pollutant loads based on current and future land use and management strategies. Under existing conditions, 11,800 acre-feet/yr of stormwater runoff is generated in the watershed and produces loads of 9.4×10^4 lb/yr of total nitrogen (TN); 1.2×10^4 lb/yr of total phosphorus (TP); 4.9×10^6 lb/yr of total suspended sediments (TSS); and 8.3×10^{14} MPN[1]/yr of *E. coli* bacteria.

[1] MPN is the most probable number; it is an estimate of the number of bacteria in a water sample.

WTM analysis indicates the largest sources of total nitrogen (TN) in the watershed are Commercial (20%) and Medium Density Residential (18%) areas and includes nonpoint pollution sources such as runoff containing fertilizers. Medium Density Residential (20%), Commercial (16%), and Channel Erosion (15%) contribute to most of the TP load. Sediment, measured in the form of total suspended solids (TSS), can be attributed to channel erosion, which accounts for 49% of the load. Finally, Medium Density Residential (35%) and High Density Residential (21%) produce the most bacteria in the watershed. Likely sources of bacteria in the watershed include pet waste and runoff from impervious surfaces.

The benefits from implementing all recommended practices (e.g., education, street sweeping), as well as 20 recommended projects, in the Lower Caw Caw Swamp Watershed include reductions in all four categories of pollutants in the WTM model: over 100% for TN, TP, and TSS, and 30% for bacteria when considering only the current conditions' human related sources (developed land use and sewage).

1.0 Introduction

1.1 Background, Purpose, and Need

1.1.1 Watersheds and Why They Matter

According to the United States Environmental Protection Agency (EPA), a watershed is a land area that drains to one stream, lake, or river. Watersheds exist at different geographic scales and nest within one another based on landscape composition qualities such as topography, geomorphology, and soil composition. A smaller watershed that drains into a smaller stream may be within much larger watershed where the smaller stream eventually drains into a lake or a larger river. In this sense, the concept of the watershed facilitates tracking water as it travels through different stages of the water cycle.

All water travels over a watershed as surface water, or underground as groundwater. Along this process, water may function as a vehicle that carries material across a watershed as it flows to a downstream receiving water. Sediment, nutrients, and pollution may travel this way until eventually accumulating in the larger waterbody.

This accumulation of pollution from across a watershed is considered nonpoint source (NPS) pollution because the sum of pollution cannot be pinpointed to a single entity or point source. Changes to a watershed, such as a storm event that deposits significant precipitation, or a construction project that disturbs soil, may eventually be reflected in the larger waterbody.

Watersheds are independent of any political boundaries but are significantly impacted by human activity. Human activity in this watershed includes various developed land uses, lawn care, pet and livestock waste, septic systems, and sanitary sewer overflows. The presence of impervious terrain, such as asphalt roads, parking lots, or bridges, reduces the infiltration capacity of soil and facilitates the transfer of runoff over land. Human activity and human-induced pollution is more easily carried over impervious surfaces (Figure 1-1), negatively impacting water quality.

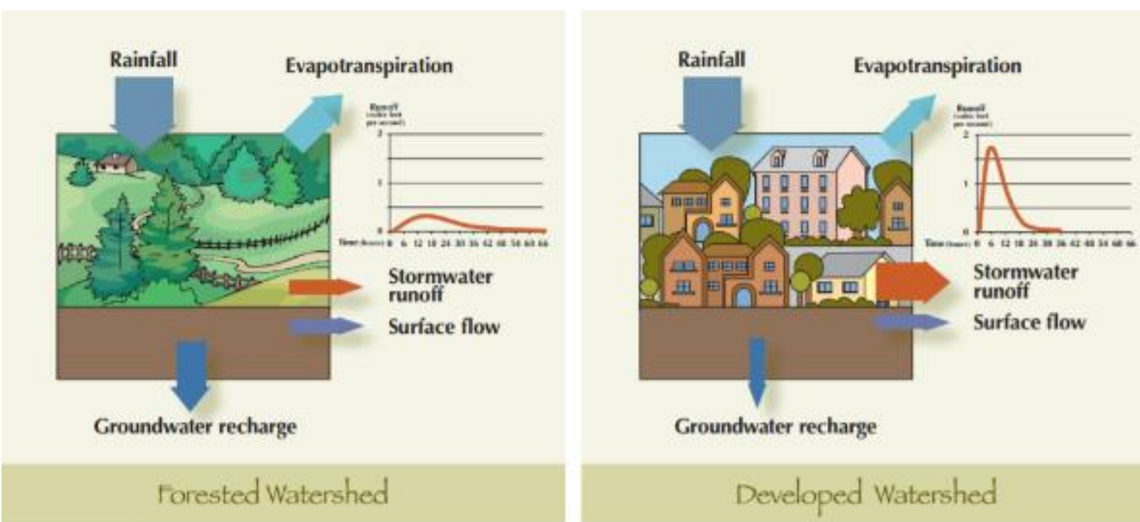

Figure 1-1: Visual representation of runoff differences between forested and developed urban watersheds (Image from SC Sea Grant, SCDNR, and NOAA)

Understanding watersheds and addressing water quality from a watershed-based approach facilitates understanding how small changes can accumulate to generate region-wide impacts. While this does not make the problem any less complex, it illustrates how a solution to water quality issues must be, by necessity, holistic and inclusive of all potential stakeholders within an area.

1.2 Lower Caw Caw Swamp – North Fork Edisto River Impairment and TMDL

The primary focus of the Lower Caw Caw Swamp WBP is a concerted, watershed-based approach to address bacterial contamination issues within the Lower Caw Caw Swamp Watershed. Currently, there is one historic SCDHEC monitoring station (E-105) located near the outlet of the watershed which is located within an approved Total Maximum Daily Load (TMDL) watershed (as shown in **Figure 1-2**) for Fecal Coliform (FC) bacteria. A TMDL is a calculation of the maximum amount of a pollutant allowed to enter a waterbody so that the waterbody will meet and continue to meet water quality standards for that particular pollutant. The existing TMDL for this watershed requires a 35% reduction in existing FC bacteria loads to station E-105. Note that the last SCDHEC sampling at this station occurred in 2009 and the TMDL report was created in 2010.

In addition to bacteria, the Lower Caw Caw Swamp WBP will provide analysis of sources of nutrients (nitrogen and phosphorus) and total suspended solids, and calculate potential benefits associated with the reduction of these pollutants in the watershed. Currently, there are no impairments or TMDLs associated with nutrients or sediment in the Lower Caw Caw Swamp Watershed; however, implementation of a variety of programs and practices within the watershed will simultaneously reduce bacteria and nutrients, which in turn improves water quality for both recreational and source water uses.

Note that FC bacteria do not threaten human health by themselves. Their presence is an indicator of potential harmful pathogens from human and animal feces, such as disease-causing bacteria, viruses, and protozoans that live in human and animal digestive systems[2]. Reducing the concentration of fecal bacteria should in turn reduce the presence of pathogens.

[2] USEPA. 2012. Water Monitoring & Assessment: Fecal Bacteria. Available online at https://archive.epa.gov/water/archive/web/html/vms511.html

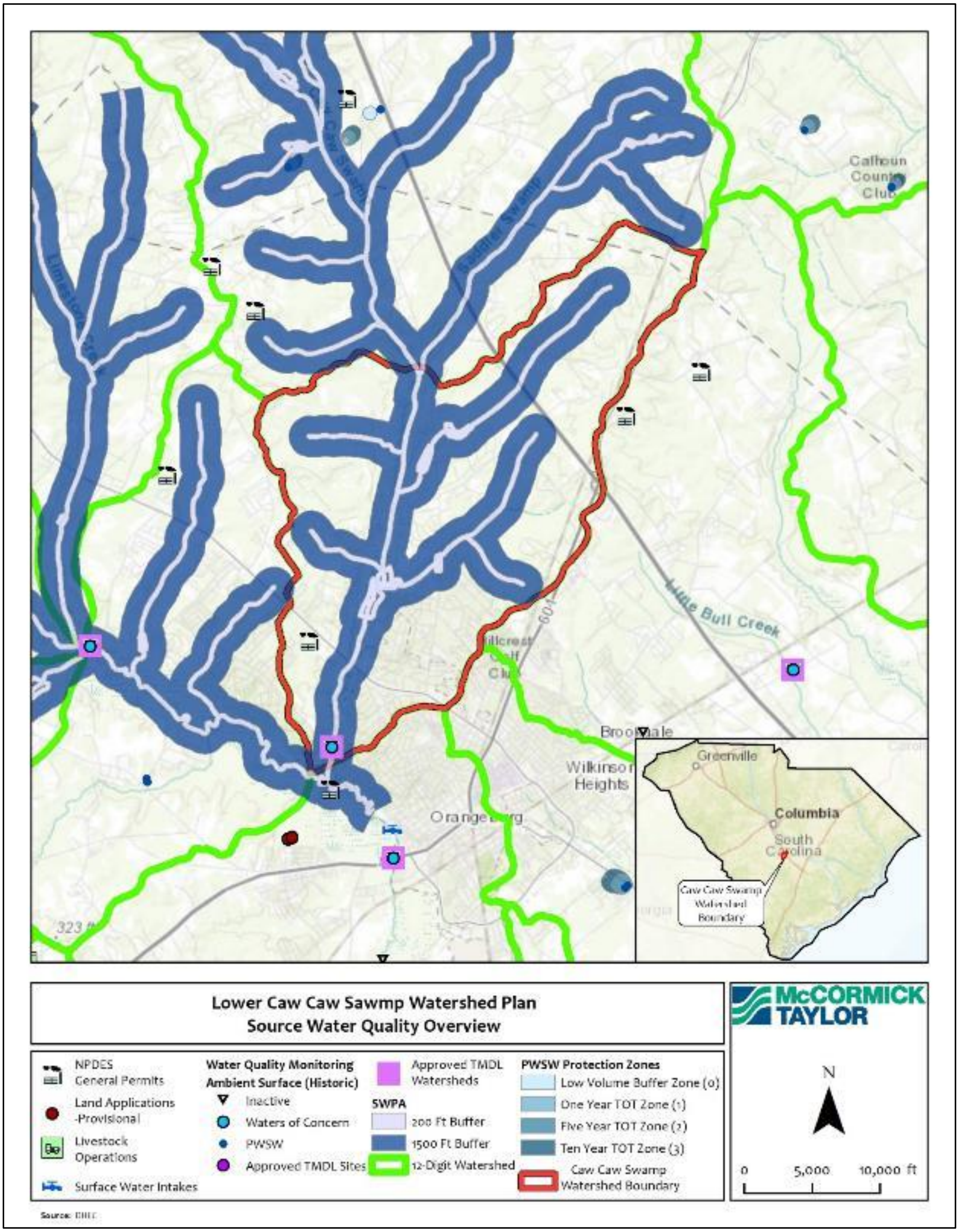

Figure 1-2: Lower Caw Caw Swamp Watershed source water quality concerns

1.3 Watershed-Based Plan

1.3.1 General Purpose and Context

Section 1. Introduction – Introduces the Watershed Management Plan, Goals and Objectives, and the overall planning context.

Section 2. Existing Conditions – Provides a detailed description of the watershed landscape, land use, living resources, and political boundaries. This section is largely based on research from existing data and reports.

Section 3. In-Stream Water Quality Monitoring – Provides a summary of currently available monitoring data in the watershed and a description of current water quality impairments.

Section 4. Pollutant Source Assessment – Describes the potential causes of water quality degradation in the watershed. This section also introduces the calculation of the pollutant loading based on existing land cover/land use conditions and assists in identifying the sources of various pollutants.

Section 5. Implementation Plan – Includes descriptions of the recommended management strategies and restoration projects, estimates of the water quality benefits that would be realized from plan implementation, and a schedule of future activities. This section includes cost estimates for strategy implementation, identifies potential funding sources, and describes schedules and monitoring programs to document plan implementation and changes in the watershed condition over time.

Section 6. Recommendations – Includes recommendations for programs, policies, and projects to improve water quality and protect source water.

1.3.2 EPA Required Nine Elements

The United States Environmental Protection Agency has established a series of nine essential watershed elements (A – I criteria) that must be addressed in the watershed plan for subsequent projects to be eligible for restoration and preservation funds under section 319 of the federal Clean Water Act. The plan was designed to satisfy these requirements. The elements are listed here with the plan sections that address each.

A. Identification of pollutant causes and sources to achieve load reductions addressed in watershed management plan:
    - Section 4.2 Land Use Nonpoint Sources
    - Section 4.3 Human Waste Pollution Sources
    - Section 4.4 Point Sources
B. Estimate of load reductions anticipated to be achieved through specified management measures:
    - Section 4.5 Watershed Pollutant Loads
    - Section 4.6 Benefits from Recommended Strategies

C. Description of nonpoint source management measures necessary to achieve load reductions:
    - Section 5.3 Management Practices and Strategies

D. Estimate of technical and financial assistance, cost, and authorities necessary to implement the watershed management plan:
    - Section 5.4.1 Priorities and Estimated Costs
    - Section 5.4.2 Potential Funding Sources

E. Information or education component to enhance public understanding of watershed management:
    - Section 5.1 Community Engagement

F. Schedule for implementing the nonpoint source management measures specified in plan:
    - Section 5.5 Schedules and Milestones

G. Interim, measurable milestones to determine implementation of nonpoint source management measures:
    - Section 5.4 Implementation Schedule

H. Criteria to determine if load reductions are being achieved:
    - Section 5.6.2 Evaluation Methods

I. Monitoring component to evaluate effectiveness of implementation efforts:
    - Section 5.6.1 Monitoring Program

1.4 Project Goals and Objectives

The overall goal of this plan is to identify and address all point and nonpoint pollution sources in the watershed; of upmost importance is fecal coliform bacteria, for which high historical concentrations have resulted in a TMDL that includes the Lower Caw Caw Swamp Watershed. Furthermore, the potential impact of climate change on the sources and magnitudes of pollutants will be examined. Lastly, the effects these pollutants may have on the surface source water intake for the City of Orangeburg Department of Public Utilities (DPU) will be discussed and recommendations for overcoming these challenges will be provided.

To accomplish that goal, the Project Team will assess watershed conditions (with field visits, stakeholder feedback, and desktop analysis), establish common water quality management goals and strategies, identify potential conservation areas, and recommend structural Best Management Practices (BMPs). As such, the watershed-based plan will provide a guidance and progress monitoring tool to reduce bacterial contamination and improve overall water quality in the Lower Caw Caw Swamp Watershed. The City of Orangeburg DPU plans to build upon the success of this WBP and create subsequent plans for other watersheds in their service area.

This plan is designed to provide a variety of water quality management strategies. The strategies vary in scope and obligation, from regional programmatic water quality monitoring coordination systems, to targeted stream restoration projects. While Section 319 grant funds are envisioned as a viable funding source for many of the BMPs, this plan also provides strategies which could be successfully implemented by individual organizations or through the leveraging of local groups such as the Orangeburg Soil & Water Conservation District, Friends of the Edisto River, or the students at Claflin University and/or South Carolina State University.

Additional Objectives:

- Water Quality Monitoring: reinstate regular water quality monitoring in the Lower Caw Caw Swamp Watershed (HUC-12) to be overseen by the City of Orangeburg DPU in partnership with students and faculty at Claflin University and/or the SC Adopt-a-Stream program
- Instate a program for Stream/Floodplain/Habitat Restoration and Preservation that will help protect vulnerable flora and fauna, as well as the source water intake
- Stabilize eroding streams, fields, and improperly stored construction materials

2.0 Analysis of Watershed Conditions

For the purpose of this watershed-based plan, the Project Team has analyzed available and predicted data for both existing conditions and future conditions in the Lower Caw Caw Swamp Watershed, including climate, soils, land use, and waste treatment processes. The following sections summarize the findings of this research.

2.1 Watershed Location and Boundaries

2.1.1 Jurisdictional Boundaries

The Lower Caw Caw Swamp Watershed encompasses 14,227 acres of land and extends across three different political jurisdictions consisting of two counties (Orangeburg and Calhoun), and one municipality (City of Orangeburg). Currently, the counties and city are not part of a Municipal Separate Storm Sewer System (MS4) area; however, the South Carolina Department of Transportation (SCDOT) is a large MS4 that has responsibilities for DOT-owned roadways (such as I-26) that are within the watershed boundary.

2.1.2 Subwatershed Boundaries

McCormick Taylor subdivided the overall Lower Caw Caw Swamp Watershed into four (4) subwatersheds, as shown in **Table 2-1** and **Figure 2-1**. The purpose was to provide a method for geographically describing areas to differentiate pollutant sources and recommendations in this WBP. In each of the four subwatersheds, forest is the predominant land cover. The amount of developed area (all land use classes except forest, rural, and open water) varied across the HUC-12 watershed. The least developed subwatershed was Upper Caw Caw Swamp (139 acres). The remaining subwatersheds, in order from least to greatest development, are Early Branch (1,599 acres), Turkey Hill Branch (1,881 acres), and Lower Caw Caw Swamp (2,687 acres). A more detailed discussion of Land Cover/Land Use analysis is included in **Section 2.6.3** of this WBP.

Table 2-1: Land Use in Subwatersheds of the Lower Caw Caw Swamp HUC-12 Watershed

Land Use	Upper Caw Caw Swamp	Lower Caw Caw Swamp	Turkey Hill Branch	Early Branch
Residential, Low	28.50	236.02	142.27	113.29
Residential, Medium	103.23	714.10	812.12	784.14
Residential, High	0.09	1,065.34	109.82	-
Residential, Multifamily	-	58.16	1.36	-
Commercial	-	507.22	469.27	248.49
Roadway	7.38	106.43	71.52	58.13
Industrial	-	-	274.50	394.55
Forest	2,076.89	1,160.28	1,654.92	2,195.58
Rural	3.88	3.58	7.08	403.11
Open Water	105.11	164.28	109.48	43.45
Total Area (Acres):	**2,185.88**	**1,941.78**	**2,586.78**	**3,343.32**

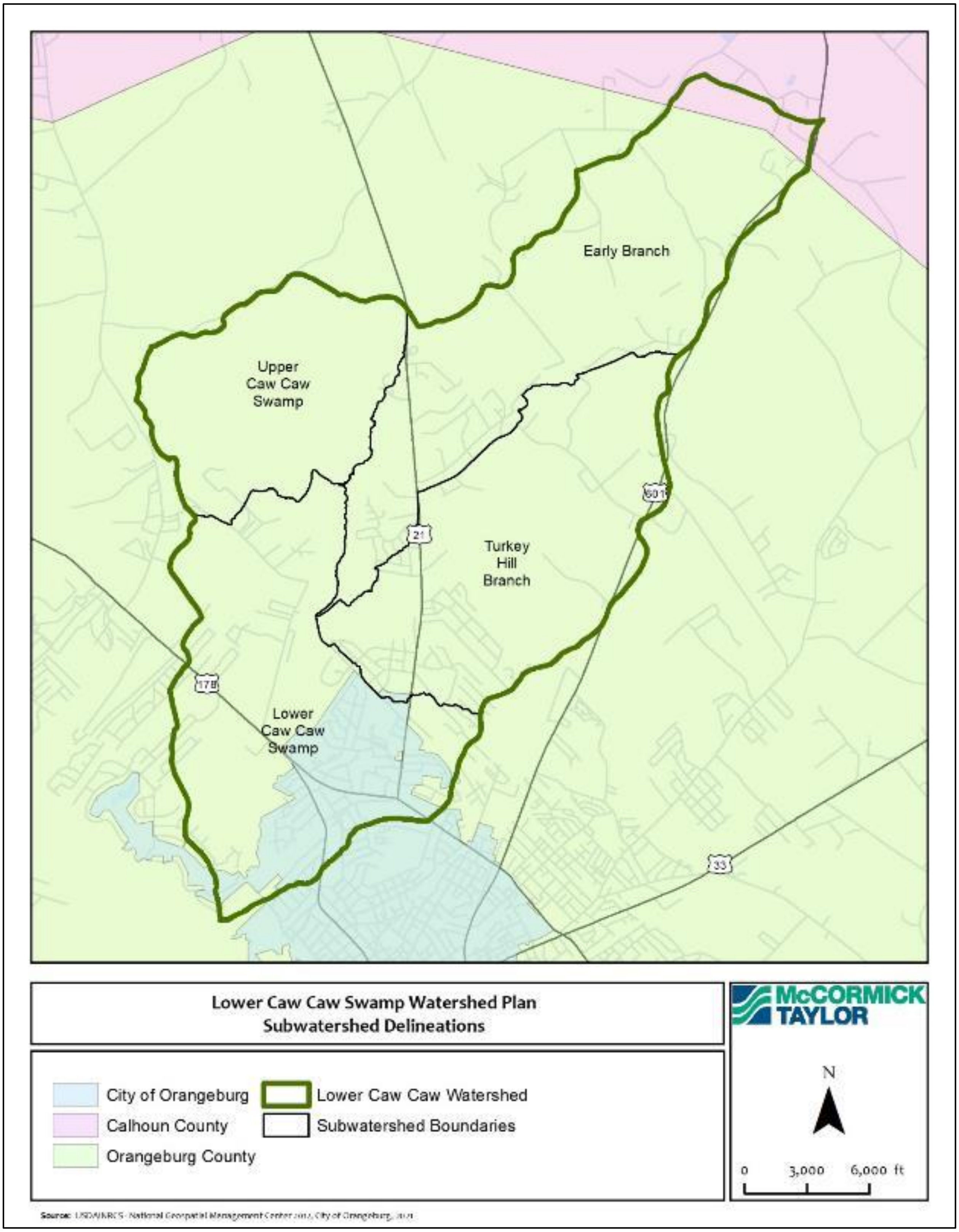

Figure 2-1: Lower Caw Caw Swamp Watershed and Jurisdictional Boundaries

2.2 Climate

Climate influences soil formation and erosion processes, stream flow patterns, vegetation coverage, and a significant part of the geomorphology of a watershed. Precipitation not only provides water to streams and vegetation, but the intensity, frequency, and amount of rainfall can greatly influence watershed characteristics.

2.2.1 Historic Temperature Data

Based on the 1981 – 2010 Summary of Monthly Normals (National Environmental Satellite, Data, and Information Service), Orangeburg, SC has a temperate climate with a mean annual temperature of 62.9°F. The monthly average maximum, minimum, and mean temperatures for the Orangeburg 2 station are summarized in **Table 2-2** below.

Table 2-2: Summary of Monthly Temperature Normals for Orangeburg* (1981-2010)

Month	Average Max. Temp (°F)	Average Min. Temp (°F)	Mean Temp (°F)
January	55.4	33.5	44.5
February	59.5	36.5	48.0
March	66.8	42.7	54.8
April	74.4	49.7	62.1
May	81.8	58.6	70.2
June	87.6	67.2	77.4
July	90.0	70.2	80.1
August	88.8	69.7	79.3
September	83.6	63.7	73.6
October	75.0	52.4	63.7
November	66.8	42.4	54.6
December	57.9	35.3	46.6
Annual Mean	**74.0**	**51.8**	**62.9**

**National Centers for Environmental Information, Station Orangeburg 2 (USC00386527)*

2.2.2 Analysis of Historic Precipitation Data

The mean annual rainfall is the precipitation value utilized for the water quality analysis method in the Watershed Treatment Model (WTM), as described in **Section 4.0 Pollutant Source Assessment**. Several sources of precipitation information were analyzed for the Lower Caw Caw Swamp Watershed and are summarized in **Table 2-3**. The Project Team focused on a long-serving station called “Orangeburg 2” with records from 1947 to present. For additional context, a report from Climate Division 6, which includes Orangeburg County, was included. This record comprises from multiple stations in the region and has a longer time series. The data are very similar statistically; because of averaging across stations the extremes are muted somewhat in comparison to the single station. The precipitation values that are bolded are the ones that CISA recommended for analysis in the WTM model. This range of precipitation values will help inform the climate scenarios for future conditions.

Table 2-3: Summary of Historic Precipitation Data for Orangeburg

Annual Precipitation (in)	Orangeburg 2 (1947-2020)	Orangeburg 2 (1981-2010)	Orangeburg 2 (1991-2020)	Climate Division 6 (1895-2020)
Lowest recorded	**25.41**			26.82
5th percentile	34.60			35.96
10th percentile	**36.75**			38.23
25th percentile	42.06			41.92
median	47.45			45.45
mean	**48.14**	46.97	50.48	46.34
75th percentile	54.69			50.64
90th percentile	**62.08**			55.39
95th percentile	65.33			59.18
Highest recorded	**71.47**			69.68

2.2.3 Analysis of Future Climate Conditions

There are several broad areas for climate considerations in the Lower Caw Caw Swamp WBP which have implications for watershed management issues, such as changes in temperature and precipitation projections. Climate considerations potentially change current and future water quality management actions, which could result in future cost savings and a more resilient watershed. These considerations prompted a WTM exercise that envisions a future climate scenario which integrates modeled changes to temperature and precipitation in the Lower Caw Caw Swamp Watershed (as described in **Section 4.5.2**). These climate impacts were also considered through the context of watershed planning and the EPA Nine Elements of a Watershed-Based Plan. The climate projection analysis of the Lower Caw Caw Swamp Watershed indicates a need to plan for shifts in temperature and precipitation, and their potential future impacts on bacterial contamination. This section describes some of these implications and provides potential strategies to address them, helping create a more resilient watershed.

In the Orangeburg area, climate change is resulting in an increase in average temperature over time, and changes in seasonal and daily temperature patterns (for instance, a warming of overnight lows and a rise in average winter temperatures). Extreme heat will be a core impact of climate change in the Lower Caw Caw Swamp Watershed, which is expected to see more frequent and severe heatwaves in most climate scenarios.[3] In the watershed area, Coupled Model Intercomparison Phase 5 (CMIP5) models suggest a doubling of days per year above 100 °F, a ~60% increase in days above 95 °F, and a ~2 °F increase in average annual temperature by the mid-century.[4] Temperature change could drive increased recreational use of the watershed (such as swimming and boating) and potentially affect BMP efficacy and upkeep.

Furthermore, climate change is resulting in an increase in average rainfall in the Lower Caw Caw Swamp Watershed. It is also changing the frequency and intensity of precipitation events and patterns, which in

[3] 4th National Climate Assessment Southeast Chapter, see https://nca2018.globalchange.gov/chapter/19/
[4] Climate and Hazard Mitigation Planning (CHaMP) Tool, see https://champ.rcc-acis.org/

turn impacts the frequency and intensity of both drought and heavy rainfall events.[5] The number of extreme rainfall events observed since the 1950s is increasing and their frequency is expected to further double or triple by the end of the century.[6] Precipitation change introduces water quality planning considerations such as managing stormwater runoff, flooding, sampling water quality measures, fecal coliform bacterial loads, and BMP capacity and efficacy. Increases in extreme rainfall events and flooding can pose a particular challenge for watershed management if a short duration rainfall event exceeds BMP capacity.

Because precipitation is a key input into the WTM model, CISA evaluated available annual precipitation data from Coupled Model Intercomparison Phase (CMIP6) models and compared it to available historical averages. A recent evaluation of CMIP6 models suggest that CMIP6 models continued to improve in accuracy for the southeast region but tend to underestimate shifts in precipitation indices representing both averages and extreme precipitation conditions.[7] In CISA's analysis, model data from the watershed area show an increase in annual precipitation over time, in line with existing projections available for the Southeast. Shared Socioeconomic Pathway 5 (SSP5) is the scenario used in the model and is equivalent to Representative Concentration Pathway 8.5 (RCP 8.5), or a high carbon emissions future.

Based on guidance from CISA, the consultant used the 90th percentile total annual rainfall (62.08 inches) from the Orangeburg 2 weather station historic precipitation data. This reflects a shift in the CMIP6 data, as illustrated in **Figure 2-2**.

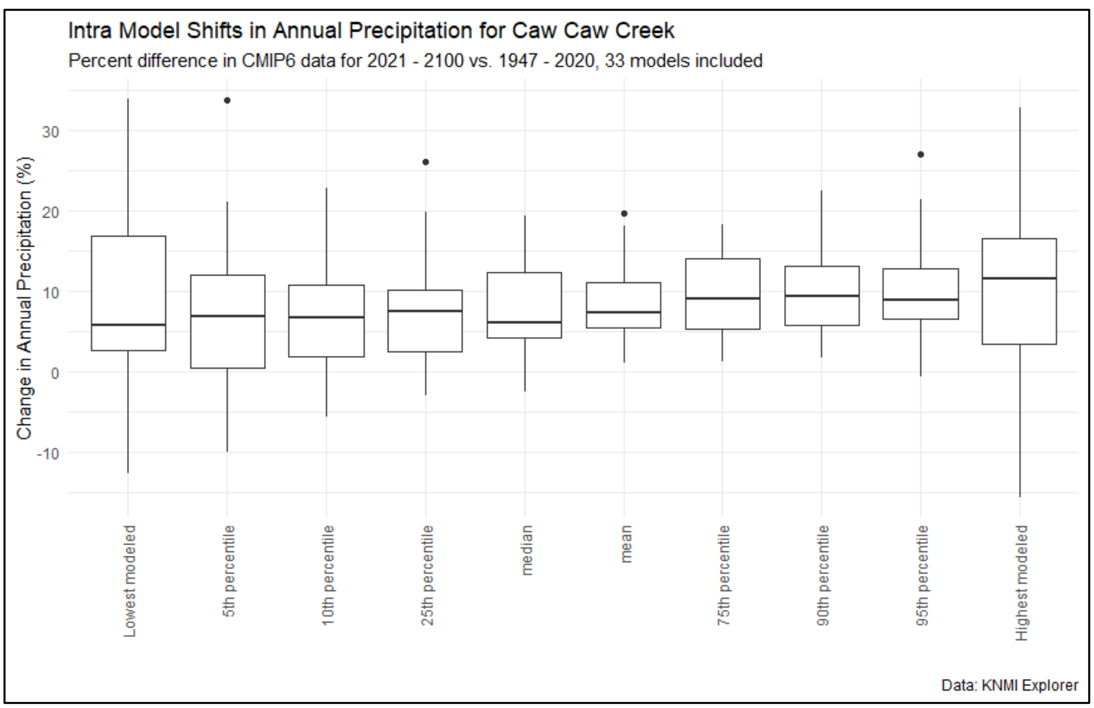

Figure 2-2: Range of Climate Model Projections for Annual Precipitation

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[5] 4th National Climate Assessment Southeast Chapter, see https://nca2018.globalchange.gov/chapter/19/
[6] 4th National Climate Assessment Section 7.2.2, see https://science2017.globalchange.gov/chapter/7/
[7] For several examples, see the NOAA Climate Program Office's Water Utility Study. https://cpo.noaa.gov/Meet-the-Divisions/Climate-and-Societal-Interactions/Water-Resources/Water-Utility-Study

2.3 Surface Water Resources

2.3.1 Streams and Rivers

The Lower Caw Caw Swamp Watershed contains 31.3 miles of streams (based on 2018 National Hydrography dataset[8]), as summarized in **Table 2-4** and shown in **Figure 1-1**. Along these waterways, there are currently 17 SCDHEC regulated dams (8 low hazard, 5 high hazard, 2 significant hazard). A high-hazard (C1) dam is a structure where failure will likely cause loss of life and/or serious damage to infrastructure. A significant-hazard (C2) dam is a structure where failure will not likely cause loss of life, but infrastructure may be damaged. A low-hazard (C3) dam is a structure where failure may cause limited property damage. Dams have the potential to impact water quality in positive or negative ways. Water held in reservoirs tends to heat up and increase the downstream temperature of the river. If water is released from the bottom of a dam, it can be low in dissolved oxygen which can cause problems for fish downstream. If the water is allowed to fall over a spillway, it may mix more oxygen into the water.

Additionally, reservoirs have the potential to produce large amounts of algae and other plants which can increase the concentration of nutrients in the water. Large amounts of algae and aquatic plants are the result of excess nutrients and can strip the water column of nutrients while creating a significant amount of nutrient cycling within a reservoir.[9] A substantial die-off of algae and plants (seasonal or otherwise) can cause a spike in nutrient concentrations in the reservoir's water and cause low dissolved oxygen concentrations as a result of decomposition of the excess plant material. This low DO, high nutrient water flows out of the reservoir via the tailwaters exiting the dam, which results in similar processes occurring downstream – excessive aquatic vegetation/algal growth, subsequent die-off, and increased oxygen consumption.

Additionally, sediments settle out in reservoirs behind dams, which helps reduce sediment loads downstream of the dam. However, sediments also have the potential to trap pollutants and toxic chemicals which can become resuspended in the water if the sediments are disturbed.

Table 2-4: Tributaries of the Lower Caw Caw Swamp Watershed

Name	Miles
Turkey Hill Branch	3.47
Early Branch	4.76
Caw Caw Swamp	6.53
Unnamed	16.54
TOTAL	**31.30**

[8] USGS. 2022. https://www.usgs.gov/national-hydrography/national-hydrography-dataset
[9] EPA. 2022. https://www.epa.gov/nutrientpollution/effects-dead-zones-and-harmful-algal-blooms

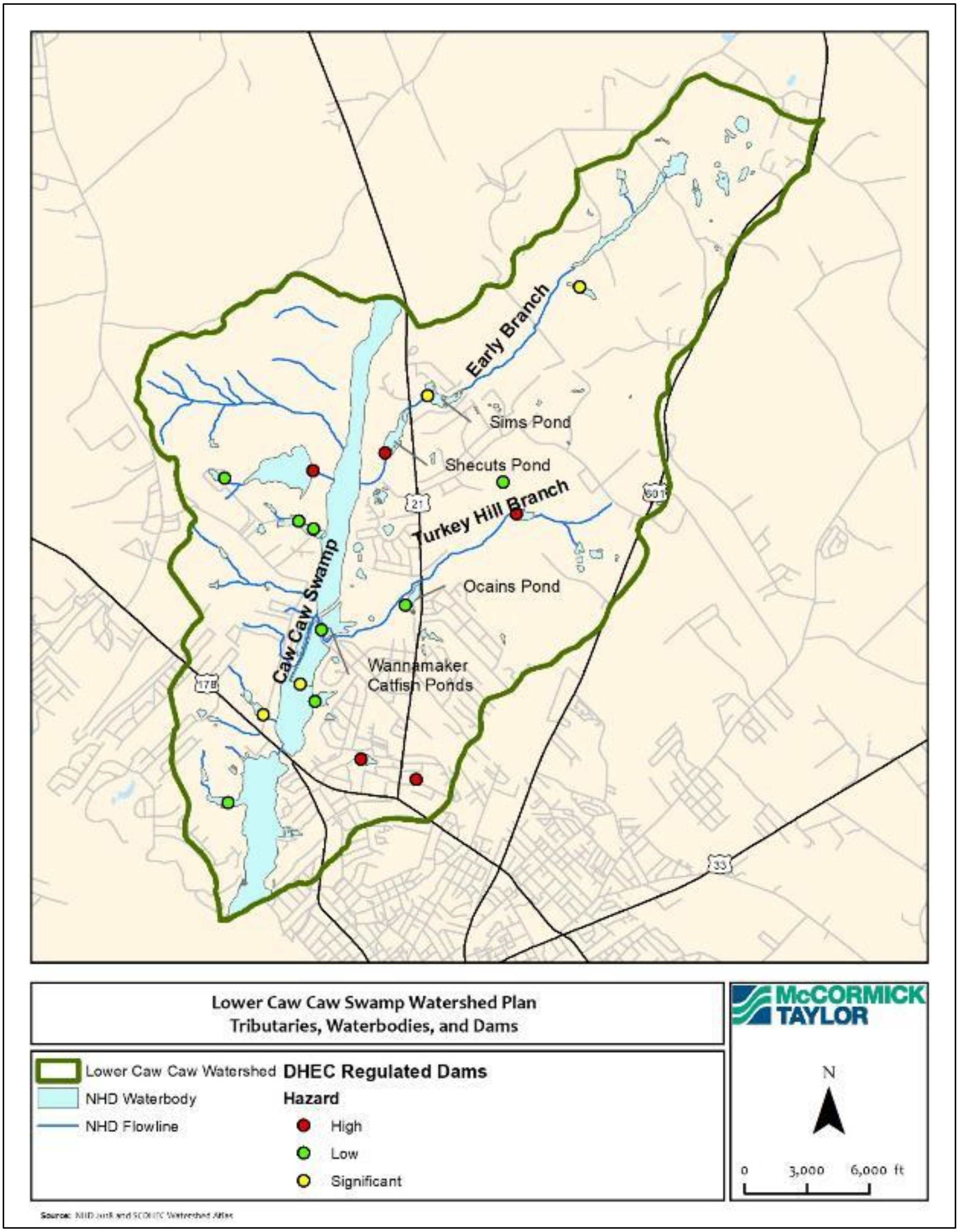


Figure 2-3: Lower Caw Caw Swamp Watershed Tributaries, Waterbodies, and Dams

2.3.2 Riparian Buffer Analysis

The consultant team performed analysis of the current condition of riparian buffers in the watershed via Geographic Information System (GIS) data, aerial imagery, and site visits. Streamlines were defined by the National Hydrography Dataset (NHD). The summary table of buffer requirements by each jurisdiction in the watershed is summarized in **Table 2-5**. The existing conditions of the riparian buffers in the watershed are in varying degrees of health and functionality as illustrated by the photos in **Figure 2-4.** Using a minimum buffer width 40', in accordance with the Orangeburg County and the City of Orangeburg buffer width requirements 31.6 miles of stream buffer was analyzed (**Figure 2-5**) and it was determined that 19.9 miles (63%) had adequate buffer width and 11.7 miles (37%) of stream buffer was considered inadequate.

Table 2-5: Buffer Requirements by Jurisdictional Area

Jurisdiction	Buffer Requirements
Orangeburg County	A riparian buffer setback not less than 40 feet or one-third the depth of a lot or parcel, whichever is less, shall be provided along the banks of all lakes, streams, and rivers. The buffer area shall remain undeveloped, except for piers, docks, and pervious access paths to the water's edge. Any disturbance of the buffer area shall adhere to Best Management Practices (BMPs) For Forestry, in streamside management zones, promulgated by the SC Forestry Commission.
City of Orangeburg	Same as Orangeburg County
Calhoun County	An undisturbed, natural vegetative buffer shall be maintained along both banks of streams and along all impoundments. The buffer shall be a variable width buffer with an average width of at least 50 feet, and a minimum width of 30 feet.
South Carolina Dept. of Natural Resources	A minimum 50 to 100-foot riparian buffer should be established and maintained along both sides of the stream. Native vegetation, typically trees, shrubs, grasses, and forbs, should characterize the buffer. Any development within buffer areas should be avoided. Where possible, the Scenic Rivers Program advocates a more extensive buffer, a minimum of 100 feet, on the stream to allow for additional protection of water quality and preservation of other important values such as aesthetics and wildlife habitat.

Figure 2-4 shows pictures collected as part of a field survey of the watershed conducted by the consultant. This process was spread out over several field days and was focused on water bodies depicted in the National Hydrography Dataset (NHD). The result of this field work was the creation of a baseline assessment of existing riparian buffer conditions, as shown in **Figure 2-5**.

Figure 2-4: Photos of observed riparian buffer conditions

Photo Top Left: Unvegetated berm south of Wannamaker Catfish Farm.
Photo Top Right: Headwaters of the Caw Caw Swamp, south of Farnam Road.
Photo Bottom Left: East of “Right Direction Christian Center,” Caw Caw Swamp.
Photo Bottom Right: Western edge of Sims Pond – South of Ginger Lake Drive.

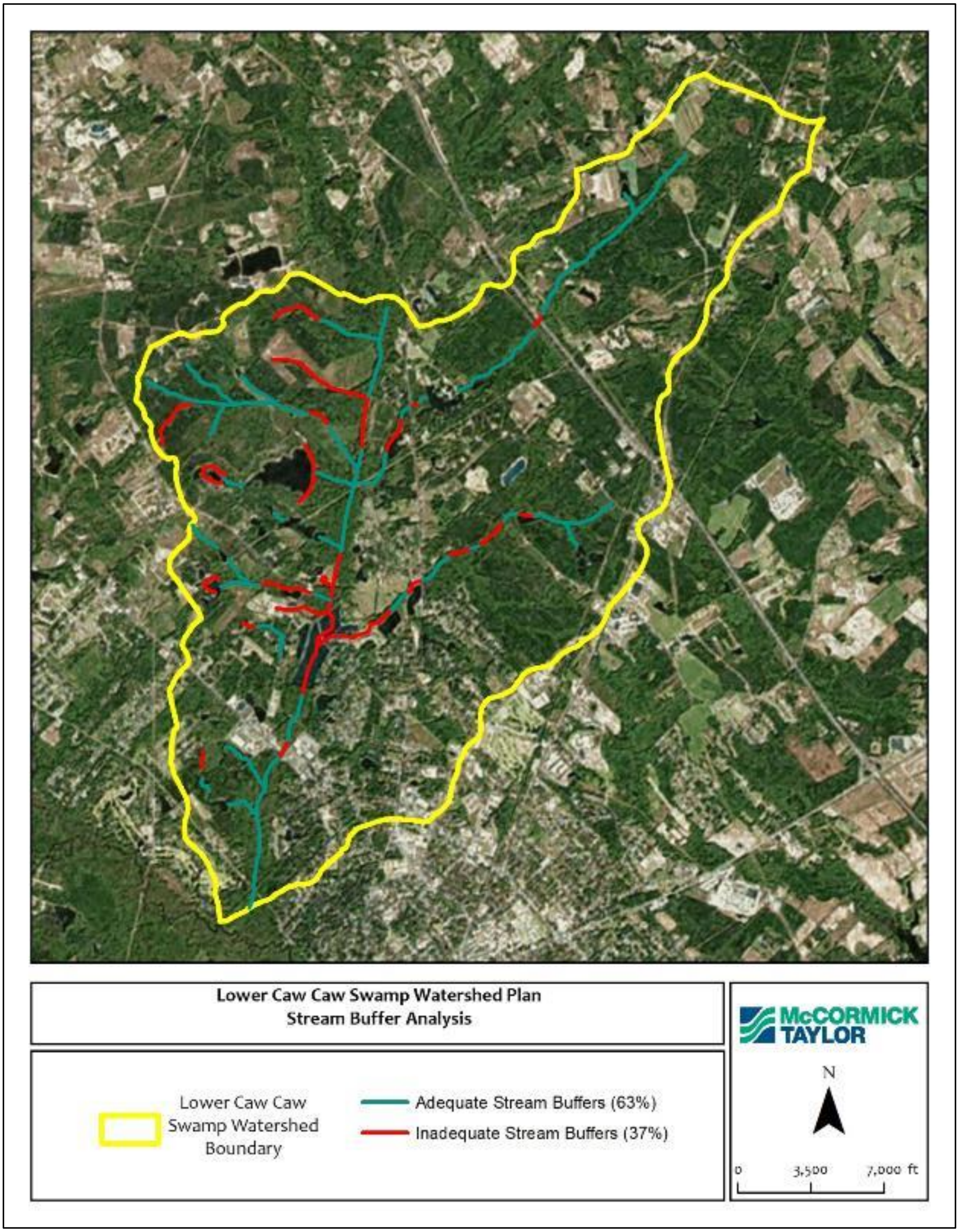


Figure 2-5: Analysis of observed riparian buffer conditions for compliance with ordinance

2.3.3 Wetlands

Section 404 of the Clean Water Act (EPA, 1972) defines wetlands as “those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soils. Wetlands generally include swamps, marshes, bogs, and similar areas.”

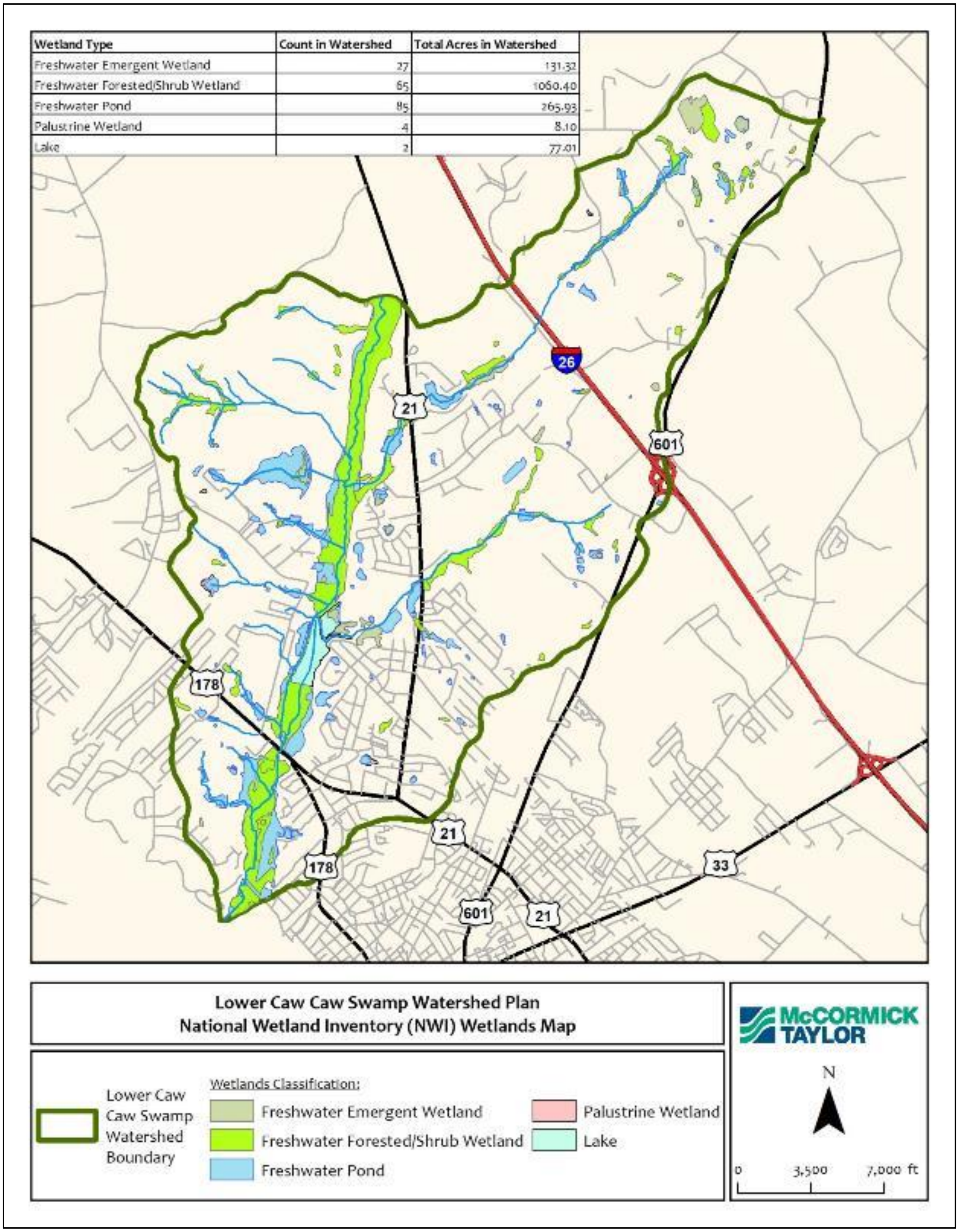
Wetlands are environmentally sensitive habitats that play an integral part in supporting the water quality and water storage of a watershed. These reservoirs help to control flooding by retaining surface runoff and releasing steady flows of water downstream. Wetlands also support biological diversity, erosion control, and sediment retention.

