Total Maximum Daily Load Document

Cattail Branch, Black Creek, and Tributaries

Stations RS-16312 and PD-251

Hydrologic Unit Codes 030402010601, 030402010602, 030402010603, 030402010604, 030402010606

Escherichia coli Bacteria Pathogen Indicator

March 2021

Bureau of Water

Technical Document Number: 003-2021

dhec

Healthy People. Healthy Communities.

Prepared by Susan Waldner

On reverse: Left: Little Black Creek at Highway 268

Upper Right: Longleaf Pine and Turkey Oak typical of the Sandhills Ecoregion

Lower Right: Impoundment on Ham Creek in Carolina Sandhills National Wildlife Refuge

Abstract

§303(d) of the Clean Water Act (CWA) and EPA's *Water Quality Planning and Management* Regulations (40 CFR Part 130) require states to develop total maximum daily loads (TMDLs) for water bodies that are included on the §303(d) list of impaired waters. A TMDL is the maximum amount of pollutant a waterbody can assimilate while meeting water quality standards for the pollutant of concern. All TMDLs include a waste load allocation (WLA) for any National Pollutant Discharge Elimination System (NPDES)-permitted discharges, a load allocation (LA) for all nonpoint sources, and an explicit and/or implicit margin of safety (MOS). This report describes the development of an *Escherichia coli (E. coli)* TMDL for impaired water quality monitoring (WQM) stations RS-16312 on Cattail Branch and PD-251 on Black Creek. These sites are included as impaired for recreational uses on the State's final 2018 303(d) list due to excessive *E. coli* bacteria. *E. coli* counts exceeded the recreational use water quality standard at RS-16312 50% of the time. Considering data collected beginning in 2013, E. coli counts exceeded the water quality standard at PD-251 24.6% of the time. The watersheds draining to these sites are located in Chesterfield County. Probable sources of fecal contamination include direct and indirect loading from urban and suburban runoff, failing septic systems, surrounding wildlife, and agricultural activities.

The load-duration curve methodology was used to calculate existing and TMDL loads for each impaired station. Existing pollutant loadings and proposed TMDL reductions for critical hydrologic conditions are presented in Table Ab-1. Critical hydrologic conditions were defined as either moist, mid-range, or dry depending on which condition demonstrated the highest load reductions necessary to meet water quality standards. To achieve the target load (slightly less than the maximum load due to the margin of safety) for the TMDL watersheds, reductions in the existing loads of 89% at RS-16312 and 50% at PD-251 will be necessary.

For SCDOT, existing and future NPDES MS4 permittees, compliance with terms and conditions of their NPDES permit is effective implementation of the WLA to the Maximum Extent Practicable (MEP) and demonstrates consistency with the assumptions and requirements of the TMDL. For existing and future NPDES construction and industrial stormwater permittees, compliance with terms and conditions of their permit is effective implementation of the WLA. Required load reductions in the LA portion of this TMDL can be implemented through voluntary measures and are eligible for CWA §319 grants.

The South Carolina Department of Health and Environmental Control (SCDHEC) recognizes that adaptive management/implementation of these TMDLs might be needed to achieve the water quality standard and we are committed towards targeting the load reductions to improve water quality in the Cattail Branch and Black Creek watersheds. As additional data and/or information become available, it may become necessary to revise and/or modify the TMDL target accordingly.

Table Ab1. Total Maximum Daily Loads for Cattail Branch, Black Creek and Tributaries

	Existing Load	TMDL	Margin of Safety	Waste Load Allocation (WLA)			Load Allocation (LA)	
Station	***E. Coli* (MPN/day)**	***E. coli* (MPN/day)**	***E. coli* (MPN/day)**	**Continuous Source[1] (MPN/day)**	**Non-Continuous Sources[2,3] (% Reduction)**	**Non-Continuous SCDOT[3,4] (% Reduction)**	***E. coli* (MPN/day)**	**% Reduction to Meet LA[3]**
PD-251	2.24E+12	1.18E+12	5.74E+10	--- (see note 1)	50%	50%	1.12E+12	50%
RS-16312	2.10E+11	4.48E+10	2.18E+09	1.98E+10 (see note 1)	89%	89%	2.28E+10	89%

1. WLAs are expressed as a daily maximum. Existing and future continuous discharges are required to meet the prescribed loading for the pollutant of concern. Future loadings will be developed based upon permitted flow and an allowable permitted maximum *E. coli* concentration of 349 MPN/100ml.

2. Percent reduction applies to all NPDES-permitted stormwater discharges, including current and future MS4, construction and industrial discharges covered under permits numbered SCS & SCR. Stormwater discharges are expressed as a percentage reduction due to the uncertain nature of stormwater discharge volumes and recurrence intervals. Stormwater discharges are required to meet percentage reduction or the existing instream standard for pollutant of concern in accordance with their NPDES Permit.

3. Percent reduction applies to existing instream *E. coli*.

4. By implementing the best management practices that are prescribed in either the SCDOT annual SWMP or the SCDOT MS4 permit to address fecal coliform bacteria or *E. coli*, SCDOT will comply with these TMDLs and their applicable WLAs to the maximum extent practicable (MEP) as required by its MS4 permit.

Contents

List of Figures

List of Tables

1.0 Introduction

1.1 Background

The federal Clean Water Act (CWA) directs each state to review the quality of its waters every two years to determine if water quality standards are being met. If it is determined that the standard is not being met, the states are to list the impaired water body under §303(d) of the *CWA*. These impairments are then addressed by a Total Maximum Daily Load (40 CFR 130.31(a)).

A Total Maximum Daily Load document (TMDL) is a written plan and analysis to determine the maximum pollutant load a waterbody can receive and still meet applicable water quality standards. The TMDL process includes estimating pollutant loadings from all sources, linking these sources to their impacts on water quality, allocation of pollutant loads to each source, and establishment of control mechanisms to achieve water quality standards. All TMDLs include a waste load allocation (WLA) for all National Pollutant Discharge Elimination System (NPDES) permitted discharges, a load allocation (LA) for all unregulated nonpoint sources, and an explicit and/or implicit margin of safety (MOS).

Escherichia coli (E. coli) bacteria are members of the fecal coliform group of bacteria and are part of the normal flora of the gastrointestinal tract of warm-blooded animals. These bacteria play an important role in preventing the overgrowth of harmful bacteria in the gut, vitamin K production, lactose digestion, and fat metabolism. Some Shiga toxin producing strains of *E. coli*, such as O157:H7can cause gastrointestinal illnesses, kidney failure and death. *E. coli* bacteria in surface waters are indicators of recent human or animal waste contamination and may originate from failing septic systems, agricultural runoff, and leaking sewers, among other sources (Blount, 2015, Wolfson and Harrigan, 2010).