Table 2-6 summarizes the National Wetland Inventory (NWI) for the Lower Caw Caw Swamp Watershed. There are 1,542.75 acres of wetland habitat throughout the watershed (USFWS, 2016), the majority of which are freshwater forested/shrub wetlands (69%). Note that these wetlands have not been field-verified and there may be wetlands present in the watershed that may not be shown in the NWI. **Figure 2-6** shows wetland types from the NWI in the watershed.

Table 2-6: Wetlands in Lower Caw Caw Swamp Watershed

Wetland Category	Acres	Percent
Freshwater Emergent Wetland	131.32	9%
Freshwater Forested/Shrub Wetland	1,060.40	69%
Freshwater Pond	265.93	17%
Palustrine Wetland	8.10	1%
Lake	77.01	5%
TOTAL:	1,542.75	100%

The United States Army Corps of Engineers (USACE) classifies wetlands in accordance with their existing conditions. Existing condition is defined as “the degree of disturbance relative to the ability of a site to perform its physical, chemical, and biological functions.” This rating system was created to quantify wetland value as it relates to creating a wetland impact mitigation plan. The rating system gives a numerical value to the wetland based on the four following classifications: 1) fully functional, 2) partially impaired, 3) impaired, and 4) very impaired (ACOE, 2010).



Wetland Type	Count in Watershed	Total Acres in Watershed
Freshwater Emergent Wetland	27	131.32
Freshwater Forested/Shrub Wetland	65	1060.40
Freshwater Pond	85	265.93
Palustrine Wetland	4	8.10
Lake	2	77.01

Figure 2-6: National Wetland Inventory Map for Lower Caw Caw Swamp Watershed

2.3.4 Floodplains

The process by which streams swell during storms and spill out on to their floodplain is natural. The Federal Emergency Management Agency (FEMA) 100-year floodplains are shown in **Figure 2-7**. Anthropocentric concerns with flooding problems often stem from land development occurring in flood-prone areas and/or structures being built in floodplains. Such flooding concerns are exacerbated when development throughout the watershed, and the associated impervious surfaces, result in increased volumes of runoff and expansion of those flood-prone areas over time. These concerns are also provoked by the gradually increasing storm frequencies and intensities we are experiencing as a result of climate change.

Flooding is a major hazard and concern for both water and wastewater utilities.[10] Floods are high volumes of water flow over areas that are normally dry land, and can inundate areas where chemicals, fuel, bacteria, and other potential pollutants harmful to human health and the environment may be located. The result is a significant and serious risk to anyone or anything the floodwater has contacted, including individual drinking water wells or community water systems. The force of floodwaters can also disrupt or damage water supply infrastructure and directly introduce the contaminated water into the treatment or distribution system.[11]

Flood waters can also increase the concentration of Total Organic Carbon (TOC) in receiving waterbodies for many weeks, which increases the risk of disinfectant byproducts in the drinking water. More information about TOC monitoring and treatment can be found in **Section 3.4.3 Organic Matter**.

Flooding creates additional concerns for septic systems.[12] If the soil is saturated and flooded, the wastewater will not be treated properly, and will become a source of nonpoint source pollution in the watershed that can include raw sewage and chemicals (which can cause skin, eye, and respiratory irritation). Flooding of the septic tank may cause the system to back up into the house, creating a health hazard for residents. As is discussed in further detail in **Section 2.7.2**, 57% of all buildings in the Lower Caw Caw Swamp Watershed are not connected to sanitary sewer, and of those, 10% are within 100 feet of a receiving waterbody.

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[10] USEPA. 2014. Flood Resilience: A Basic Guide for Water and Wastewater Utilities. EPA 817-B-14-006. Available at https://www.epa.gov/sites/default/files/2015-08/documents/flood_resilience_guide.pdf

[11] University of Nebraska-Lincoln Institute of Agriculture and Natural Resources. 2017. Floodwater and stormwater can contaminate your water well. Available at https://water.unl.edu/article/drinking-water-wells/floodwater-and-stormwaters-can-contaminate-your-water-well

[12] USEPA. 2005. Septic Systems – What to Do after the Flood. EPA 816-F-05-029. Available at https://www.epa.gov/sites/default/files/2015-11/documents/2005_09_22_faq_fs_whattodoafteraflood_septic_eng.pdf

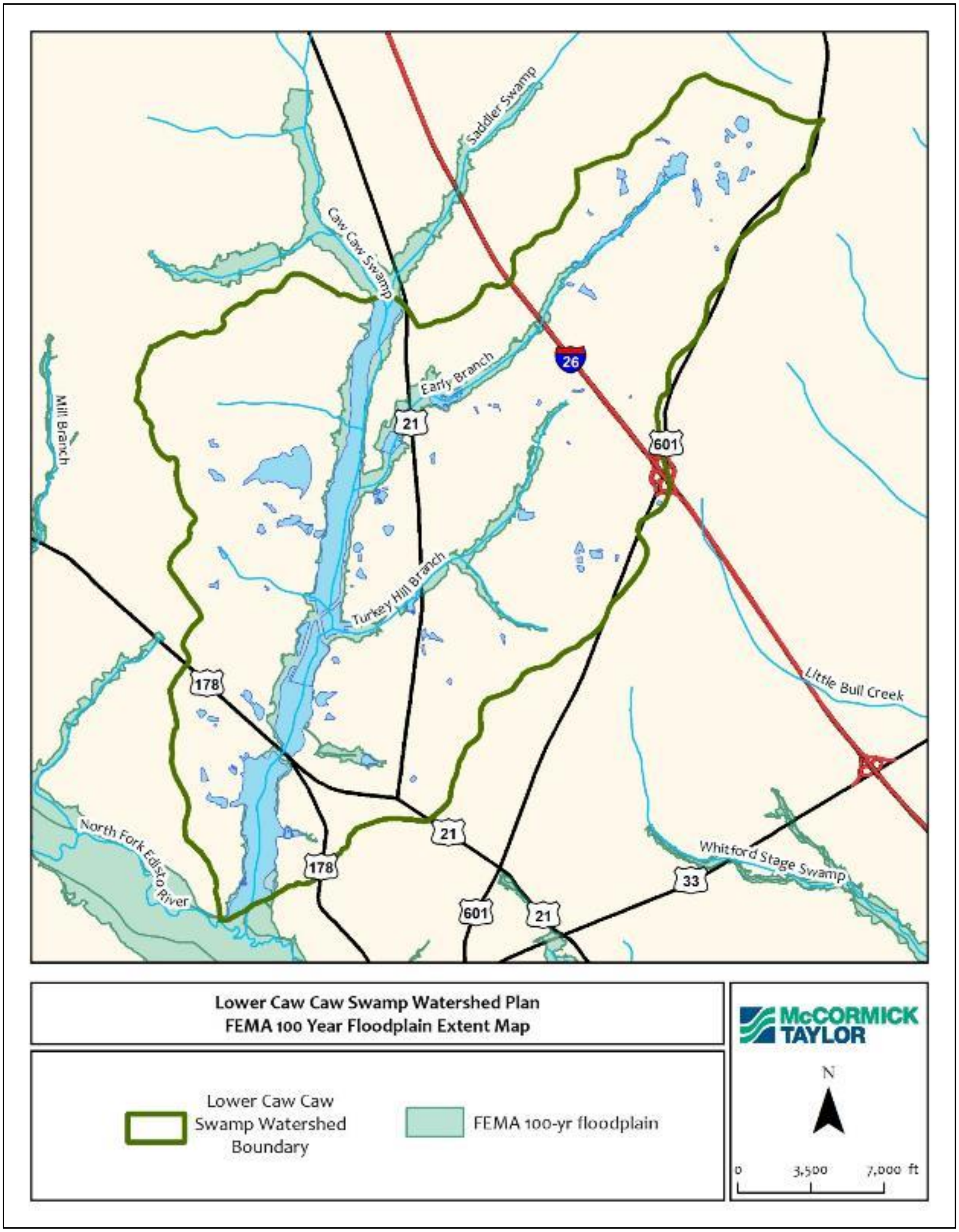

Figure 2-7: 100-year FEMA Floodplain for the Lower Caw Caw Swamp Watershed

2.4 Geology and Soils

2.4.1 Geology

The geologic formations underlying a watershed have a significant effect on the water resources. Geology is a major determinant of the type of topography and surface features in an area. The chemical composition and minerals of the parent rock or unconsolidated sediments determines in large part the soil characteristics, including erodibility and infiltration rates.

Ecoregions are areas of general similarity in the type, quality, and quantity of environmental resources. Currently, the EPA has mapped four levels of detail for the southeast region. The Lower Caw Caw Swamp Watershed is located within the Southeastern Plains ecoregion, specifically the Atlantic Southern Loam Plains (65L). The 65L region is characterized as low and flat with fine textured soils. It is considered a major agricultural zone due to its deep, well drained soils and has a high concentration of Carolina Bays – "shallow, elliptical depressions, often swamp or wet in the middle with dry sandy rims" (Griffith et al., 2002).

2.4.2 Soils

As summarized in **Table 2-7**, the most common soil series in the Lower Caw Caw Swamp Watershed are Neeses loamy sand complex (17.1%), Bonneau sand (12.4%), and Orangeburg loamy sand complex (11.7%). The Neese series consists of deep, well drained soils that formed in clayey and loamy sediments on the coastal plain. The soils are on broad to narrow ridges and in long narrow ridges and in narrow areas parallel to streams and other drainageways (NRCS, 1988). The Bonneau series consists of well drained soils that formed in sandy and loamy marine sediments on the Coastal Plain. The soils are on low ridges and side slopes (NRCS, 1988). The Orangeburg series consists of well drained soils that formed in loamy marine sediment on the Coastal Plain. The soils are on ridges and side slopes (NRCS, 1988).

Figure 2-8 illustrates the locations of the Hydrologic Soil Group (HSG) classifications in the watersheds, as assigned by the United States Department of Agriculture Natural Resources Conservation Service (USDA-NRCS). The HSG describes a group of soils having similar runoff potential under similar storm and cover conditions:

- Group A are soils having a high infiltration rate (or low runoff potential) when thoroughly wet. These consist mainly of deep, well-drained sands or gravelly sands. These soils have a high rate of water transmission.
- Group B are soils having a moderate infiltration rate when thoroughly wet.
- Group C are soils having a slow infiltration rate when thoroughly wet. These soils typically have a layer that impedes the downward movement of water.
- Group D are soils that have a very slow infiltration rate (or high runoff potential) when thoroughly wet. Generally, these are soils that have a clay layer at or near the surface; soils that have a high-water table; and/or soils that are shallow over nearly impervious material.

There are also three dual HSG classifications (A/D, B/D, and C/D). These soils are given two classifications to make a distinction between a drained and undrained condition. For the purposes of this watershed study, in order to make a conservative estimate of runoff potential, all three dual HSG groups were assumed to be undrained (HSG D). The HSG soils within the Lower Caw Caw Swamp Watershed make up 2.0% of the total soils within the drainage area.

The soils within the Lower Caw Caw Swamp Watershed are predominantly well-drained, with almost half (48%) of the soils in the watershed being classified as hydrologic group A and B. The remaining area of the Lower Caw Caw Swamp Watershed is 21% hydrologic group C and 28% hydrologic group D.

Table 2-7: Lower Caw Caw Swamp Hydrologic Soil Group Classifications

Soil Series Name	HSG	Area (acres)	Total Area	Percent
Alpin sand, 0 to 6 percent slopes, Southern Coastal Plain	A	1.58	409	3%
Alpin sand, 0 to 6 percent slopes, Southern Coastal Plain	A	134.66		
Alpin sand, 6 to 10 percent slopes	A	61.13		
Blanton sand, 0 to 6 percent slopes	A	132.01		
Troup coarse sand, 0 to 6 percent slopes	A	21.30		
Troup sand, 0 to 6 percent slopes, Southern Coastal Plain	A	58.01		
Ailey sand, 2 to 6 percent slopes	B	29.45	6,081	43%
Bonneau sand, 0 to 4 percent slopes	B	1,764.14		
Dothan loamy sand, 0 to 2 percent slopes	B	176.43		
Dothan loamy sand, 2 to 6 percent slopes	B	996.84		
Faceville fine sandy loam, 6 to 10 percent slopes	B	18.83		
Faceville loamy sand, 0 to 2 percent slopes	B	108.45		
Faceville loamy sand, 2 to 6 percent slopes	B	461.34		
Fuquay sand, 0 to 6 percent slopes	B	374.43		
Lucy loamy sand, 0 to 6 percent slopes	B	214.79		
Lucy loamy sand, 6 to 10 percent slopes	B	61.37		
Orangeburg loamy sand, 0 to 2 percent slopes	B	135.12		
Orangeburg loamy sand, 2 to 6 percent slopes	B	1,397.17		
Orangeburg loamy sand, 6 to 10 percent slopes	B	213.26		
Udorthents, loamy	B	129.67		
Ailey sand, 2 to 6 percent slopes	C	641.88	4,686	33%
Ailey sand, 6 to 10 percent slopes	C	379.69		

Soil Series Name	HSG	Area (acres)	Total Area	Percent
Clarendon loamy sand, 0 to 2 percent slopes	C	13.20		
Duplin loamy sand, 0 to 2 percent slopes	C	46.44		
Goldsboro sandy loam, 0 to 2 percent slopes	C	264.79		
Neeses loamy sand, 10 to 15 percent slopes	C	32.82		
Neeses loamy sand, 2 to 6 percent slopes	C	923.15		
Neeses loamy sand, 6 to 10 percent slopes	C	1,487.17		
Noboco loamy sand, 0 to 2 percent slopes	C	128.98		
Noboco loamy sand, 2 to 6 percent slopes	C	749.95		
Vaucluse loamy sand, 10 to 15 percent slopes	C	4.90		
Vaucluse loamy sand, 2 to 6 percent slopes	C	12.69		
Vaucluse loamy sand, 6 to 10 percent slopes	C	0.20		
Bibb sandy loam	D	34.62		
Coxville sandy loam	D	363.47		
Elloree loamy sand	D	562.97		
Johns loamy sand	D	181.63		
Johnston sandy loam	D	988.10		
Lumbee loamy sand, frequently flooded	D	75.27		
Lynchburg fine sandy loam, 0 to 2 percent slopes	D	0.85	2,607	18%
Mouzon fine sandy loam	D	146.12		
Ocilla loamy sand, 0 to 2 percent slopes	D	31.65		
Pantego fine sandy loam	D	34.34		
Pelham loamy sand, 0 to 2 percent slopes	D	15.70		
Rains sandy loam	D	172.33		
Water	Water	449.78	450	3%

The depth to groundwater was estimated using the soil survey information, as summarized in **Table 2-8**. About one-third of the watershed has a shallow groundwater elevation, which presents several water quality concerns. In the WTM, the depth to groundwater influences both the septic system failure rate (surface discharge from the system), and pollutant transport from septic systems to groundwater and proximate waterways. When a septic system intersects with the groundwater table, it can cause the system to back up and discharge to the surface.

The soil type and depth both affect the ability of the soil to filter pollutants. In general, coarse or sandy soils have a lower pollutant removal, and pollutant removal increases with increasing depth to groundwater. For this reason, the WTM applies a 50% discount factor for TN, TP, and bacteria removal in sandy or gravely soils. The WTM assumes 100% bacteria removal for depths greater than three feet; 71% of the soils in the Lower Caw Caw Swamp have a depth to groundwater greater than three feet. The WTM assumes no nitrogen removal at depths less than three feet, 10% removal at depths between three and five feet, and 20% removal at depths greater than five feet. Phosphorus removal is also dependent on depth to groundwater. The WTM assumes 50% TP removal in depths less than three feet, 80% removal at depths between three and five feet, and 100% removal at depths greater than five feet. Finally, the WTM assumes that 100% of the TSS load is removed by soil filtering.

Table 2-8: Depth to Groundwater in Lower Caw Caw Swamp Watershed

Depth to Groundwater (ft)	Soil Fraction (%)
Less than 3 feet	29%
3-5 feet	24%
Greater than 5 feet	47%

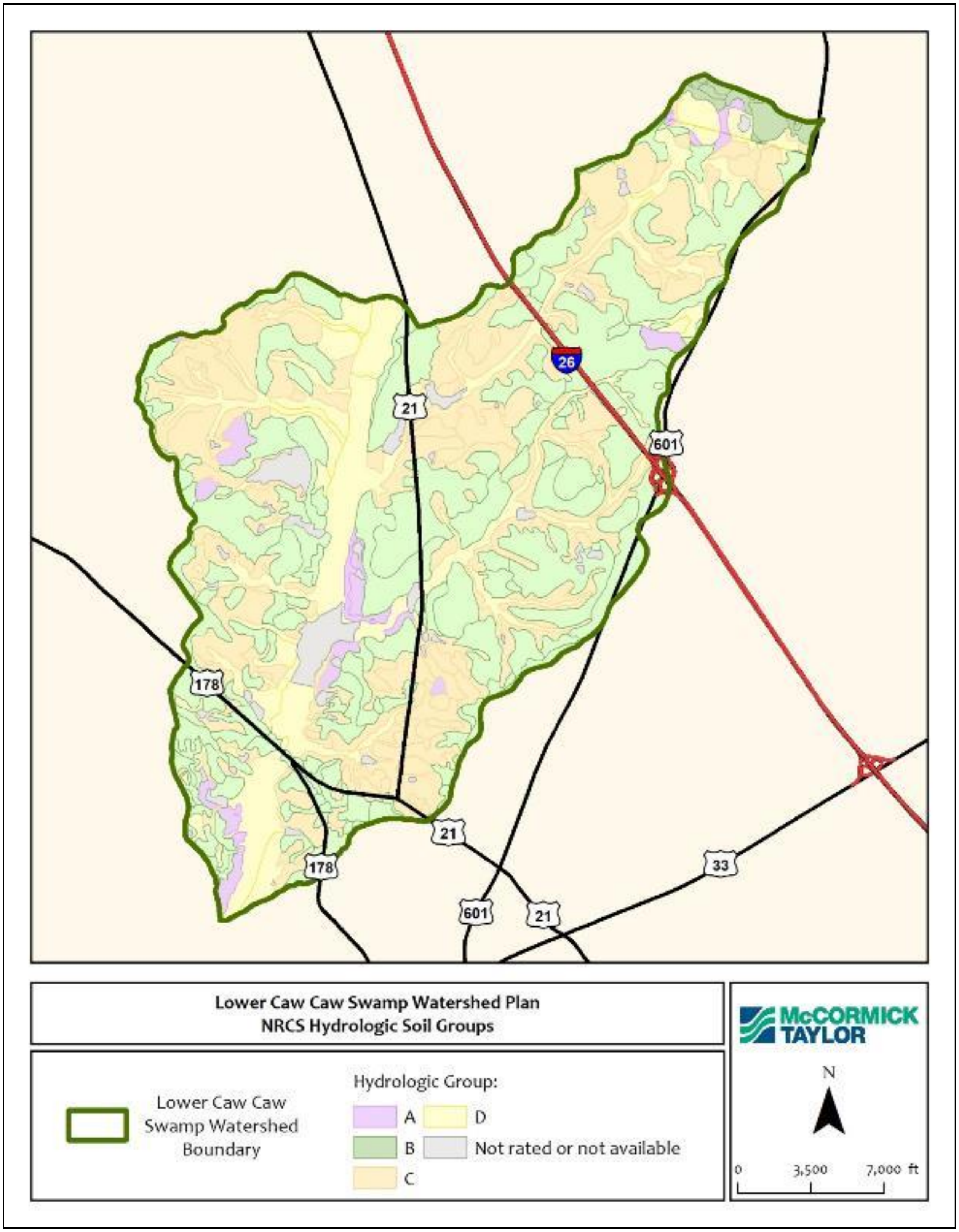

Figure 2-8: Hydrologic Soil Groups in the Lower Caw Caw Swamp Watershed

2.4.3 Soil Erodibility

Modification of the hydrologic regime due to land disturbance in a watershed can result in elevated volumes of stormwater runoff flowing into creeks, streams, and other waterbodies. These increased volumes and the quick delivery of these runoff events can lead to scour of stream channels, incision, and streambank erosion. Hydrologic scour of the streambed can also limit key microhabitats (e.g., leaf packs, sticks, and coarse substrate) for aquatic species. While it is difficult to delineate the different sources of sediment that are being delivered to streams (e.g., streambank erosion as opposed to upland sources such as construction sites), instream sedimentation and subsequent lack of microhabitat are a result of sediment input to streams from streambank erosion. Channel widening through streambank erosion can also exacerbate low flow conditions because channels become overly wide and shallow.

The influence of streambank erosion was quantified throughout the Lower Caw Caw Swamp Watershed using a geospatial assessment that involved an analysis of the Universal Soil Loss Equation (USLE) K-factor values within 10 feet of all existing natural stream channels. This data was obtained from the USDA NRCS web soil survey. The USLE K-factor—having units of tons/acre—is a measure of the susceptibility of a soil to particle detachment and transport by rainfall. The K-factor was calculated from direct soil loss measurements for a series of benchmark soils from study plots located across the United States. It is calculated assuming the highest potential for erosion: soil is in cultivated (plowed or disturbed), continuous fallow (bare soil, no vegetation or protective cover) conditions (Schwabb et al., 1993). Without field measurements, it is the best available measure of a specific soil's susceptibility to streambank erosion. Moreover, the K-factor values most likely underestimate the risks of streambank erosion because the erosive power of stream flows on (most likely) saturated streambank soils is presumed to be greater than that of rainfall. The sub-surface K-factor was used so that bank and channel erodibility was most closely reflected by the data. The degree of soil erodibility is classified as shown in **Table 2-9** and illustrated in **Figure 2-9**.

Table 2-9: Lower Caw Caw Swamp Watershed Stream Soil Erodibility

K-factor	Length (ft)	Percent
Low Erodibility <0.24	128,034.27	77.5%
Medium Erodibility 0.24-0.32	10,264.75	6.2%
High Erodibility >0.32	0.00	0.0%
Null or Unavailable	27,001.43	16.3%

The average sub-surface K-factor related to streambank erosion for the entire Lower Caw Caw Swamp Watershed ranges from 0.02 to 0.32 tons/acre, and the area weighted average is 0.15 tons/acre. For the available data, it appears as though the watershed has a low potential for erosion. However, as will be discussed in the Stakeholder Input (**Section 2.9**), there were many observations of erosion problems in the watershed.

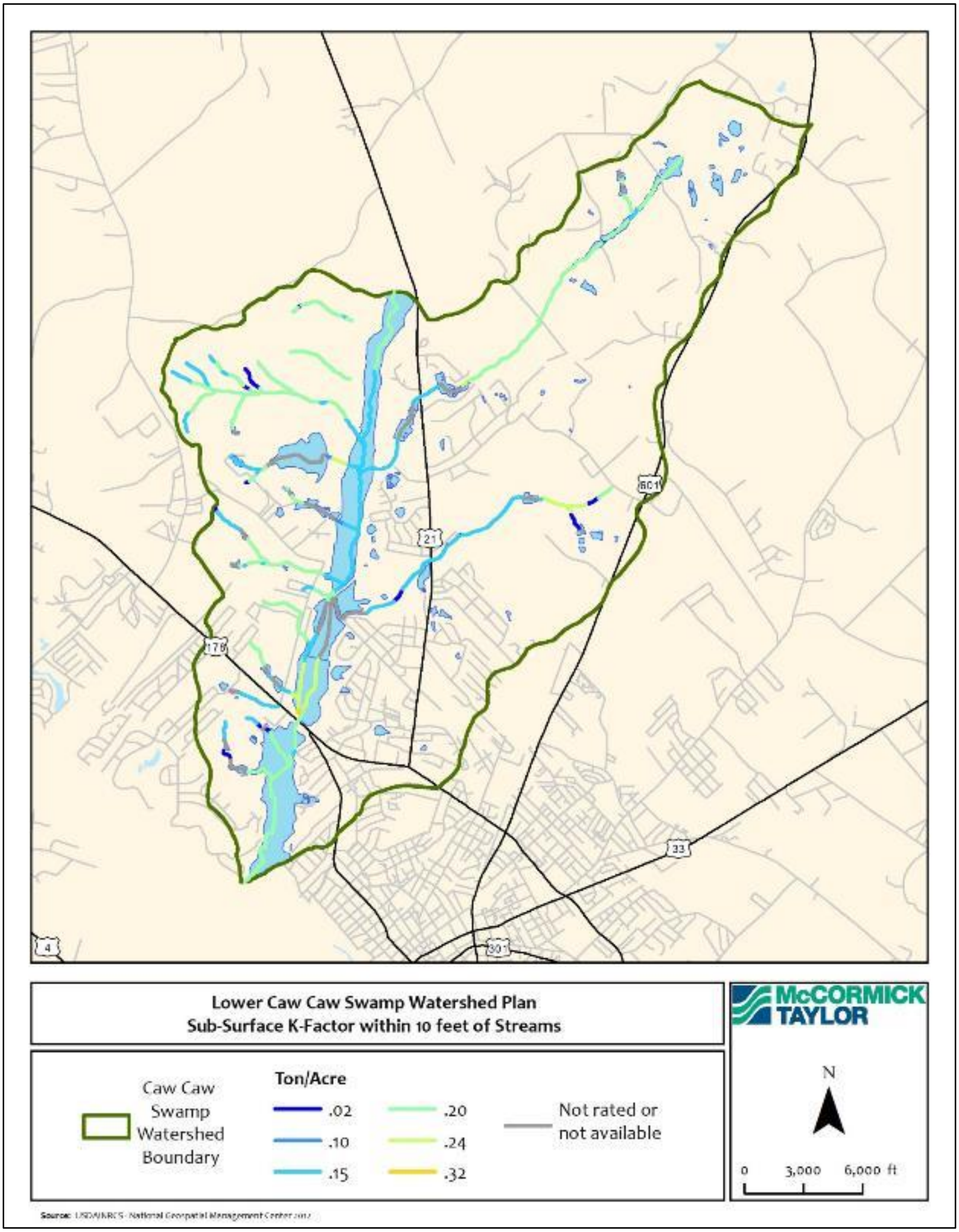

Figure 2-9: Sub-surface K-Factor within 10 feet of Streams in the Lower Caw Caw Swamp Watershed

2.5 Endangered or Protected Species

Table 2-10 and **Table 2-11** summarize the rare, threatened, and endangered species that have ranges or habitat in the Lower Caw Caw Swamp Watershed, according to a report (included in Appendix B of this WBP) by the SC Department of Natural Resources Heritage Trust Program (SCNHP). There are 10 tracked species that are found within the Lower Caw Caw Swamp Watershed boundary; however, the exact locations of these species are not labeled in the SCNHP report due to the sensitive nature of this information.

In total, about 1,000 species are tracked by the SCNHP and are considered rare for a variety of reasons: there is a lack of data, the species are regionally or locally endemic or rare, or they are beginning to show a downward trend in population. Each species is given a global rank by Natureserve (G-rank) which indicates its relative state of imperilment across its global range, with the rankings as follows:

1. Critically imperiled: typically having 5 or fewer occurrences or 1,000 or fewer individuals
2. Imperiled: typically having 6 to 20 occurrences, or 1,001 to 3,000 individuals
3. Vulnerable/rare: typically having 21 to 100 occurrences, or 3,001 to 10,000 individuals
4. Apparently secure: uncommon but not rare, but with some cause for long-term concern; typically having 101 or more occurrences, or 10,001 or more individuals
5. Secure: common, widespread, abundant, and lacking major threats or long-term concerns

The State Wildlife Action Plan (SWAP) is a comprehensive plan that addresses the species that the State deemed had the greatest conservation need due to factors such as rarity, threats, lack of management funding, and lack of data (SCDNR, 2015).

Table 2-10: Rare, Threatened, or Endangered Plant Species in the Lower Caw Caw Swamp

Common Name	Scientific Name	G-Rank	Protection Status*	SWAP Priority
Carolina Birds-in-a-Nest	*Macbridea caroliniana*	G2/G3	ARS	High
Carolina Dwarf Trillium	*Trillium pusillum var. pusillum*	G3	NA	Moderate

** ARS = At Risk Species*

Table 2-11: Rare, Threatened, or Endangered Animal Species in the Lower Caw Caw Swamp

Common Name	Scientific Name	G-Rank	Protection Status*	SWAP Priority
Bald Eagle	*Haliaeetus leucocephalus*	G5	ST	High
Snail Bullhead	*Ameiurus brunneus*	G4	NA	Moderate
American Eel	*Anguilla rostrata*	G4	NA	Highest
Blackbanded Sunfish	*Enneacanthus chaetodon*	G3/G4	NA	High
Ironcolor Shiner	*Noptropis chalybaeus*	G4	NA	Moderate
Lowland Shiner	*Pteronotropsis stonei*	G5	NA	Moderate

** ST = State Threatened*

2.6 Growth and Development

2.6.1 Demographic Characteristics

Population for the HUC-12 area of the Lower Caw Caw Swamp was estimated from block-level 2020 US Census American Community Survey[13] (ACS) data. The area of the block that fell within the Lower Caw Caw Swamp Watershed was calculated as a percentage of the overall HUC-12 watershed area, and then multiplied by the population. Following this methodology, we estimated that the Lower Caw Caw Swamp Watershed has an estimated population of 7,962. As of November 2020, the entire City of Orangeburg DPU's current service area encompasses 217.56 square miles and a total of 17,962 accounts (which equates to an estimated population of 48,940 people)[14].

A similar methodology was followed to calculate the minority population (6,285) and low-income population (3,171) within the Lower Caw Caw Swamp HUC-12 watershed using data from the EPA's Environmental Justice Screening and Mapping Tool[15] (EJSCREEN). Low income is defined as household income that is less than or equal to twice the federal poverty level. Percent People of Color (or minority population) is defined as individuals who list their racial status as a race other than white alone and/or list their ethnicity as Hispanic or Latino.

2.6.2 Cultural Resources

Cultural resources include any natural or manmade sites, events, activities, or historic structures and can have a general social significance in the community. Cultural resources can enhance community interaction as well as provide beneficial social outlets for the community. Upon selection of BMPs to improve water quality and reduce pollutants, we will consult with the South Carolina Department of Archives and History to determine if any cultural resources or archaeological remains exist within or near the project area.

Orangeburg has a long and important history which includes significant events important in shaping the outcome of our state and country. These events would never have been possible had it not been for the perfect combination of a hardworking people and fertile land nourished by an abundance of natural waterways found in and around Orangeburg. A full write up of the cultural resources that was provided by the Orangeburg County Historical Society can be found in Appendix C.

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[13] United States Census Bureau. 2020. American Community Survey. Available at https://www.census.gov/programs-surveys/acs

[14] Orangeburg DPU. 2020. Population and Demand Projections. *Water System Hydraulic Model/Master Plan Update.*

[15] USEPA. 2021. Environmental Justice Screening and Mapping Tool. Available at https://www.epa.gov/ejscreen

2.6.3 Existing Land Cover and Land Use

Land cover indicates the physical land type, such as forest or open water. Land use describes how people are managing the landscape, such as for development or conservation. Different types of land cover can be managed or used differently[16].

Determination of existing land cover and land use was based on the most recent National Land Cover Dataset[17] (NLCD), published in 2016. Land cover classifications were combined with zoning data provided by the City of Orangeburg, Orangeburg County, and Calhoun County. This data was organized into ten different categories that were used as inputs into the Watershed Treatment Model (WTM), as is illustrated in **Figure 2-10** and summarized in **Table 2-12**. Some land cover classifications were combined to fit a particular land use category in the WTM. Forest areas included forest, shrub/scrub, and wetlands NLCD land covers. Rural areas included barren, dwarf scrub, herbaceous, and planted/cultivated NLCD land covers. Roadway areas were estimated by creating a 10-ft buffer around road centerlines.

The largest land use categories in the Lower Caw Caw Swamp Watershed are forest (7,219.58 acres) and low-density residential (2,372.19 acres). Roadways (243.46 acres) and multifamily residential (59.52 acres) were the smallest land use categories in the watershed.

[16] NOAA. 2020. What is the difference between land cover and land use? Available at https://oceanservice.noaa.gov/facts/lclu.html
[17] Multi-Resolution Land Characteristics Consortium. 2019. National Land Cover Database (NLCD) 2016. https://www.mrlc.gov/national-land-cover-database-nlcd-2016

Table 2-12: Existing Land Use in the Lower Caw Caw Swamp Watershed

Land Use Category	WTM Category	Area (acre)	Percent
Water	Open Water	422.32	3.0%
Rural Community (County Zoning)	Rural	417.65	2.9%
Hay/Pasture (NLCD)			
Cultivated Crops (NLCD)			
Herbaceous (NLCD)			
Forest and Agriculture (County Zoning)	Forest	7,219.58	50.0%
Shrub/Scrub (NLCD)			
Woody Wetlands (NLCD)			
Deciduous Forest (NLCD)			
Evergreen Forest (NLCD)			
Mixed Forest (NLCD)			
Emergent Herbaceous Wetlands (NLCD)			
Developed, Low Intensity (NLCD)	Residential, Low Intensity	429.56	3.0%
Developed, Open Space (NLCD)			
Residential Single-Family (County Zoning)	Residential, Medium Intensity	2,372.19	16.7%
Developed, Medium Intensity (NLCD)			
Residential General (County Zoning)	Residential, High Intensity	1,175.28	8.3%
Residential Single Unit (County Zoning)			
Developed, High Intensity (NLCD)			
Residential Multi Unit (County Zoning)	Residential, Multifamily	59.52	0.4%
Commercial General (County Zoning)	Commercial	1,224.98	8.6%
Commercial Neighborhood (County Zoning)			
Office Institutional Residential (County Zoning)			
General Business (County Zoning)			
Business Industrial (County Zoning)	Industrial	669.06	5.0%
10ft buffer on centerlines	Roadway	243.46	1.7%

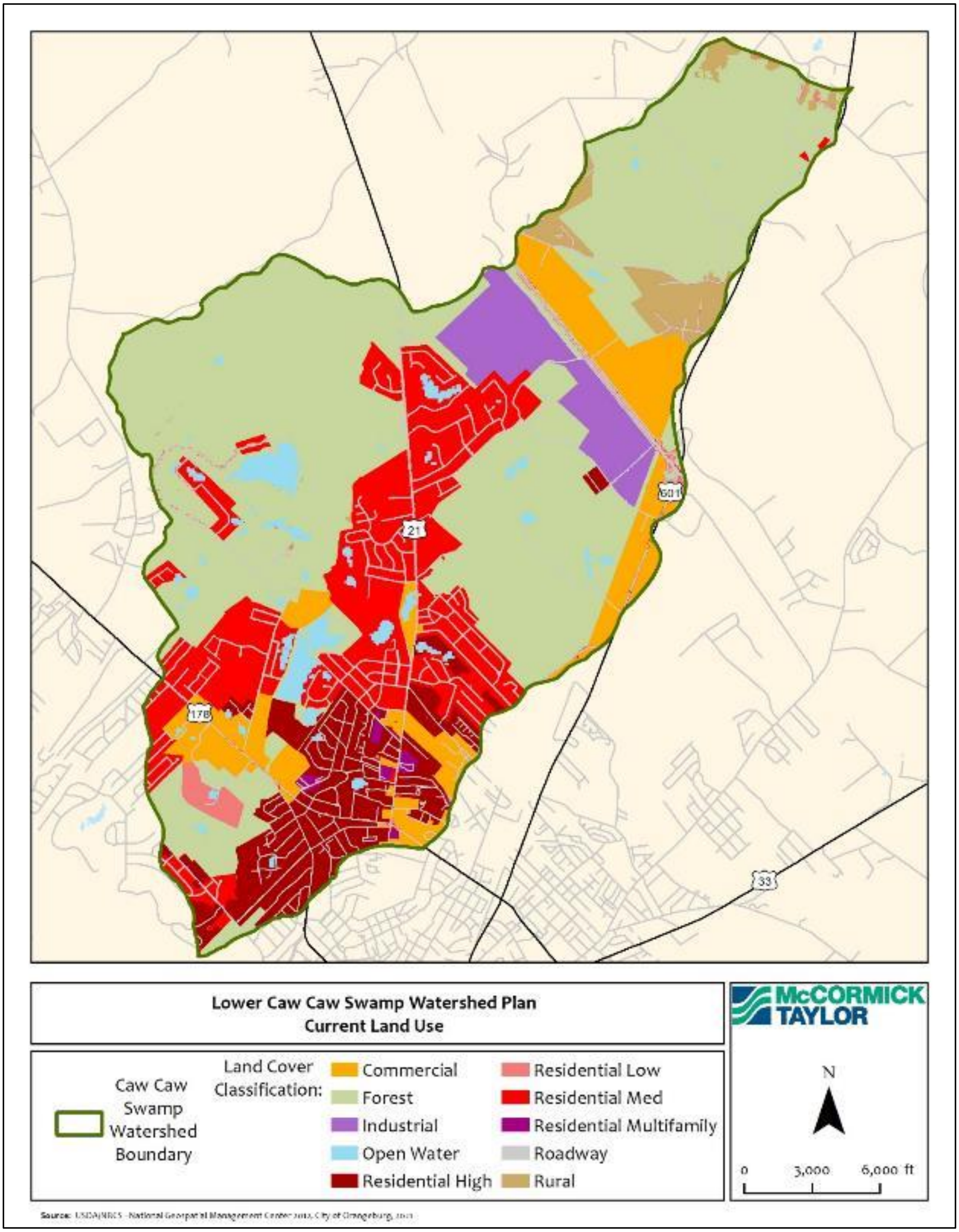

Figure 2-10: Existing Land Use Condition in Lower Caw Caw Swamp Watershed

2.6.4 Existing Imperviousness

Impervious surfaces are hard surfaces that do not allow water to infiltrate slowly into the ground as it would in pervious landscapes, such as a forest, meadow, or open field. Examples of impervious surfaces include roadways, parking lots, driveways, sidewalks, and rooftops. These surfaces generate higher volumes of stormwater runoff, which is typically concentrated into drainage infrastructure (such as gutters, pipes, and ditches), which in turn accelerate flow rates and direct stormwater to a receiving waterbody. This accelerated, concentrated runoff often causes stream erosion and habitat degradation. Runoff from impervious surfaces picks up and washes off contaminants (oil, metals, sediment, etc.) and is highly polluted relative to the minimal amounts of runoff generated from pervious areas. In general, undeveloped watersheds with small amounts of impervious cover are more likely to have better water quality in local streams than urbanized watersheds with greater amounts of impervious cover. Impervious cover is a primary factor when determining pollutant characteristics and loadings in stormwater runoff.

The degree of imperviousness in a watershed also affects aquatic life. There is a strong relationship between watershed impervious cover and the decline of a suite of stream indicators. As imperviousness increases, the potential stream quality decreases, as referenced in research indicating that stream quality begins to decline at or around 10% imperviousness[18]. However, there is considerable variability in the response of stream indicators to impervious cover observed from 5-20% imperviousness due to historical effects, watershed management, riparian width and vegetative protection, co-occurrence of stressors, and natural biological variation. Due to this variability, one cannot conclude that streams draining low impervious cover will automatically have good habitat conditions and a high-quality aquatic life.

The Lower Caw Caw Swamp Watershed contains impervious cover in the residential, industrial, and commercial areas. Approximately 44% of the watershed (6,306 acres) consists of land uses associated with impervious surfaces, including residential land use (29%), commercial land use (9%), industrial (5%), and roads (1%). Even in these developed areas, impervious surfaces do not cover every square foot of land area. The amount of actual impervious surface cover is less than the total area, and not every land use category includes the same proportions of actual impervious cover. For example, as a percentage, low density residential use includes less impervious cover than commercial or institutional development. **Table 2-13** estimates these ranges for the different development land cover categories for the overall HUC-12 watershed and each of the four subwatersheds. The increased intensity of these land uses is reflected implicitly in the land cover but is not explicitly measured in this dataset. The mean percent imperviousness for each land use[19] is summarized as follows:

[18] Schueler, T., L. Fraley-McNeal, and K. Cappiella. 2009. Is Impervious Cover Still Important? Review of Recent Research. Journal of Hydrologic Engineering. 14(4). https://doi.org/10.1061/(ASCE)1084-0699(2009)14:4(309)
[19] Caraco, D. 2013. *Watershed Treatment Model 2013 Documentation.* Center for Watershed Protection.

- Rural: 2%
- Low intensity residential: 14%
- Medium intensity residential: 21%
- High intensity residential: 33%
- Multifamily residential: 44%
- Industrial: 53%
- Commercial: 72%
- Roadway: 80%

The imperviousness for the overall HUC-12 watershed is 17%, but three of the subwatersheds' imperviousness are higher than this. The Upper Caw Caw subwatershed is the least developed subwatershed, and thus has the least amount of impervious area (1%). In contrast, the Lower Caw Caw subwatershed has the greatest level of impervious surfaces (52%). At this level of imperviousness in a watershed, the stream health is predicted to be non-supporting, as illustrated in **Figure 2-11**.

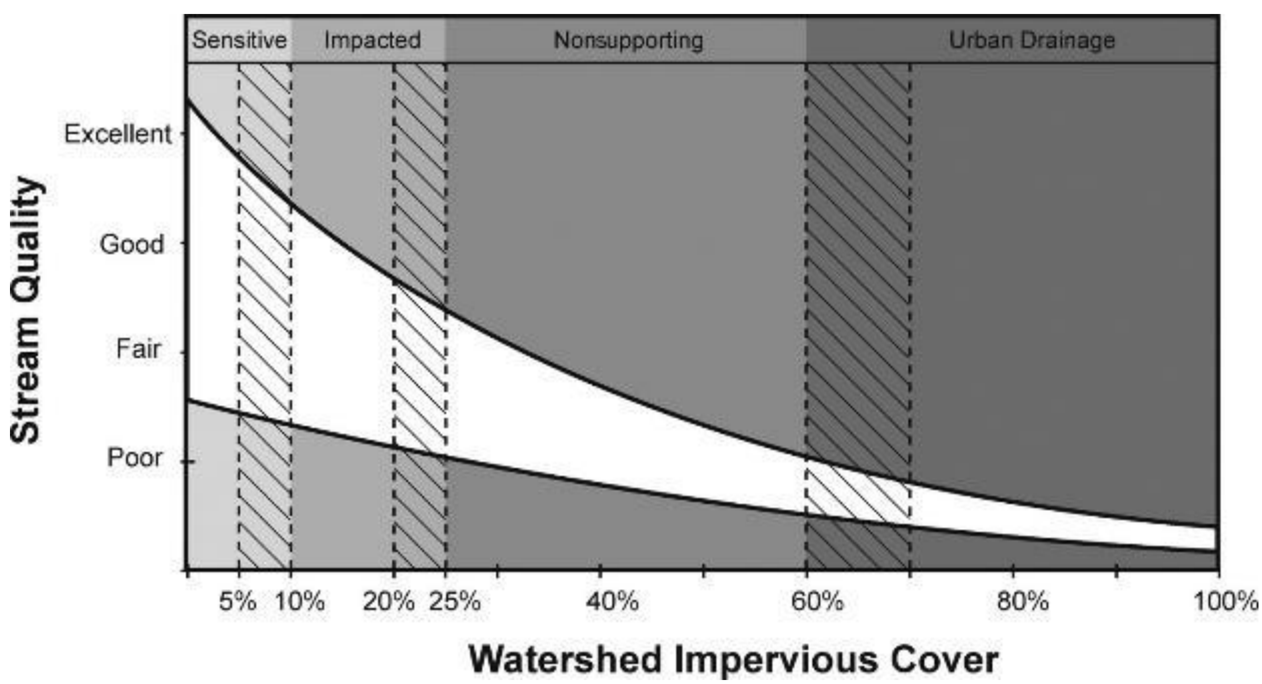

Figure 2-11: Stream Water Quality as a factor of Watershed Impervious Cover (Schueler et al., 2009)

Table 2-13: Lower Caw Caw Swamp Watershed Impervious Area Estimate

Land Cover/Land Use	HUC-12		Upper Caw Caw		Lower Caw Caw		Turkey Hill Branch		Early Branch	
	Total Area (acres)	Impervious Area (acres)	Total Area (acres)	Impervious Area (acres)	Total Area (acres)	Impervious Area (acres)	Total Area (acres)	Impervious Area (acres)	Total Area (acres)	Impervious Area (acres)
Rural	418	8	4	0.1	4	0	7	0	403	8
Residential Development										
Low Intensity	520	73	29	4	236	33	142	20	113	16
Medium Intensity	2,414	507	103	22	714	150	812	171	784	165
High Intensity	1,175	388	0.9	0.03	1,065	352	110	36	-	-
Multifamily	60	26	-	-	58	26	1	1	-	-
Commercial	1,225	882	-	-	507	365	469	338	248	179
Industrial	669	355	-	-	-	-	275	145	395	209
Roadway	243	194	7	6	106	85	72	57	58	47
Forest*	7,088	-	2,077	-	1,160	-	1,655	-	2,196	-
Open Water*	422	-	105	-	164	-	109	-	43	-
Total Area	**14,234**	**2,433**	**2,189**	**32**	**1,938**	**1,011**	**2,580**	**768**	**2,940**	**623**
% Impervious		**17%**		**1%**		**52%**		**30%**		**21%**

* Not impervious; included for total area calculation
(Adapted from Caraco, 2013[20])

[20] Caraco, Deb. 2013. Watershed Treatment Model (WTM) 2013 documentation. Available at https://owl.cwp.org/mdocs-posts/watershed-treatment-model-documentation-final/

2.6.5 Future Development

In consultation with the Orangeburg DPU and Orangeburg County Planning, the Project Team created a Future Condition to model in WTM for the purpose of illustrating the increase in future coliform loads that will result from future development combined with climate change across the Lower Caw Caw Swamp Watershed, should no additional management measures be implemented.

The Future Condition utilized a future land use dataset developed as part of the US Geological Survey LandCarbon project. A component of the USGS work was an assessment of historic, current, and future landscape change on biogeochemical cycling. Historic landscape change from 1992 to 2005 was mapped and modeled for the conterminous United States, while scenarios of future LULC through 2100 were modeled for four IPCC Special Report on Emissions Scenarios (SRES); the USGS year 2050, A1B scenario/RCP 8.5 (higher emissions scenario) was selected for the Lower Caw Caw Swamp WBP. The USGS land use categories have 11 different undeveloped categories and one "developed" category (that would encompass 7 of the specific WTM categories) as summarized in **Table 2-14**.

Table 2-14: Comparison of WTM and USGS Land Use Categories

WTM Land Use Category	USGS Land Use Category
Forest	Undeveloped
Rural	Undeveloped
Open Water	Undeveloped
Commercial	Developed
Residential, Medium	Developed
Residential, High	Developed
Residential Low	Developed
Residential, High Multifamily	Developed
Industrial	Developed
Roadway	Developed

GIS analysis and professional judgment were used to classify land use changes from Current Condition to Future Condition. This involved four main assumptions:

1. The area of open water would remain constant
2. Current developed areas would not become undeveloped in the future (e.g., commercial could not become forest)
3. Undeveloped area (forest and rural) could become developed in the future
4. The relative development character of the watershed would remain the same (the proportions of residential, commercial, and industrial would be constant in the future as the total developed area increases).

As summarized in **Table 2-15**, the percent developed for each land use category was based on its respective area divided by the total developed area in the watershed. For example, the percent commercial area is calculated as 1,225 acres/6,306 acres = 19%. The percent forest or rural area is likewise its respective area divided by the total undeveloped area for that subwatershed. The resulting calculation shows that 2,540 acres of forest and 150 acres of rural land uses will be developed and converted proportionally to various residential, commercial, industrial, and roadway uses.

Table 2-15: Calculation of Future Land Use in the Lower Caw Caw Swamp Watershed

WTM Land Use Category	Current LU (acres)	% Developed	% Undeveloped	Future LU (acres)	Change (acres)
Residential, Low	520	8%		742	222
Residential, Med	2,414	38%		3,443	1,029
Residential, High	1,175	19%		1,677	501
Residential, Multifamily	60	1%		85	25
Commercial	1,225	19%		1,747	522
Industrial	669	11%		347	104
Roadway	243	4%		954	285
Developed Total	**6,306**	**100%**		**8,996**	**2,690**
Forest	7,088		94%	4,548	(2,540)
Rural	418		6%	268	(150)
Undeveloped Total	**7,506**		**100%**	**4,816**	**(2,690)**
Open Water	422			422	-

2.7 Human Waste Treatment

2.7.1 Orangeburg Department of Public Utilities WWTP

The City of Orangeburg has a wastewater collection system that dates back to as early as 1906. At that time, it served an area of approximately 3 square miles. The service area since then has grown to approximately 22 square miles. The area includes a variety of users, primarily consisting of residential customers; however, commercial and industrial customers are also included. The system serves approximately 10,700 customers in all. The sewer system consists of gravity lines ranging from 4 inches to 42 inches in diameter and pressure force mains ranging from 4 inches to 16 inches in diameter. The force mains are fed by 19 pump stations in the outlying area.

The treatment process (**Figure 2-12**) begins with industrial customers whose discharges meet established regulatory requirements. These discharges, along with wastewater from domestic sources, are treated at the wastewater treatment plant (WWTP) using a biological process. A majority of the biosolids remaining after treatment are the excess organisms that are produced during the treatment process, along with organic and inorganic material that cannot be further broken down during treatment. The standards for Use or Disposal of Sewage Sludge, 40 CFR Part 503, were signed into law and became effective in 1994. The purpose of these standards is to establish numerical, management, and operational standards for the use or disposal of biosolids that is applied to land or placed on a surface disposal site. Regulatory compliance at the industry level and the dedication of wastewater treatment personnel make possible the production of Class A “EQ” (exceptional quality) biosolids that are safe for use on a wide variety of crops.

Wastewater biosolids can be used as a natural soil amendment. They contain essential plant nutrients and organic matter and are a beneficial soil conditioner. Around the world, applying biosolids to agricultural land for crop production has been a common practice for decades. They also can be used in forestry and landscaping applications.

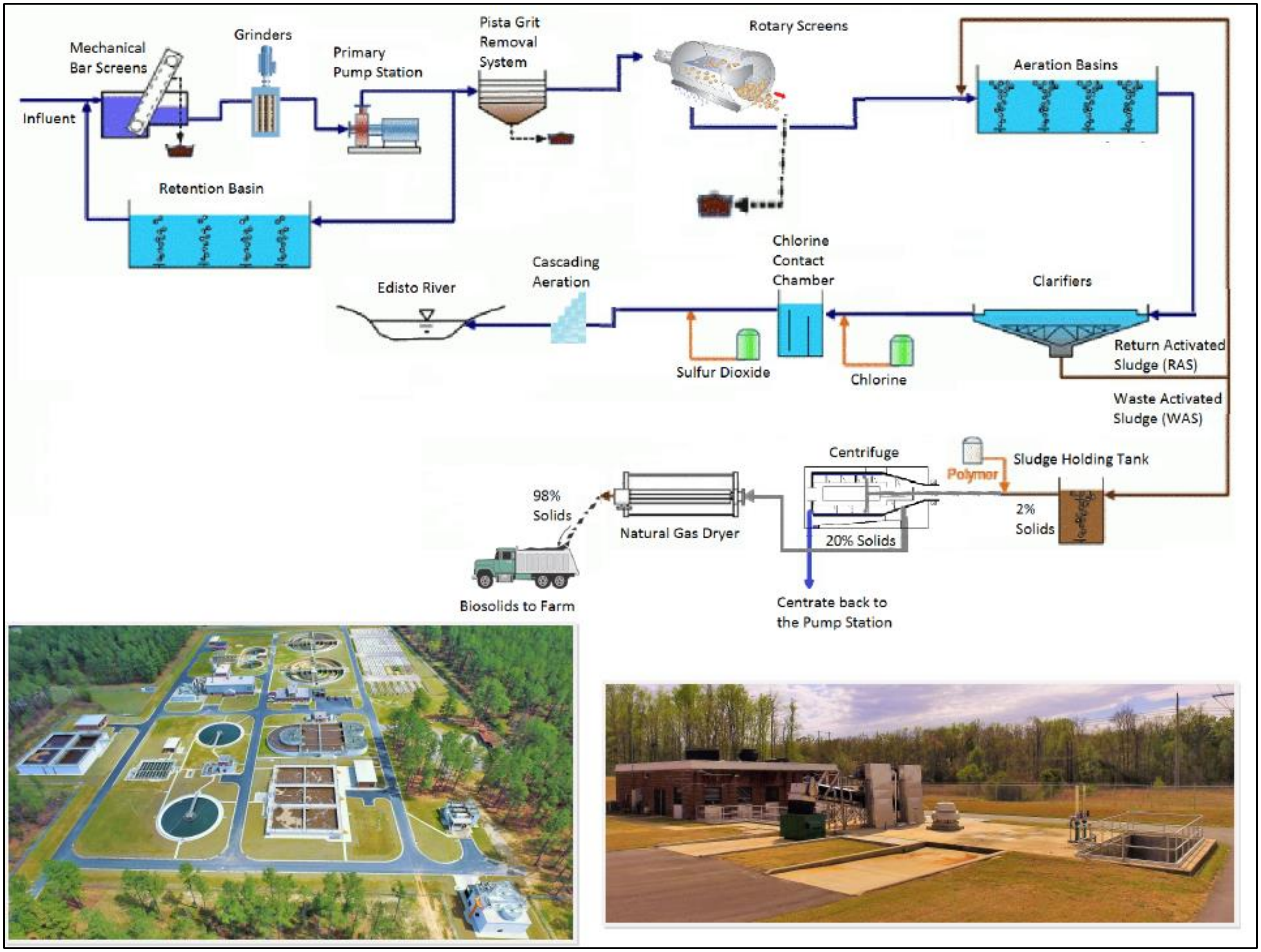

Figure 2-12: City of Orangeburg Wastewater Treatment Process (provided by Orangeburg DPU)

2.7.2 Onsite Sewage Disposal Systems (OSDS)

The number of residential and commercial parcels not connected to the DPU sanitary sewer system was estimated from GIS information (**Figure 2-13**) related to proximity to the sanitary sewer lines (Lateral Line, Gravity Main, and Pressurized Main). Parcels that did not have sanitary sewer data within the parcel or within a four-foot distance from the parcel boundary were considered non connected. The Project Team estimates that there are 1,850 residential and commercial buildings that are currently not connected to sanitary sewer and thus are assumed to have onsite sewage disposal systems. The assumed failure rate[21] of these septic systems is 10%. The Project Team also utilized GIS analysis to determine that 184 buildings (10% of total buildings with septic systems) are within 100 feet of a waterway, which poses a greater threat to water quality.

The Project Team had several unsuccessful attempts to have productive dialogues with septic system service companies about the existing conditions in the watershed. Discussions with the SCDHEC Division of Onsite Wastewater provided useful information regarding the regulatory requirements of septic systems. Regulations require a minimum 6-inch separation from the zone of seasonal saturation and a septic system. Soils evaluations are part of the permitting process, and an inspection is conducted before the OSDS is covered up. Currently, there are no restrictions on the number of systems permitted in a particular area; however, limiting factors include setbacks from property lines, wells, ponds, and other structures as well as the topographical features of the site.

If the Department is made aware of a malfunctioning system, then there is an enforcement process that could lead to civil penalties if not corrected. Currently SCDHEC does not offer assistance to have the system repaired. The most common types of septic systems are the conventional trench systems. Because the Department does not regulate or keep records of repairs, it is not possible to estimate the failure rate for systems in this watershed.

[21] EPA. 2002. Onsite Wastewater Treatment Systems Manual. https://nepis.epa.gov/Adobe/PDF/30004GXI.pdf

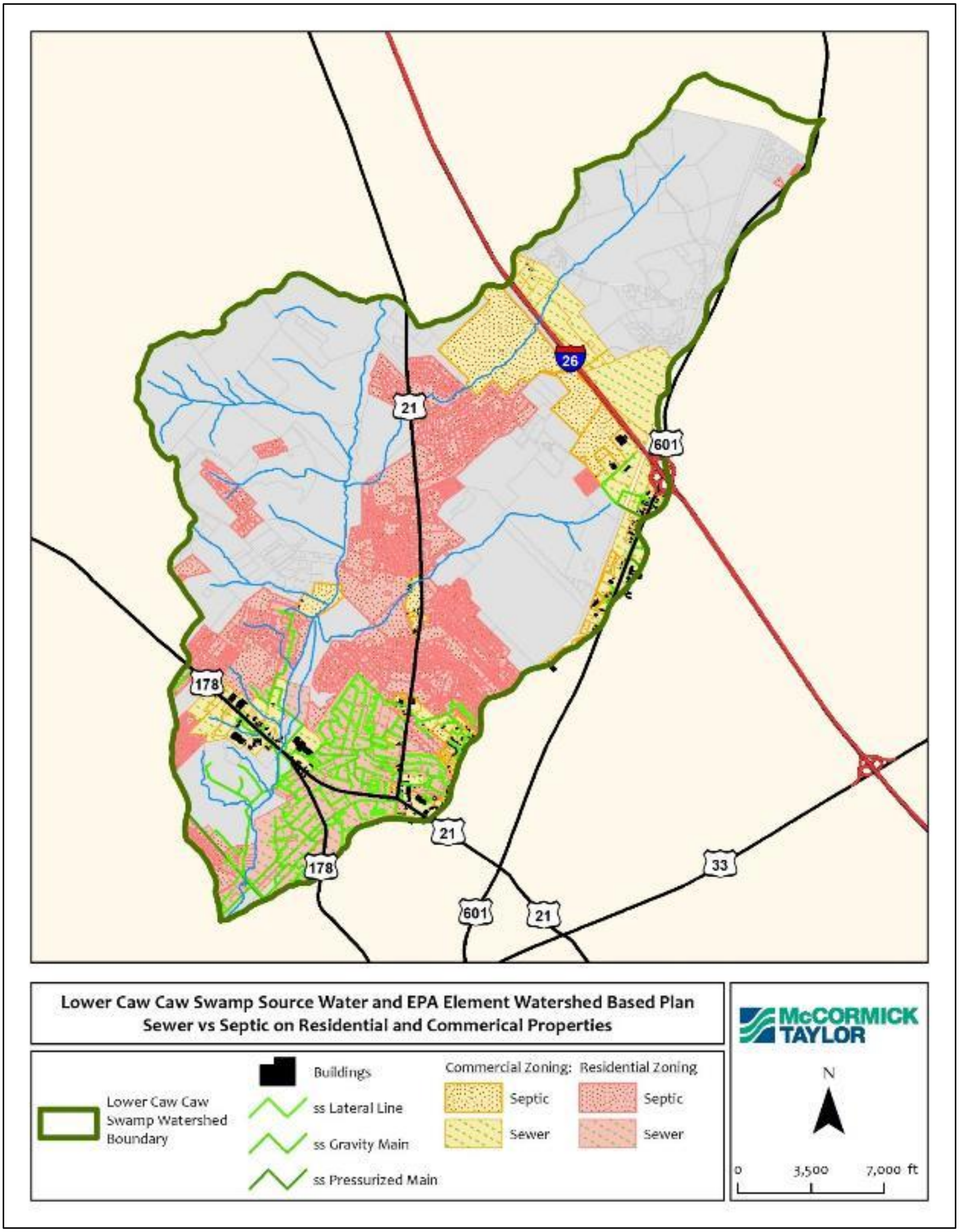

Figure 2-13: Sewer and Septic Service Areas in the Lower Caw Caw Swamp Watershed

2.8 Surface Water Withdrawals/Drinking Water Intakes

2.8.1 City of Orangeburg Department of Public Utilities

The City of Orangeburg DPU, the water utility department of City of Orangeburg, has the largest customer base in Orangeburg County with approximately 20,400 customer connections serving a population of 43,700. It has two source water supplies, one on the North Fork Edisto River, and two Aquifer Storage and Recovery (ASR) Wells located onsite at the Water Treatment Plant. The John F. Pearson Water Treatment Plant was built in 1937, has undergone six major expansion phases. It has a capacity of 30 million gallons per day and serves the City of Orangeburg as well as the greater Orangeburg area including portions of Calhoun County.

Water for the City of Orangeburg is pumped from the North Fork Edisto River at the Raw Water Pump Station and into the water treatment plant (**Figure 2-14**). Once it arrives at the plant, the pH is adjusted and water is rapidly mixed with aluminum sulfate (alum), a coagulant that helps the impurities stick together to form bigger particles called floc. After rapid mixing, the water flows into flocculation basins, where the flow of water is slowed, and the floc has time to grow bigger. From there the water flows into sedimentation basins where the heavier floc particles sink to the bottom to be removed and the clean water is captured off the top. Next, the water travels through large filters made of sand, gravel, and anthracite. Filtration removes any remaining microscopic particles and microorganisms. Finally, the water is disinfected to protect against bacteria. Orangeburg Department of Public Utilities Water Treatment Plant uses a combination of chlorine and ammonia called chloramines to disinfect the water. Fluoride is also added to support good dental health, and phosphate is added to control corrosion in our distribution system. Finished water is then sent to two 4-million-gallon clearwells where it is stored for distribution. The clean water is pumped into the distribution system where it is delivered to more than 20,000 homes and businesses in the Greater Orangeburg area.

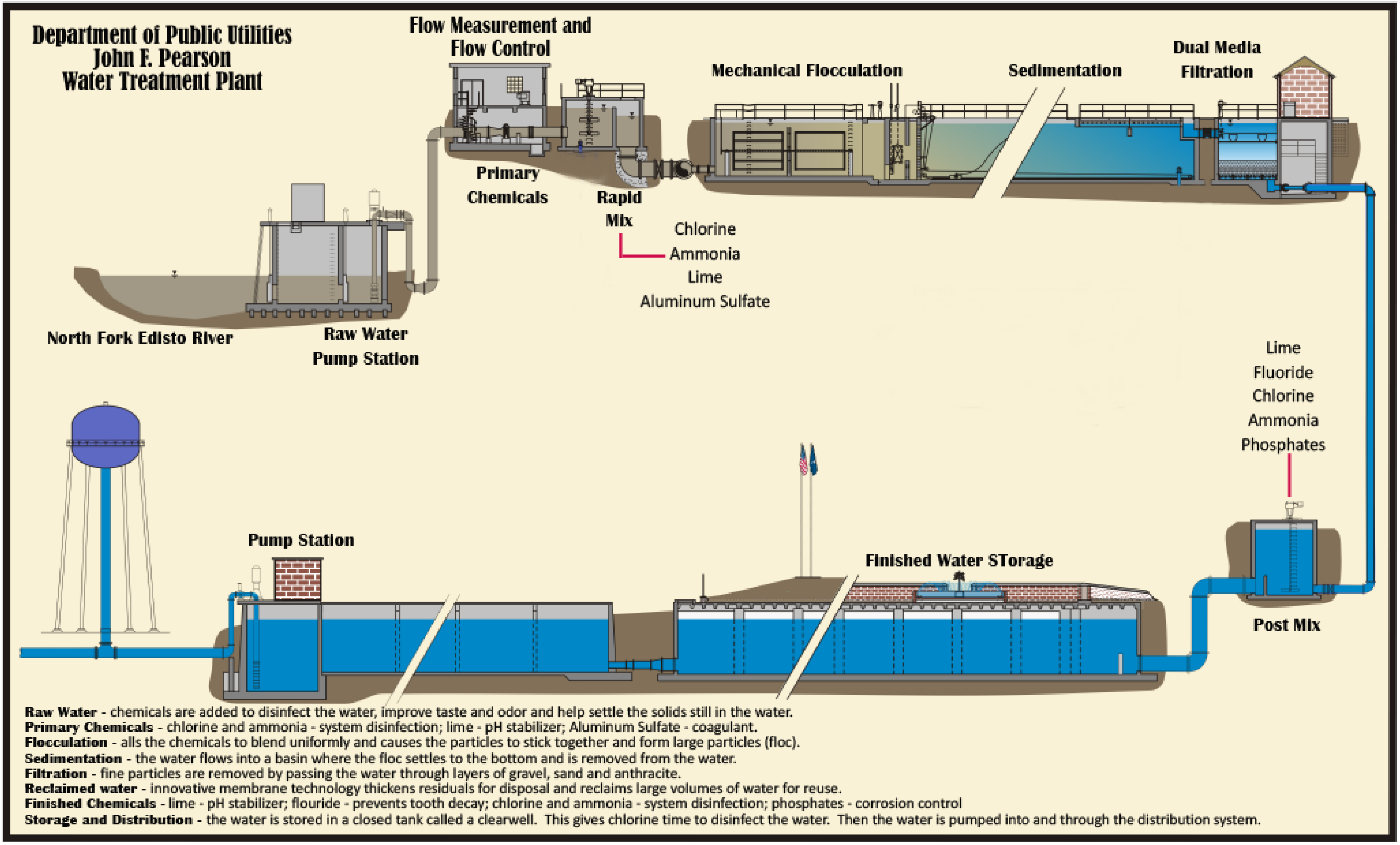

Figure 2-14: Orangeburg DPU Water Treatment Process

2.9 Stakeholder Input

2.9.1 Webmap Input

The project team utilized a webmap[22] as a tool to record observations and engage stakeholders in the watershed, as illustrated in **Figure 2-15**. The tool allowed users to place color-coded points, lines, and polygons to indicate different features or concerns within the watershed, such as erosion problems, stormwater BMPs, recreational areas, farms, and large impervious areas. Additionally, areas notable for their amount of pet waste and those containing excessive litter were also highlighted. The user could also include notes and/or pictures with each entry.

Table 2-16 and **Figure 2-16** summarize the data collected in the webmap. The total number of responses was 89, with three responses for locations outside of the watershed. The most frequent response was "other" and included responses such as "stream blockage," "trees removed," and locations of pipe outfalls. The next most common response was for erosion.

Table 2-16: Summary of Stakeholder Responses

Type	Count
Inside Watershed	**86**
Construction Site	2
Erosion Problems	30
Farms	6
Litter	7
Other	40
Sanitary Sewer Issues	1
Outside Watershed	**3**
Construction Site	1
Erosion Problems	2
Grand Total	**89**

[22] Lower Caw Caw Swamp web map available at https://mtgis.maps.arcgis.com/apps/webappviewer/index.html?id=b494984f2aca493796f835a912ac74fb

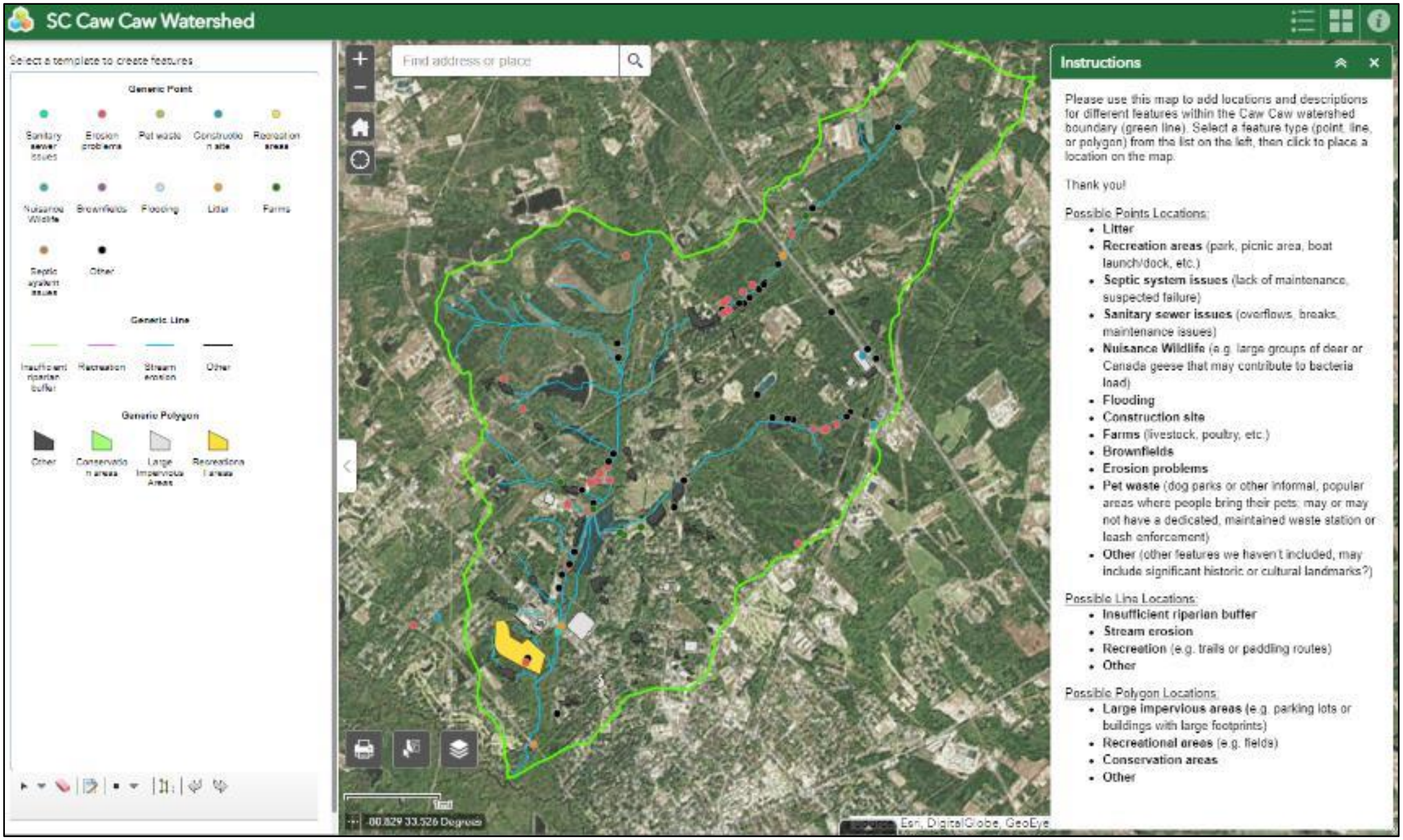

Figure 2-15: Screenshot of Lower Caw Caw Swamp Watershed Stakeholder Webmap

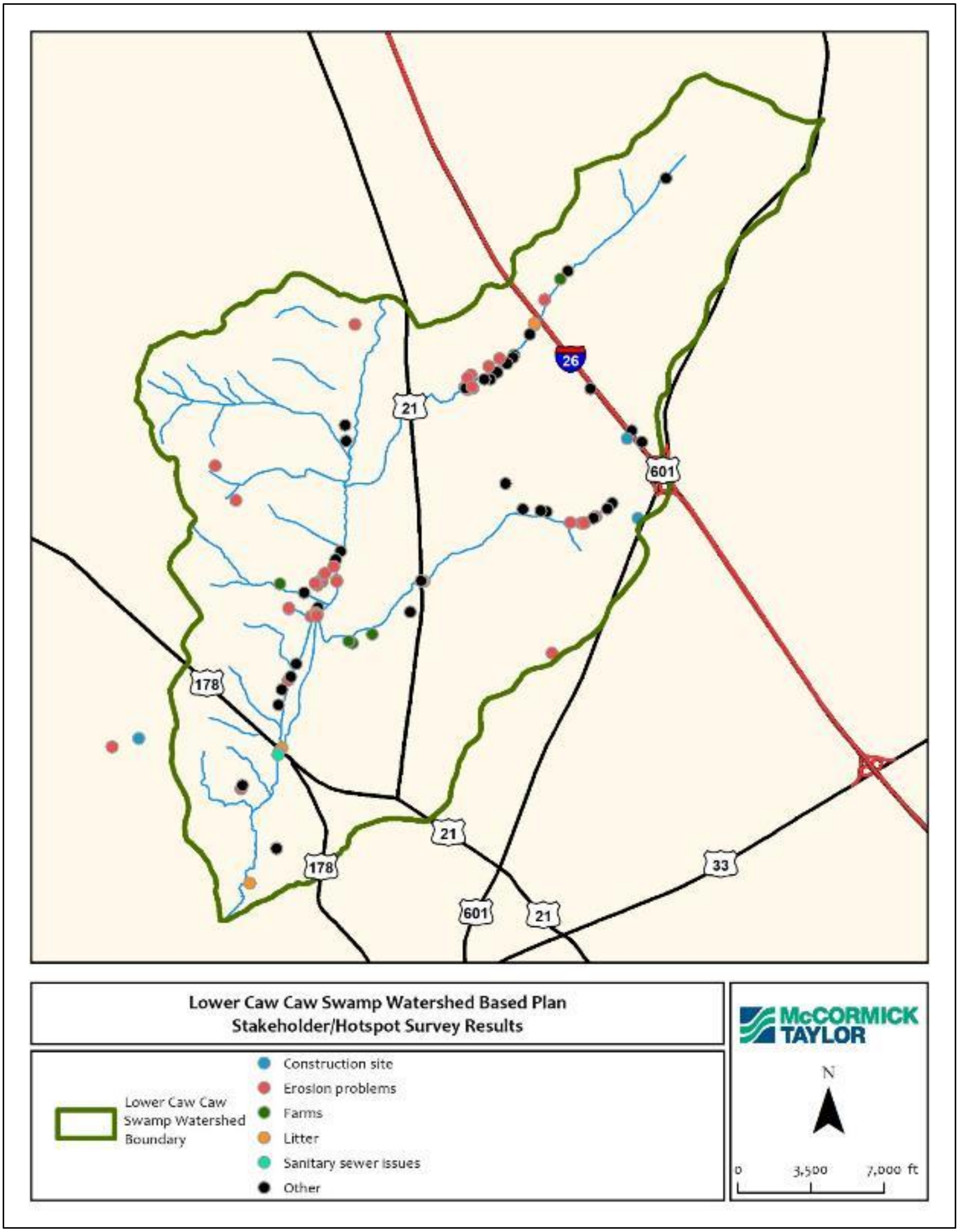

Figure 2-16: Lower Caw Caw Swamp Watershed Stakeholder Responses

2.9.2 Focus Group Discussions

On May 19, 2021, the Project Team convened a meeting with agriculture and forestry professionals to discuss conditions in the watershed. The ten participants represented Clemson University Cooperative Extension, the South Carolina Forestry Commission (SCFC), the South Carolina Department of Natural Resources (SCDNR), the Orangeburg Soil & Water Conservation District (SWCD), and the Longleaf Alliance. A summary of notes and recommendations from that meeting is included in **Appendix A** of this WBP.

The Project Team, with assistance from the SCDHEC Watershed Manager, were unsuccessful at recruiting members for a single septic system focus group meeting. We were unable to facilitate a discussion that included private businesses that provide septic system installations and repairs as well as the SCDHEC septic system inspectors. Most of the feedback that the Project Team received was through one-on-one telephone conversations or emails. The feedback was general, regarding requirements and procedures, but could not identify areas of concern (e.g., areas with known failing or poorly maintained systems). Likewise, there were no locations of concern related to septic systems identified on the stakeholder webmap.

3.0 In-Stream Water Quality Monitoring

3.1 Use Designations and Classifications

State water quality standards are determined based on the water use classification for each waterbody. Water use classifications are based on the desired uses of a waterbody and not necessarily the actual water quality. Classifications are used to determine NPDES permit limits. This also means that waterbodies can be reclassified if the desired or existing use justifies reclassification. The tributaries and lakes in the Lower Caw Caw Swamp Watershed are all freshwater (FW) and are defined by SCDHEC in R.61-68 (2014):

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.

In addition to water-use classifications, the state has four “use support” designations:

1. Aquatic Life Use Support (AL) – based on the composition and functional integrity of the biological community.
2. Recreational Use Support (REC) – the degree to which a waterbody meets fecal coliform bacteria water quality standards. Waters that have fecal coliform excursions in greater than 25% of samples are considered non-supporting of recreational uses.
3. Fish Consumption Use Support (FISH) – a risk-based approach is used to evaluate fish tissue data and to issue consumption advisories.
4. Drinking Water Use Support (DW) – nonattainment occurs when the median concentration (based on a minimum of three samples) for any pollutant exceeds the appropriate drinking water Maximum Contaminant Level (MCL).

3.2 Antidegradation Rules

The SC Regulation R.61-68, Water Classifications and Standards, details the State’s antidegradation rules. Antidegradation rules provide a minimum loss of protection to all waters of the State and include conditions under which water quality degradation is allowed. The State’s antidegradation rules require existing uses be maintained and water quality be protected regardless of the water’s classification. Conditions under which water quality degradation is allowed that apply to the Lower Caw Caw Swamp Watershed include:

- Existing uses and water quality necessary to protect uses may be affected by instream modifications as long as the stream flows protect classified and existing uses and water quality supporting these classified uses is consistent with riparian rights to reasonable use of water.
- Benefits the people and economy of an area where water quality would remain adequate to fully protect existing and classified uses; and
- Natural conditions cause a depression of dissolved oxygen (DO).

3.3 Numeric and Narrative Criteria

Water quality standards for waters classified as freshwater are listed in **Table 3-1**.

Table 3-1: Freshwater Water Quality Standards in the State of South Carolina (R. 61-68)

Parameter	Standard
(a) Garbage, cinders, ashes, oils, sludge, or other refuse	None allowed
(b) Treated wastes, toxic wastes, deleterious substances, colored or other wastes, except those given in (a) above	None alone or in combination with other substances or wastes in sufficient amounts to make the waters unsafe or unsuitable for primary contact recreation or to impair the waters for any other best usage as determined for the specific waters which are assigned to this class.
(c) Toxic pollutants listed in the appendix	As prescribed in Section E of this regulation
(d) Stormwater, and other nonpoint source runoff, including that from agricultural uses, or permitted discharge from aquatic farms, concentrated aquatic animal production facilities, and uncontaminated groundwater from mining	Allowed if water quality necessary for existing and classified uses shall be maintained and protected consistent with antidegradation rules.
(e) Dissolved oxygen	Daily average not less than 5.0 mg/l with a low of 4.0 mg/1.
(f) *E. coli*	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.
(g) pH	Between 6.0 and 8.5
(h) Temperature	As prescribed in E.12 of this regulation
(i) Turbidity (except for Lakes) Lakes only	Not to exceed 50 NTUs provided existing uses are maintained. Not to exceed 25 NTUs provided existing uses are maintained.

3.4 Historic Water Quality Sampling Data

Water quality monitoring stations in the Lower Caw Caw Swamp Watershed are shown in **Figure 3-1**. Historic monitoring was conducted from 2001-2009 by SCDHEC at WQMS E-105. As part of this watershed-based plan, the City of Orangeburg DPU also conducted several grab samples in various locations around the watershed to 1) compare the historic data to current measurements and 2) identify potential bacteria hotspots. A summary of available water quality data is contained in **Table 3-2**, and the corresponding explanation of abbreviations is listed in **Table 3-3**.

Table 3-2: Water Quality Monitoring Locations in Lower Caw Caw Swamp Watershed

Station	Subwatershed	Organization	Measured Parameters	Time Period
E-105*	Lower Caw Caw	SCDHEC	ALK, AMM, BOD, CA, CD, CR, DEPTH, DO, FC, HARD, NO2/NO3, FE, TKN, PB, MG, MN, HG, NI, TN, TOC, PH, TP, TEMP, TSS, TURB, ZN	Jan 2001 – Dec 2009; 2019 quarterly
North Rd. (Lidl)	Lower Caw Caw	DPU	TC, ECOLI, PH, OP, TEMP	3/31/2021
Willington Rd.	Lower Caw Caw	DPU	TC, ECOLI, PH, OP, TEMP	3/31/2021
Livingston Terrace	Lower Caw Caw	DPU	TC, ECOLI, PH, OP, TEMP	3/31/2021
Turkey Hill – Creekmore	Turkey Hill Branch	DPU	TC, ECOLI, PH, OP, TEMP	3/31/2021
Riverbank – Hillsboro	Lower Caw Caw	DPU	TC, ECOLI, PH, OP, TEMP	3/31/2021
Church Camp/OP site	Lower Caw Caw	DPU	TC, ECOLI, PH, OP, TEMP	4/8/2021
OP Fields/Catfish Pond	Early Branch	DPU	TC, ECOLI, PH, OP, TEMP	4/8/2021
Frontage Rd – I-26	Early Branch	DPU	TC, ECOLI, PH, OP, TEMP	4/27/2021
Waterspring Rd.	Early Branch	DPU	TC, ECOLI, PH, OP, TEMP	4/27/2021
House off Waterspring Rd.	Early Branch	DPU	TC, ECOLI, PH, OP, TEMP	4/27/2021
Farnum Rd.	Upper Caw Caw	DPU	TC, ECOLI, PH, OP, TEMP	5/4/2021
Tamara Ln.	Upper Caw Caw	DPU	TC, ECOLI, PH, OP, TEMP	5/4/2021
Baseball Field site 1	Lower Caw Caw	DPU	TC, ECOLI, PH, OP, TEMP	5/14/2021
Baseball Maintenance Facility ditch	Lower Caw Caw	DPU	TC, ECOLI, PH, OP, TEMP	5/14/2021

* no *E. coli* sampling at this station; historic data included FC only

Table 3-3: Summary of Water Quality Monitoring Parameters in Lower Caw Caw Swamp Watershed

Parameter	Name	Units	Quality Standards for Freshwaters
ALK	= alkalinity	mg/L	
AMM	= ammonia	mg/L	
BOD	= biochemical oxygen demand	mg/L	
CA	= calcium	mg/L	
CD	= cadmium	mg/L	
CR	= chromium	mg/L	
CU	= copper	mg/L	
DEPTH	= depth	m	Depth of water sample = 0.3 m
DO	= dissolved oxygen	mg/L	Daily avg. > 5.0 mg/L
ECOLI	= *Escherichia coli*	#/100mL	Monthly avg. <126 MPN/100mL; Single sample <349 MPN/100mL
FC	= Fecal coliform	#/100mL	TMDLs converted to *E. coli*
FE	= iron	mg/L	
HARD	= total hardness	mg/L	
HG	= mercury	mg/L	
MG	= magnesium	mg/L	
MN	= manganese	mg/L	
NI	= nickel	mg/L	
NO2/NO3	= nitrite/nitrate	mg/L	
OP	= orthophosphate	mg/L	
PB	= lead	mg/L	
PH	= pH		Between 6.0 and 8.5
TEMP	= temperature	deg C	
TKN	= total Kjeldahl nitrogen	mg/L	
TN	= Total Nitrogen	mg/L	*0.69 mg/L
TOC	= total organic carbon	mg/L	MCL dependent on Treatment Technique
TP	= total phosphorus	mg/L	*35.56 µg/L
TSS	= total suspended solids	mg/L	
TURB	= turbidity	NTU	< 50 NTUs for streams
ZN	= zinc	mg/L	

* At the time of publishing this WBP, there are no numeric criteria for nutrients in South Carolina. Values for recommendations provided by EPA[23]

[23] EPA. 2000. Ambient Water Quality Criteria Recommendations. Information Supporting the Development of State and Tribal Nutrient Criteria for Rivers and Streams in Nutrient Ecoregion IX. https://www.epa.gov/sites/default/files/documents/rivers9.pdf

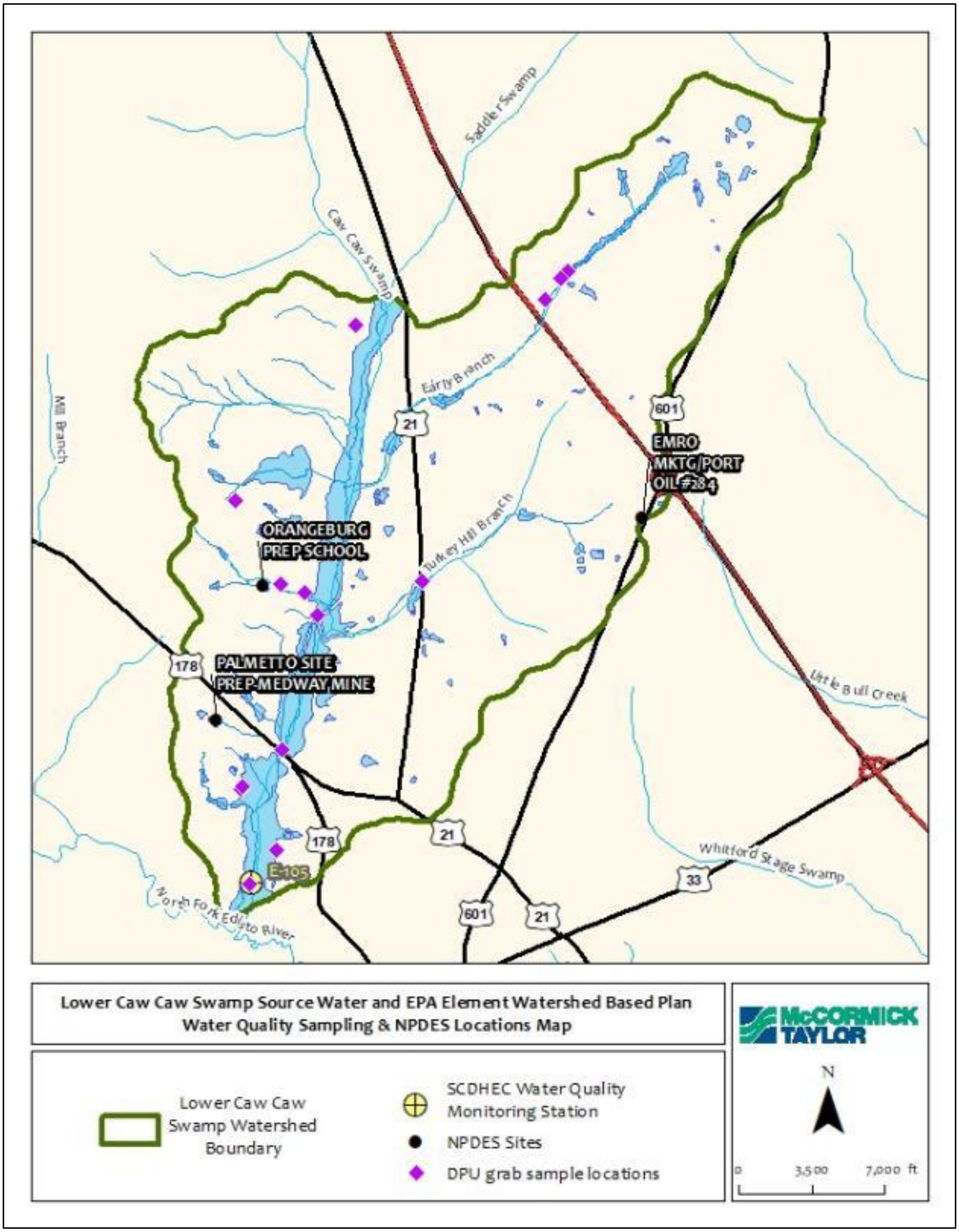

Figure 3-1: Water Quality Monitoring Locations in Lower Caw Caw Swamp Watershed

3.4.1 Nutrients

Nutrients are an element or chemical essential to life that include (but are not limited to) nitrogen and phosphorus. Currently, there are no numeric criteria for freshwater streams and rivers in South Carolina. Therefore, the EPA's Ecoregional Nutrient Criteria for Rivers and Streams[24] has been cited to provide some context of what the implications are for the nutrient concentrations observed at E-105. The numeric nutrient criteria for total nitrogen (0.69 mg/L) and total phosphorus (36.56 µg/L) in Ecoregion IX are summarized in **Table 3-3**.

The following two figures summarize available historical monitoring data for total nitrogen (TN) and total phosphorus (TP) at various SCDHEC ambient surface water monitoring stations from May 1999 to March 2020 (**Figure 3-2** and **Figure 3-3**). These data were selected for presentation in the watershed management plan due to their relevance to WTM model outputs.

Sources of nitrogen and phosphorus in the watershed may include runoff from fertilizer use, leaching from septic tanks, sewage, or erosion of natural deposits.[25] It is important to consider the impacts to both the natural ecosystem and the source water when evaluating the impact of nutrients.

As shown in **Figure 3-2**, the SCDHEC monitoring station E-105 has records of 93 TN measurements, of which 73 samples were below the water quality standard (0.69 mg/L for rivers and streams) and 20 were at or above the water quality recommendation. The lowest measured value was 0.028 mg/L and the highest was 1.02 mg/L.

Note that the National Primary Drinking Water Regulations have established criteria for nitrate (10 mg/L) and nitrite (1 mg/L) in potable water[26], but none for phosphorus. The purpose of these limits is to protect infants below the age of six months who could become seriously ill, and if untreated, die if they drink water containing nitrates and nitrites above these thresholds.

Figure 3-3 illustrates the results of 93 total phosphorus (TP) samples collected by SCDHEC from January 2002 to December 2009. In total, 85 (91%) samples were above the water quality recommendation for rivers and streams. The lowest measured TP concentration was 0.027 mg/L (February 2004) and the highest was 0.14 mg/L (May 2005).

[24] EPA. 2000. https://www.epa.gov/nutrient-policy-data/ecoregional-nutrient-criteria-rivers-and-streams
[25] EPA. 2021. https://www.epa.gov/nutrientpollution/sources-and-solutions
[26] EPA. 2022. https://www.epa.gov/ground-water-and-drinking-water/national-primary-drinking-water-regulations

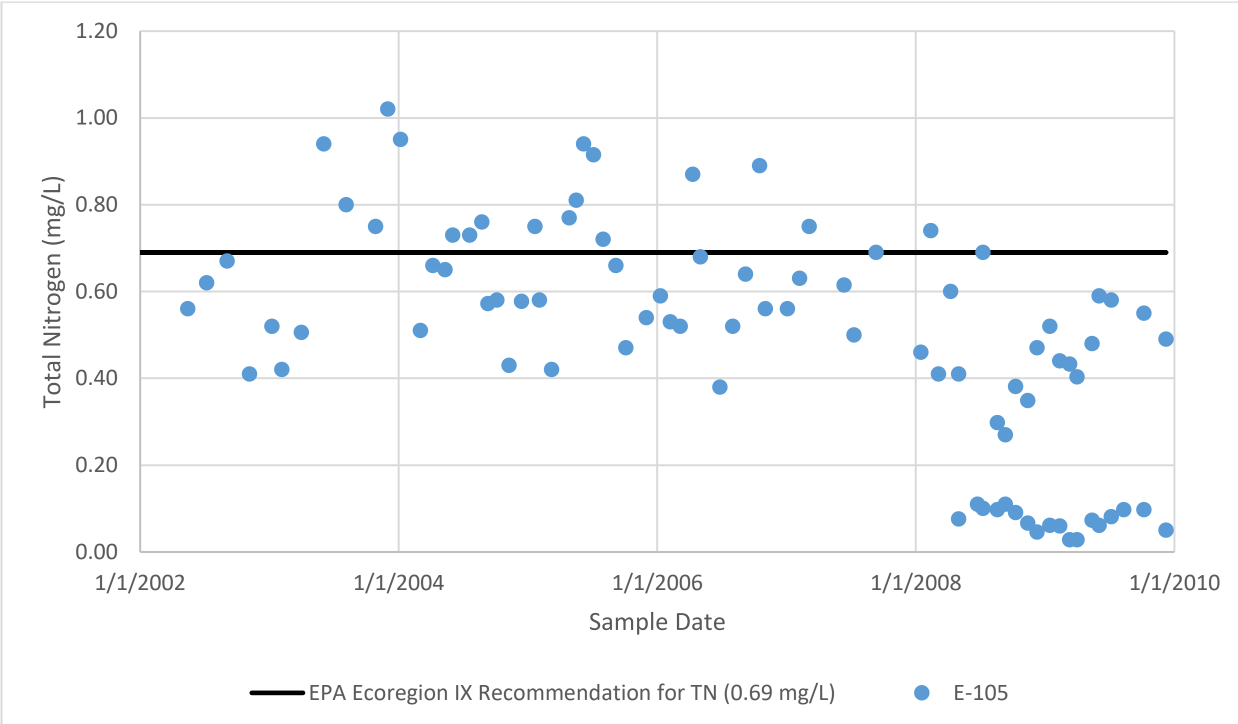

Figure 3-2: Monitoring Results for Total Nitrogen in the Lower Caw Caw Swamp Watershed

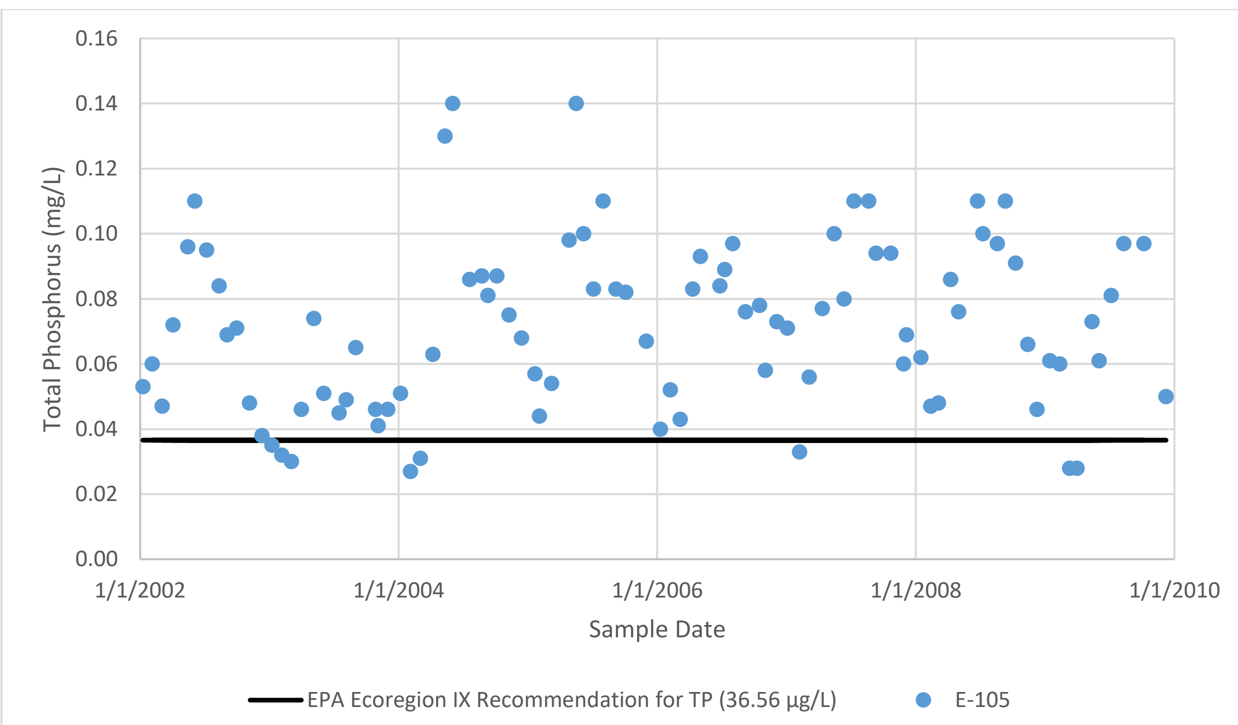

Figure 3-3: Monitoring Results for Total Phosphorus in the Lower Caw Caw Watershed

3.4.2 Turbidity

Figure 3-4 illustrates the SCDHEC turbidity monitoring results from 105 samples collected from January 2001 to December 2009. Note that turbidity is not calculated as part of the WTM analysis. However, Total Suspended Solids (TSS) is calculated in WTM. There are no standards for TSS currently in R.61-68, but there is the freshwater standard for turbidity. Turbidity and TSS are typically well-correlated; however, the relationships are site specific and dependent on factors like organic matter content, particle size, and color. Turbidity measurements at station E-105 ranged from a low of 2.2 NTU to a high of 31 NTU. None of the samples' turbidity levels were above the water quality standard (50 NTU).

From a water treatment perspective, neither TSS nor turbidity are concerns for the DPU at this time. However, if construction or other land-disturbing activities increase the sediment load in stormwater runoff, it has the potential to become an issue.

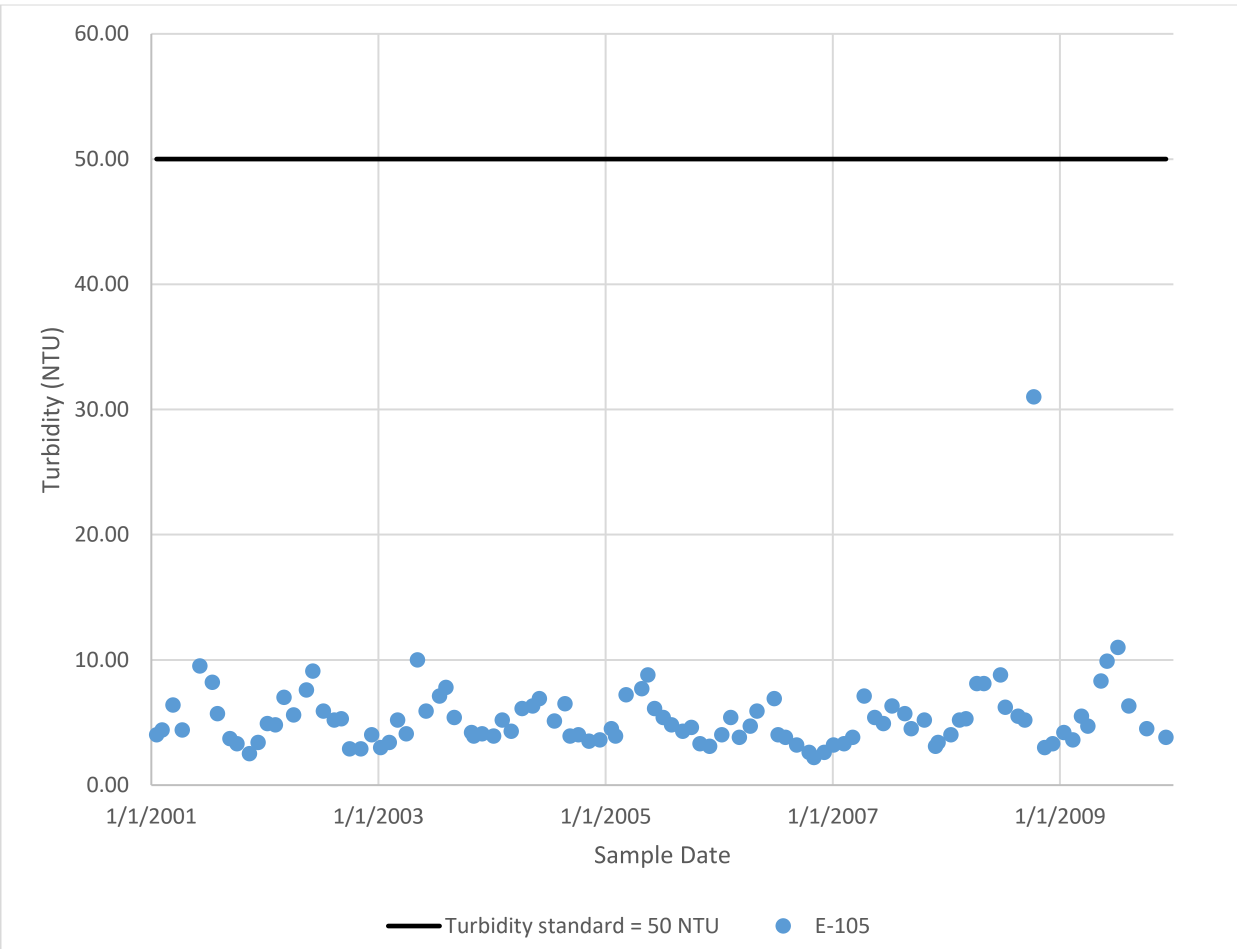

Figure 3-4: Monitoring Results for Turbidity in the Lower Caw Caw Swamp Watershed

3.4.3 Organic Matter

The Edisto River and its tributaries are classified as blackwater systems, which are distinguished by significant terrestrial contributions of organic matter such as decaying forest and marsh materials. Organic matter, measured as Total Organic Carbon (TOC), is a concern for the City of Orangeburg DPU. Monitored TOC from E-105 and the DPU intake (about 1.5 miles downstream of the Lower Caw Caw Swamp watershed outlet) are shown in **Figure 3-5**. The Edisto River has high background levels of TOC, and the DPU must use additional flocculants (aluminum sulfate, also known as alum) to reduce the formation of disinfection byproducts, including trihalomethanes (TTHMs) and haloacetic acids (HAAs). Drinking water containing these byproducts in excess of the Maximum Contaminant Levels (MCLs) may cause liver or kidney problems, or nervous system effects, and may contribute to an increased risk of getting cancer. The Orangeburg DPU provides a Monthly Operating Report to SCDHEC that includes 12 months of Raw TOC, Finished TOC, and Percent Removal Data. Different levels of TOC removal are required based on the concentration in the water, as illustrated in **Figure 3-5**. The 2020 Water Quality Report for the water intake for the City of Orangeburg DPU shows that the average raw water TOC concentration is 9.27 mg/L with a low of 8.93 mg/L and a high of 9.76 mg/L.

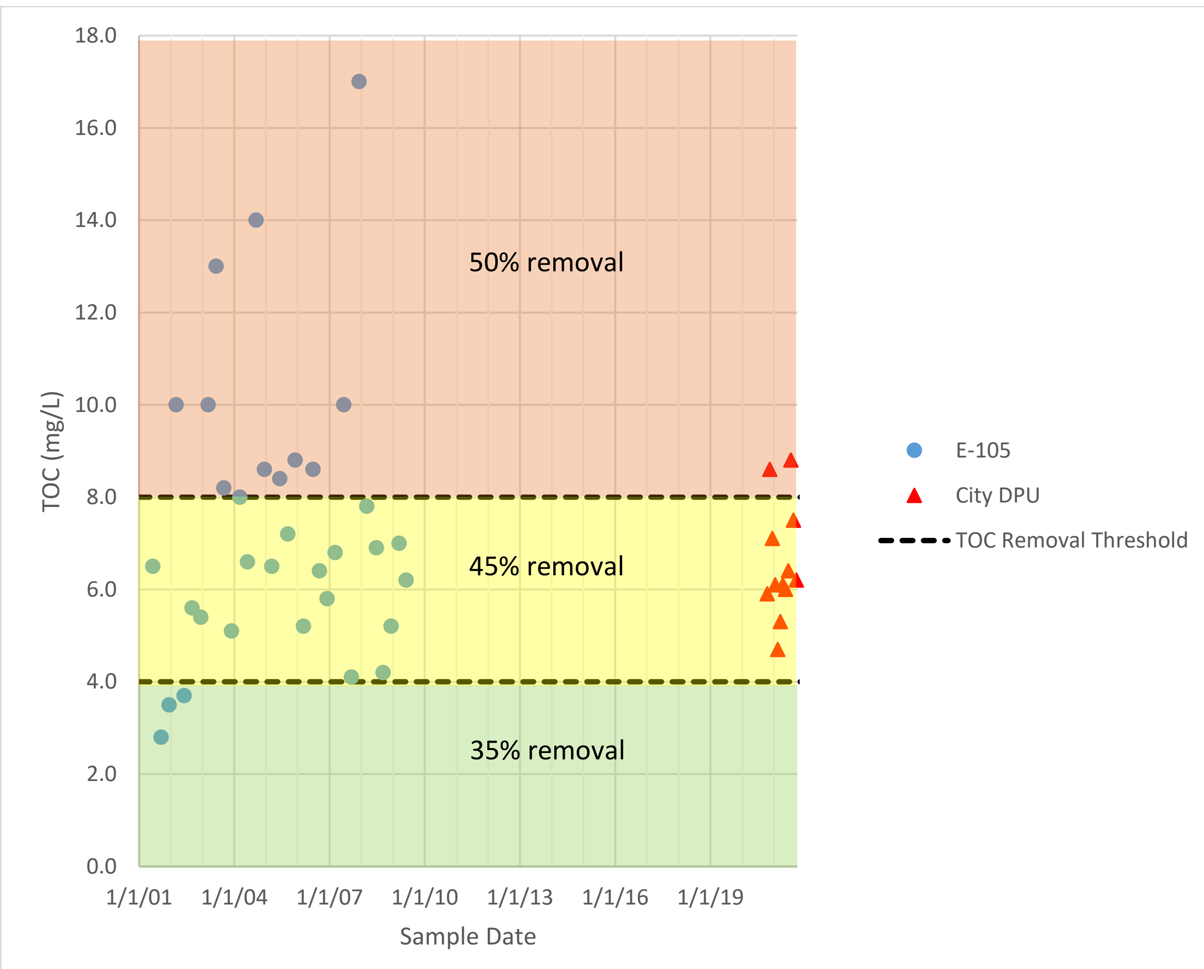

Figure 3-5: Monitoring Results and Removal Requirements for Total Organic Carbon

3.4.4 Bacteria

Figure 3-6 summarizes the monitoring available Fecal Coliform and *E. coli* data (note that FC numbers were calculated as *E. coli* using a conversion factor of 0.8725). In total, 105 measurements were taken from January 2001 to Dec 2009; with an additional 14 samples collected in the summer of 2021 by City of Orangeburg DPU staff. The largest recorded measurement was 2792 MPN/100 mL (at E-105 on 10/09/2008), and the smallest detectable was 20 MPN/100 mL (collected on 5/4/2021 by the City DPU). Over the entire record, 100 measurements (84%) were below the standard of 349 MPN/100 mL; and 19 measurements (16%) were above the standard. The three highest *E. coli* concentrations were observed at E-105 (2,792 MPN/100 mL) and near the newly constructed baseball fields (1,627.5 and 1,093.5 MPN/100mL) behind the Walmart Supercenter on North Rd.

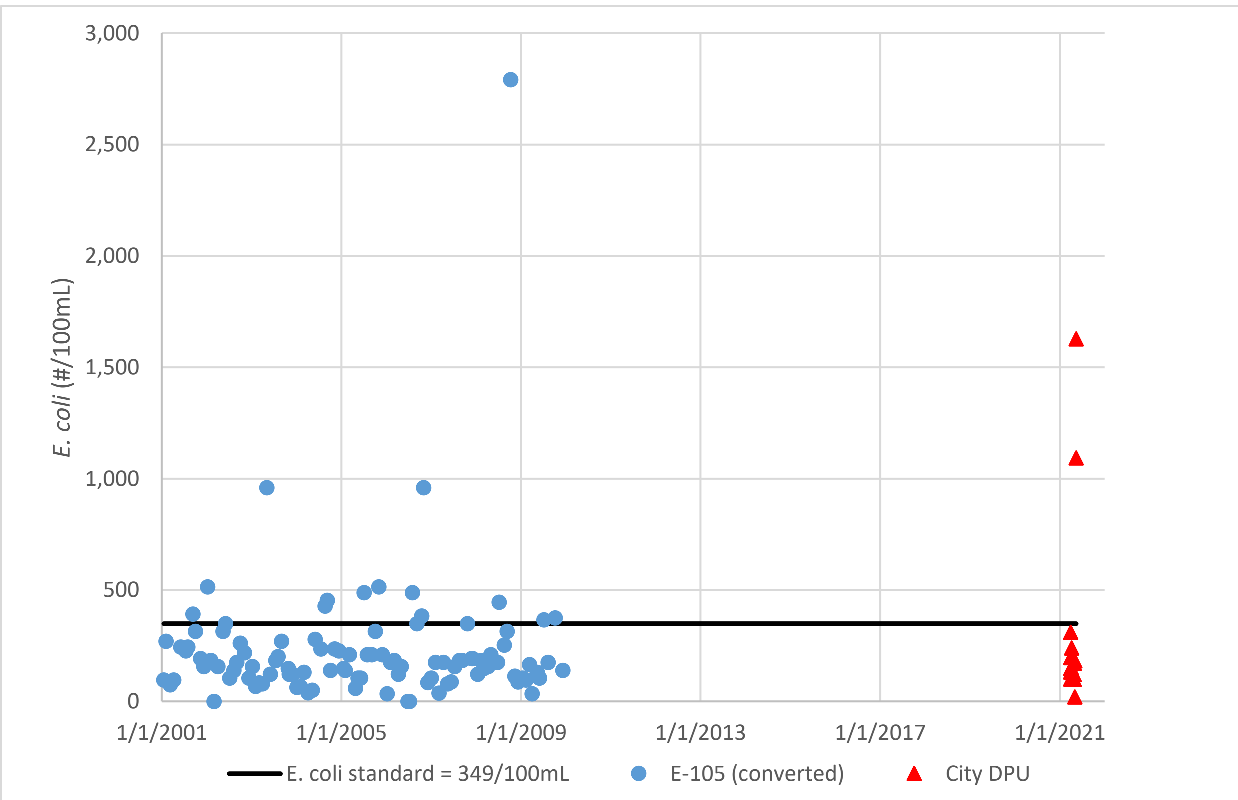

Figure 3-6: Monitoring Results for E. coli in Lower Caw Caw Watershed

The results of the DPU's grab sampling efforts are summarized by subwatershed in **Table 3-4** and illustrated in **Figure 3-7**. Only one sample was collected at each of 14 unique sites within the watershed. The most samples were collected in the Lower Caw Caw subwatershed (7) and only one sample was collected from the Turkey Hill Subwatershed. Only two samples exceeded the water quality standard for *E. coli* of 349 MPN/100 mL; however, those exceedances were 3 to 4.5 times greater than the standard. The order of average *E. coli* concentration from highest to lowest is Lower Caw Caw (most developed subwatershed), Turkey Hill, Early Branch, and Upper Caw Caw (least developed subwatershed). The two highest bacteria samples were also collected near the ball fields in the Lower Caw Caw subwatershed. The Early Branch subwatershed also had the highest "rural" land uses, which may explain a slightly higher bacteria concentration than Turkey Hill subwatershed, despite Turkey Hill having a higher overall developed land use. One of the sampling sites with a relatively high concentration (170.5 MPN/100mL) was located near Waterspring Rd. and the other near the Wannamaker Catfish Ponds (147.5 MPN/100 mL). It is possible that because the sampling was limited, additional monitoring would be necessary to provide more robust analysis of water quality. Recommendations for continued bacteria monitoring are included in **Section 5.6.1** of this WBP.

Table 3-4: DPU Grab Sample Bacteria Concentration Summary by Subwatershed

Subwatershed	Number of Samples	Average *E. coli* (MPN/100mL)	Developed Land Use (%)
Early Branch	4	135	38%
Lower Caw Caw	7	531	67%
Turkey Hill	1	132	51%
Upper Caw Caw	2	101	6%

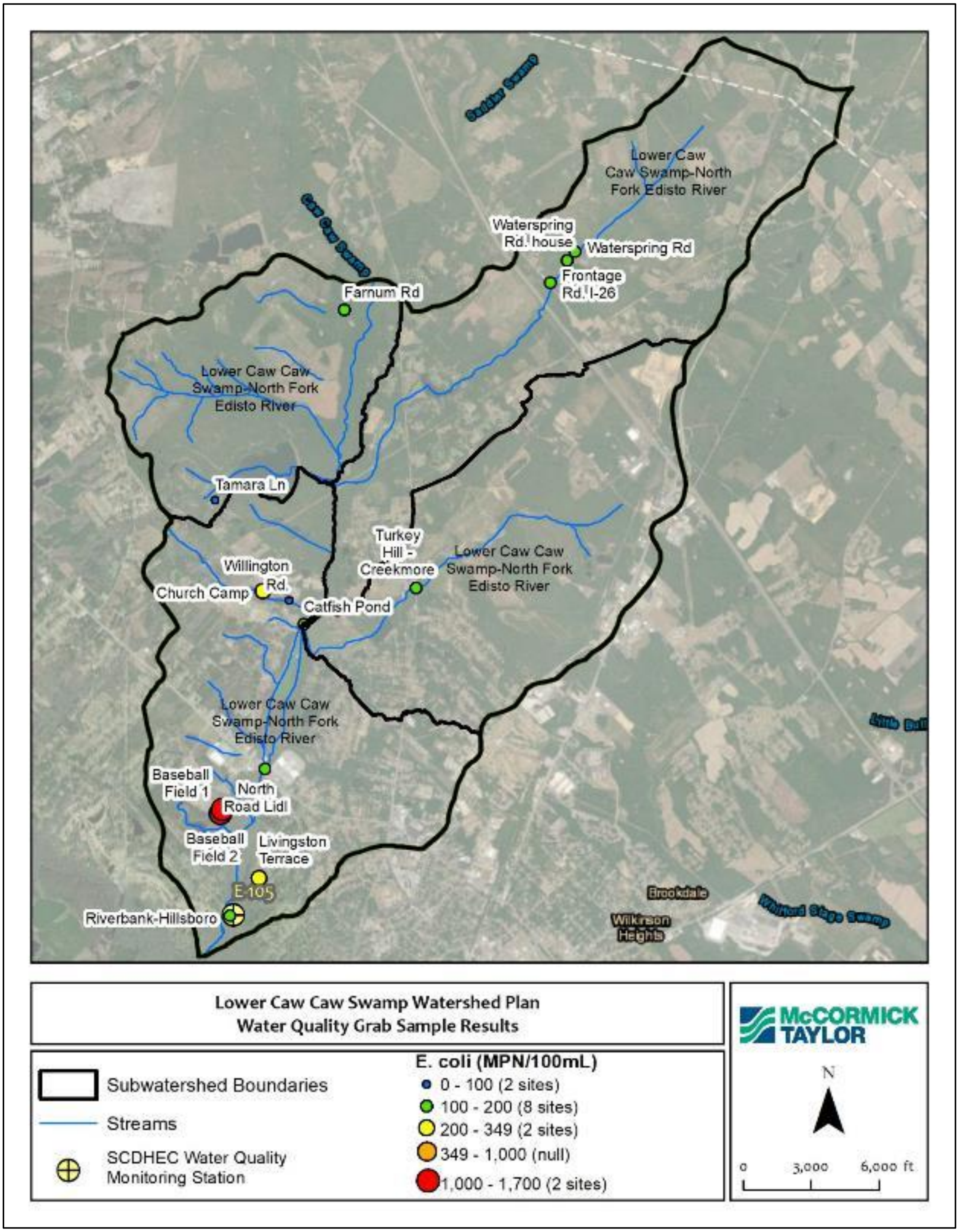

Figure 3-7: Grab Sample E. Coli Concentration Results

3.5 Impaired Waters

Waterbodies that do not meet these designated uses are impaired and identified by the state in accordance with the Federal Clean Water Act Section 303(d), known as the "303(d) list." The 303(d) list is updated every two years by SCDHEC. SC Regulation 61-68 defines Freshwaters as those suitable for primary and secondary contact recreation and as a source for drinking water. The quality standards for these waters are such that garbage, cinder, oils, or other refuse are not allowed. Furthermore, stormwater and other nonpoint source runoff are allowed if water quality is maintained and protected such that it is consistent with anti-degradation rules.

The state uses the 303(d) list to target waterbodies that need to be restored to meet water quality standards. Generally, a total maximum daily load (TMDL) is developed for waters identified on the 303(d) list. A TMDL is the calculation of the maximum amount of a pollutant that is allowed to enter a waterbody so that the waterbody will meet its water quality standards for a particular pollutant. A TMDL must include both point and nonpoint sources of pollution and some margin of safety.

The current 2018 303(d) list[27] does not include any sections of the Lower Caw Caw Watershed. However, station E-105 is included in an approved TMDL for fecal coliform to protect recreational uses. Historically, the standard for fecal coliform in freshwater was "Not to exceed a geometric mean of 200/100 ml, based on five consecutive samples during any 30-day period; nor shall more than 10% of the total samples during any 30-day period exceed 400/100 ml." The current standard for *E. coli* in order to protect recreational uses in freshwaters is a monthly average of 126 MPN per 100 ml or a daily maximum of 349 MPN per 100 ml.

Additionally, E-105 is included in the SC Waters of Concern (WOC) list for lead. Waters of Concern can also be referred to as "waterbodies that demonstrate degradation or are threatened for nonattainment of classified uses."[28] It is possible that WOC may be included on a future 303(d) list.

[27] SCDHEC. 2020. South Carolina 303(d) List of Impaired Waters & TMDLs. Available at https://scdhec.gov/bow/south-carolina-303d-list-impaired-waters-tmdls
[28] SCDHEC. 2020. State of South Carolina Integrated Report Part 1: Listing of Impaired Waters. Available at https://scdhec.gov/sites/default/files/media/document/IR_Part_I_Final_Submittal_2018_1.pdf

4.0 Pollutant Source Assessment

Potential sources of pollutants are reviewed in the following section using available data and information. Sources of nutrients, sediment, metals, bacteria, and other pollutants are considered in relation to where these sources may occur in the watershed and the potential impacts they may have on water quality (for both public drinking water and recreation) and aquatic life.

4.1 Summary of Scenarios for WTM Analysis

In order to evaluate the pollutant sources and associated annual TN, TP, TSS, and bacteria loads, three scenarios were evaluated in the WTM: Current Condition, Future Condition, and Recommended Condition. The Current Condition is a representation of existing factors, such as land use, management practices, and precipitation. The Future Condition analyzes pollutant loads that will result from future development and climate change across the study area if no additional management measures are implemented. The Recommended Condition includes structural and nonstructural management practices to reduce pollutant loads identified in the Current Condition Scenario; examples include recommendations for stream restoration, reforestation, and education programs for pet waste and septic systems. A summary of the input variables for WTM are summarized in **Table 4-1**. Please note that the WTM calculates bacteria loads in terms of FC (as reflected in the FC loading rates below). To reflect the current water quality standard, all FC loads calculated in WTM were converted to E. coli by multiplying the WTM loads by 0.8725.[29]

[29] Fecal coliform values can be converted to E. coli values using a standard conversion factor of 0.8725, that represents the ratio of 349/400. 349 is the water quality standard (WQS) for E. coli and 400 the WQS for fecal coliform.

Table 4-1: Lower Caw Caw Swamp Watershed WTM Scenarios

Variable	Current	Future	Recommendation
Annual Precipitation	48.14”	62.08”	48.14”
Dwelling Units	3,226	4,602	3,226
Buffer Length	19.9 miles (40 ft width)	19.9 miles (40 ft width) 4.4 miles (20 ft width)	19.9 miles (40 ft width)
Land Use	2016 NLCD + Zoning	USGS Projections (A1B Scenario)	2016 NLCD + Zoning
Residential FC loading (MPN/100mL)	9,000	15% increase (10,350)	9,000
Commercial FC loading (MPN/100mL)	3,000	15% increase (3,450)	3,000
Roadway & Industrial FC loading (MPN/100mL)	2,000	15% increase (2,300)	2,000
Unsewered Dwelling Units	57%	40%	57%
OSDS failure rate	10%	10%	10%
Miles of sanitary sewer	39.8	56.8	39.8
Volume per SSO overflow (gallons)	1,000	1,000	1,000
Pet Waste Education	Yes, 30% awareness	Yes, 30% awareness	Yes, 40% awareness
Stormwater BMPs Capture discount Design discount Maintenance discount	 83% 0.8 0.6	 83% 0.8 0.6	 90% 0.9 0.9

4.2 Land Use Nonpoint Sources

The purpose of this section is to make a distinction between sources of nonpoint pollution that are directly linked to human waste (Sanitary Sewer Overflows and Septic Systems, **Section 4.3**) and those that are related to other uses of the land (such as agriculture and suburban development). The focus of the analysis was on the current condition of the watershed. These values were calculated using the WTM Existing Conditions, which reports bacteria as Fecal Coliform. Those values were converted to *E. coli* – the current water quality standard – by multiplying FC values by 0.8725.

4.2.1 Agriculture

On May 19, 2021, a focus group comprised of professionals from Clemson Extension, SC Forestry Commission (SCFC), SC Department of Natural Resources (SCDNR), Orangeburg Soil and Water Conservation District (SWCD), and Longleaf Alliance met to discuss forestry and agriculture in the Lower Caw Caw Swamp Watershed. Consensus in the group was that there are minimal row crops, logging operations, and livestock currently within the watershed boundary. They do not expect any expansion in cattle or row crop production currently due to high startup costs.

Livestock

Livestock production can lead to increased pollutant concentrations in downstream waterbodies. Where livestock have unlimited access to streams, animals may contribute fecal matter directly to streams and cause severe disturbance to stream banks. Runoff from livestock facilities (pasture, paddocks, manure storage areas, etc.) can introduce sediment, nutrients, bacteria, and toxins to surface waters – all of which can pose a direct threat to the downstream public water intake. Very few livestock operations are believed to exist in the watershed. The Forest and Agriculture (FA) district zoning classification in Orangeburg County exist to “conserve, sustain, and protect agricultural areas” but does not appear to have limitations on numbers of animals.

According to the SCDHEC Watershed Atlas[30] there are no SCDHEC Regulated Permits for Livestock Operations in this area. However, based on field observations, the Project Team estimated that 30 cows reside in the Lower Caw Caw Swamp Watershed (permits are not required for small farms). The WTM estimates annual loading associated with livestock to be a secondary source (not based on land use, but rather on the number of animals present), and does not directly calculate TSS per animal. The Current Conditions scenario estimated pollutant loadings for the Lower Caw Caw Swamp Watershed are 788 lb/yr TN; 90 lb/yr TP; and 2.6×10^{12} MPN/yr of *E. coli* bacteria. Observations of the cow farm indicate that the animals are not prevented from entering the impoundments on the property; the result is significant bank erosion as shown in **Figure 4-1** and probable manure runoff into the water. Flow into the impoundments comes from upstream sections of Turkey Hill Branch and then is allowed to discharge downstream to the Wannamaker Catfish Ponds and the main trunk of the Lower Caw Caw Swamp. As a reminder, the Turkey Hill subwatershed had the second highest percent impervious area (30%) and would be considered “non-supporting” for aquatic life.

Figure 4-1: Small Cow Farm in Lower Caw Caw Swamp Watershed

30 SC Watershed Atlas available at https://gis.dhec.sc.gov/watersheds/

Cropland

Nonpoint source pollutants associated with agricultural crop production include nutrients, sediment, bacteria, and toxins, which can threaten public water intakes, aquatic life, and recreational uses of the waterways. Nutrients in agricultural runoff originate from exposed soil as well as from applied fertilizers. Sediment loading occurs through erosion of bare or disturbed soils. Bacteria may originate from livestock manure applied to agricultural land (although the Forestry & Agriculture Focus Group did not think there was much land application in the watershed). Toxins in agricultural runoff, including pesticides, typically originate from chemical applications to cropland. Metals, which are potential toxins, may also be released in agricultural runoff, and these toxins may originate from both manure and mineral-based fertilizer applications. Toxins from chemical applications may contribute to declines in aquatic species populations in combination with other sources (urban/suburban runoff, point sources, and hazardous waste). The WTM calculates pollutant loads for rural/cropland areas (which estimates that the total annual loading associated with rural/cropland areas (which included Rural Community Zoning and Hay/Pasture, Cultivated Crops, and Herbaceous NLCD land uses) to be 1,921 lb/yr TN; 292 lb/yr TP; 41,765 lb/yr TSS; and 1.4×10^{13} MPN/yr *E. coli* bacteria.

4.2.2 Silviculture

Silviculture, which involves managing forests for a particular goal, can have both positive and negative effects on water quality and aquatic habitat. When a forest is managed to prevent catastrophic fires, a watershed is at less risk for high sediment loading that would occur after a catastrophic event. On a much smaller scale, fire prevention techniques may increase sediment loading due to removal of vegetation during prescribed burns or thinning. Forests account for 7,088 acres in the Lower Caw Caw Swamp Watershed, but there are no large silviculture industries in the watershed (as indicated by feedback from the SCFC and Clemson representatives in the Focus Group).

As a general estimate of pollutant loads associated with forested land in the Current Condition of the Lower Caw Caw Swamp Watershed, WTM calculates 17,719 lb/yr TN; 1,418 lb/yr TP; 708,768 lb/yr TSS; and 7.4×10^{13} MPN /yr of *E. coli* bacteria.

In addition to pollutants associated with forested land use, there is also pollution related to runoff from areas where the forest has been cleared and a sufficient vegetative cover has not been established. During the watershed survey, McCormick Taylor identified 29 acres of clear-cut areas. The WTM estimates that the pollutant loads associated with these practices is the difference between active construction and forested land use: 5.3 $\times 10^{4}$ lb/yr TN; 1.1 $\times 10^{4}$ lb/yr TP; and 3.65.3 $\times 10^{7}$ lb/yr TSS.

4.2.3 Wildlife

Natural areas that support wildlife are generally considered to represent the natural, unimpacted state of the watershed, and wildlife feces are considered a background source of nutrients and bacteria in surface water. About 51% (7,220 acres) of the Lower Caw Caw Swamp Watershed is forest (which includes shrub/scrub, woody wetlands, deciduous forest, evergreen forest, mixed forest, and emergent herbaceous wetlands from the NLCD dataset) and 3% (422 acres) is open water areas where wildlife is likely to exist. The WTM does not explicitly calculate a specific loading associated with wildlife; however, if bacteria concentrations are very high in a particular area, microbial source tracking (MST) could be useful to determine if the bacteria are originating from human or a variety of animal species. More discussion of MST is included in **Section 5.6.1**.

4.2.4 Urban/Suburban Runoff

Urban/suburban runoff is similar to cropland runoff in that it includes nutrients, sediment, bacteria, and toxins. However, a major difference lies in how and when the runoff from urban and suburban landscapes is delivered to waterbodies. Urban/suburban runoff is usually routed from impervious surfaces either directly to the waterbodies or somewhere just upstream of the waterbodies. These different runoff characteristics threaten streams and other waterbodies from urban/suburban runoff in several different ways. The first, and potentially most influential threat, is from the increased stormwater discharges that are delivered directly to streams where both the volume and velocities of the flows are often drastically higher than runoff from undeveloped lands. Secondly, the increased overland flow that is often associated with urban/suburban impervious surfaces decreases the amount of stormwater that flows through subsurface processes from which groundwater is recharged, thus leading to lower base flows. Thirdly, urban/suburban land uses can increase pollutant loads in stormwater runoff through erosion from disturbed areas (e.g., construction sites), build-up and wash-off of pollutants, illicit connections, and dumping into storm sewers. Another common threat from urban/suburban development is the increase in stream temperatures due to lack of shading as well as heated stormwater runoff from ponds and impervious areas. Finally, a decreased population and diversity of plants and animals is usually observed in urban/suburban areas due to the poor quality of habitat. All of these mechanisms can contribute to waterbody impairment, both from a human health and aquatic life perspective.

A significant portion of the Lower Caw Caw Swamp Watershed has been developed into suburban and urban lands (6,174 acres or 43% of the entire HUC-12), which includes residential, commercial, industrial, and road land uses. The amount of undeveloped land (8,060 acres or 57% of the entire HUC-12 watershed) is greater than the amount of developed land, which includes open space, forest, rural, and water land use categories. The subwatersheds with the most developed land to least developed are Lower Caw Caw (67%), Turkey Hill (51%), Early Branch (38%), and Upper Caw Caw (6%). Across the entire HUC-12 watershed (the combination of all four subwatersheds), commercial land uses contribute the most runoff volume and TN; medium density residential contributes the most TP and TSS. **Table 4-2** summarizes the contributions of each of the seven urban/suburban land uses for each of the model pollutants and runoff volume. Values in bold text are the maximum for each pollutant category. In summary, commercial land uses are estimated to generate the largest volume of runoff and contribute to the highest load of TN; medium density residential land uses contribute the highest loads of TP, TSS, and bacteria. For the current conditions, the WTM estimates that the annual pollutant contribution of urban/suburban development is 62,273 lb/yr TN; 7,942 lb/yr TP; 1.7×10^6 lb/yr TSS; and 6.8×10^{14} MPN /yr of *E. coli* bacteria.

Table 4-2: Current Conditions Estimated Pollutant Loads

Urban/Suburban Land Use	TN (lb/year)	TP (lb/year)	TSS (lb/year)	E. coli (MPN/year)	Runoff Volume (acre-feet/year)
LDR (<1du/acre)*	2,906	429	67,799	5.0E+13	510
MDR (1-4 du/acre)*	16,928	**2,499**	**394,981**	2.9E+14	2,972
HDR (>4 du/acre)*	10,478	1,547	244,484	1.8E+14	1,840
Multifamily	634	94	14,803	1.1E+13	111
Commercial	**18,493**	1,937	378,667	1.1E+14	**3,247**
Roadway	4,364	474	254,224	1.5E+13	700
Industrial	8,471	963	311,880	3.1E+13	1,420
Urban/Suburban Total:	6.23E+04	7.94E+03	1.67E+06	6.8E+14	1.1E+04

**du = dwelling unit*

4.2.5 Streambank Erosion

Modification of the hydrologic regime due to land development in a watershed can result in elevated volumes of stormwater runoff being delivered to creeks, streams, and other waterbodies. These increased volumes and the quick delivery of these runoff events can lead to scour of stream channels, incision, and streambank erosion. Hydrologic scour of the streambed can also limit key microhabitats (e.g., leaf packs, sticks, and coarse substrate) for aquatic species. While it is difficult to delineate the different sources of sediment that are being delivered to streams (e.g., streambank erosion as opposed to upland sources such as construction sites), instream sedimentation and subsequent lack of microhabitat are, to some degree, a result of sediment input to streams from streambank erosion. Channel widening through streambank erosion can also exacerbate low flow conditions because channels become overly wide and shallow. **Section 2.4.3** of this watershed plan describes how the USLE K-factor was calculated and used to estimate the soil's susceptibility to erosion.

The estimated annual loads for the current condition in the Lower Caw Caw Swamp Watershed that can be attributed to stream bank erosion are 2.4×10^3 lb/yr TN; 1.93×10^3 lb/yr TP; and 2.41×10^6 lb/yr TSS. Although the WTM assumes that there is no bacteria loading associated with streambank erosion, there is evidence that suggests that fecal coliform bacteria can attach to sediment particles, and colonize and persist in biofilms and sediments in ditches and streams.[31] However, bacteria that is persistent in the environment likely has not been recently excreted from a warm-blooded animal, and probably is not associated with actual disease-causing pathogens.

[31] McCormick Taylor and Moffatt & Nichol. 2020. May River Watershed Action Plan Update & Modeling Report. Available at https://www.townofbluffton.sc.gov/DocumentCenter/View/2068/2020-May-River-Action-Plan-Update-and-Model-Report

4.3 Human Waste Nonpoint Pollutant Sources

Human waste is a direct contributor to fecal coliform pollution (freshwater standards are based on the number of *E. coli* colonies), and negatively impacts water quality if it contacts surface water resources, such as through sanitary sewer spills or septic system infiltration. In general, human sewage contamination represents a direct health risk and is a controllable source (the city and county can fix underperforming septic systems and/or sanitary sewer conveyance systems). Fecal indicator bacteria (FIB), such as *E. coli*, are bacteria that are normally prevalent in the intestines and feces of warm-blooded animals. The FIB are used because direct testing for pathogens (what actually presents the human health risk) is very expensive. In other words, it is possible to find FIB in areas where there are not pathogens present. This section provides estimates, based on the current condition of the watershed, of sources that may contribute to human waste and the potential negative impacts that poor maintenance of these systems may have on water quality.

4.3.1 SSOs

Sanitary Sewer Overflows (SSOs) are sources of sediment, nutrients, bacteria, and toxins during storm events. These overflows are caused when surface water enters sewer systems beyond their designed flow capacity, causing the sewers to overflow and release raw sewage. During these events, the released sewage may enter nearby waterbodies and cause an acute increase in pollutant concentrations. **Figure 2-13** (from **Section 2.7**) illustrates the municipal sewer service areas in the Lower Caw Caw Swamp Watershed; in total there are 47.35 miles of sanitary sewer lines (including gravity, force main, and lateral line) connecting all the homes and business in the watershed to treatment plants. Based on online reports for SSOs in the City of Orangeburg (including areas outside of the Lower Caw Caw Swamp Watershed), the average size of spill was 1,000 gallons. However, please note that the DPU has not encountered an SSO within the Lower Caw Caw Swamp Watershed boundaries. Using the average spill size for the City, the WTM estimates that the average annual loads associated with SSOs in the current condition of the Lower Caw Caw Swamp Watershed are 3 lb/yr TN; 0.5 lb/yr TP; 19 lb/yr TSS; and 1.8×10^{12} MPN/yr *of E. coli*.

4.3.2 Septic Systems

Septic systems that are not properly maintained are a potential source of nutrients and bacteria in surface and groundwater. In the Lower Caw Caw Swamp Watershed, 57% of the residential dwellings are not currently served by municipal sewer systems and assumed to have septic systems on-site, as shown in **Figure 2-12** (from Section 2.7). These estimates can be adjusted as better information is made available. Based on an assumption of 10% failure rate, sandy soils, and a conventional system type installed at a density of 1-2 units/acre, the WTM predicts the average annual loading associated with septic systems (in the current condition) to be 3.5×10^{3} lb/yr TN; 581 lb/yr TP; 2.3×10^{4} lb/yr TSS; and 5.8×10^{13} MPN/yr *of E. coli*.

4.4 Point Sources

4.4.1 NPDES Permits

The National Pollutant Discharge Elimination System (NPDES) was developed by EPA to regulate point source pollutant discharges to surface waters. In South Carolina, NPDES permitted dischargers must comply with discharge limitations that are set by SCDHEC to protect downstream waterbodies.

Table 4-3 and **Figure 4-2** list and illustrate the three NPDES permitted facilities within the Lower Caw Caw Swamp Watershed boundary. The NPDES discharges may contribute to declines in aquatic species populations in combination with other sources of potential toxins (stormwater runoff, agriculture, and hazardous waste), and some may be significant pollutant sources in the watershed. However, if the conditions of the NPDES permit are met, there should be minimal impact to water quality. In the Lower Caw Caw Swamp Watershed, the one domestic permit refers to an outfall from a sewage treatment facility, and the industrial permits refer to stormwater that may contain pollutants from each of the two sites (gasoline service station and a mine). Currently, only one of the permits (Palmetto Site Prep-Medway Mine) is active. The concern with this site is that non-metallic minerals could be transported from the property via stormwater runoff and end up in the Lower Caw Caw Swamp, which then could have the potential to impact downstream resources (such as the City of Orangeburg DPU drinking water intake).

Table 4-3: NPDES Permits in the Lower Caw Caw Swamp Watershed

NPDES	Name	Activity	Type	Description
SC0028606	Orangeburg Prep School	Inactive	Domestic	Elementary and Secondary Schools
SC0041424	EMRO Mktg/Port Oil #284	Inactive	Industrial	Gasoline Service Stations
SCG731360	Palmetto Site Prep-Medway Mine	Active	Industrial	Misc. Non-metallic minerals

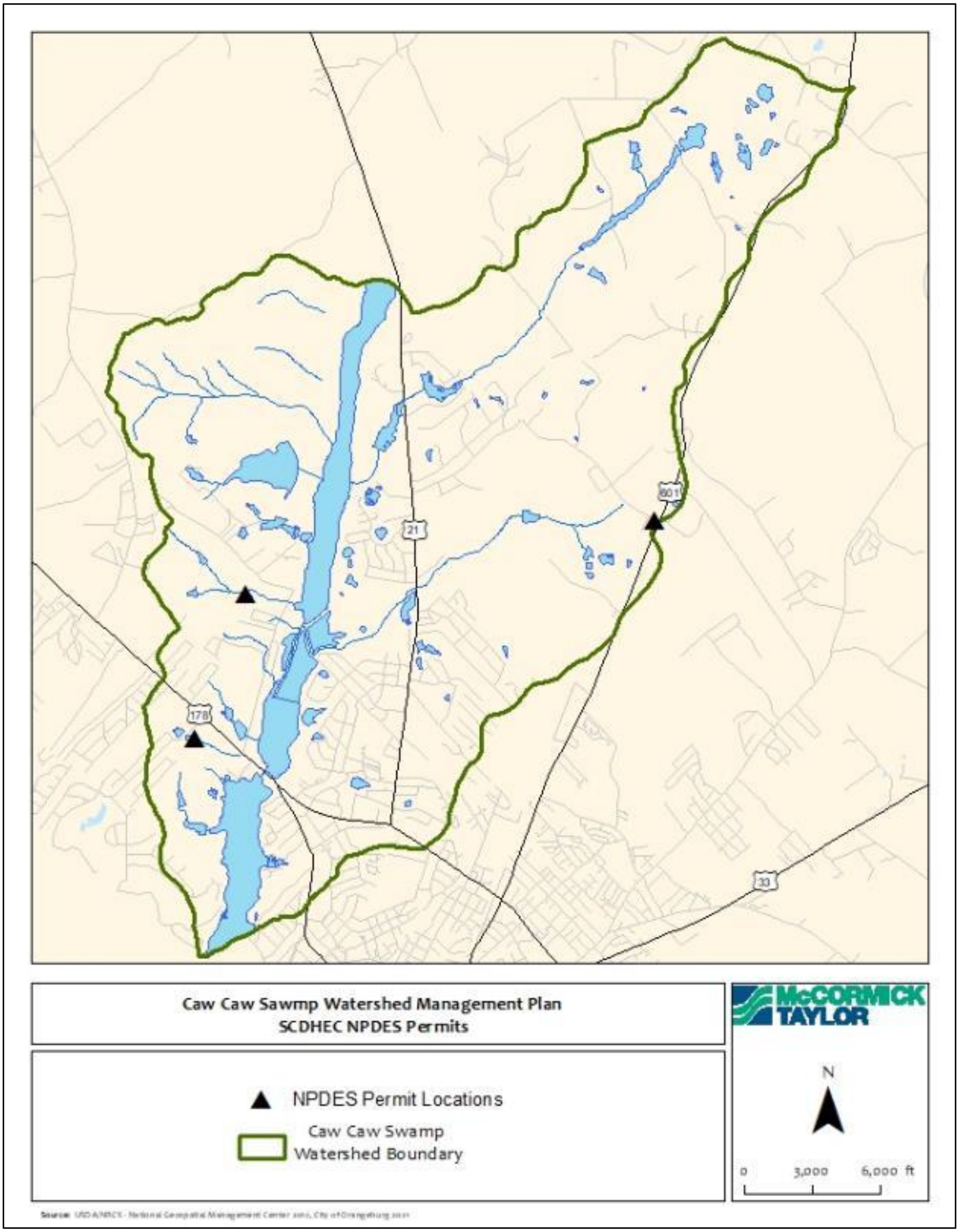

Figure 4-2: SCDHEC Permitted NPDES Locations in Lower Caw Caw Swamp Watershed

4.5 Watershed Pollutant Loads

The existing and future pollutant loads for the watershed were estimated using the Center for Watershed Protection's Watershed Treatment Model (WTM) and can track sediment, nutrients, bacteria, and runoff volume on an annual basis. The model incorporates many simplifying assumptions that allow the watershed manager to assess various programs and sources. The pollutant sources component estimates the load from a watershed without treatment measures in place and considers primary (land use) and secondary sources (such as sewage treatment, nutrient concentration in stream channels, urban channel erosion). Treatment options include turf management, erosion and sedimentation control, stormwater structural best management practices, pet waste education, riparian buffers, and street sweeping. The WTM calculates bacteria loading in terms of fecal coliform; therefore, it was necessary to apply a conversion factor (0.8725) to translate the loads to be in terms of *E. coli* for this WBP.

4.5.1 Pollutant Loads from Current Conditions

As described previously in **Table 4-1** of this chapter, the Current Condition Scenario evaluated in the WTM for the Lower Caw Caw Swamp Watershed involved multiple unique input values. The pollutant removal capacity for the watershed was estimated to come from existing wet and dry detention ponds. A desktop and windshield survey conducted by the DPU and MT identified 45 wet ponds and 31 dry ponds (of which 11 appear to be overgrown with vegetation and in need of maintenance). Lacking access to drainage records for the watershed, the Project Team used professional judgement to assume that each individual wet pond would treat 10-25 acres of drainage area and individual dry ponds would treat at least 10 acres of drainage area, based on design recommendations provided by *Low Impact Development in Coastal South Carolina: A Planning and Design Guide*.

Based on zoning/land use, there are 6,306 acres of developed land uses (residential, roads, commercial, industrial) in the watershed and of that, there is an estimated 2,425 acres of impervious surfaces (38% of developed drainage areas are impervious). The consultant assumed that 1,125 acres drained to wet ponds and 310 acres drained to dry ponds. For WTM analysis, the consultant assumed various "discount factors" based on methodology in the WTM user manual:

- Capture Discount (D1): the existing BMPs captured 1" of runoff (which equates to 83% of annual rainfall events being 1" or less)
- Design Discount (D2): less specific standards (there is no City of Orangeburg or Orangeburg County stormwater design manual) that are legally binding (enforced by permits) = 0.8
- Maintenance Discount (D3): maintenance is specified but poorly enforced = 0.6

Using these inputs, the WTM calculates a load reduction for existing stormwater infrastructure to be 1.92×10^{3} lb/yr TN; 667 lb/yr TP; 3.7×10^{4} lb/yr TSS; and 3.2×10^{13} *E. coli* bacteria per year. Note that no reduction of runoff volume is attributed to dry or wet ponds, because it is assumed that water does not infiltrate in these BMPs.

A load is the pollutant concentration multiplied by a volume of water. For the Current Condition, **Figure 4-3** summarizes the volume of runoff generated by each source of pollution. Note that secondary sources (septic systems, SSOs, channel erosion, and hobby farms) do not create runoff, but they still contribute to the pollutant loads.

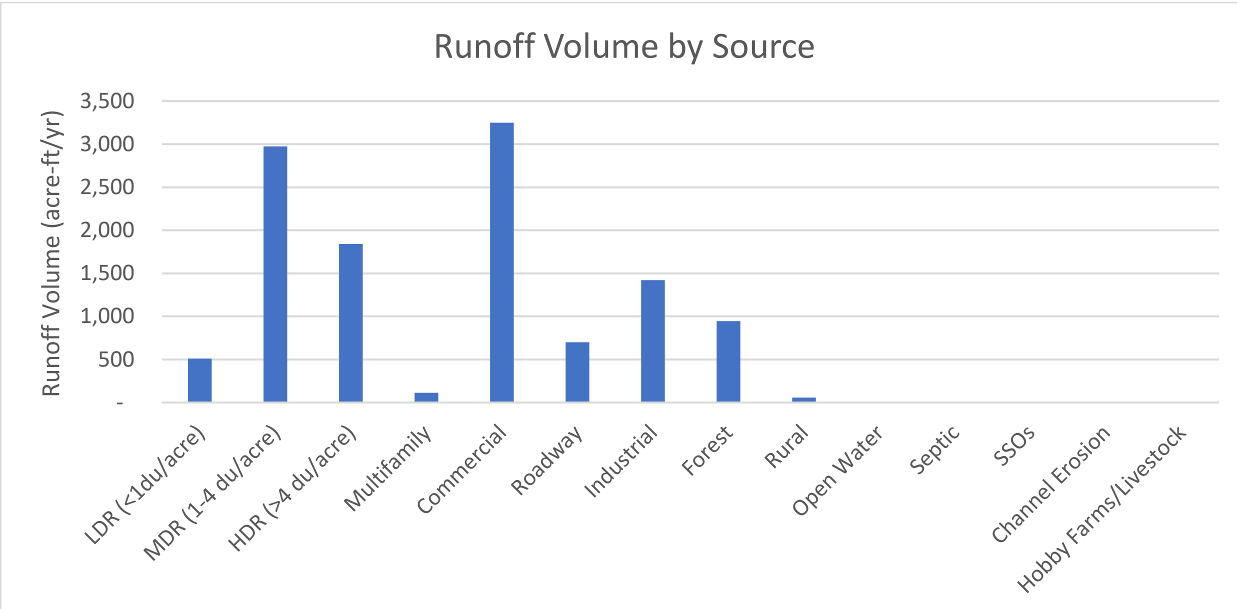

Figure 4-3: Runoff Volume Produced in Current Condition

Table 4-4 represents the primary (land use) and secondary (septic, SSO, erosion, and livestock) pollutant loads if there were no practices in place to help improve water quality. In the 2010 TMDL for fecal coliform bacteria[32] (for both the upper and lower Caw Caw Swamp at station E-105), the loading estimate for the entire Caw Caw Swamp Watershed was 1.17×10^{11} cfu/day of FC (which we have converted to 3.7×10^{13} MPN/yr of *E. coli*). The TMDL estimate is an order of magnitude lower than the *E. coli* loading estimate of 8.3×10^{14} MPN/yr of *E. coli* that was calculated using current (2022) land use and zoning in the WTM for this WBP. We hypothesized that development in the watershed has increased since the time of the TMDL, which resulted in a higher bacteria load estimate. A Watershed Manager from SCDHEC recommended focusing on evaluating the human-related bacteria loading (7.4×10^{14} MPN/yr as indicated in Table 4-4) but keep the same 35% load reduction recommendation from the TMDL. For the Lower Caw Caw Swamp Watershed, 35% of the 7.4×10^{14} MPN/yr of human-related *E. coli* bacteria sources is 2.6×10^{14} MPN/yr of *E. coli* bacteria that must be reduced in the watershed.

[32] 2010. SCDHEC. Total Maximum Daily Load Document E-105, Caw Caw Swamp Watershed. https://scdhec.gov/sites/default/files/docs/HomeAndEnvironment/Docs/tmdl_cawSwamp.pdf

Table 4-4: Current Conditions Estimated Pollutant Loads in the Lower Caw Caw Swamp Watershed

	TN (lb/year)	TP (lb/year)	TSS (lb/year)	*E. coli* (MPN/year)	Runoff Volume (acre-feet/year)
LDR (<1du/acre)	2.9E+03	4.3E+02	6.8E+04	5.0E+13	5.1E+02
MDR (1-4 du/acre)	1.7E+04	2.5E+03	3.9E+05	2.9E+14	3.0E+03
HDR (>4 du/acre)	1.0E+04	1.5E+03	2.4E+05	1.8E+14	1.8E+03
Multifamily	6.3E+02	9.4E+01	1.5E+04	1.1E+13	1.1E+02
Commercial	1.8E+04	1.9E+03	3.8E+05	1.1E+14	3.2E+03
Roadway	4.4E+03	4.7E+02	2.5E+05	1.5E+13	7.0E+02
Industrial	8.5E+03	9.6E+02	3.1E+05	3.1E+13	1.4E+03
Forest	1.8E+04	1.4E+03	7.1E+05	7.4E+13	9.4E+02
Rural	1.9E+03	2.9E+02	4.2E+04	1.4E+13	5.6E+01
Open Water	5.4E+03	2.1E+02	6.5E+04	0.0E+00	0.0E+00
Channel Erosion	2.4E+03	1.9E+03	2.4E+06	0.0E+00	0.0E+00
Septic	3.5E+03	5.8E+02	2.3E+04	5.8E+13	0.0E+00
SSOs	3.0E+00	5.0E-01	1.9E+01	1.8E+12	0.0E+00
Hobby Farms/Livestock	7.9E+02	9.0E+01	0.0E+00	2.6E+12	0.0E+00
ALL SOURCES TOTAL:	**9.4E+04**	**1.2E+04**	**4.9E+06**	**8.3E+14**	**1.2E+04**
HUMAN SOURCES TOTAL:	**6.7E+04**	**8.6E+03**	**1.7E+06**	**7.4E+14**	**1.1E+04**

Fortunately, the Lower Caw Caw Swamp Watershed does have multiple existing programs and practices to help reduce the current levels of bacteria. **Table 4-5** summarizes the load reduction benefits associated with structural and nonstructural programs and practices currently implemented in the watershed. Inputs in the WTM included an estimated fertilizer application for residential turf areas of 200 lb N/acre (which is the default value in WTM). Pet waste education was assumed to have a 30% awareness in the watershed. Fifty acres of residential areas were swept by the City's regenerative air sweeper. There were no official records of existing stormwater infrastructure; therefore, the existing stormwater infrastructure benefits were estimated using the procedure described earlier in this section. In all practices, except turf management, there is a reduction in runoff and pollutants (the addition of TN and TP are a result of assumed lawn fertilization). In the Recommended Condition, the benefits of a lawn education program will be included in the analysis of load reductions.

Table 4-5: Estimated Pollutant Reduction Benefits from Existing Practices

Program/Practice	TN (lb/year)	TP (lb/year)	TSS (lb/year)	*E. coli* (MPN/year)	Runoff Volume (acre-feet/year)
Turf Management	-6,638	-4,751	-	0.0E+00	-375
Pet Waste Education	312	41	-	2.4E+12	-
Street Sweeping	149	22	4,376	0.0E+00	-
Structural BMPs	1,924	667	99,115	3.2E+13	-
Riparian Buffers	1,013	187	24,612	1.0E+13	165
EXISTING PRACTICE LOAD REDUCTION:	-3.2E+03	-3.8E+03	1.3E+05	4.5E+13	-210

Table 4-6 shows the pollutant reduction after applying existing programs/practices to the existing human-related pollutant load. TSS and bacteria pollutant loads resulting from human-related activities (development, sewage, etc.) are slightly reduced in the current condition (by 8% and 6% respectively). The TN and TP loads, as well as runoff volume increase as a result of the baseline turf management practice. The WTM assumes that both disturbed soils and managed turf have the same runoff coefficients (Rv), which are greater than forested or rural land. This shows that turf, although better for runoff reduction than impervious cover, still does not capture and infiltrate stormwater as effectively as other vegetated covers.

Table 4-6: Estimated Net Loads from Human Activities and Existing Practices

	TN (lb/year)	TP (lb/year)	TSS (lb/year)	*E. coli* (MPN/year)	Runoff Volume (acre-feet/year)
CURRENT HUMAN LOAD	6.7E+04	8.6E+03	1.7E+06	7.4E+14	1.1E+04
EXISTING PRACTICE LOAD REDUCTION	-3.2E+03	-3.8E+03	1.3E+05	4.5E+13	-2.1E+02
EXISTING LOAD	7.0E+04	1.2E+04	1.6E+06	7.0E+14	1.1E+04
CHANGE IN CURRENT HUMAN LOAD %	**+5%**	**+45%**	**-8%**	**-6%**	**+2%**

4.5.2 Pollutant Loads from Future Conditions

Future conditions in the watershed consider both climate change (increased precipitation, increases in bacteria concentrations in stormwater) and pressures from development. As development increases, not only are rural and forested areas converted to urban/suburban land uses, but there are also increases in the secondary sources. For example, as new homes and businesses are built, the DPU will add more sanitary sewer lines in the watershed (which in turn increases the chances for sanitary sewer overflows).

In the WTM, the current conditions were compared to three future scenarios that reflect how a warmer climate may increase bacteria concentration as well as produce more annual precipitation:

- Scenario 1: annual precipitation increase (from 48.14” to 62.08”)
- Scenario 2: 62.08” precipitation + 15% increase in FC concentration in runoff
- Scenario 3: 62.08” precipitation + 15% increase in FC + development

The increases in development included incorporation of:

- future land use, which includes climate change considerations by using the USGS year 2050, A1B scenario/RCP 8.5 (higher emissions scenario)
- future dwelling units increase from 3,226 to 4,602
- adjusting the unsewered dwellings from 57% to 40% of the total watershed (assumption that the newer development would be connected to sanitary sewer)
- increasing the sanitary sewer length from 39.8 miles to 56.8 miles

The results of the future analysis are provided in **Table 4-7** in the context of two categories: human-related pollutant sources and all pollutant sources. **Figure 4-4** illustrates the magnitude of change between these scenarios and current conditions in the Lower Caw Caw Swamp Watershed. Overall, the human sources of the bacteria loads comprise the vast majority of the entire watershed bacteria load (ranging from 89% to 96% of the total watershed bacteria loads in all four scenarios). In the worst-case scenario (Scenario 3), the bacteria load increases 119% for human-related sources and 98% for all sources from the current condition. This near doubling of the current bacteria load will present direct threats to source water and recreational uses of the Lower Caw Caw Swamp Watershed if no further action is taken.

Table 4-7: Future Pollutant Loads in the Lower Caw Caw Swamp Watershed

Category	Source Scenario	TN (lb/year)	TP (lb/year)	TSS (lb/year)	*E. coli* (MPN/year)	Runoff Volume (acre-feet/year)
human	Current Load	66,550	8,614	1,690,101	7.4E+14	10,800
human	Future Scenario 1	80,835	10,361	2,085,338	8.7E+14	13,270
human	Future Scenario 2	80,835	10,361	2,085,338	9.9E+14	13,270
human	Future Scenario 3	113,478	14,493	2,964,199	1.4E+15	18,927
all	Current Load	94,004	12,461	4,913,872	8.3E+14	11,800
all	Future Scenario 1	108,772	14,594	5,791,779	9.6E+14	14,559
all	Future Scenario 2	108,772	14,594	5,791,779	1.1E+15	14,559
all	Future Scenario 3	135,047	18,653	7,075,706	1.5E+15	19,754

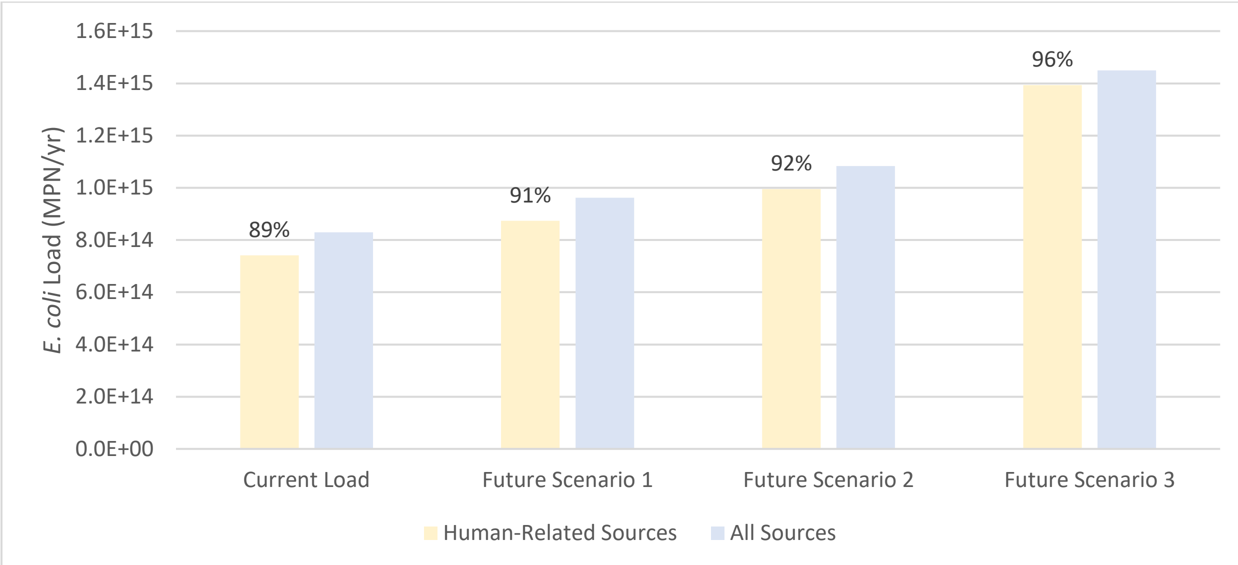

Figure 4-4: Bacteria Load of Current Conditions and Future Scenarios in the Lower Caw Caw Swamp Watershed

4.5.3 Pollutant Load Reductions after Implementation of Recommendations

This scenario provides suggestions for practices and programs to reduce pollutant loads (with a focus on bacteria, climate adaptation, and source water protection) in the Lower Caw Caw Swamp Watershed. More detailed descriptions of the practices and their respective pollution reduction benefits are discussed in **Section 4.6 Benefits from Recommended Strategies**.

- Improve **turf management**: Instate an education program with the goal of 40% public awareness WTM assumes initiatives such as television advertising have the greatest impact with 40%; followed by newspaper (30%) and radio (25%)). Other effective methods include billboard advertisements (13%), brochures (8%), and workshops (7%). Goals of the residential lawn care education program will be to reduce fertilizer use to recommended levels, switch to non-phosphorus fertilizer, add soil amendments to lawns, switch to organic (dairy compost) fertilizer, add soil amendments to lawns, and convert 25% of lawn to forest or native vegetation.
- Enhance existing **pet waste education**: expand public awareness and education from 30% awareness to 40% awareness
- Expand existing **street sweeping** (50 acres of residential in City) to include all roadways in the watershed (including City and County jurisdictional areas) for a total of 243 acres.
- Reduce runoff through a **residential impervious disconnection program**: encourage residents to treat rooftop runoff using a filter strip or other practice. Assume disconnection can be applied in 70% of the homes (this practice is feasible on lots greater than 1/8 of an acre and therefore applies to the 2,934 acres of LDR and MDR). The model assumes that a broad education program is implemented that reaches 40% of the population, and that 25% of individuals who hear the message are willing to implement impervious disconnection.
- Plan for **SSO Repair/Abatement**: The WTM calculated the benefits of 100% reduction through two methods:

- **Sanitary Sewer Overflow Prevention**--The WTM estimates that SSOs from sanitary sewer system are a relatively small source of bacteria in the overall Lower Caw Caw Swamp Watershed. Problems that can cause chronic SSOs include too much rainfall infiltrating through the ground into leaky sewer systems; runoff that is directly connected to sewer systems; sewers and pumps too small to carry sewage from newly-developed subdivisions or commercial areas; blocked, broken, or cracked pipes due to tree roots, pipe settlement, and material build-up such as fats, oils, and grease (FOG) within pipes; power failures that prevent the system from functioning; or vandalism to the sanitary sewer conveyance system.
- **Hotspot and Illicit Discharge Detection and Elimination (IDDE)** Dry weather flows discharging from storm drain systems can contribute significant loads to stream systems. Inspection and testing of water quality from outfalls, or from upland 'hotspots' during dry weather can assist in the detection of inappropriate discharge entering the stream both from storm drains and from other pipes potentially conveying discharge. Hotspots generally include commercial and industrial properties that may be specific sources of pollutants from poor housekeeping practices that allow pollutants to wash into the storm drain system. When an illicit discharge is found it can be tracked to its source for resolution. Discharge types can include sewage and septage flows, washwater flows such as laundry and car washing discharge, liquid waste such as oils and paints, landscape irrigation, dumpster runoff, and tap water.

- Evaluate the impact of **Septic System Education, Repair, and Upgrades**: Assume that 40% of the population with septic systems is aware of messaging for the best practices for maintenance. Assume that 100% of the septic systems are inspected, and 40% of the population is willing to make repairs or upgrade to a better performing system.
- Improve/restore **riparian buffers**: Ensure that the protection of the existing 20 miles of buffers is enforced and that educational programs are in place for property owners. Also, create 1.5 miles of new 20-ft wide buffers at 3 separate projects along Catfish Pond, one section of Caw Caw Swamp near the intersection of Willington Rd and Camp Rd., and one section of Turkey Hill Branch near the Hwy 21 crossing. Create an additional 0.7 miles of buffers by fencing out cows and replanting with riparian vegetation. Buffers apply to both sides of the stream channel, so the additional lengths equate to a total of 4.4 miles of 20-ft buffer.
- Ensure conservation easements (through Congaree Land Trust) to protect 312 areas of forested buffer and uplands surrounding the Lower Caw Caw Swamp. The value of this conservation is not a direct output of the WTM; it was estimated by finding the difference in watershed loading if 312 acres of forest was converted to medium-density residential land use.
- Install **stormwater BMP retrofits**: Six properties with large impervious surfaces were identified for further study into the feasibility of retrofits with low impact development techniques. The assumption is that they will provide infiltration with an underdrain if needed (modeled as bioretention but could also include pervious pavement or bioswales). Note, a detailed design and infiltration test will need to be completed to ascertain the exact benefits of these practices. If soils have a high infiltration capacity, it may be possible to have a higher pollutant removal. If infiltration is not completely feasible, another option would be to investigate the possibility of greenroofs or rainwater harvesting cisterns at these sites. Results in WTM assume that runoff

from 1.4 inches of precipitation (90th percentile storm) will be captured and treated by infiltration BMPS.
  - **Prince of Orange Mall**: 2390 Chestnut Street NE. Parcel area = 43.6 acres; area of imperviousness = 33.3 acres.
  - **First Baptist Child Development Center**: 2865 Columbia Road NE. Parcel area = 12.62 acres; area of imperviousness = 3.2 acres
  - **Orangeburg Preparatory School** (south campus): 2651 North Road. Parcel area = 15.81 acres; area of imperviousness = 5.1 acres.
  - **Orangeburg Preparatory School** (north campus): 168 Prep St. Parcel area = 26.64 acres; area of imperviousness = 3.2 acres.
  - **Sheridan Elementary School:** Parcel area = 9.82 acres; area of imperviousness = 4.0 acres.
  - **Marshall Elementary School:** Parcel area = 9.52 acres; area of imperviousness = 2.4 acres
- Provide **stream restoration**: A proposed project will repair 2,952 ft of badly eroding, unvegetated drainage channel at **Orangeburg Preparatory School** (north campus) at 168 Prep St. Assumed load reductions (lb/ft/yr) for stream restoration are 0.075 TN, 0.068 TP, and 248 TSS (estimates come from the Maryland Department of the Environment[33]).
- **Revegetate** (with hydroseed) 29 acres of four separate clear-cut areas spread across four unique locations: 3.2 acres near Lake Marston Dr.; 18.8 acres near Countryside Dr.; 3.1 acres near Cambridge Rd.; and 3.9 acres near the intersection of Saint Matthews Rd. and Ruf Rd. Estimate benefits in WTM by calculating the load difference between rural land and active construction.
- **Remove stockpiled soil** near the intersection of Camp and Willington Rd. This will clear approximately 100 cubic yards of soil, which is equivalent to 6" deep soil covering 0.1 acre of land. This was also modeled as the load difference between rural land and active construction.

Table 4-8 summarizes all benefits to pollutant reduction associated with the full suite of recommendations (REC) in combination with existing (EX) programs and practices. Existing practices (EX) are highlighted in light blue to facilitate comparison of improvements associated with the recommendations. For example, the benefits of the existing pet waste program are greater than the benefits associated with new recommendations. However, the net benefit of the two practices is the addition of their respective pollution reduction amounts (e.g., 3.6×10^{12} MPN/yr *E. coli* bacteria removed from the watershed).

[33] Maryland Department of the Environment. 2020. Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated. Available at https://mde.maryland.gov/programs/Water/StormwaterManagementProgram/Documents/2020%20MS4%20Accounting%20Guidance.pdf

Table 4-8: Pollution Reduction from Implementation of Recommended Programs Practices

	TN (lb/year)	TP (lb/year)	TSS (lb/year)	*E. coli** (MPN/year)	Runoff Volume (acre-feet/year)
Turf Management (EX)	(2,657)	(4,163)	0.0E+00	0.0E+00	(483)
Turf Management (REC)	3,317	4,391	0.0E+00	0.0E+00	483
Pet Waste Education (EX)	312	41	0.0E+00	2.4E+12	-
Pet Waste Education (REC)	104	14	0.0E+00	7.9E+11	-
Street Sweeping (EX)	149	22	4.4E+03	0.0E+00	-
Street Sweeping (REC)	10,754	1,587	3.1E+05	0.0E+00	-
Riparian Buffers (EX)	1,221	212	3.2E+04	1.3E+13	213
Riparian Buffers (EX + education)	306	69	5.2E+03	2.1E+12	35
Riparian Buffers (REC + education)	169	31	4.1E+03	1.7E+12	27
Revegetate clear cut areas	52,532	10,506	3.6E+07	0.0E+00	52
Remove stockpiled soil	181	36	1.2E+05	0.0E+00	0.2
Stream restoration	221	201	7.3E+05	0.0E+00	-
SSO Repair/Abatement	3	0.46	1.9E+01	1.8E+12	-
OSDS Education	1,395	232	9.3E+03	2.3E+13	-
OSDS Repair	837	139	5.6E+03	1.4E+13	-
OSDS upgrade	502	84	3.3E+03	8.4E+12	-
Structural BMPs (EX)	1,924	667	9.9E+04	3.2E+13	-
Prince of Orange Mall	499	71	1.2E+04	4.8E+12	44.26
First Baptist Child Development Ctr.	86	17	1.9E+03	7.6E+11	7.24
Orangeburg Prep (North Rd.)	124	23	2.7E+03	1.1E+12	10.5
Orangeburg Prep (Prep St.)	146	30	3.6E+03	1.2E+12	12.1
Sheridan Elementary	82	15	1.8E+03	7.4E+11	7.0
Marshall Elementary	65	12	1.4E+03	5.7E+11	5.5
Downspout Disconnection	19	2	5.0E+02	2.1E+11	3.3
Practices Total:	**62,114**	**12,737**	**3.7E+07**	**1.1E+14**	**417**

* Although some practices are shown with no bacteria removal benefits, there probably is some benefit that the WTM may not capture/estimate for the reductions attributed to those practices.

4.6 Benefits from Recommended Strategies

Each management strategy has its own set of watershed benefits. Benefits include estimated pollutant reductions, improvements to aquatic and riparian habitat, and community benefits such as improved aesthetics or access to recreational opportunities. The following sections address the overall impact that the suite of management measures will have on water quality and source water protection in qualitative and quantitative terms.

4.6.1 Qualitative Benefits of Recommended Practices

The benefits from enacting the suite of recommendations extend beyond the numeric pollutant load reduction. **Table 4-9** highlights various ways that different projects can have a positive impact in the Lower Caw Caw Swamp Watershed, from community aesthetics and engagement to flood control.

Table 4-9: Watershed Benefits for Selected Practices

Practice	Water Quality	Runoff Reduction	Channel Protection	Flood Control	Instream Habitat	Community Aesthetics	Community Engagement
Lawn Care Education	●				○	○	●
Pet Waste Education	●				○	●	●
Downspout Disconnect	○	●	○	○	○	●	●
Stream Restoration/ Buffers	○	○	●		●	●	○
Stormwater BMPs	●	○	○	○		●	
Hotspot and IDDE	●					●	
SSO Repair/ Abatement	●				○	○	
Septic System Education	●				○	○	●
Septic System Repair	●				○	○	
Stream Clean Up	●		○		○	●	●
Street Sweeping	●					●	
Erosion and Sediment Control	●	○	○	○	○	○	
● *Primary benefit is the intended outcome of the initiation of a specific action.* ○ *Secondary benefit is an ancillary benefit provided through the initiation of a specific action, but not considered to be the determining factor in the execution of that action.*							

4.6.2 Pollutant Load Reductions

The practices that contribute to the greatest amount of bacteria reduction are shown in **Figure 4-5**. If all recommended practices and programs are initiated, the result would be a reduction of 1.1×10^{14} MPN/year of *E. coli* bacteria in the Lower Caw Caw Swamp Watershed. The reduction in bacteria will improve water quality for recreational use and decrease the amount of chloramine treatment required at the DPU water treatment plant. The proposed septic programs account for 43% of the total reduction, followed by the combined effects of the existing BMPs (30%). Although pet waste education provides a small amount of bacteria reduction (3%), it is still an important tool to use for public education.

The existing and proposed practices that contribute to the greatest amount of TN reduction are shown in **Figure 4-6**. Most of the total TN reduction (62,114 lb/year) is attributed to revegetating the 29 acres of clear-cut land (85%), and the bulk of the remaining reductions come from programs to improve septic systems (4%), existing BMPs (3%), and riparian buffers (3%). Programs that reduce TN help prevent harmful algal blooms and help keep nitrates out of drinking water.

The existing and proposed practices that contribute to the greatest amount of TP reduction (total amount of 12,737 lb/yr) are shown in **Figure 4-7**. Most of the TP reduction is attributed to revegetating the 29 acres of clear-cut land (83%), which reflects the importance of stabilizing exposed soils from erosion. The bulk of the remaining reductions come from existing BMPs (5%), programs to improve septic systems (4%), and riparian buffers (2%). Programs that reduce TP help prevent harmful algal blooms, which can increase organic matter in the source water intake and require extra treatment.

The practices that contribute to the overall TSS reduction (3.7×10^{7} lb/yr) are shown in **Figure 4-8**. As with TP and TN, the bulk of the TSS reduction benefit is attributed to revegetating clear-cut areas (97%). The other notable reductions come from stream restoration (2%).

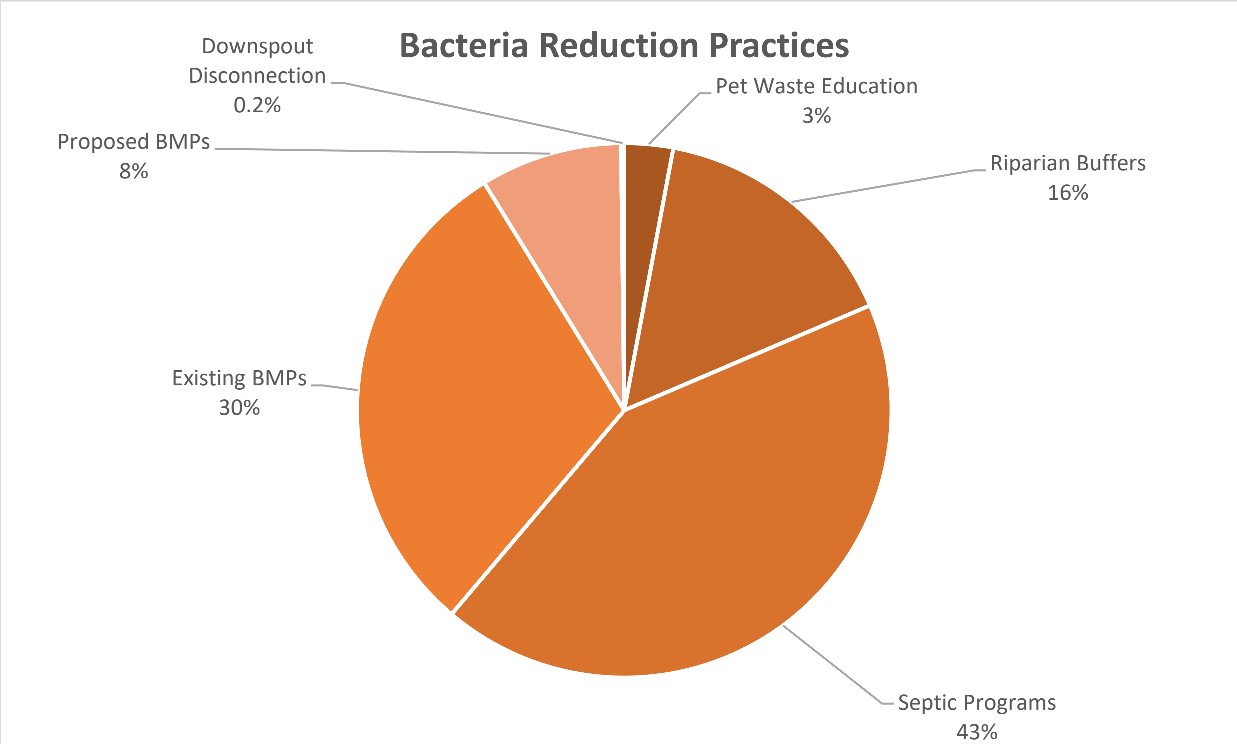

Figure 4-5: Practices that contribute to overall bacteria reduction

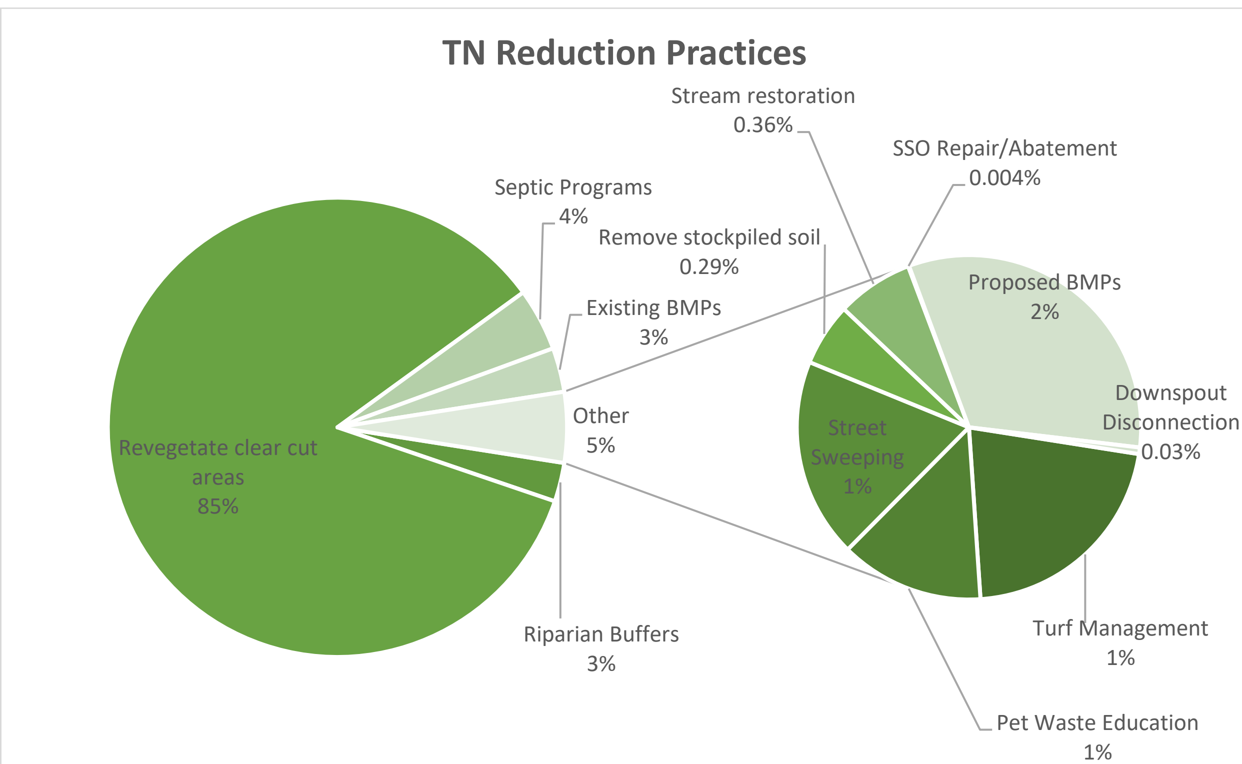

Figure 4-6: Practices that contribute to overall TN reduction

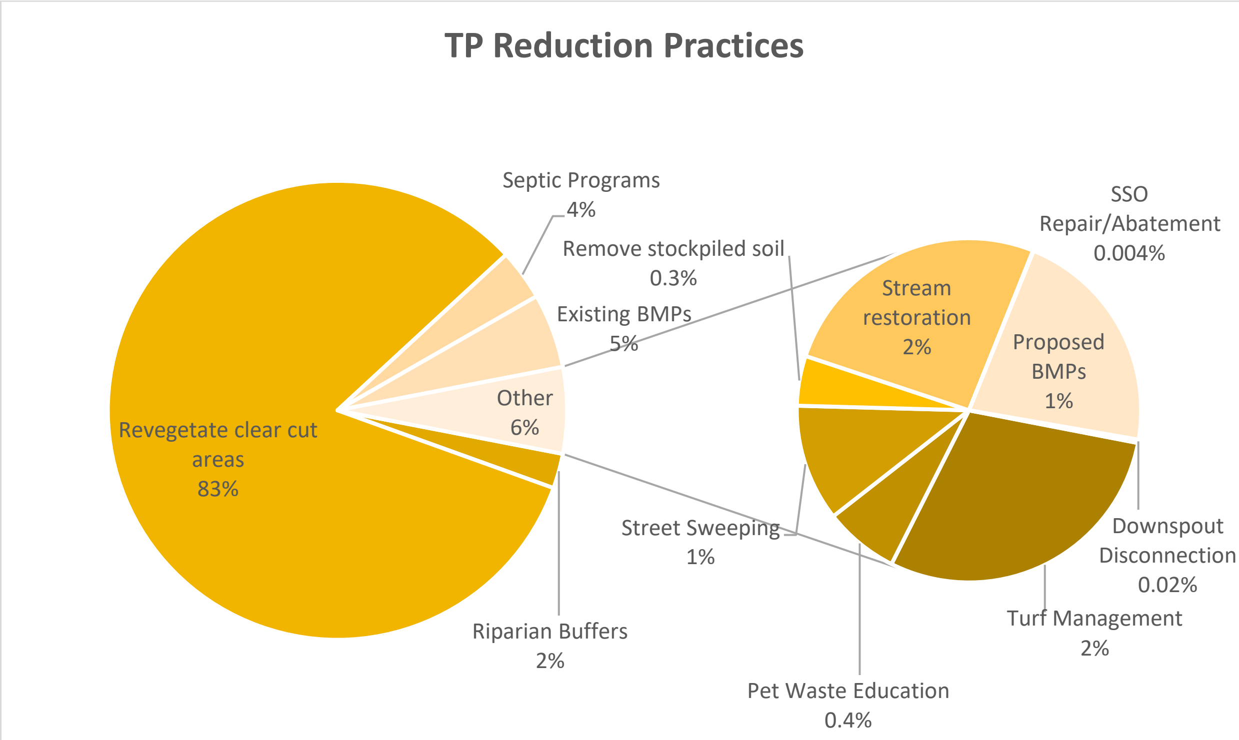

Figure 4-7: Practices that contribute to overall TN reduction

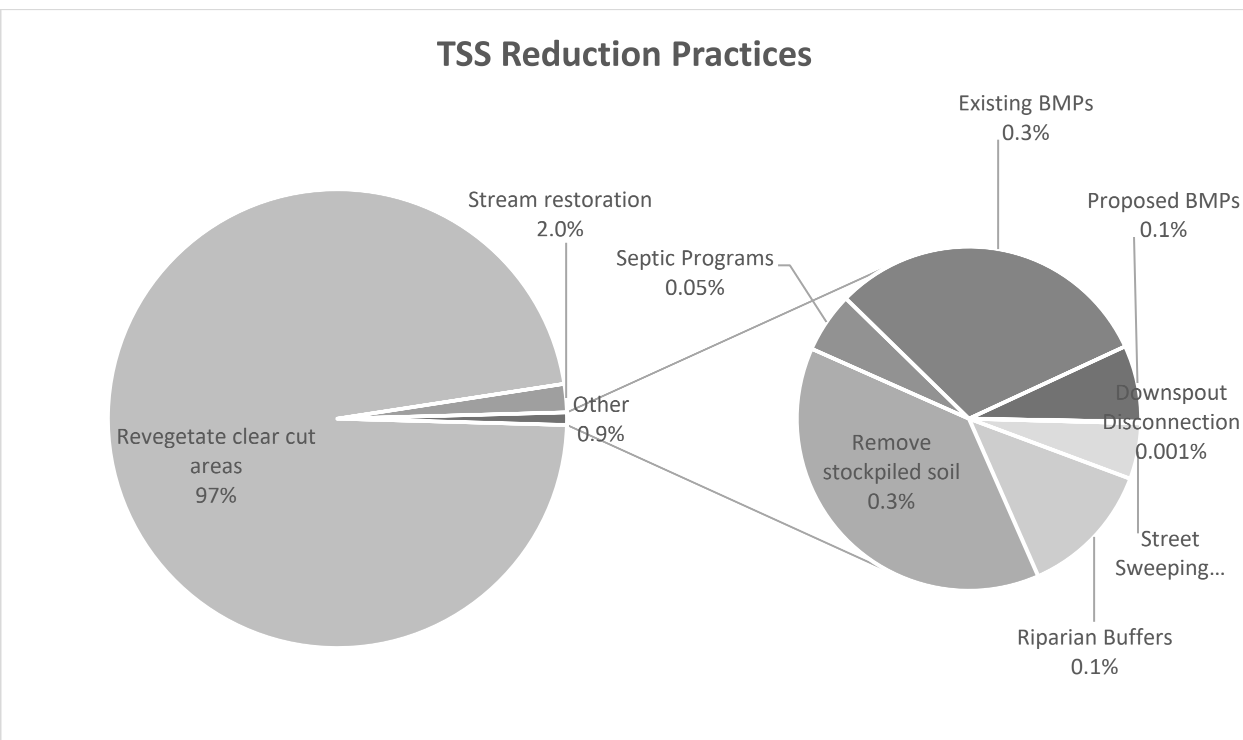

Figure 4-8: Practices that contribute to overall TSS reduction

A summary of the benefits from implementing all recommended stormwater retrofit projects in the current condition in the Lower Caw Caw Swamp Watershed are listed in **Table 4-10**. The goal of this WBP was to reduce the human-related sources of bacteria by 35% to be consistent with the existing TMDL recommendations. The recommended projects are about one-third of that goal in the current condition, with an anticipated 13% -15% reduction in bacteria loads. We have found that returning a system that is impaired to a healthier condition is subject to hysteresis: it takes much more effort to improve water quality than degrade it. As summarized in a modeling study for the May River Headwaters[34] in Bluffton, SC, bacteria removal in South Carolina tends to be difficult due to several factors that favor bacteria persistence and growth: warmer temperatures, reduced light penetration in blackwater systems, and forms of fecal bacteria that have been documented growing in sediments (e.g. outside of a warm-bodied host organism). Furthermore, it is commonly accepted that freshwater influxes as a result of runoff from development create favorable conditions for bacteria survival.

WBPs are meant to be living documents that will be evaluated and updated periodically. This is an opportunity to revisit this WBP after continued monitoring and evaluation of the proposed projects in order to guide future recommendations. Potentially, the City and County could look into expanding projects into private property, such as integrating more infiltration-based practices like bioretention and pervious pavement. Retrofits with stormwater filtering systems could also be applied to reduce bacteria in parking lots. See **Section 5.6.1 Monitoring Program** for discussion of how monitoring will be used to understand and treat sources of bacteria in the watershed. Pollution removal rates greater than 100% for TN, TP, and TSS indicate that there is a greater potential for pollutant removal than the actual load calculated for the watershed.

Table 4-10: Overall Benefits from Proposed Projects in Current Conditions

Condition	TN (lb/yr)	TP (lb/yr)	TSS (lb/yr)	*E. coli* (MPN/yr)	Runoff (acre-ft)
Existing Total Load	9.4E+04	1.2E+04	4.9E+06	8.3E+14	1.2E+04
Management Practice Reductions	6.2E+04	1.3E+04	3.7E+07	1.1E+14	4.2E+02
Reduced Load:	3.2E+04	-2.8E+02	-3.2E+07	7.2E+14	1.1E+04
Reduction %	66%	102%*	749%*	13%	4%
Existing Human-Related Load	6.7E+04	8.6E+03	1.7E+06	7.4E+14	1.1E+04
Management Practice Reductions	6.2E+04	1.3E+04	3.7E+07	1.1E+14	4.2E+02
Reduced Load:	4.4E+03	-4.1E+03	-3.5E+07	6.3E+14	1.0E+04
Reduction %	93%	148%*	2176%*	15%	4%

**indicates greater potential for pollution removal than actual existing load*

[34] McCormick Taylor. 2020. May River Watershed Action Plan Update & Modeling Report. https://www.townofbluffton.sc.gov/DocumentCenter/View/2068/2020-May-River-Action-Plan-Update-and-Model-Report-?bidId=

Table 4-11 summarizes the pollutant loads and runoff volumes for the future scenario, with the total and human-related loads separated. The recommended projects still provide more TSS removal than the actual load, which is useful considering that there are chemicals and pathogens (such as heavy metals or bacteria) which can be attached to sediment particles and may be transported downstream to the source water intake. Additionally, TSS in urban/suburban areas can cause sediment build up in or clogging of stormwater BMPs; the result is a smaller or bypassed treatment volume. **Table 4-11** also shows that bacteria reduction is half as effective in the future. This emphasizes the need for periodic evaluation of this WBP's recommendations. Recommendations for adapting to future conditions are provided in **Section 5.2 Climate Change Recommendations**.

Table 4-11: Overall Benefits from Proposed Projects in Future Conditions

Condition	TN (lb/yr)	TP (lb/yr)	TSS (lb/yr)	E. coli (MPN/yr)	Runoff (acre-ft)
Future Total Load	1.3E+05	2.1E+04	6.7E+06	1.3E+15	2.0E+04
Future + Recommended Practices	6.2E+04	1.3E+04	3.7E+07	1.1E+14	4.2E+02
Reduced Load:	7.1E+04	7.8E+03	-3.0E+07	1.2E+15	2.0E+04
Reduction %	47%	62%	552%	8%	2%
Future Human-Related Load	1.1E+05	1.9E+04	6.1E+06	1.3E+15	1.9E+04
Future + Recommended Practices	6.2E+04	1.3E+04	3.7E+07	1.1E+14	4.2E+02
Reduced Load:	5.3E+04	6.5E+03	-3.1E+07	1.2E+15	1.9E+04
Reduction %	54%	66%	601%	9%	2%

The city, county, and stakeholders will build off each success and use adaptive management strategies to periodically evaluate and change priority projects and programs. The evaluation process will be described in more detail in **Section 5.6 Measures of Success**.

5.0 Implementation Plan

The implementation plan includes a description of the recommended management strategies and restoration projects and provides an estimation of the water quality benefits that would be realized from plan implementation. This section includes cost estimates for strategy implementation, identifies potential funding sources and partners, and describes monitoring programs to document plan implementation and changes in the watershed condition over time. The recommendations of this plan also incorporate considerations for climate change and source water protection, in order to help ensure the long-term success of these projects.

5.1 Community Engagement

Development of the plan has included positive community engagement efforts to both inform the public about watershed issues and to encourage them to participate. The following sections describe efforts in place throughout the assessment and planning process, and the strategies for future outreach. **Table 5-1** summarizes potential partnering organizations to help execute the recommendations in this WBP.

Table 5-1: Outreach and Education Partnerships

Program	Program Goals or Outcomes
Clemson Extension	Provide stormwater education, outreach, and public involvement opportunities for water quality and livestock waste management
Orangeburg County Soil & Water Conservation Districts	Develop and implement programs to protect and conserve soil, woodland, riparian, and wetland resources
SC Forestry Commission	Provide support and education for forestry
Long Leaf Alliance	Provide public education for conservation, riparian buffers, water quality
Congaree Land Trust	Provide public education for conservation, riparian buffers, water quality
SC Natural Heritage Program	Provide information regarding rare, threatened, or endangered species with ranges in the watershed
South Carolina Native Plant Society	Provide speakers/information/plants for rain garden and sustainable landscaping practices
Palmetto Pride	Provide support for litter removal
SC Wildlife Federation	Provide support for invasive species removal
Friends of the Edisto	Protect and enhance the Edisto River Basin's natural and cultural character and resources through conservation and responsible use.
Edisto Riverkeeper	Engages in advocacy, stewardship, education, and outreach to achieve a healthy, flowing, sustainable Edisto River system.
Claflin University student organizations	Claflin's Public Health Alliance and Friends of the Earth provide opportunities for undergraduate and graduate students to serve the Orangeburg community through activities such as Earth Day, litter sweeps, Adopt-a-Stream, and work with elementary schools.

5.1.1 Outreach Strategies

The following strategies may be used to gain additional community support and involvement.

Website – Workers from the DPU/County can add information about the watershed plan to existing resources (for example, a copy of the WBP can be uploaded to https://www.orbgdpu.com/information or https://www.orangeburgcounty.org/239/Planning) to keep the public informed about the watershed plan. In the future, if the DPU or County add a stormwater program, the information can be maintained and updated on that department's website. The purpose of the website will be to disseminate important information about stormwater management, upcoming events (such as litter sweeps, drain markings, etc.), and accomplishments (highlighting successful completion of projects and recommendations from this plan).

Social Media –Facebook and Instagram accounts can be created specifically for information related to programs and news about the Lower Caw Caw Swamp Watershed; or, updates about programs and progress related to the WBP can be posted to existing social media accounts, such as https://www.facebook.com/OrangeburgCounty and https://www.facebook.com/dpucityoforangeburg/. This is another means of providing quick, engaging updates to all interested parties without having to produce a formal update to the website.

Factsheets – The DPU and County could choose to develop their own version of stormwater related factsheets, or they could take advantage of the publications already available from Clemson University's Home & Garden Information Center's database of factsheets, including these specifically geared towards water: https://hgic.clemson.edu/category/water/

- Aquatic and Shoreline Plant Selection (HGIC 1709)
- Rainwater Harvesting Systems Guidance for Schoolyard Applications (HGIC 1729)
- Illicit Discharges and Water Pollution (HGIC 1850)
- Shorescaping Freshwater Shorelines (HGIC 1855)
- Bioretention Cells: A Guide for Your Residents (HGIC 1862)
- Introduction of Bioswales (HGIC 1863)

Media Coverage – Publicizing and reporting on activities related to the implementation of the Lower Caw Caw Swamp Watershed Plan can be accomplished through broadcast and print news media outlets, such as the *Times and Democrat* newspaper. Reaching out to local television news media would also provide an opportunity to reach a broad audience about upcoming and completed activities and projects related to the WBP.

Mailings – Direct mailings allow the City and County to fill potential information gaps (people who do not read the paper, participate in social media, or follow local government news). Fliers, postcards, and posters can all be used to inform residents in the Lower Caw Caw Swamp Watershed about the benefits of the proposed stormwater practices. They could generate a list of the addresses of the residents in the watershed (could be included with the DPU's water billing statements), which could be used to send invitations to meetings and workshops or provide other information about nonpoint source pollution outreach events (for example: storm drain markings, construction of stormwater detention basins, etc.).

Community Meetings – Providing stakeholders, such as residents and business owners, in the Lower Caw Caw Swamp Watershed the opportunity to provide feedback and receive updates on aspects of this plan and its implementation will greatly enhance the public's support of this work. The DPU could host meetings at their new facility, with the Orangeburg Soil and Water Conservation District could take the lead on coordinating. Topics of meetings may include:

- Overview of watershed, implementation strategy, and benefits
- Possible funding sources
- General stormwater education seminars (what is stormwater and why is it a problem)

Individual Outreach – Working with property owners in the Lower Caw Caw Swamp Watershed is a crucial link between the planning and implementation phases. This will be especially important when trying to inventory and assess the current condition of existing septic systems in the watershed (identifying those that need repairs or replacement). Through the other education outreach/involvement opportunities listed in this section, it may be possible to identify individuals who would be willing to participate in activities such as stream restoration, riparian buffer plantings, and other stormwater BMPs. One method of individual outreach could involve the DPU sending targeted mailings to water customers without a sewer service (e.g., property owners with septic systems). Another possibility could be the Orangeburg Soil and Water Conservation District reaching out to property owners with cattle and/or streambank erosion for help applying for grant funding for BMPs. Another option to try to engage residents is door-to-door outreach. In areas where recommended projects would be implemented, this would be a good follow-up approach to mailings and provide an opportunity for residents to learn about the positive water quality outcomes. The DPU could coordinate with the consultant team or other WBP stakeholders (such as the Orangeburg SWCD, Edisto Riverkeeper, or Clemson Extension) to organize volunteers or employees to undertake this task.

Watershed Association – Interested citizens, City/County representatives, professionals, and educational partners can form a Lower Caw Caw Swamp Watershed Association to oversee the implementation and periodic evaluation of this watershed management plan. This organization would function as a non-profit organization that can partner with the City/County jurisdictions to apply for grants and implement public outreach/education endeavors. There are many examples of successful groups in the state of South Carolina (such as the Gills Creek Watershed Association in Columbia) and across the region (such as the Ellerbe Creek Watershed Association in Durham, NC) that could be used as a reference for the organization and work of a watershed organization.

Workshops – Workshops related to specific measures that residents can implement on their property will both build support and provide the tools for individual action. Potential workshop topics are varied and may include lawn care, pet waste, septic system maintenance, native and invasive vegetation, and rain gardens. The Orangeburg Soil and Water Conservation District, Clemson Extension, and/or Edisto Riverkeeper could coordinate these workshops.

Professional Training Opportunities – Training geared towards specific audiences (HOAs, landscapers, maintenance crews, etc.) will prepare the "boots on the ground" in the Lower Caw Caw Swamp Watershed to manage newly-installed BMPs effectively. Examples of courses offered through Clemson Extension are the *Master Pond Manager* and *Master Rain Gardener* certifications:

https://www.clemson.edu/extension/water/hybrid-training/mpm/index.html

https://www.clemson.edu/extension/raingarden/mrg/index.html

Community-wide Programs

Several recommendations are made to implement community-wide programs that are based on education and community engagement. Participation by watershed residents in practices that they can implement at their homes, businesses, schools, and places of worship is crucial. These programs are generally referred to as 'source control' strategies, as they reduce or eliminate the pollutant at its source before it can enter the waterway.

Residential Lawn Care Education – Educate watershed residents on the impact of various lawn care practices on water quality. Excess fertilizer can run off into waterways and be a significant source of nutrients, in addition to being potentially unnecessary and costly to the property owner. Topics would include soil testing, recommended fertilizer levels, non-phosphorus fertilizers, organic fertilizers, conversion of lawn to native vegetation, and mowing practices. Programs could be implemented or sponsored by the City, County, Orangeburg SWCD, and/or Clemson Extension Services. The WTM predicts that a residential lawn care education program, assuming 40% of audience (assumed message is distributed via television/radio/newspaper to reach the entire Lower Caw Caw Swamp Watershed population of 7,962 people), or 3,185 people, receives and remembers the message. If this audience changes their behavior, they could reduce pollutant loads by 660 lb/yr TN and 227 lb/yr TP. Reducing nutrient pollution in source water helps reduce plant and algal growth, which in turn reduces the amount of organic carbon that needs to be removed from the drinking water to prevent disinfection byproducts. Additionally, education related to reducing lawn area helps improve climate resiliency of urban/suburban landscapes. Native plants require less maintenance and irrigation, and larger woody or herbaceous plants can reduce runoff better than turf.

Pet Waste Education – Proper disposal of pet waste helps protect the source water for the City of Orangeburg DPU by reducing both bacteria and nutrients from source water. In many neighborhoods, improperly disposed pet waste can be a source of fecal bacteria and nutrients, particularly from dogs. An outreach program to educate residents on the environmental and hygiene/health impacts of pet waste disposal is needed in both the City and County. The program should be coupled with pet waste disposal stations, signage in high-traffic dog walking areas, and possibly a local ordinance for removal and proper disposal of pet waste. The WTM predicts that a pet waste education program, assuming 40% of audience (same methods and population reached as the lawn education) receives message and changes behavior, could reduce pollutant loads by 416 lb/yr TN; 54 lb/yr TP; and 3.2×10^{12} MPN/year of *E. coli* bacteria per year.

At this time, the WTM does not calculate load reductions associated with practices such as reducing the number of domestic animals (dogs and cats) kept as outdoor pets or reducing the feral cat population. In addition to reducing bacteria, reducing the number of outdoor/feral cats in the watershed will yield other positive environmental results such as protecting smaller animals (birds, reptiles, amphibians, and mammals) that would be hunted and killed otherwise. The Audubon Society estimates that domestic cats kill between 1.4 to 3.7 billion birds and 6.9 to 20.7 billion mammals each year in the continental United States.

Septic System Education – Septic systems, or on-site disposal systems (OSDS), can be contributors of viruses, pathogens, and nitrogen to the groundwater and eventually to surface waters. This is a substantial threat in the Lower Caw Caw Swamp Watershed, where 57% of residential dwellings are not connected to the sanitary sewer system. Furthermore, with potential increases in rainfall and an upward shift in bacteria concentrations due to warmer weather, managing septic systems should be a key consideration of climate resiliency in this watershed. Regular maintenance of these systems is necessary to ensure long-term operation and safe source water supplies. Educational materials and workshops can be developed to present recommendations and explain existing local ordinances for septic tank pumping, drain field care and percolation testing, proper disposal of household hazardous waste, and general best management practices for proper maintenance and operation. Programs could be organized by the City and County, with support from SCDHEC. The WTM offers several options to estimate reductions of the pollutant loads associated with septic systems. These four practices represent different techniques that either improve performance or reduce the number of septic systems in the watershed: OSDS education, OSDS repair, OSDS upgrade, and OSDS conversion to sanitary sewer/WWTP. It is the recommendation of this plan to gather more detailed information pertaining to the current status of septic systems in this watershed before determining the types of practices needed to estimate load reductions, as described in **Section 5.3.2** of this WBP. The WTM estimates that a septic education program alone could reduce pollutant loads by 1,395 lb/yr TN; 232 lb/yr TP; 9.3×10^3 lb/yr TSS, and 2.3×10^{13} MPN/year of *E. coli* bacteria per year.

Rain Barrels / Downspout Disconnect – Many towns and cities have traditionally used gutter and downspout systems to 'connect' stormwater from homes, businesses, schools to the storm drain system. Disconnecting these systems to direct rainwater from roofs to open grassy areas or to rain barrels and cisterns reduces the overall volume of stormwater runoff, conserves water use, reduces pollutants entering the stream, and provides clean water for gardens and everyday outside use. Encouraging stormwater to be detained and treated via infiltration onsite reduces downstream burden on stormwater infrastructure, which improves the community's climate resiliency. Additionally, onsite use of water reduces the amount of organic matter that can be conveyed downstream (which presents a source water treatment concern). An education program can include rain barrel workshops to distribute rain barrels and instruct on their installation and use. Programs can be implemented by educational partners such as Clemson Extension or Orangeburg SWCD. Additionally, the Clemson Extension program offers a "Master Rain Gardener" certification program that is focused on rain garden and rainwater harvesting system design for both residents and landscape professionals. For more information, see Sections 4.6 Rainwater Harvesting and 4.7 Impervious Surface Disconnection in *Low Impact in Coastal South Carolina: A Planning and Design Guide*. The WTM estimates that a residential impervious surface disconnection program could reduce pollutant loads by 18.83 lb/yr TN; 2.4 lb/yr TP; 504 lb/yr TSS, and 2.1×10^{11} MPN/year of *E. coli* bacteria per year.

Rain Gardens/Bioswales – The City of Orangeburg and Orangeburg County should include rain gardens and bioswales in future capital improvement projects. This also provides an opportunity for educational signage for the public, as shown in an example project from the City of Aiken (**Figure 5-1**). Outreach and Education partner organizations (such as Orangeburg SWCD, Friends of the Edisto, and the Native Plant Society) can also encourage residents to participate in workshops and programs, such as the Carolina Rain Garden Initiative, to install rain gardens on private property. Educational messaging to residents should include information about how rain gardens provide opportunities to infiltrate and absorb stormwater runoff, mange erosion, beautify the home landscape, create pollinator and bird-friendly habitats, and protect clean water downstream. Smaller stormwater practices such as these, which are spread out across the watershed, will help the landscape mimic the natural hydrologic cycle and increase on-site infiltration and treatment of stormwater, which is a form of climate resiliency. These programs should make the connection for homeowners about how their landscape choices help protect their drinking water.

Figure 5-1: Example rain garden and educational signage in City of Aiken

5.2 Climate Change Recommendations

Climate adaptation is the practice of implementing plans and strategies in response to current and predicted climate impacts, usually with the goal of decreasing damage and increasing resilience.[35] Reasons for using climate ready planning include saving communities money (by mitigating future damages), increasing equitable outcomes and co-benefits, and broadening planning by directly linking watershed management to other local planning goals.[36] This section provides a process for implementing climate considerations into watershed planning in the Lower Caw Caw Swamp Watershed Area, with recommendations on:

1. Seeing the watershed as infrastructure
2. Adopting a climate planning framework
3. Integrating climate planning with the EPA 9 Elements

5.2.1 Step 1: See the Watershed as Infrastructure

River landscapes are complex systems that benefit individuals and neighborhoods, forming part of the community landscape.[37] Viewing watershed planning as a solely technical problem decreases the likelihood that planning goals will be met. Plans that instead recognize watersheds as sources of social and economic value are more likely to achieve their goals and bring value to the community,[38] because planning that considers changing conditions is flexible and able to change alongside a changing climate.[39]

There is a growing paradigm of viewing water systems through an infrastructure lens. Through this lens, the watershed becomes an "essential service" to the community.[40] Watersheds create and distribute benefits to the community, and management strategies that consider these benefits a form of infrastructure are more likely to succeed.[41] Planning that only considers traditional inputs (such as impervious surface or bacterial contamination) in isolation is more likely to fail.[42]

[35] IPCC AR5, Chapter 15. https://www.ipcc.ch/site/assets/uploads/2018/02/WGIIAR5-Chap15_FINAL.pdf
[36] For examples of climate ready planning, consult the Adaptation Clearinghouse Water Sector Database: https://www.adaptationclearinghouse.org/sectors/water/
[37] Burbach et al. (2019). Catalyzing Change: Social Science for Water Resources Management. https://doi.org/10.1111/j.1936-704X.2019.03307.x
[38] Verbrugge et al. (2019). Integrating sense of place in planning and management of multifunctional river landscapes: experiences from five European case studies. https://doi.org/10.1007/s11625-019-00686-9
[39] Bloemen et al. (2018). Lessons learned from applying adaptation pathways in flood risk management and challenges for the further development of this approach. https://doi.org/10.1007/s11027-017-9773-9
[40] Logan & Guikema. (2020). Reframing Resilience: Equitable Access to Essential Services. https://doi.org/10.1111/risa.13492
[41] Narayanan et al. (2020). From Awareness to Action: Accounting for Infrastructure Interdependencies in Disaster Response and Recovery Planning. https://doi.org/10.1029/2020GH000251
[42] Schell et al. (2020). The ecological and evolutionary consequences of systemic racism in urban environments. https://doi.org/10.1126/science.aay4497

5.2.2 Step 2: Adopting a Climate Planning Framework

Through a series of focused planning discussions, the DPU and research partners at Carolinas Integrated Sciences & Assessments (CISA) selected two planning frameworks, *Co-Benefits* and *Equitable Adaptation*, which could be used to guide climate-ready planning in the Lower Caw Caw Swamp Watershed Area. Frameworks are useful because they simplify the planning process and allow a community to focus on its goals and the actions it can take to meet them.

Co-Benefits

Co-Benefits is the idea that climate planning is more likely to be successful if it considers more than one benefit to the community.[43] This framework has been used in a variety of urban planning contexts, particularly where problems intersect within a confined geographic area and multiple groups can join to collaborate.[44] Implementing co-benefits through a watershed plan is as simple as listing and categorizing them according to local priorities, and then using this list as a baseline in decision making (See **Figure 5-2**). For a given BMP (in this example a rain garden), all the benefits are listed and grouped by topic. Some topics may address the goals of the watershed plan, while others are co-benefits that may be goals in other local plans and/or provide tangible benefits to the community. Consideration of co-benefits can lower risk and increase resilience. For example, two BMPs may be comparable when solely considering watershed pollutant reductions, but a green infrastructure BMP could have additional benefits such as increasing the watershed's recreational value, absorbing carbon pollution from the atmosphere (carbon capture), and providing protection from extreme heat by lowering nearby ground temperatures. If initial cost is the only metric used to make planning decisions, then a BMP which provides fewer co-benefits could be chosen instead of a BMP which provides more co-benefits or a higher cost-benefit ratio. Depending on the co-benefits considered, this would increase risk and decrease resilience.

[43] Diringer et al. (2020). Incorporating Multiple Benefits into Water Projects: A Guide for Water Managers. https://pacinst.org/publication/incorporating-multiple-benefits-into-water-projects/

[44] Rotatori et al. (2020). Breathing Life Back into Cities. https://rmi.org/insight/breathing-life-back-into-cities

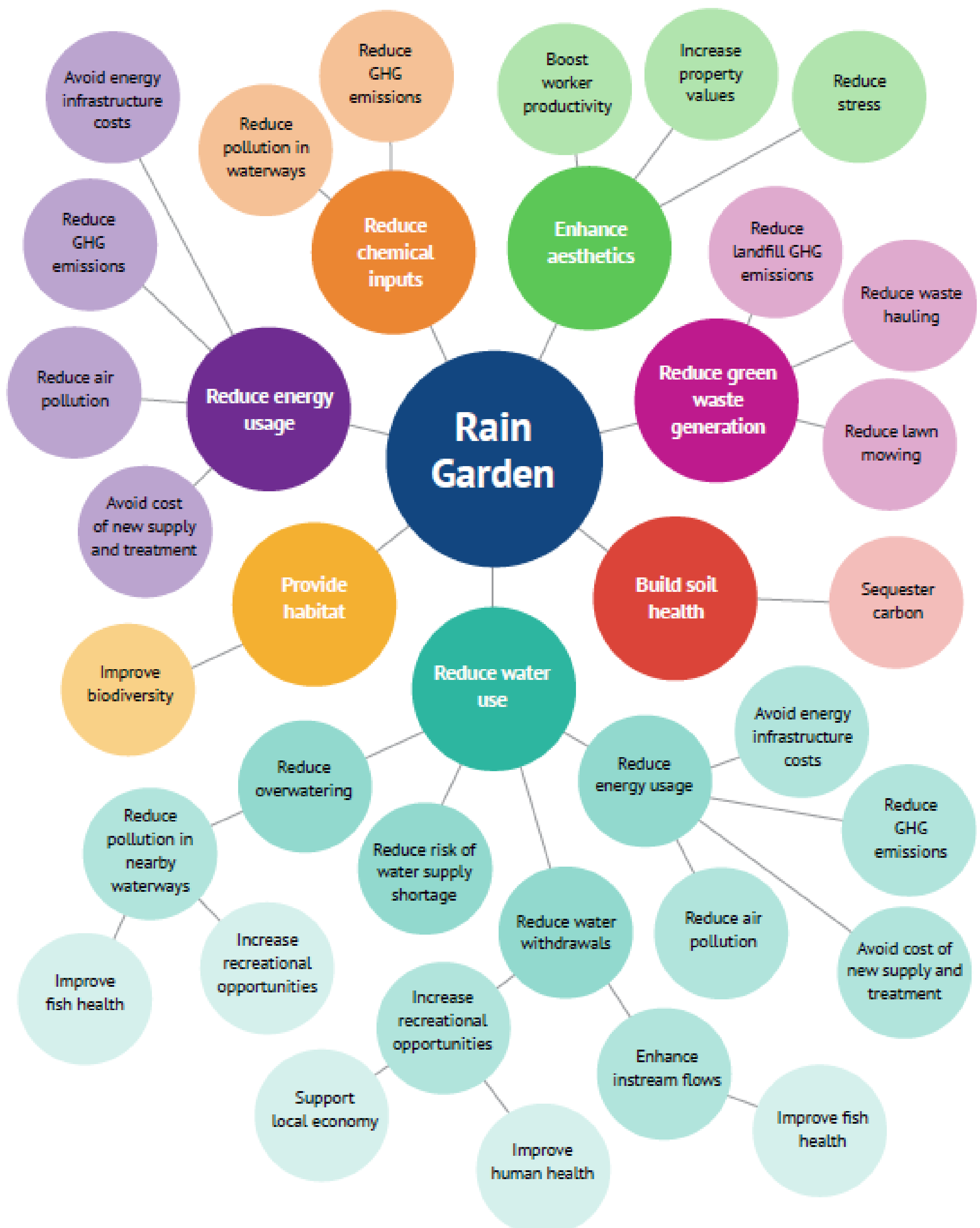

Figure 5-2: A diagram from Diringer et al. illustrating an implementation of the co-benefits framework for watershed management.

Equitable Adaptation

The Equitable Adaptation framework incorporates considerations of social and environmental equity into climate planning choices. Managing risks from climate change while adequately addressing equity concerns is often a challenge for community planning.[45] Equity means working to remove barriers and helping everyone in a community thrive.[46] Future changes in climate and resulting impacts (e.g., extreme weather events or watershed disturbances) will not be felt equally in the community, which worsens pre-existing inequality.[47]

Research in other contexts shows that not meeting this challenge can result in maladaptation, or the failure of adequately adapting to the situation at hand.[48] In the area of watershed planning and stormwater management, there is a growing recognition of the utility of considering equitable adaptation in managing future impacts. [49] The Chesapeake Bay Watershed is a leading example in incorporating equity into watershed management. Their Environmental Justice and Equity Dashboard (see **Figure 5-3**) includes information that can be used to create outreach programs for at-risk communities and help locate green infrastructure projects in socially vulnerable areas.[50] The watershed dashboard assists local governments in the watershed in creating projects that benefit underserved communities by breaking down demographic and watershed data using a web-based Geographic Information System (GIS).

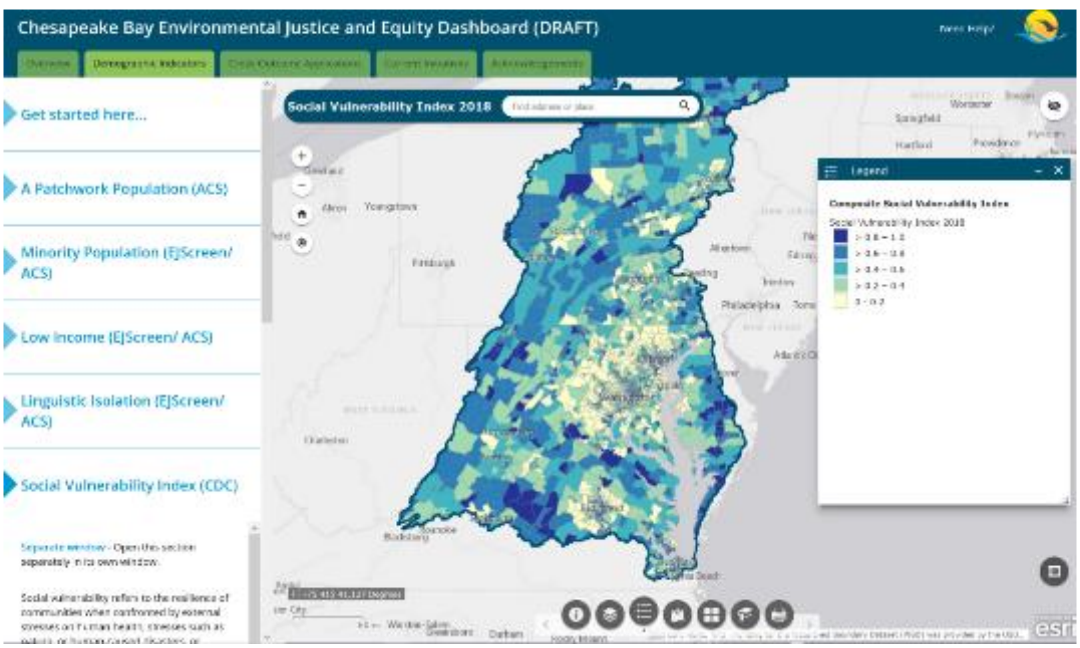

Figure 5-3: A screenshot of the Chesapeake Bay Program's GIS dashboard

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[45] Jabobs & Street. (2020). The next generation of climate services. https://doi.org/10.1016/j.cliser.2020.100199
[46] U.S. Climate Action Network, see https://www.usclimatenetwork.org/justice_equity_diversity_and_inclusion
[47] Hsiang et al. (2017). Estimating economic damage from climate change in the United States. https://doi.org/10.1126/science.aal4369
[48] Magnan et al. (2016). Addressing the risk of maladaptation to climate change. https://doi.org/10.1002/wcc.409
[49] Georgetown Equitable Adaptation Toolkit, see https://www.georgetownclimate.org/adaptation/toolkits/equitable-adaptation-toolkit/resilient-water.html
[50] View the dashboard live at https://gis.chesapeakebay.net/diversity/dashboard

5.2.3 Step 3: Integrate Climate Planning with EPA 9 Elements for Watershed-Based Plans

Climate planning can be used to expand the reach of management measures in the Lower Caw Caw Swamp WBP and achieve the goals of the EPA 9 Elements of a Watershed-Based Plan. The potential application of climate informed planning is particularly prominent in three of the EPA's 9 Elements.

Education and Outreach

Community groups facing adverse watershed impacts may be a reservoir of community knowledge and resilience: faith-based organizations, ethnic networks, community-based organizations, etc. Co-management can engage these community assets, but the relationship between citizens and government must go beyond stakeholder engagement and involve them in the decision-making process.[51] This co-management strategy can be aided by considering how communications about the watershed take place in the community[52]; framing communications to resonate with different priority community concerns while still addressing broad water quality remediation goals.[53]

To align with EPA guidelines, educational outreach activities must be created to encourage public participation and awareness. Building equity into the communication ensures all segments of the population (e.g. low-income communities, people of color, or other frontline communities) have a voice throughout the process and ensures education reaches communities that did not have prior access to information.[54] Community education and outreach are instrumental to a successful watershed-based plan and are more successful when directed towards vulnerable populations, warranting increased attention to accessibility.[55] For example, in the Michigan Huron Watershed area communicating relevant watershed impacts was highly effective because all citizens were informed of the risk and involved in decision-making.[56] Following are examples of guides and toolkits available to draw from:

Education and Outreach Guides and Toolkits

- NOAA Office for Coastal Management's Enhanced Engagement and Risk Communication for Underserved Communities: Research Findings and Emerging Best Practices.
- American Rivers' Water Justice Toolkit: A Guide to Address Environmental Inequities in Frontline Communities.

Best Management Practices (BMPs)

Because they serve as new components in the watershed system, BMPs can be a source of co-benefits and may reduce structural inequality if equity is considered in their design, location, and implementation. Concentrating stormwater management investment in certain

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[51] Wyborn et al. (2019). Co-Producing Sustainability: Reordering the Governance of Science, Policy, and Practice. https://doi.org/10.1146/annurev-environ-101718-033103

[52] Yuen et al. (2017). Guide to Equitable, Community-Driven Climate Preparedness Planning. https://www.adaptationclearinghouse.org/resources/guide-to-equitable-community-driven-climate-preparedness-planning.html

[53] Orlove et al. (2020). Climate Decision-Making. https://doi.org/10.1146/annurev-environ-012320-085130

[54] Georgetown Equitable Adaptation Toolkit, see https://www.georgetownclimate.org/adaptation/toolkits/equitable-adaptation-toolkit/resilient-water.html

[55] Floress et al. (2015). The Role of Social Science in Successfully Implementing Watershed Management Strategies. https://doi.org/10.1111/j.1936-704X.2015.03189.x

[56] Cheng et al. (2017). Risk Communication and Climate Justice Planning: A Case of Michigan's Huron River Watershed. https://doi.org/10.17645/up.v2i4.1045

areas may disproportionately benefit that area and can lead to green-gentrification or other unintended planning consequences.

Incorporating co-benefits and equitable adaptation in locating and prioritizing investment for new watershed infrastructure could lead to prioritizing green infrastructure BMPs.[57] Green infrastructure BMPs (such as rainwater harvesting, rain gardens, bioswales, permeable pavements, green roofs, urban tree canopy, and land conservation[58]) can be less expensive compared to other types of BMPs.[59] The following are a variety of information hubs and efforts that could provide a template for prioritizing and implementing green infrastructure BMPs in the Lower Caw Caw Swamp Watershed Area:

Green Infrastructure BMP Guides

- SC Forestry Commission's Evaluating and Conserving Green Infrastructure Across the Landscape: A Practitioner's Guide.
- FEMA's Building Community Resilience With Nature-Based Solutions: A Guide for Local Communities.
- NOAA Office for Coastal Management's Natural Instructure Hub.
- EPA's Soak Up the Rain Hub.

Green Infrastructure BMP Examples

- Charleston SC
- SC Floodwater Commission
- American Forest partner cities
- The Nature Conservancy partner geographies
- MIT Senseable City Lab Treepedia
- The Center for Watershed Protection

Forestry & Agriculture Recommendations

Through discussions with the Ag and Forestry Focus Group, several suggestions for forestry best management practices were provided. These included following the recommendations from several programs:

- Apply for NRCS EQIP grant funding
- Encourage landowners to utilize BMPs for production soil tillage, fertilization, soil sampling
- encourage all harvesting operations should be to follow the voluntary guidance from the SC Forestry Commission BMPs for logging jobs to prevent problems before they start
- Encourage Timber Operation Professionals certification for loggers
- Encourage American tree farm certification
- Encourage livestock owners to receive manure management training provided by Clemson

[57] Seddon et al. (2020). Understanding the value and limits of nature-based solutions to climate change and other global challenges. https://doi.org/10.1098/rstb.2019.0120
[58] EPA (2022). What is Green Infrastructure? https://www.epa.gov/green-infrastructure/what-green-infrastructure
[59] Odefey et al. (2012). Banking on Green: A Look at How Green Infrastructure Can Save Municipalities Money and Provide Economic Benefits Community-wide. Link.

- Encourage planting the "right tree in the right place" to provide resilience to wildfire, drought, disease, and insects. A well-managed forest is a resilient forest.

Funding Options

Cities are increasingly preparing their watersheds and stormwater infrastructure to protect against the impacts of extreme rainfall events and other climate changes.[60] Considering climate change in this way can save money, while failing to proactively address climate risks can increase costs and limit the ability to raise capital.[61]

Cities are also using specialized income taxes and financial tools to fund green infrastructure projects. For example, in response to lack of funds and growing climate risks, Grand Rapids, Michigan set a 1.5% income tax and a stormwater credit trading program to fund green infrastructure BMPs.[62] In addition to creative financing tools[63], considering climate change can also unlock new sources of funding and meet federal requirements of various planning activities:

1. Private firms seeking carbon offsets: certain BMPs (e.g., permanent green infrastructure projects which absorb sufficient carbon) may have co-benefits such as carbon capture which can be monetized as carbon offsets and sold to private firms. While the marketplace and standards for carbon offsets are emerging, this could become a viable source of supplemental funding. Recent research found 30% of companies in the U.S. have set a net zero target, suggesting this market may emerge within the timeline for the implementation schedule set for this plan.[64] For example, Microsoft is spending $1 billion on carbon offsets by 2025, some of which could potentially be allocated towards green infrastructure.[65] At least one project in South Carolina has already been funded by a carbon market.[66]
2. Federal grant requirements: Partners implementing the Lower Caw Caw Swamp Watershed Plan may be required to consider environmental justice when seeking federal funding. For example, the Justice 40 initiative will require that 40% of federal investments in certain categories go to disadvantaged communities for covered programs. In the interim guidance, one such category includes all federal programs investing in "critical clean water and waste infrastructure."[67] Considering equitable adaptation and climate planning is also likely to benefit applications for other types of grant-based or philanthropic funding.

[60] Morrison. (2021). What lurks beneath: A new answer to more intense storms. https://www.washingtonpost.com/climate-solutions/2021/06/06/stormwater-infrastructure-sensor/
[61] Painter. (2020). An inconvenient cost: The effects of climate change on municipal bonds. https://doi.org/10.1016/j.jfineco.2019.06.006
[62] For more information, see http://glpf.org/blog/creative-partnership-forges-a-path-to-innovative-green-infrastructure-funding-in-grand-rapids/
[63] A useful tool for TRW partners is the American Flood Coalition's funding database, see https://floodcoalition.org/resources/floodfundingfinder/
[64] Cullen et al. (2021). Leveling up net zero climate leadership in the United States: An analysis of subnational net zero targets & recommendations for the Federal Government. https://www.smithschool.ox.ac.uk/publications/wpapers/workingpaper21-01.pdf
[65] For more information, see https://blogs.microsoft.com/blog/2020/01/16/microsoft-will-be-carbon-negative-by-2030/
[66] For more information, see https://www.postandcourier.com/news/sc-forests-are-protected-for-trapping-carbon-with-a-little-help-from-california/article_323ee998-39ed-11e9-a438-df43b4df1939.html
[67] White House Guidance Memo M-21-28, see https://www.whitehouse.gov/wp-content/uploads/2021/07/M-21-28.pdf

5.3 Management Practices and Strategies

These practices are different from the community-wide programs, as they will be targeted to specific areas.

5.3.1 Municipal Programs

Watershed management strategies that can be implemented broadly by either the City or County are described here. The recommendations in this section focus on street sweeping, reduction of illicit discharges to the stormwater system, and prevention of sanitary sewer overflows (SSOs). SSOs are spills from structures (pipes, pump stations, etc.) in a wastewater conveyance system that can cause untreated sewage to spill into city streets, streams, and other areas before the untreated sewage reaches a treatment facility. Illicit discharges are defined as water discharges to the municipal separate storm drain system that are not entirely composed of stormwater. That is, they are harmful and often illegal connections to the stormwater system from business or commercial activities. In some cases, the recommendation may be to build on or add frequency to existing programs.

Street Sweeping – Street sweeping at regular intervals (monthly) can be a very effective method for reducing the runoff of many pollutants including nitrogen, sediment, oils, grease, and metals typically found in stormwater runoff from roadways. Removing sediment from roadways enhances climate resilience by preventing clogging of the existing stormwater conveyance and pond system. An additional benefit for source water protection is that street sweeping also removes leaves and other organic material from entering the Caw Caw Swamp and flowing to the source water intake. Sweeping should be targeted to most heavily traveled roads and areas most connected to the storm drain system. At this time, the City sweeps the downtown area on weekends and in neighborhoods at least once a month or as needed (reducing pollutant loads by 149 lb/yr TN; 22 lb/yr TP; and 4.4×10^3 lb/yr TSS). A goal of this management plan will be to coordinate with County to implement a residential street sweeping program in the future. If all the roadway areas (243 acres) were swept monthly, assuming no parking restrictions, the WTM predicts an additional annual pollutant load reduction of 577 lb/yr TN; 85 lb/yr TP; and 1.7×10^4 lb/yr TSS.

Sanitary Sewer Overflow Prevention – The WTM estimates that SSOs from sanitary sewer system are a relatively small source of bacteria in the overall Lower Caw Caw Swamp Watershed. Problems that can cause chronic SSOs include:

- Too much rainfall or snowmelt infiltrating through the ground into leaky sewer systems;
- Runoff that is directly connected to sewer systems;
- Sewers and pumps too small to carry sewage from newly developed subdivisions or commercial areas;
- Blocked, broken, or cracked pipes due to tree roots, pipe settlement, and material build-up within pipes;
- Power failures that prevent the system from functioning; or
- Vandalism to the sanitary sewer conveyance system.

Practices to reduce or eliminate SSOs include routine sewer system cleaning or maintenance; repairing broken or leaking sewer service lines; enlarging or upgrading the sewer/pump station capacity or reliability; and construction of wet weather storage and treatment facilities to treat excess flows.

Additionally, the DPU can provide public education to prevent blockages in existing sanitary sewer systems by discouraging flushing wipes and encouraging residents to dispose of fats, oils, and grease (FOG) properly. The DPU encourages residents to report problems via the website and Facebook page.[68] The WTM model estimates that an SSO repair/abatement program with a goal of 100% completion of reducing all SSOs would result in pollutant reductions of 3 lb/yr TN; 0.5 lb/yr TP; 19 lb/yr TSS; and 1.8×10^{12} MPN/year of *E. coli* bacteria per year.

Hotspot and Illicit Discharge Detection and Elimination (IDDE) – Dry weather flows discharging from storm drain systems can contribute significant loads to stream systems. Inspection and testing of water quality from outfalls, or from upland 'hotspots' during dry weather can assist in the detection of inappropriate discharge entering the stream both from storm drains and from other pipes potentially conveying discharge. Hotspots generally include commercial and industrial properties that may be specific sources of pollutants from poor housekeeping practices that allow pollutants to wash into the storm drain system. When an illicit discharge is found it can be tracked to its source for resolution. Discharge types can include sewage and septage flows, washwater flows such as laundry and car washing discharge, liquid waste such as oils and paints, landscape irrigation, dumpster runoff, and tap water. The bacteria hotspots detected near the baseball fields by the DPU's initial watershed water sampling warrant further investigation into the source of the bacteria; it could be the result of an illicit discharge.

5.3.2 Septic System Recommendations

In addition to the public education recommendations included in **Section 5.1.2**, there must be an effort to survey and assess the existing septic systems in the Lower Caw Caw Swamp Watershed. Over half of all residential properties in the Lower Caw Caw Swamp Watershed are not connected to the sanitary sewer system, and thus septic systems may have a substantial contribution to bacteria pollution. According to the GIS desktop analysis summarized in **Table 5-2**, the subwatershed with the most potential residential septic systems is Turkey Hill Branch. We recommend starting the survey in this subwatershed, and then moving on to the other subwatersheds in descending order. We recommend utilizing the DPU's billing system to identify customers who have an account for water services but not sewer (most likely these are properties with septic). A note can be included with the billing statement that would include questions like:

- Do you (or someone you know) have problems with your septic system?
- Do your toilets, sinks, or bathtubs consistently back up?
- Does your septic system need to be pumped frequently?
- Do you have standing water or a foul odor in the yard where your septic system is located?

[68] The public can contact the DPU at https://www.orbgdpu.com/ or https://www.facebook.com/dpucityoforangeburg/

The letter would then inform the resident that the DPU/County can help provide funding to cover the cost to repair or replace septic systems that are currently failing. The DPU and Orangeburg County could partner with septic maintenance companies to perform the inspections and provide recommendations. Once the number and location of failing septic systems have been identified, then the DPU and County can work on applying for funding to help homeowners make the necessary changes.

Table 5-2: Residential Septic Systems by Subwatershed

Subwatershed	Number of Residences with Septic
Upper Caw Caw Swamp	53
Early Branch	423
Lower Caw Caw Swamp	463
Turkey Hill Branch	740

5.3.3 Stormwater Retrofit Projects

Stormwater retrofit projects include many types of projects that capture and treat stormwater runoff from impervious surfaces in existing development. The proposed projects include a total of six BMP retrofit sites that are planned to maximize the treatment of runoff from 51.2 acres of impervious area in the Lower Caw Caw Swamp Watershed by providing a total of 86.45 ac-ft of annual stormwater runoff reduction. For purposes of the WTM model, all practices were input as bioretention, which assumes removal efficiencies of 50% for TSS, 60% for TN, 50% for TP, and 50% for bacteria.[69] Additionally, residential downspout disconnection was another recommendation, which provided an additional 3.3 ac-ft of annual runoff volume reduction.

The net benefits of all retrofit projects would be a reduction in pollutant loads of 1,020 lb/yr TN; 169 lb/yr TP; 2.4×10^{4} lb/yr TSS; and 9.4×10^{12} MPN/yr of *E. coli* bacteria per year. These projects would also result in a total runoff reduction of 90 ac-ft per year. The individual project pollutant and runoff reductions are summarized in **Table 5-3**. Stormwater retrofit projects like these are useful for climate resilience planning and adaptation and help protect source water quality.

[69] Caraco, Deb. 2013. Watershed Treatment Model (WTM) 2013 documentation. Available at https://owl.cwp.org/mdocs-posts/watershed-treatment-model-documentation-final/

Table 5-3: Pollutant Reductions Provided by Each Retrofit Project

BMP	TN (lb/year)	TP (lb/year)	TSS (lb/year)	*E. coli* (MPN/year)	Runoff Volume (acre-ft/yr)
Prince of Orange Mall	499	71	1.2E+04	4.8E+12	44.26
First Baptist Child Development Ctr.	86	17	1.9E+03	7.6E+11	7.24
Orangeburg Prep (North Rd.)	124	23	2.7E+03	1.1E+12	10.5
Orangeburg Prep (Prep St.)	146	30	3.6E+03	1.2E+12	12.1
Sheridan Elementary	82	15	1.8E+03	7.4E+11	7.0
Marshall Elementary	65	12	1.4E+03	5.7E+11	5.5
Residential Impervious Disconnection	19	2	5.0E+02	2.1E+11	3.3
TOTAL:	**1,020**	**169**	**2.4E+04**	**9.4E+12**	**90**

5.3.4 Riparian Buffer Projects

Well-managed and adequately sized buffers are important for processing nutrients, filtering pollutants, providing habitat, retaining flood waters, and providing erosion prevention. Research has indicated that approximately 80% of nitrogen removal is achieved by stream buffers approximately 80-90 ft wide and widths of 150 feet or wider are more likely to consistently achieve their maximum potential for nitrogen removal.[70] The minimum 80-foot stream buffer width recommended for nitrogen removal was estimated to provide around 66% removal of total phosphorus. However, for this analysis, we will use the minimum buffer requirement associated with the City of Orangeburg and Orangeburg County (40 feet).

Using a minimum buffer width of 40 feet, 31.6 miles of stream buffer was analyzed, and it was determined that 19.9 miles (63%) had adequate buffer width, while 11.7 miles (37%) had inadequate buffer. There are several areas throughout the watershed that need improved riparian buffers. One area in particular need is the area adjacent to the Wannamaker Catfish Ponds. This section is comprised of a non-stabilized soil berm that was constructed as a boundary between the ponds and the linear reaches of Caw Caw Swamp, north of US 178 (North Road). Another area of consideration is the land adjacent to the Tamara Lane Pond. This area is not along the main branch of the Caw Caw but does drain to it. Both are illustrated in **Figure 5-4** below.

[70] Bason, C. 2008. Recommendations for an Inland Bays Watershed Water Quality Buffer System. Delaware Center for the Inland Bays. Rehoboth Beach, DE.


Figure 5-4: Locations for proposed riparian buffer improvements. Left: Wannamaker Catfish Pond location. Right: Tamara Ln.

The benefits of existing (EX) and recommended (REC) actions in the riparian buffers are summarized in **Table 5-4** below. Education refers to ensuring that property owners know what ordinances specify as acceptable and unacceptable activities in the buffer, and that signage is available for homeowners to identify these protected areas. This signage could be provided by the City, County, Clemson Extension, Edisto Riverkeeper, or the Orangeburg Soil & Water Conservation District. Riparian buffers also enhance source water protection by filtering pollutants from runoff before they reach the downstream intake point. A robust riparian buffer also helps offset potential climate change challenges, such as increased precipitation and increased in-stream water temperature, by providing vegetation to reduce erosion and shade the stream.

Table 5-4: Pollutant Reductions Provided by Riparian Buffer Activities

Riparian Buffer Condition	TN (lb/year)	TP (lb/year)	TSS (lb/year)	*E. coli* (MPN/year)	Runoff Volume (acre-ft/yr)
Buffers (EX, no education)	1,221	212	3.2E+04	1.3E+13	213
Buffers (EX + education)	306	69	5.2E+03	2.1E+12	35
Buffers (REC + education)	169	31	4.1E+03	1.7E+12	27
Buffers (EX + REC + education)	1,696	313	4.10E+04	1.7E+13	275

The location of all the proposed projects is illustrated in **Figure 5-5**.

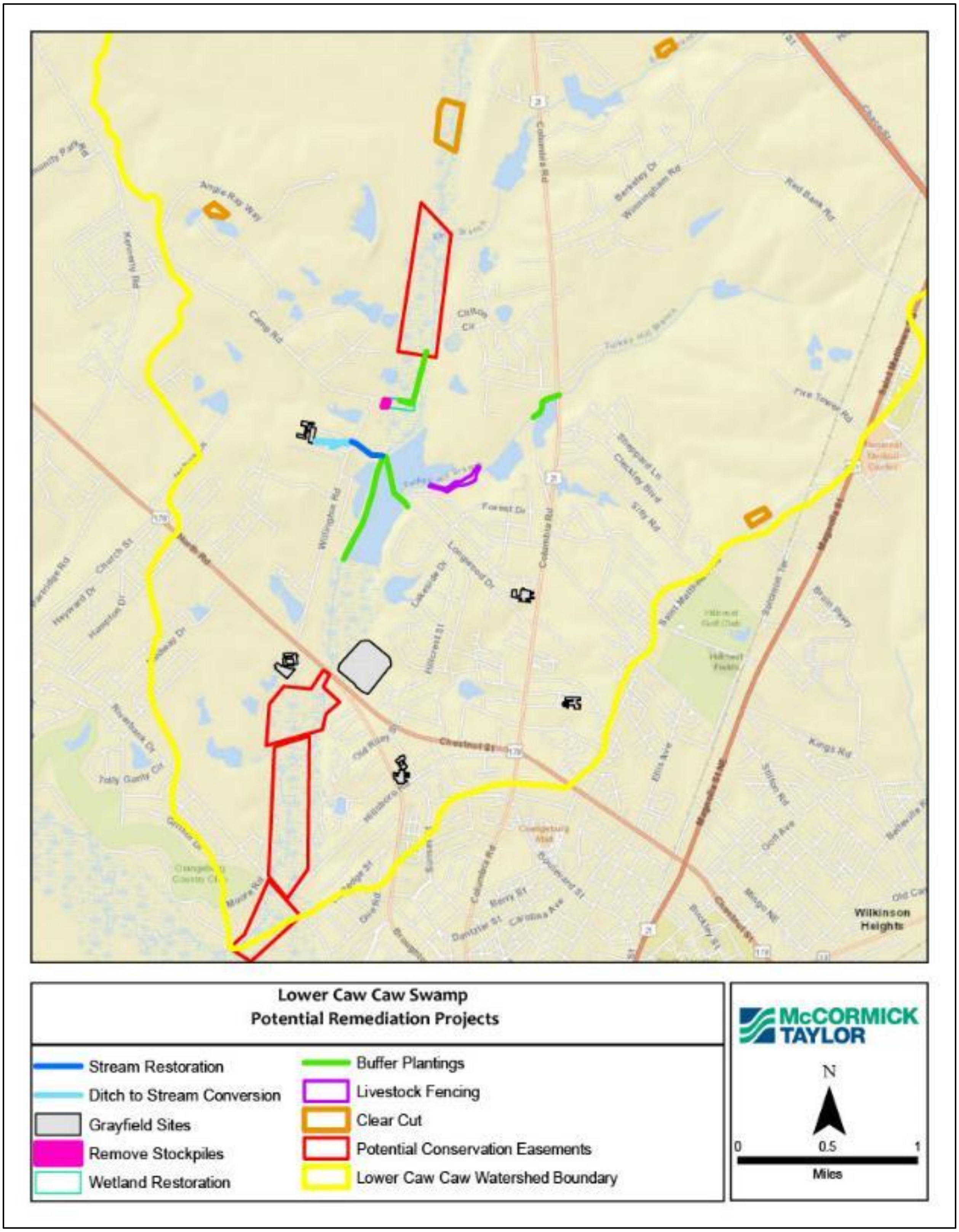


Figure 5-5: Recommendations for Projects in the Lower Caw Caw Swamp

5.3.5 Conservation Recommendations

The DPU has identified several areas in the watershed that will be prioritized for conservation easements (as shown previously in **Figure 5-5**) to help with source water protection. Located primarily along the main channel of the Lower Caw Caw Swamp, these areas are not suitable for development and would continue to provide vegetative buffers along the swamp that would capture nutrients and sediments. The conservation area would be made up of portions of 40 separate parcels, as summarized in **Table 5-5**. Note that three parcels owned by the City of Orangeburg would contribute to 55 acres (18%) of conservation. It may be easier to establish permanent conservation easements on publicly owned parcels rather than privately-held property, as private property would either need to be purchased or otherwise require additional outreach to convince the landowner to agree to the stipulations of an easement. As evaluated in the Existing Conditions WTM model, converting 312 acres of forest (the conservation area) to medium density residential (predominant land use in the watershed) would result in an increase of 1,408 lb/yr TN; 261 lb/yr TP; 19,859 lb/yr TSS; 3.4×10^{13} MPN/yr of *E. coli* bacteria; and 343 acre-feet of runoff each year in the Lower Caw Caw Swamp Watershed. Therefore, the City and County should collaborate with the Congaree Land Trust to try to protect these important riparian areas.

Table 5-5: Conservation Area Details

Location	Number of Parcels	Total Area (acres)
1	8	46.12
2	6	60.52
3	21	106.43
4	5	99.08
TOTAL:	40	312.14

5.4 Implementation

5.4.1 Priorities and Estimated Costs

The estimated cost to implement all these projects and preventative measures is $2.3 million (**Table 5-6** and **Table 5-7**). A detailed cost sheet for each of the projects is included in Appendix C. Currently, the City and County do not have funding set aside for these projects. Neither jurisdiction has a stormwater program in place, nor do they collect a stormwater utility fee for projects like these. Although the City was recently awarded a grant from the SC Office of Resiliency for a flood study, the focus area for this project is completely outside the Lower Caw Caw Swamp Watershed. The jurisdictions in the Lower Caw Caw Swamp Watershed cannot support the financial burden of all the recommended projects in this watershed-based plan without help from outside funding opportunities. This watershed plan has included several potential funding programs and financing mechanisms that could support the implementation of these activities. The following ranked list suggests which of these might be appropriate pursuits based on several factors including the timing of the opportunity, the project(s) it could support, and the organizational capacity needed to pursue it.

Table 5-6: Cost Estimates to Implement Recommended Projects

Ditch to Stream Conversion			
	Total Construction Cost with 10% Contingency	$	66,634.70
	Total Professional Services Fee	$	3,000.00
	Total Project Cost	**$**	**69,634.70**
Buffer Plantings			
	Total Construction Cost with 10% Contingency	$	125,015.00
	Total Project Cost	**$**	**125,015.00**
Livestock Planting			
	Total Construction Cost with 10% Contingency	$	7,869.40
	Total Project Cost	**$**	**7,869.40**
Clear Cut Rehabilitation			
	Total Construction Cost with 10% Contingency	$	239,250.00
	Total Project Cost	**$**	**239,250.00**
Remove Stockpiled Soils at Church			
	Total Construction Cost with 10% Contingency	$	7,961.80
	Total Project Cost	**$**	**7,961.80**
Stream Restoration			
	Total Construction Cost with 10% Contingency	$	990,000.00
	Total Project Cost	**$**	**990,000.00**
Grayfield Conversions			
	Total Construction Cost with 10% Contingency	$	2,257,200.00
	Total Project Cost	**$**	**2,257,200.00**

Table 5-7: Cost Estimate to Implement Community-Based Programs

Project Type	Cost	Unit	Quantity	Extended Cost
Workshop (general cost)				
Printed materials (fliers)	$0.72-$1.01	Per flier	200	$173
Printed materials (tri-fold brochure)	$1.60-$2.40	Per brochure	200	$480
Printed materials (maps / posters)	$6.00-$40.00	Per map	5	$115
Newspaper ad in local paper	$312-$540	Per advertisement	1	$426
Workshop space	$200	Per workshop	1	$200
Workshop staff	No cost	Per workshop	-	-
Workshop supplies and food	$100-$200	Per workshop	1	$150
		Per workshop		$1,544
Residential Lawn Care Education				
Lawn Care Advice	$2.10-$3.84	Per household	100	$297
Soil Testing	$9.60-$14.40	Per household	100	$1,200
Workshop	$1,543.80	Per workshop	1	$1,544
		Practice Total		$3,041
Pet Waste Education				
Bag stations	$400	Per station	2	$800
Waste pick-up signage	$100	Per sign	2	$200
Workshop	$1,543.80	Per workshop	1	$1,544
		Practice Total		$2,544
Rain Barrel / Downspout Disconnect				
Rain barrel distribution	$50-$60	Per barrel	50	$2,750
Workshop	$1,543.80	Per workshop	1	$1,544
		Practice Total		$4,294
Septic System Education				
Septic System Inspections	$180-$312	Per household	50	$12,300
Workshop	$1,543.80	Per workshop	1	$1,544
		Practice Total		$13,844

5.4.2 Potential Funding Sources

Funding needed to implement components of the plan will vary depending on the type of strategy. Funding will come from current program resources, local and state government funding, and a variety of grants, cost share programs, and private programs that focus on water quality, and environmental restoration. Examples of grant funding sources and the types of projects they may serve are listed below in **Table 5-8**.

Table 5-8: Funding Source Summary

Program	Funder/Partner	Program Goals or Outcomes
Nonpoint Source Implementation Program (Section 319)	SCDHEC/EPA	Assist in implementing projects for urban and agricultural runoff, land conservation for water quality benefits, natural channel design, and streambank stabilization.
SC Rural Infrastructure Authority (RIA) Grants	SC RIA	Assist municipalities in keeping up with repairs or upgrades to aging or overburdened infrastructure.
State Revolving Fund (SRF)	SCDHEC	Provide low-interest rate loans for sanitary sewer repairs and stormwater quality improvement projects
Regional Conservation Partnership Program (RCPP)	NRCS	Support projects including a range of on-the-ground conservation activities implemented by farmers, ranchers, and forest landowners such as land management, restoration, and public works/watersheds.
Five Star & Urban Waters Restoration Program	NFWF	Design and planning services for habitat, water quality, and social media campaigns.
Resilient Communities Program	NFWF	Enhance community capacity to plan and implement resiliency projects and improve the protections afforded by natural ecosystems by investing in green infrastructure and other measures.
Environmental Education Association of SC Mini-Grant	EEASC	Provide grants up to $1,000 for innovative projects that support environmental education and stewardship.
Champions of the Environment	SCDHEC	Provide up to $2,500 for K-12 students and educators to implement projects that prevent or reduce pollution in the air, water, or land; and restore, preserve, or enhance natural areas.

5.5 Schedules and Milestones

A preliminary schedule for implementation of the activities discussed above is provided in **Table 5-9**.

Table 5-9: Timeline of Implementation

Measurable Milestones														
Sources	BMPs	Location	Years 1 to 3	Years 4 to 6	Years 7 to 9	Years 10 to 12	Years 13 to 15	Preventative Measures	Years 1 to 3	Years 4 to 6	Years 7 to 9	Years 10 to 12	Years 13 to 15
Community-Wide Programs													
Residential Lawns	provide soil testing kits	varied	x	x	x	x	x	Lawn care educational workshops	x	x	x	x	x
	provide lawn waste disposal bags	varied	x	x	x	x	x	Composting educational workshops	x	x	x	x	x
Pet Waste	install waste stations	trails, parks, HOAs	x	x	x	x	x	Pet waste PSAs	x	x	x	x	x
	provide portable waste bags	public events	x	x	x	x	x						
Trash	install trash cans	public trails, parks	x	x	x	x	x	Litter PSAs	x	x	x	x	x
	fishing line recycling	boat launches	x	x	x	x	x						
Funding Opportunities:	Apply for grants: 319, EEASC mini-grant, Champions of the Environment								x	x	x	x	x
Potential Partnerships:	Clemson Extension, Orangeburg SWCD, SC Native Plant Society, Palmetto Pride, Friends of the Edisto, Claflin University												
Septic													
Residential Septic Systems	Field-verify location and condition of septic systems by subwatershed	Turkey Hill Branch	x					Education on preventative maintenance	x	x	x	x	x
		Lower Caw Caw Swamp		x				Education on repair and upgrades	x	x	x	x	x
		Early Branch			x								
	Repair/Upgrade failing systems	varied		x	x	x	x						
Funding Opportunities:	Apply for grants: 319, SC RIA								x	x			
Potential Partnerships:	SCDHEC, Clemson Extension, Orangeburg SWCD, Friends of the Edisto												
Sanitary Sewer													
Sanitary Sewer Overflows	Inspection and Maintenance (DPU)	varies	x	x	x	x	x	Wipes and FOG Education	x	x	x	x	x
Illicit Discharge	Illicit Discharge Detection & Elimination	varies	x	x	x	x	x						
Funding Opportunities:	Apply for grants: 319, SC RIA, SRF									x	x	x	x
Potential Partnerships	SCDHEC, Orangeburg County												

Measurable Milestones														
Sources	BMPs	Location	Years 1 to 3	Years 4 to 6	Years 7 to 9	Years 10 to 12	Years 13 to 15	Preventative Measures	Years 1 to 3	Years 4 to 6	Years 7 to 9	Years 10 to 12	Years 13 to 15
Urban/Suburban													
Channel Erosion	Riparian Buffer Restoration Projects	Catfish Pond	x					Floodplain education for residents	x	x	x	x	x
		Willington Rd./Camp Rd.		x				Riparian buffer education for residents	x	x	x	x	x
		Hwy 21 crossing			x								
	Downspout/ Impervious Surface Disconnection	Residential areas	x	x	x	x	x	Engage homeowners to participate in Carolina Yards program	x	x	x	x	x
Residential and Commercial Development	Stormwater BMP retrofits	Prince of Orange Mall	x					Engage HOAs with Master Pond Manager Program	x	x	x	x	x
		First Baptist Child Development Center	x					Encourage homeowners and professionals to obtain Master Rain Gardener Certification	x	x	x	x	x
		Orangeburg Prep (North Rd.)		x									
		Orangeburg Prep (Prep St.)		x									
		Sheridan Elementary School			x								
		Marshall Elementary School			x								
	Street Sweeping	varies	x	x	x	x	x						
	Roads, Parking Areas	Street Sweeping	x	x	x	x	x						
Construction Sites	properly dispose of stockpiled soils		x										
Funding Opportunities:	Apply for grants: 319, NFWF Five Star & Urban Waters Restoration, SC RIA, SRF, EEASC, Champions of the Environment								x	x	x	x	
Potential Partnerships	SCDHEC, Clemson Extension, Orangeburg SWCD, Friends of the Edisto												
Agricultural													
Small Farms	install cow fencing		x	x									
clear cut areas	replant with longleaf pine		x	x									
Funding Opportunities:	Apply for grants: 319, NRCS RCPP								x	x			
Potential Partnerships	Clemson Extension, SC Forest Commission, SC Wildlife Federation,												

5.5.1 Permitting Schedule and Timeline

Agency permitting timelines are generally contingent on project size and complexity. Below is a generalized description of the permitting steps and associated review times for standard permitting needs for engineering activities. Projects involving impacts to wetlands or streams are governed by the Army Corps of Engineers (ACOE). Prior to submitting a permit application for impacts, you are required to submit a request for Jurisdictional Determination (JD) to the ACOE.

A JD consists of completion of a field survey and inventory of natural resource features, followed by a jurisdictional wetland report, including color photographs, data sheets, and maps depicting the location, acreage, and Cowardin classifications of the water and wetland features. Sensitive habitats are also usually identified during the field survey and described in the report. Total time of completion and issuance of approval is approximately 6 months.

Permitting for stream restoration primarily consists of completing an SCDHEC Notice of Intent (NOI) application to alter stormwater. This application is more commonly known as an NDPES or stormwater permit. The extent of the land disturbance (acreage) will determine if a short form application is sufficient or if a Comprehensive Stormwater Pollution Prevention Plan (C-SWPPP).

USACE Wetland Permit

Depending on the amount of impacts to environmental resources, the project may fall under a Regional General Permit (GP), or a Nationwide Permit (NWP)if impacts to wetlands are less than 3.0 acres and impacts to streams are less than 300 linear feet. Depending on design constraints, an individual 401/404 ACOE permit may be required. The design will also reflect the need for “minimization and avoidance” of WOTUS as required by the ACOE. Expected wait time for the approval of a GP or NWP is approximately 6 to 9 months. Wait time for the issuance of approval of an individual report is approximately 9 to 18 months.

SCDHEC Water Quality Certification (Section 401)

All activities requiring a U.S. Army Corps of Engineers Permit for the discharges into waters or wetlands, must also receive a Water Quality Certification (Section 401) from SCDHEC. Upon receipt of the 401-certification form, SCDHEC submits to the USACE for review for completeness. Once SCDHEC receives the Joint Public Notice from the USACE, a 30-day comment period is initiated. If no appeals are received, SCHEC will submit final certification to the USACE and the applicant.

Negotiations and Permit Acquisition

The negotiation and permit acquisition process can be confusing and untimely if not properly guided at certain bottleneck areas. The bullet points below provide the highlights for the process of obtaining an ACOE 401/404 permit:

- Application submitted and application acknowledged. ACOE Project Manager assigned.
- Review of application for completeness.
- Public Notice prepared and published in newspaper. This initiates the State certification process.
- Public comment period.
- Comments received and assessed. Concerns and objections categorized.
- Alternatives analysis. Mitigation plan worked out. Resolution of concerns.
- Preparation of decision document.

- Recommendation of permit issuance or permit denial.
- Permit issued or denied
- Permit decision appealed if necessary

SWPPP/NOI:

Activities that disturb over 1 acre of land are required to submit a Notice of Intent (NOI) to SCDHEC. SCDHEC has 15 days to reply for a request for more information, and 30 days to approve or deny the permit request. However, for projects that disturb more than 5 acres of land, and/or are part of a larger common plan, a comprehensive stormwater pollution plan (C-SWPPP) to get permit approval. A C-SWPPP is a site-specific document or collection of documents that identifies the potential sources of stormwater pollution resulting from the construction activities associated with the project. Additionally, the C-SWPPP describes stormwater control measures, such as BMPs, to reduce or eliminate the identified pollutants and contains detailed construction plans and hydrologic analysis. Although the review time for SCDHEC does not change with size of the project, the drafting of a C-SWPPP is generally considered to be at least a three-month engineering task.

5.6 Measures of Success

It will take a much larger effort to return a watershed to a goal of a water quality threshold after it is impaired than the actions it took for it to become polluted. While the best management practices proposed provide an overall net pollution reduction, any progress, however small, is a change in the right direction. The city, county, and stakeholders will build off each success and use adaptive management strategies to periodically evaluate and change priority projects and programs.

5.6.1 Monitoring Program

Monitoring data for any waterbody is a crucial element that can assist in determining current conditions, developing targeted management strategies, and tracking progress over time. It is recommended that additional monitoring be conducted to better pinpoint sources of pollutants, to establish a solid baseline of conditions, to track progress made towards attaining water quality standards, and to track changes in stream and watershed condition as implementation of restoration projects occurs. This is also known as adaptive management. Some specific recommendations are provided here:

Stream Monitoring – The sampling conducted by SCDHEC and the Orangeburg DPU should be repeated and expanded to regularly to track trends in baseflow water quality. There are opportunities for the County and/or volunteer organizations (such as Adopt-a-Stream) to support monitoring in this watershed. The S.C. Adopt-a-Stream Program (SC AAS) is a public water quality monitoring network administered by Clemson Public Service and Agriculture. SC AAS is comprised of local communities, educators, volunteers, and local government officials, tasked with a role in providing baseline information about stream conditions, and helping to monitor and track water quality parameters. Currently, Friends of the Edisto (FRED), a member of the Waterkeeper Alliance, participates in SC AAS in the Whirlwind Creek-North Fork Edisto River watershed; the 12-unit HUC to the immediate south of the Lower Caw Caw watershed. Hugo Krispin, the Edisto Riverkeeper, has suggested that FRED would be open to expanding their role in the SC AAS north into the Lower Caw Caw.

Additionally, the DPU and Claflin University staff have had initial discussions to plan out how students can be mentored by DPU laboratory professionals in exchange for collecting and analyzing water quality samples.

Other upstream monitoring locations should include:

- Areas with observed bacteria hotspots, such as ditches adjacent to the new ball fields, should be continued to be monitored to try to pinpoint sources of the bacteria.
- Locations downstream of implemented projects to measure water quality improvements. For example:
    - Downstream of the proposed stream restoration project at Orangeburg Prep
    - Downstream of the proposed cattle fencing near Wannamaker Catfish Ponds
    - At the outlet of Turkey Branch Creek before and after septic inspections and subsequent repairs have been implemented

Microbial Source Tracking (MST) – Sources of bacteria throughout the watershed are cause for concern. Initiating a Microbial Source Tracking effort can identify the source of the bacteria (e.g., human, pets, and wildlife), which will then help managers control the problem. For example, if the source is indicated as canine, a focus on pet waste education and the installation of pet waste stations would be more helpful than if the human marker was detected; then the focus would shift to searching for potential septic or sanitary sewer sources.

5.6.2 Evaluation Methods

In addition to the monitoring data proposed in section 5.6.1, the success of this watershed plan will be evaluated based on several criteria:

1. Urban Sources (Residential and Commercial land use types)
    a. The number of contacts for outreach/education (through television, billboards, etc.)
    b. The number of pet waste stations installed
    c. The number of marked storm drains
    d. The number of rain barrels distributed/voluntarily installed
    e. The amount of impervious surfaces treated by installation of stormwater retrofits
    f. The amount of impervious surfaces (streets and parking lots) serviced by street sweeping each year
    g. The number of catch basins cleaned each month
    h. The number of volunteers trained and certified by the SC Adopt-a-Stream program
        i. The number of samples collected and analyzed by volunteers
2. Sewer Sources
    a. The number of attendees at FOG and wipes educational programs
    b. The length of sewer lines inspected and upgraded (coordinate with utilities)
    c. The measured reduction of SSOs reported per year
3. Septic Sources

a. The number and location of septic systems identified and mapped
b. The number of septic systems inspected
c. The number of septic systems upgraded to more efficient systems
d. The number of households on septic that connect to sanitary sewer system

4. Agriculture Sources
    a. The number of cattle fenced out of waterways
    b. Number of properties placed under conservation easements to limit future land development
5. Forestry Sources
    a. Number of landowners to become certified or utilize qualified logging professionals who are certified in the Timber Operations Professional Program (TOP).
    b. Number of properties placed under conservation easements to limit future land development

6.0 Recommendations

The purpose of this watershed-based plan is to restore and protect water quality in the Lower Caw Caw Swamp. The Lower Caw Caw Swamp is a valuable resource because it drains directly to the source water intake for the City of Orangeburg DPU. The source water is vulnerable to pollution from bacteria, nutrients, sediment, and organic material.

Recommendations that will help **reduce bacteria loading** into Lower Caw Caw Swamp Watershed include:

- Continuing public education about the importance of proper pet waste disposal;
- Encouraging livestock owners to participate in a manure management program provided by Clemson;
- Conducting a sanitary system assessment in the watershed to determine if there are any leaking pipes and manholes, particularly along stream and water crossings;
- Determining the locations of any remaining septic systems and ensuring that they are maintained, or that the property owners connect to the sanitary sewer; and
- Implementation of recommended best management practices that encourage infiltration, such as bioretention or vegetated swales.

Recommendations that will help **reduce nutrient and sediment loading** in the Lower Caw Caw Swamp Watershed include:

- Ensuring that the existing and future stormwater infrastructure in the watershed are maintained properly;
- Encouraging all logging jobs to follow the voluntary BMPs provided by the SC Forestry Commission;
- Encouraging timber landowners to contract with loggers that have fulfilled the certification requirements from the Timber Operations Professional (TOP) program;
- Encouraging agricultural landowners to follow best practices for soil tillage, fertilization, and soil sampling;
- Keeping the vegetated buffer around the tributaries and lakes intact; and
- Conducting the recommended outreach workshops, specifically strategies that homeowners should employ to retain stormwater on their own property (e.g. rain gardens, rain barrels, and impervious surface disconnection).

Recommendations that will help **reduce organic matter** in the source water intake include:

- Regular street sweeping in residential and commercial areas to reduce the amount of debris entering the storm drain system and being conveyed downstream
- Manage nutrient inputs in the Lower Caw Caw Swamp Watershed through residential lawn care education so that runoff from these areas will not create algal blooms that contribute to organic matter in the source water intake.
- Ensuring maintenance of existing and future stormwater ponds (clearing out vegetation/debris in existing ponds)

Recommendations that will help **reduce sediment loading** into Lower Caw Caw Swamp Watershed include:

- Ensuring that the existing and future stormwater infrastructure in the watershed are maintained properly;
- Ensuring that clear-cut areas follow forestry best management practices to limit erosion;
- Ensuring that other land-disturbing activities have sufficient erosion & sediment control practices in place, and that inspections are conducted regularly throughout construction; and
- Encouraging robust riparian buffers that are not impacted by cattle.

In the longer term, it is recommended that further evaluation of the priority list of potential stormwater and stream restoration sites be undertaken in future phases of this management plan. This evaluation should include detailed estimates for permitting and preliminary construction drawings. Communication with the owners of the private stormwater retrofit and stream restoration sites identified for priority consideration should also be started. Cooperation from these landowners will vary, but landowner cooperation and collaboration are essential for program success.

A final important recommendation is continued watershed education opportunities for the community. These can be collaborative with other educational groups such as the Orangeburg Soil and Water Conservation District, Clemson Extension, Friends of the Edisto, or student groups. This can be accomplished with formal training workshops (such as Adopt-a-Stream and rainwater harvesting) or more passively through interpretive signage in greenways and boardwalks through conserved riparian areas. An educated and engaged community will make an impact in water quality.

APPENDIX A: Focus Group Meeting Summaries

Lower Caw Caw Swamp:
Forestry and Agriculture Focus Group

May 19, 2021

- Attendees
    - Katie Ellis, *Water Resources Engineer, McCormick Taylor*
    - Jason McMaster, *Environmental Services Senior Project Manager, McCormick Taylor*
    - Eric Odom, *Water Division Director, City of Orangeburg DPU*
    - Rachel Cooper, *Water Division Laboratory Supervisor, City of Orangeburg DPU*
    - Charly McConnell, *Water Resources Agent, Clemson University Cooperative Extension*
    - Nicole Correa, Livestock/Forages Agent, *Clemson University Cooperative Extension*
    - Jonathan Croft, *Agriculture Extension Agent, Clemson University Cooperative Extension*
    - Janet Steele, *Forestry and Wildlife, Clemson University Cooperative Extension*
    - John Bryan*, Project Forester, South Carolina Forestry Commission*
    - Bill Marshall, *SCDNR, program manager scenic rivers & heritage trust program*
    - Chris Workman, *SCDNR, Watershed Districts Program Manager*
    - Lisa Rigden, *Orangeburg SWCD, District Coordinator*
    - Dianne Curlee, *Orangeburg SWCD, Education Coordinator*
    - Lisa Lord, *Longleaf Alliance, Conservation Programs Director, Savannah River Clean Water Fund*
- Background Info
    - included slides from presentation
- Stakeholder Webmap
    - Reach out to County for parcel information (ownership)
    - Ag lands; minimal row crops; some hay fields; one area horse pasture (off 21 trying to sell?); not much poultry litter spread on land; bulk probably “farmlet”
    - NRCS fencing funds; filter strips; buffers
        - New residents may not be aware of programs
    - Acreage: Agriculture census vs. NLCD
    - Extension: individual landowners
        - Contacts when landowner ex
        - Orangeburg Forest Landowners Association
            - Older members; not computer savvy
    - Active logging jobs/assessments SCFC
    - Action Item: MT/DPU will work with County and GIS to overlay landowner parcel information, and current land use/land cover in webmap
- Discussion: Existing Conditions
    - Location/Size/Description of farms and silviculture
    - Existing programs for land owners
        - NRCS EQUIP
        - Best practices for production soil tillage, fertilization, soil sampling
        - Clemson stream repair for homeowners

        - Forestry Commission BMPs for logging jobs (voluntary); prevent problems before they start
        - Timber Operation Professionals certification for loggers (site prep, logging); mills require this for delivery of materials
        - American tree farm certification
        - More wood available in SC than market
            - Prices still depressed
        - Don't expect any expansion in cattle or row crop production in this particular zone (start up/input costs, etc.); corn is currently profitable, but may not remain; doesn't make sense to take other land uses (forest) into row crop production right now
        - Permits
            - Forestry: right to practice law; not needed for logging; however managing water on wetlands (Corps of Engineers)
            - Confined animals, manure management program; Clemson does education; SCDHEC does record keeping
    - Conservation
        - State/federal: could follow rare species, need a willing seller
        - Urban Orangeburg, not many landowners will put in conservation; economic expansion/build up in housing
        - Action Item: MT will reach out to Congaree Land Trust (CLT) to enquire about opportunities.
- Recommendations to include in Plan
    - NRCS regional conservation partnership program (RCPP)
        - Tries to leverage funds for multiple groups and organizations to address a concerns in an area
        - SC rural grant in PeeDee
        - Action Item: MT will reach out to contacts at SC Rural Water Association, SCRWA (James Kilgo and Sarah Nyikos)
    - Windshield surveys
    - Working with landowners
        - Recommendations for communication pathways, people, groups
        - This is not an enforcement process
        - We have the means to do it, but letting landowners know about it is the main hurdle
    - Climate Change
        - Forest management practices implemented properly along streams they are designed to be buffer strips to filter water;
        - Clemson working with drought commission
        - DNR report on climate change and impacts on wildlife/habitat in SC https://www.dnr.sc.gov/pubs/CCINatResReport.pdf
        - Situational where property is in landscape
            - Right tree in right place
            - Resilient to wildfire, windstorms, drought, disease, insects

      - Good forest management makes more resilient
- Recommendations for future/vulnerable properties to protect (discuss with CLT)
- What to include for metrics of evaluation in WBP
  - Initiation of conservation plans, BMPs
    - Start attending producer education programs
      - Don't know if anyone from watershed; need to look at parcel owner info to look for matches between names/sign in sheets
    - Attempting to/funded by NRCS cost sharing (water/soil conservation)
      - Share numbers, but not individual information
      - Did you use any of the information provided? Implement practices?
    - County land owner association meetings sign in sheets
    - Forestry: webinars, Clemson education;
    - Timber Operations Professional (TOP) Program https://www.scforestry.org/top-forestry-programs.htm

APPENDIX B: SC Natural Heritage Program Species Screening Report

South Carolina Department of

Natural Resources

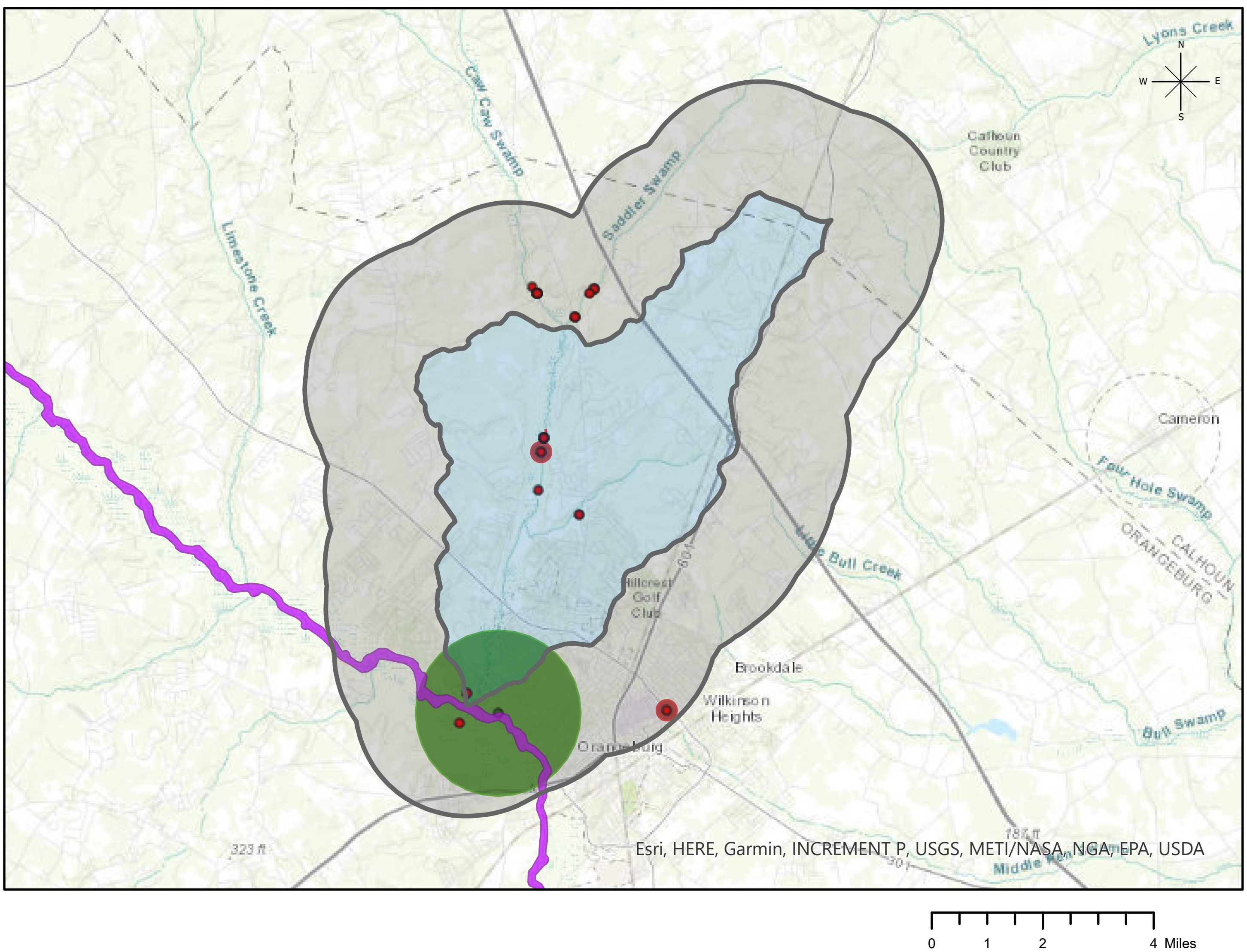
PO Box 167
Columbia, SC 29202
(803) 734-1396
speciesreview@dnr.sc.gov

Robert H. Boyles, Jr.
Director
Emily C. Cope
Deputy Director for
Wildlife and Freshwater Fisheries

Requested on Tuesday, April 20, 2021 by *Kathryn Ellis*.

Re: Request for Threatened and Endangered Species Consultation
City of Orangeburg Department of Public Utilities - Lower Caw Caw Watershed Plan
Land Protection
Orangeburg-Calhoun County, South Carolina

The South Carolina Department of Natural Resources (SCDNR) has received your request for threatened and endangered species consultation of the above named project in Orangeburg-Calhoun County, South Carolina. The following map depicts the project area and a 2 mile buffer surrounding:



South Carolina Department of

Natural Resources

Robert H. Boyles, Jr.
Director
Emily C. Cope
Deputy Director for
Wildlife and Freshwater Fisheries

This report includes the following items:
A - A report for species which intersect the project area
B - A report for species which intersect the buffer around the project area
C - A list of best management practices relevant to species near to or within the project area
D - A list of best management practices relevant to the project type
E - Instructions to submit new species observation records to the SC Natural Heritage Program

The technical comments outlined in this report are submitted to speak to the general impacts of the activities as described through inquiry by parties outside the South Carolina Department of Natural Resources. These technical comments are submitted as guidance to be considered and are not submitted as final agency comments that might be related to any unspecified local, state or federal permit, certification or license applications that may be needed by any applicant or their contractors, consultants or agents presently under review or not yet made available for public review. In accordance with its policy 600.01, Comments on Projects Under Department Review, the South Carolina Department of Natural Resources, reserves the right to comment on any permit, certification or license application that may be published by any regulatory agency which may incorporate, directly or by reference, these technical comments.

Interested parties are to understand that SCDNR may provide a final agency position to regulatory agencies if any local, state or federal permit, certification or license applications may be needed by any applicant or their contractors, consultants or agents. For further information regarding comments and input from SCDNR on your project, please contact our Office of Environmental Programs by emailing environmental@dnr.sc.gov or by visiting www.dnr.sc.gov/environmental. Pursuant to Section 7 of the Endangered Species Act, requests for formal letters of concurrence with regards to federally listed species should be directed to the USFWS.

Should you have any questions or need more information, please do not hesitate to contact our office by email at speciesreview@dnr.sc.gov or by phone at 803-734-1396.

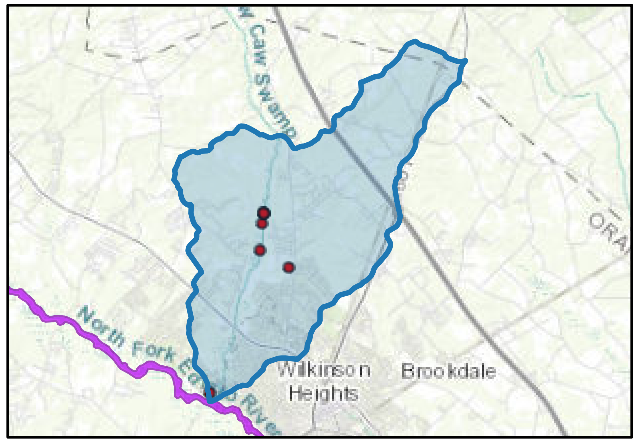
Sincerely,

Joseph Lemeris, Jr.
Heritage Trust Program
SC Department of Natural Resources

A. Project Area - Species Report

There are 10 tracked species records found within the project foot print. The following table outlines occurrences found within the project footprint (if any), sorted by listing status and species name. Please keep in mind that this information is derived from existing databases and do not assume that it is complete. Areas not yet inventoried may contain significant species or communities. You can find more information about global and state rank status definitions by visiting Natureserve's web page. Please note that certain sensitive species found on site may be listed in this table but are not represented on the map. Please contact speciesreview@dnr.sc.gov should you have further questions related to sensitive species found within the project area.

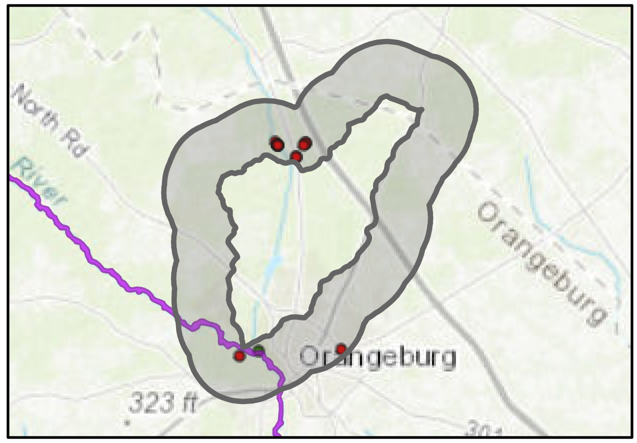
Map Credits: Esri, HERE, Garmin, USGS, NGA, EPA, USDA, NPS



Scientific Name	Common Name	G Rank	S Rank	Fed. Status	State Status	SWAP Priority
Macbridea caroliniana	Carolina Birds-in-a-nest, Carolina Macbridea	G2G3	S3	ARS: At-Risk Species	Not Applicable	High
Haliaeetus leucocephalus	Bald Eagle	G5	S3B,S3N	Bald & Golden Eagle Protection Act	ST: State Threatened	High
Haliaeetus leucocephalus	Bald Eagle	G5	S3B,S3N	Bald & Golden Eagle Protection Act	ST: State Threatened	High
Ameiurus brunneus	Snail Bullhead	G4	S3S4	Not Applicable	Not Applicable	Moderate
Anguilla rostrata	American Eel	G4	S3S4	Not Applicable	Not Applicable	Highest
Enneacanthus chaetodon	Blackbanded Sunfish	G3G4	S2S3	Not Applicable	Not Applicable	High
Notropis chalybaeus	Ironcolor Shiner	G4	S3S4	Not Applicable	Not Applicable	Moderate
Notropis chalybaeus	Ironcolor Shiner	G4	S3S4	Not Applicable	Not Applicable	Moderate
Pteronotropis stonei	Lowland Shiner	G5	S3S4	Not Applicable	Not Applicable	Moderate
Trillium pusillum var. pusillum	Carolina Least Trillium, Carolina Dwarf Trillium	G3T2	S1	Not Applicable	Not Applicable	Moderate

B. Buffer Area - Species Report

The following table outlines rare, threatened or endangered species found within 2 miles of the project footprint, arranged in order of protection status and species name. Please keep in mind that this information is derived from existing databases and do not assume that it is complete. Areas not yet inventoried may contain significant species or communities. You can find more information about global and state rank status definitions by visiting Natureserve's web page. Please note that certain sensitive species found within the buffer area may be listed in this table but are not represented on the map.



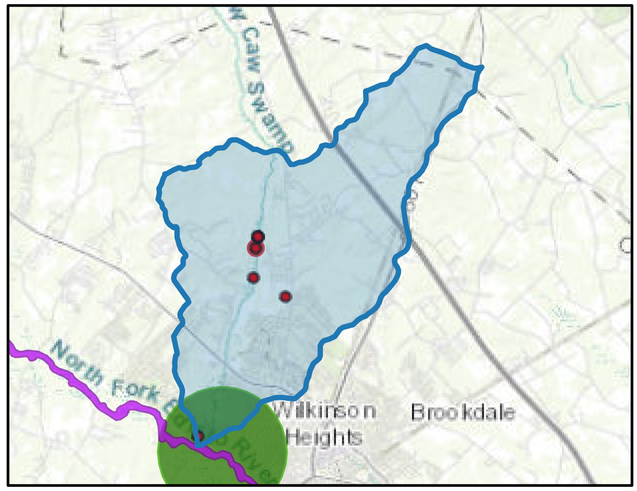
Map Credits: Esri, HERE, Garmin, USGS, NGA, EPA, USDA, NPS

Scientific Name	Common Name	G Rank	S Rank	Fed. Status	State Status	SWAP Priority	Last Obs. Date
Macbridea caroliniana	Carolina Birds-in-a-nest, Carolina Macbridea	G2G3	S3	ARS: At-Risk Species	Not Applicable	High	1900-08-03
Ameiurus brunneus	Snail Bullhead	G4	S3S4	Not Applicable	Not Applicable	Moderate	2011-06-22
Ameiurus platycephalus	Flat Bullhead	G4	S4	Not Applicable	Not Applicable	Moderate	2011-06-22
Ameiurus platycephalus	Flat Bullhead	G4	S4	Not Applicable	Not Applicable	Moderate	2008-05-29
Ameiurus platycephalus	Flat Bullhead	G4	S4	Not Applicable	Not Applicable	Moderate	1978-06-28
Anguilla rostrata	American Eel	G4	S3S4	Not Applicable	Not Applicable	Highest	2011-06-22
Anguilla rostrata	American Eel	G4	S3S4	Not Applicable	Not Applicable	Highest	2011-06-22
Anguilla rostrata	American Eel	G4	S3S4	Not Applicable	Not Applicable	Highest	2010-07-22
Ardea herodias	Great Blue Heron	G5	S5	Not Applicable	Not Applicable	Moderate	2013
Enneacanthus chaetodon	Blackbanded Sunfish	G3G4	S2S3	Not Applicable	Not Applicable	High	No Date
Etheostoma fricksium	Savannah Darter	G4	S3	Not Applicable	Not Applicable	Highest	No Date
Etheostoma serrifer	Sawcheek Darter	G5	S4	Not Applicable	Not Applicable	Moderate	1978-06-28
Notropis chalybaeus	Ironcolor Shiner	G4	S3S4	Not Applicable	Not Applicable	Moderate	1978-06-28
Notropis chalybaeus	Ironcolor Shiner	G4	S3S4	Not Applicable	Not Applicable	Moderate	1978-06-29
Notropis chalybaeus	Ironcolor Shiner	G4	S3S4	Not Applicable	Not Applicable	Moderate	1978-06-28
Procambarus hirsutus	Shaggy Crayfish	G4	S4	Not Applicable	Not Applicable	Moderate	2007-10-25
Procambarus hirsutus	Shaggy Crayfish	G4	S4	Not Applicable	Not Applicable	Moderate	No Date
Procambarus hirsutus	Shaggy Crayfish	G4	S4	Not Applicable	Not Applicable	Moderate	No Date
Pteronotropis stonei	Lowland Shiner	G5	S3S4	Not Applicable	Not Applicable	Moderate	1995-03-14
Pteronotropis stonei	Lowland Shiner	G5	S3S4	Not Applicable	Not Applicable	Moderate	1978-06-28
Pteronotropis stonei	Lowland Shiner	G5	S3S4	Not Applicable	Not Applicable	Moderate	1978-06-28
Trillium pusillum var. pusillum	Carolina Least Trillium, Carolina Dwarf Trillium	G3T2	S1	Not Applicable	Not Applicable	Moderate	No Date

C. Species Best Management Practices (1 of 1)

SCDNR offers the following comments and best management practices (BMPs) regarding this project's potential impacts to species of concern which may be found on or near to the project area. Please contact speciesreview@dnr.sc.gov should you have further questions with regard to survey methods, consultation, or other species-related concerns.

Map Credits: Esri, HERE, Garmin, USGS, NGA, EPA, USDA, NPS

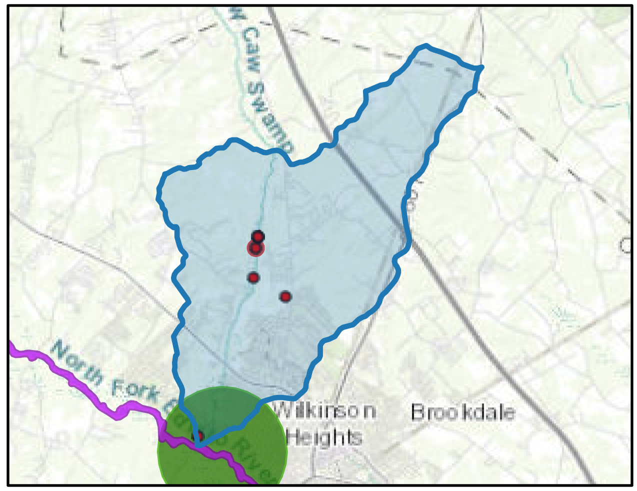


A river near to your project area is designated critical habitat for Atlantic sturgeon under the Endangered Species Act. SCDNR recommends consultation with the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NMFS) to determine if construction activities are likely to negatively impact spawning or foraging sturgeon.
An active bald eagle nest(s) is known to occur within or near to your project area. Surveys during the nesting season (October through May) to rule out nests in the project area are advised to avoid negative impacts to bald eagles. Eagle nests may occur in areas which have not yet been surveyed where suitable habitat is present, as the SCDNR does not survey every nest every year. Bald eagles are a state listed threatened species and are federally protected under the Bald and Golden Eagle Protection Act. If bald eagle nests are found to be within 660 feet of the project area, please consult with the U.S. Fish and Wildlife Service before proceeding with any construction activities.
In the interest of preserving plant diversity, the South Carolina Plant Conservation Alliance performs native plant rescues in order to protect and preserve our diversity of native plants. If you are interested in assisting with this important endeavor please contact Mrs. April Punsalan at (843) 727-4707 ext. 218, or by email: scpca@lists.fws.gov before any development occurs onsite. There may be plants of interest on the project site that the Alliance would like to preserve.
Species in the above table with SWAP priorities of High, Highest or Moderate are designated as having conservation priority under the South Carolina State Wildlife Action Plan (SWAP). SWAP species are those species of greatest conservation need not traditionally covered under any federal funded programs. Species are listed in the SWAP because they are rare or designated as at-risk due to knowledge deficiencies; species common in South Carolina but listed rare or declining elsewhere; or species that serve as indicators of detrimental environmental conditions. SCDNR recommends that appropriate measures should be taken to minimize or avoid impacts to the aforementioned species of concern.

D. Project Best Management Practices (1 of 2)

SCDNR offers the following comments and best management practices (BMPs) regarding this project's potential impacts to natural resources within or surrounding the project area. Please contact our Office of Environmental Programs at environmental@dnr.sc.gov should you have further questions with regard to best management practices related to this project area.

Map Credits: Esri, HERE, Garmin, USGS, NGA, EPA, USDA, NPS



If this project is associated with the Federal Government and the project area is or once was used as farmland, we recommend that consultation occur with the U.S. Department of Agriculture's Natural Resource Conservation Service (NRCS) per the Farmland Protection Policy Act; areas of the site are classified as prime farmland or farmland of statewide importance.

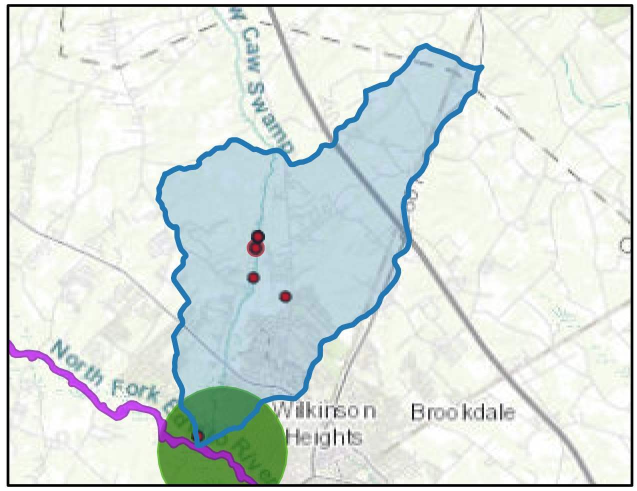
- All necessary measures must be taken to prevent oil, tar, trash and other pollutants from entering the adjacent offsite areas/wetlands/ water.
- Once the project is initiated, it must be carried to completion in an expeditious manner to minimize the period of disturbance to the environment.
- Upon project completion, all disturbed areas must be permanently stabilized with vegetative cover (preferable), riprap or other erosion control methods as appropriate.
- The project must be in compliance with any applicable floodplain, stormwater, land disturbance, shoreline management guidance or riparian buffer ordinances.
- Prior to beginning any land disturbing activity, appropriate erosion and siltation control measures (e.g. silt fences or barriers) must be in place and maintained in a functioning capacity until the area is permanently stabilized.
- Materials used for erosion control (e.g., hay bales or straw mulch) will be certified as weed free by the supplier.
- Inspecting and ensuring the maintenance of temporary erosion control measures at least:
    a. on a daily basis in areas of active construction or equipment operation;
    b. on a weekly basis in areas with no construction or equipment operation; and
    c. within 24 hours of each 0.5 inch of rainfall.
- Ensuring the repair of all ineffective temporary erosion control measures within 24 hours of identification, or as soon as conditions allow if compliance with this time frame would result in greater environmental impacts.
- Land disturbing activities must avoid encroachment into any wetland areas (outside the permitted impact area).Wetlands that are unavoidably impacted must be appropriately mitigated.
- Your project may require a Stormwater Permit from the SC Department of Health & Environmental Control, please visit https://www.scdhec.gov/environment/water-quality/stormwater

- If clearing must occur, riparian vegetation within wetlands and waters of the U.S. must be conducted manually and low growing, woody vegetation and shrubs must be left intact to maintain bank stability and reduce erosion.
- Construction activities must avoid and minimize, to the greatest extent practicable, disturbance of woody shoreline vegetation within the project area. Removal of vegetation should be limited to only what is necessary for construction of the proposed structures.
- Where necessary to remove vegetation, supplemental plantings should be installed following completion of the project. These plantings should consist of appropriate native species for this ecoregion.

D. Project Best Management Practices (2 of 2)

SCDNR offers the following comments and best management practices (BMPs) regarding this project's potential impacts to natural resources within or surrounding the project area. Please contact our Office of Environmental Programs at environmental@dnr.sc.gov should you have further questions with regard to best management practices related to this project area.

Map Credits: Esri, HERE, Garmin, USGS, NGA, EPA, USDA, NPS



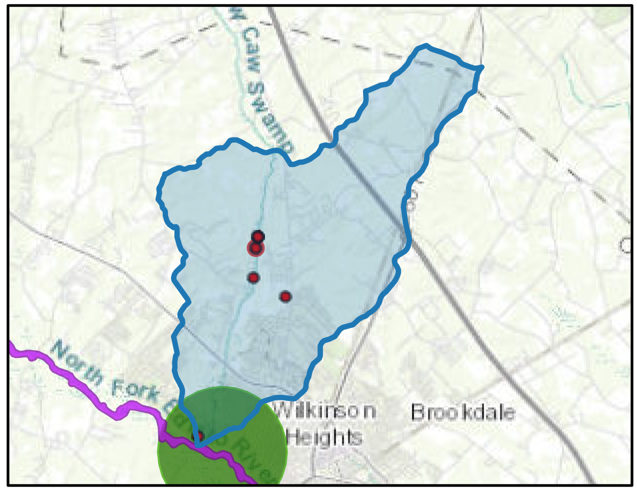
- Review of available data, National Hydrography Dataset, indicates that streams or waters of the United States are present within your project area. These areas may require a permit from the U.S. Army Corps of Engineers (USACE), as well as a compensatory mitigation plan. SCDNR advises that you consult with the USACE Regulatory to determine if jurisdictional waters are present and if a permit and mitigation is required for any activities impacting these areas. For more information, please visit their website at www.sac.usace.army.mil/Missions/Regulatory. Additionally, a 401 Water Quality Certification or a State Navigable Waters permit may also be required from the SC Department of Health & Environmental Control. For more information, please visit the following websites:
    - https://www.scdhec.gov/environment/water-quality/water-quality-certification-section-401-clean-water-act
    - https://www.scdhec.gov/environment/water-quality/navigable-waters
- Excavation/Construction activities must not occur during fish spawning season from March through June due to its negative impacts on eggs and reproduction activities.
- If clearing must occur, riparian vegetation within wetlands and waters of the U.S. must be conducted manually and low growing, woody vegetation and shrubs must be left intact to maintain bank stability and reduce erosion.
- Construction activities must avoid and minimize, to the greatest extent practicable, disturbance of woody shoreline vegetation within the project area. Removal of vegetation should be limited to only what is necessary for construction of the proposed structures.
- Where necessary to remove vegetation, supplemental plantings should be installed following completion of the project. These plantings should consist of appropriate native species for this ecoregion.

Your project area includes a FEMA special flood hazard area and may require a permit from the County National Floodplain Insurance Program Manager before impacts occur to aquatic resources and the associated floodplains on site. Please refer to https://www.dnr.sc.gov/water/flood/documents/nfipadmindirectory.pdf to find your appropriate contact information.

E. Instructions for Submitting Species Observations

The SC Natural Heritage Dataset relies on continuous monitoring and surveying for species of concern throughout the state. Any records of species of concern found within this project area would greatly benefit the quality and comprehensiveness of the statewide dataset for rare, threatened and endangered species. Below are instructions for how to download the SC Natural Heritage Occurrence Reporting Form through the Survey123 App.

Map Credits: Esri, HERE, Garmin, USGS, NGA, EPA, USDA, NPS



Instructions for accessing the SC Natural Heritage Occurrence Reporting Form

For use in a browser (on your desktop/PC):

1) Follow http://bit.ly/scht-reporting-form-point
2) Select 'Open in browser'
3) The form will open and you can begin entering data!

This method of access will also work on a browser on a mobile device, but only when connected to the internet. To use the form in the field without relying on data/internet access, follow the steps below.

For use on a smartphone or tablet using the field app:

1) Download the Survey123 App from the Google Play store or the Apple Store. This app is free to download. Allow the app to use your location.

2) No need to sign in. However, you will need to provide the app with our Heritage Trust GIS portal web address. You will only need to do this once: (this is a known bug with ESRI's software, and future releases of the form should not require the below steps. Bear with us in the meantime!).

   a. Tap 'Sign in'
   b. Tap the settings (gear symbol) in the upper right corner
   c. Tap 'Add Portal'
   d. After the 'https://', type schtportal.dnr.sc.gov/portal
   e. Tap 'Add Portal'
   f. Tap the back-arrow icon (upper left corner) twice to return to the main sign in page.

3) Use the camera app (or other QR Reader app) to scan the QR code on this page from your smartphone or tablet. Click on the 'Open in the Survey123 field app'. This will prompt a window to allow Survey123 to download the SC Natural Heritage Occurrence Reporting Form. Select 'Open.'

4) The form will automatically open in Survey123, and you can begin entering data! This form will stay loaded in the app on your device until you manually delete it, and you can submit as many records as you like.

APPENDIX C: Historical Overview of Watershed

2022 Watershed Plan Historical Overview
Eric Powell, Orangeburg County Historical Society

Orangeburg, a beautiful and robust city, has a long and eventful history. Significant events important in the development of America took place in South Carolina and Orangeburg from its beginnings. Those events helped shape the outcome of our State and Country. But those events would never have been possible had it not been for the perfect combination of a hard-working people, and fertile land nourished by an abundance of natural waterways found in and around Orangeburg.

The area's earliest inhabitants were the Native American tribes of the Cherokee, Edisto, Catawba, and Santee. They roamed and seasonally settled in the Orangeburg area and were generally amicable to other tribes. Each brought specialized knowledge of trapping, toolmaking, pottery, and other early skills, much of which depended on our local waterways. A small number of migrant white traders entered the area in the late 1600s, trading with the Native American groups for needed or prized wares. The earliest settler came in 1704 and settled a little north of Orangeburg near Saint Matthews.

To encourage settlement of the interior of Carolina, the General Assembly (British Rule) in 1730 established eleven townships, of which Orangeburgh was one, laid out along the Pon Pon or Edisto River near where the Caw Caw swamp joins the river.

The first groups of settlers, mainly Swiss and Germans, came to Orangeburgh township in 1735, 1736 and 1737, although there were already a few scattered families living through the area. Others of English, Irish, Scotch and Dutch origins joined the Swiss and Germans throughout the latter half of the 1700s. Government incentives of bounties and land grants along with the fertile soil and nearby waterways made settling in Orangeburg attractive. Many immigrants settled on or near the waterways of the Edisto, Caw Caw swamp, Four Holes swamp and all the tributaries because the waterways were the primary means of transportation to and from Charleston for goods.

The settlers were soon prosperous, taking advantage of the abundant forests and fertile lands, trading in lumber and crops and shipping their goods to Charlestown and ultimately much of Europe. Indigo (a dye) was one highly prized product exported early on, along with rice and other grains. Most of these commodities needed easy access to water for irrigation or transportation, and the waterways became vital to the people's prosperity.

During the Revolutionary War, Orangeburg was a prized stronghold, changing hands repeatedly, with General Thomas Sumter and Lord Rawdon personally taking interest and control at various times. In 1781 the last important battle of the war was fought near Orangeburg at Eutaw Springs with General Green defeating the British Lt Colonel Stewart.

By the early 1800s, settlers had claimed virtually all the land in and around Orangeburgh. The town was the judicial center of a now large Orangeburgh District, extending from Lexington and

Aiken counties to Bamberg farther south. Although overland roads now connected the district, the waterways still were an important means of transportation of the goods cultivated here. All along the waterways were mills for lumber and grain milling and trade with Charleston and the rest of the western world.

In the mid 1800s, the economy was booming. Tragically, much of the production (and resulting prosperity) throughout Orangeburgh was performed by enslaved Americans. The injustice and inhumanity of this practice along with increasing tariffs and taxes from the new American government precipitated the Civil War conflict between the southern states and the north.

The Civil War ravaged the agricultural production with the loss of a large percentage of the men and the strain on the resources of the remaining families. The burning of vast tracts of land as the Union army marched through at the end of the war also ended much of the area's timber prosperity. These setbacks, coupled with the loss of so much unpaid labor by the freeing of the enslaved, left post-war Orangeburgh struggling but not broken.

Slowly over the years after the war, the area recovered to a level of general prosperity. The formerly enslaved population now having access to their own land and commerce helped this recovery by bringing many more participants in the market, although smaller participants than before, thus stimulating growth in all areas of agriculture. Surprisingly, the recovery years were relatively short due to hard work and the abundance of good soils and abundant water for irrigation from the many streams, tributaries, and other waterways that permeate the Orangeburg area.

In the late 1800s and early 1900s, agriculture was again booming as the equilibrium between labor and market price adjusted and hard work prevailed. The prevalence of mills and other water powered tools eventually gave way to mechanization as electricity became more readily available. And with electricity came the ability to move water longer distances which spurred even more growth in the agricultural output. As Orangeburg moved into the 1950s, the economy boomed.

In the mid 1900s however, another economic force began to encroach on the agriculture: industrial production. Chemical, meat, and lumber processing were some of the industrial plants that began to expand around Orangeburg, all depending in some way on the same waterways that had been the lifeblood of the early settlers and the planters throughout the agricultural boom of the previous century.

Today, the economic climate has changed again with the abundance of small and medium farms replaced by larger conglomerated farms, with mechanization of virtually all the farm labor and the ever more important need for efficiency. Industry has continued to grow also, necessitating a denser, growing population. As the population has grown, land previously used for agriculture is being repurposed for housing and supporting business and government operations. All of these are putting larger demands on our water resources as the need for drinking water and industrial water increases alongside the existing agricultural uses.

Throughout the last two hundred years the area has developed and there is a significant base of history in Orangeburg and the rest of the county. Many of the original tracts of land granted to immigrants are still in the hands of descendants. In some cases, original homes and other structures have survived since the early 1800s. Sites of historical battles and the valiant defense of home and property are scattered around the city and county, some commemorated, some not. But the most important and most intact history we have today is the legacy of the people and the land. Most Orangeburg people can trace their ancestry back to those original settlers either as a direct line or through enslaved ownership. The underlying land and waterways of the area are much the same today as they were two hundred years ago. The symbiosis of the people, the land and the water has supported Orangeburg from its beginnings as a Native American territory into the twenty-first century's mix of farming, industry and population support. Protecting the historic and present value of that land and waterways must be a prime goal of any plan to support the overlaying population.

APPENDIX D: Cost Summaries for Proposed Projects

QUANTITY AND COST BREAKDOWN

Prepared By : McCormick Taylor, Inc.

Project: Caw Caw Watershed Based Plan BMP Estimates
Scenario #1:

Date: December 31,2021

ITEM NO	ITEM DESCRIPTION	UNITS	QUANTITY	UNIT PRICE	TOTAL COST
	Ditch to Stream Conversion				
1001	Site Survey	LS	1	$ 1,200.00	$ 1,200.00
1002	Stream Design	LS	1	$ 3,000.00	$ 3,000.00
1003	Construction staking	LS	1	$ 1,200.00	$ 1,200.00
1004	On-site stream design consultant	LS	1	$ 2,000.00	$ 2,000.00
1005	Track hoe operator	LS	1	$ 1,600.00	$ 1,600.00
1006	Mini operator	LS	1	$ 1,600.00	$ 1,600.00
1007	Dump truck driver	LS	1	$ 1,200.00	$ 1,200.00
1008	Plants	LS	1	$ 22,000.00	$ 22,000.00
1009	Plant Installers	LS	1	$ 2,000.00	$ 2,000.00
1010	Trees	LS	1	$ 17,250.00	$ 17,250.00
1011	Tree installer	LS	1	$ 700.00	$ 700.00
1012	Dump truck rental	LS	1	$ 1,036.00	$ 1,036.00
1013	308 Excavator Rental	LS	1	$ 1,827.00	$ 1,827.00
1014	305 Excavator Rental	LS	1	$ 1,482.00	$ 1,482.00
1015	Skid steer	LS	1	$ 1,482.00	$ 1,482.00
1016	Hydroseeding	LS	1	$ 1,000.00	$ 1,000.00
	0	0			$ -
	0	0			$ -
	0	0			$ -
	Sub-Total		**SUBTOTAL**		$ 60,577.00
			CONTINGENCY	10%	$ 6,057.70
			TOTAL ESTIMATED PROJECT CONSTRUCTION COST		**$ 66,634.70**
	Engineering and Professional Services				
	Permitting consulting	LS	1	$ 3,000.00	$ 3,000.00
					$ -
					$ -
	Construction Engineering and Inspection Sub-Total		**SUBTOTAL**		$ 3,000.00
			TOTAL ESTIMATED PROJECT COST		**$ 69,634.70**

Project is located at the Orangeburg Preparatory School located at 168 Prep Street, Orangeburg SC, 29118. The existing feature is a 675-foot-long eroding stormwater ditch flowing Northwest to Southeast, crossing Willington Road. The project involves converting the existing linear ditch into a meandering stream. In addition to earth moving and excavation of the channel, the stream banks will be bolstered with “live stakes” and the stream bed will contain __. To create a fully functioning riparian buffer and wildlife habitat, trees, forbs, and understory species will also be planted. The new stream will be designed in accordance with the “Rosgen Stream Restoration Design National Engineering Handbook”.

Other sources consulted for this estimate and design functionality include the Center for Watershed Protections “The Four Horseman of Stream Restoration Sustainability” and the “NRCS Specification Guide Sheet for Riparian Forest Buffers”.

Figure F-1: Figure depicts Scenario 1 (Ditch to Stream Conversion) and Scenario 6 (Stream Restoration).

QUANTITY AND COST BREAKDOWN

Prepared By : McCormick Taylor, Inc.

Project: Caw Caw Watershed Based Plan BMP Estimates
Scenario #2:

Date: December 31,2021

ITEM NO	ITEM DESCRIPTION	UNITS	QUANTITY	UNIT PRICE	TOTAL COST
Buffer Plantings					
1001	Trees	LS	460	$ 125.00	$ 57,500.00
1002	Tree staking	LS	1	$ 1,600.00	$ 1,600.00
1003	Vegetation planting	LS	1	$ 39,550.00	$ 39,550.00
1004	TRAFFIC CONTROL	LS	1	$ 15,000.00	$ 15,000.00
1035	0	0			$ -
1036	0	0			$ -
1037	0	0			$ -
1038	0	0			$ -
1039	0	0			$ -
1040	0	0			$ -
1041	0	0			$ -
1042	0	0			$ -
1043	0	0			$ -
1044	0	0			$ -
1045	0	0			$ -
Sub-Total			**SUBTOTAL**		$ 113,650.00
			CONTINGENCY	10%	$ 11,365.00
TOTAL ESTIMATED PROJECT CONSTRUCTION COST					**$ 125,015.00**
Engineering and Professional Services					
		LS	1		$ -
		LS	1		$ -
					$ -
Construction Engineering and Inspection Sub-Total			**SUBTOTAL**		$ -
TOTAL ESTIMATED PROJECT COST					**$ 125,015.00**

The riparian buffer planting areas were determined based on need and potential to have the greatest immediate impact on downstream water quality. Area One is 1,100 in length and is adjacent to the Ocains Pond, off of US 21. Area Two is approximately 1,930 feet in length, and is adjacent to the Caw Caw Swamp, west of the intersection of Camp Road and Willington Road. Area 3 is approximately 4,950 feet in length and is located south of the Wannamaker Catfish Pond. Tree species would reflect habitat needs and existing growing conditions. The National Oceanic and Atmospheric Administration (NOAA) “Nature-Based Solutions” reference sheet was consulted on this estimate.

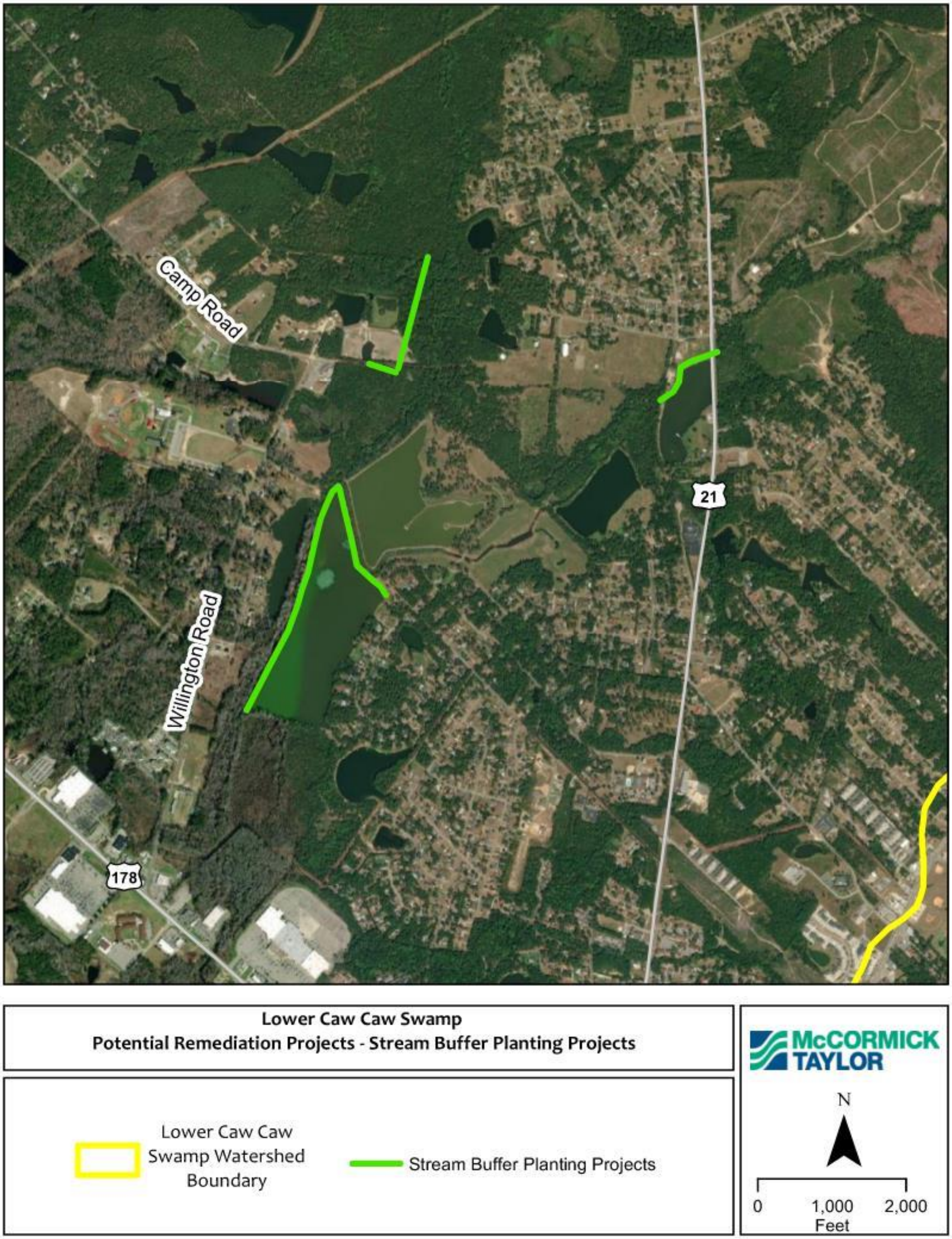


Figure F-2: Stream Buffer Planting Projects

QUANTITY AND COST BREAKDOWN

Prepared By : McCormick Taylor, Inc.

Project: Caw Caw Watershed Based Plan BMP Estimates
Scenario #3:

Date: December 31,2021

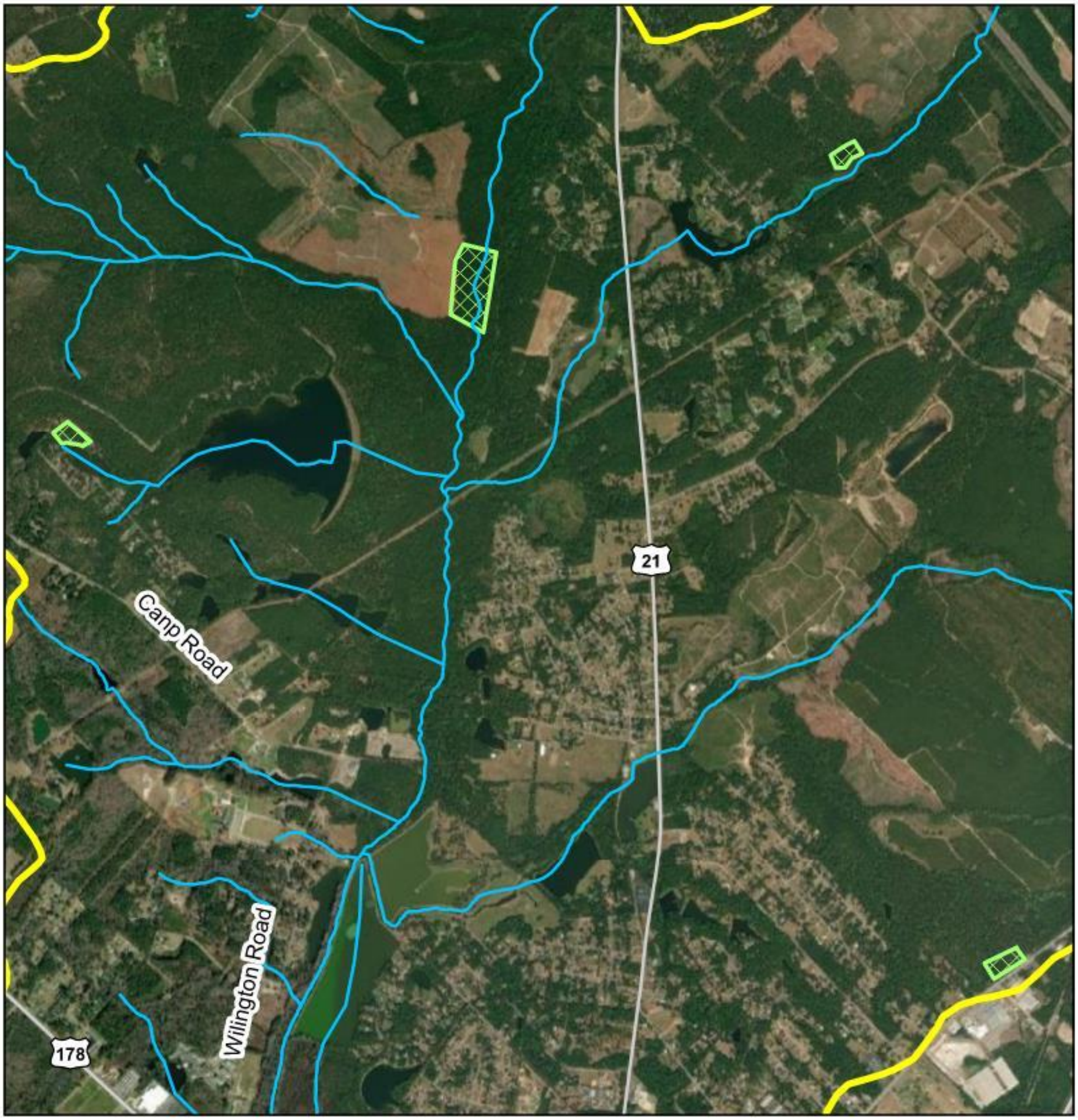
ITEM NO	ITEM DESCRIPTION	UNITS	QUANTITY	UNIT PRICE	TOTAL COST
Livestock Fencing and Riparian Buffer					
1001	Fence and installation	LS	1	$ 7,154.00	$ 7,154.00
1002	Riparian Buffer Planting	0	1	$ 13,125.00	$ 13,125.00
	0	0			$ -
	0	0			$ -
	0	0			$ -
Sub-Total			**SUBTOTAL**		$ 20,279.00
			CONTINGENCY	10%	$ 2,027.90
TOTAL ESTIMATED PROJECT CONSTRUCTION COST					**$ 22,306.90**
Engineering and Professional Services					
					$ -
					$ -
					$ -
Construction Engineering and Inspection Sub-Total			**SUBTOTAL**		$ -
TOTAL ESTIMATED PROJECT COST					**$ 22,306.90**

This suggested project is based on existing conditions of the Sanford Farm located north of Francis Street, and its proximity to the Turkey Hill Branch. There are approximately 30 head of cattle that have full access to an area of Turkey Hill Branch that is having deleterious effects to downstream water quality. This project is proposing to plant a riparian buffer around the Turkey Hill Branch and install a livestock fence to prevent the cattle from having access to the waterbody.

Figure F-3: Livestock Fencing and associated Buffer Planting.

QUANTITY AND COST BREAKDOWN					
Prepared By : McCormick Taylor, Inc.					
Project:	Caw Caw Watershed Based Plan BMP Estimates	**Date:**	December 31,2021		
	Scenario #4:				
ITEM NO	**ITEM DESCRIPTION**	**UNITS**	**QUANTITY**	**UNIT PRICE**	**TOTAL COST**
Clear Cut Rehabilitation					
1001	Grading and debris removal per acre	LS	29	$ 5,000.00	$ 145,000.00
1002	Hydroseeding per acre	LS	29	$ 2,500.00	$ 72,500.00
1043	0	0			$ -
1044	0	0			$ -
1045	0	0			$ -
Sub-Total			**SUBTOTAL**		$ 217,500.00
			CONTINGENCY	10%	$ 21,750.00
TOTAL ESTIMATED PROJECT CONSTRUCTION COST					**$ 239,250.00**
Engineering and Professional Services					
					$ -
					$ -
					$ -
Construction Engineering and Inspection Sub-Total			**SUBTOTAL**		$ -
TOTAL ESTIMATED PROJECT COST					**$ 239,250.00**

These four locations were selected because they were clear-cut and due to their proximity to water bodies. The total area of the four locations is 29 acres. To convert these areas from active erosion sites and potential sediment contributors to stabilized sites, the soil surface will need to be graded and the debris removed to attempt to restore the topographical conditions to pre-clear-cut conditions. Tree planting has not been considered at this point. The plan is only to hydroseed the areas using native forbs and wildflowers.



Lower Caw Caw Swamp
Potential Remediation Projects - Clear Cut Planting Areas

McCORMICK TAYLOR

Lower Caw Caw Swamp Watershed Boundary

NHD Streams

Clear Cut Planting Areas

N

0 1,500 3,000
Feet

Figure F-4: Clear Cut Planting Areas

QUANTITY AND COST BREAKDOWN					
Prepared By : McCormick Taylor, Inc.					
Project:	Caw Caw Watershed Based Plan BMP Estimates	**Date:**	December 12,2021		
	Scenario #5:				
ITEM NO	**ITEM DESCRIPTION**	**UNITS**	**QUANTITY**	**UNIT PRICE**	**TOTAL COST**
Remove Stockpiled Soils and Wetland Re-hab (Church)					
1001	Dump Truck Rental	LS	1	$ 1,036.00	$ 1,036.00
1002	Dump Truck Driver	LS	1	$ 600.00	$ 600.00
1003	Track hoe	LS	1	$ 1,827.00	$ 1,827.00
1004	Track hoe operator	LS	1	$ 800.00	$ 800.00
1005	Laborers	LS	10	$ 224.00	$ 2,240.00
1006	Site supervisor	LS	1	$ 735.00	$ 735.00
1042	0	0			$ -
1043	0	0			$ -
1044	0	0			$ -
1045	0	0			$ -
Sub-Total			**SUBTOTAL**		$ 7,238.00
			CONTINGENCY	10%	$ 723.80
TOTAL ESTIMATED PROJECT CONSTRUCTION COST					**$ 7,961.80**
Engineering and Professional Services					
					$ -
					$ -
					$ -
Construction Engineering and Inspection Sub-Total			**SUBTOTAL**		$ -
TOTAL ESTIMATED PROJECT COST					**$ 7,961.80**

This project is an attempt to remove existing stockpiles of fill soil from parking lot of the Right Direction Christian Center on Willington Drive, NE. The existing stockpiles are eroding downhill into the adjacent stream and wetland.

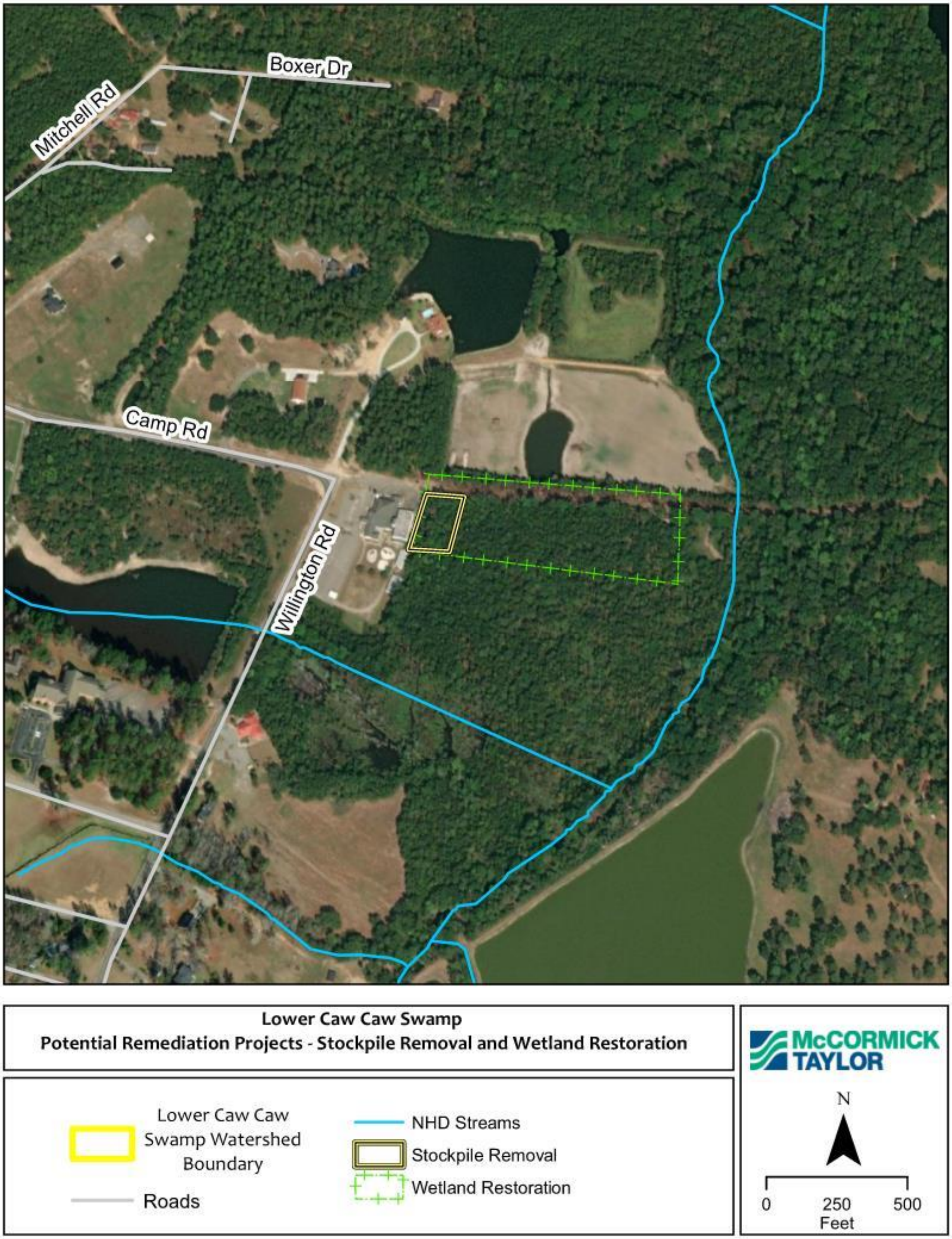


Figure F-5: Soil Stockpile Removal and Wetland Restoration

QUANTITY AND COST BREAKDOWN

Prepared By : McCormick Taylor, Inc.

Project: Caw Caw Watershed Based Plan BMP Estimates **Date:** December 31,2021

Scenario #6:

ITEM NO	ITEM DESCRIPTION	UNITS	QUANTITY	UNIT PRICE	TOTAL COST
	Stream Restoration				
1001	Stream restoration construction	LS	900	$ 1,000.00	$ 900,000.00
1002					
1003					
1004	0	0			$ -
1005	0	0			$ -
1006	0	0			$ -
1007	0	0			$ -
1008	0	0			$ -
1009	0	0			$ -
1010	0	0			$ -
	Sub-Total		**SUBTOTAL**		$ 900,000.00
			CONTINGENCY	10%	$ 90,000.00
	TOTAL ESTIMATED PROJECT CONSTRUCTION COST				**$ 990,000.00**
	Engineering and Professional Services				
					$ -
					$ -
					$ -
	Construction Engineering and Inspection Sub-Total		**SUBTOTAL**		$ -
	TOTAL ESTIMATED PROJECT COST				**$ 990,000.00**

The stream targeted for restoration is downstream of the ditch to stream conversion project, across from Orangeburg Prep (Prep Street). The estimated length of restoration is 900 linear feet. The quantification formula for this price estimate was borrowed from “The Center for Watershed Protection”, guidance document “The Four Horsemen of Stream Restoration”. This estimate quantifies the restoration of 1 linear foot of stream at $1,000.

Please refer to Figure F-1 for a visual depiction of this proposed project.

QUANTITY AND COST BREAKDOWN

Prepared By : McCormick Taylor, Inc.

Project: Caw Caw Watershed Based Plan BMP Estimates Scenario #7:

Date: December 31,2021

ITEM NO	ITEM DESCRIPTION	UNITS	QUANTITY	UNIT PRICE	TOTAL COST
Impervious Surface Conversions					
1001	Orangeburg Prep (Prep St)	LS	3	$ 40,000.00	$ 128,000.00
1002	Prince of Orange Mall	LS	33	$ 40,000.00	$ 1,332,000.00
1003	Orangeburg Prep (North Road)	LS	5	$ 40,000.00	$ 204,000.00
1004	Sheridan Elementary	LS	4	$ 40,000.00	$ 160,000.00
1005	Marshal Elementary	LS	2	$ 40,000.00	$ 96,000.00
1006	First Baptist	LS	3	$ 40,000.00	$ 132,000.00
	0	0			$ -
	0	0			$ -
	0	0			$ -
	0	0			$ -
	0	0			$ -
	0	0			$ -
	0	0			$ -
Sub-Total			**SUBTOTAL**		$ 2,052,000.00
			CONTINGENCY	10%	$ 205,200.00
TOTAL ESTIMATED PROJECT CONSTRUCTION COST					**$ 2,257,200.00**
Engineering and Professional Services					

These selected sites were considered due to their size, proximity to waterbodies, and their existing functionality.

This estimate quantifies 1 acre of Grayfield Conversion at $40,000 and was adopted from the Conservation Research Institutes "Changing Cost Perceptions: An Analysis of Conservation Development"; 2005.

Figure F-6: Potential Grayfield Conversions (water capture/infiltration projects for existing commercial infrastructure).

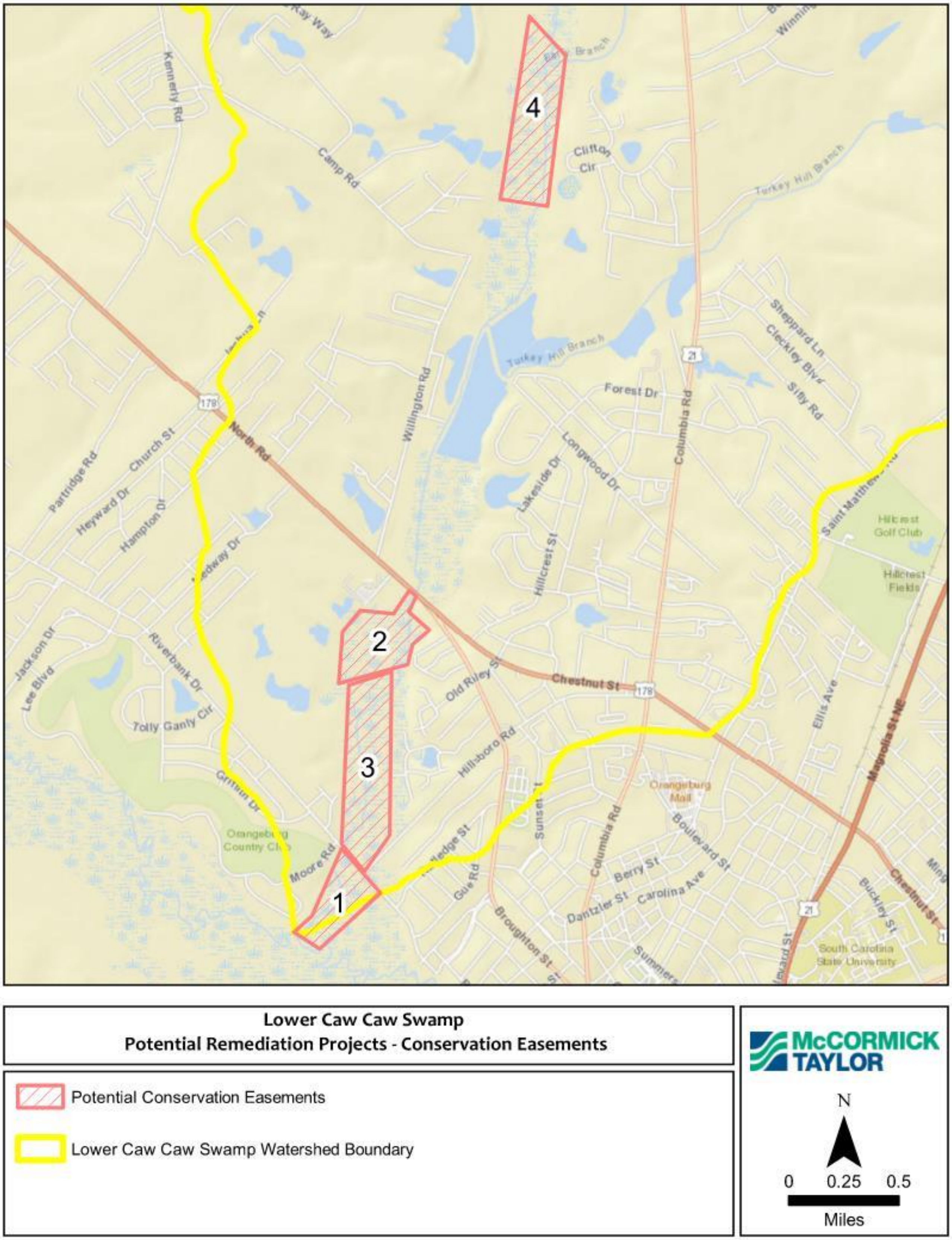


Figure F-7: Potential tracts for Conservation Easements. Cost sheet not available as properties need to be appraised.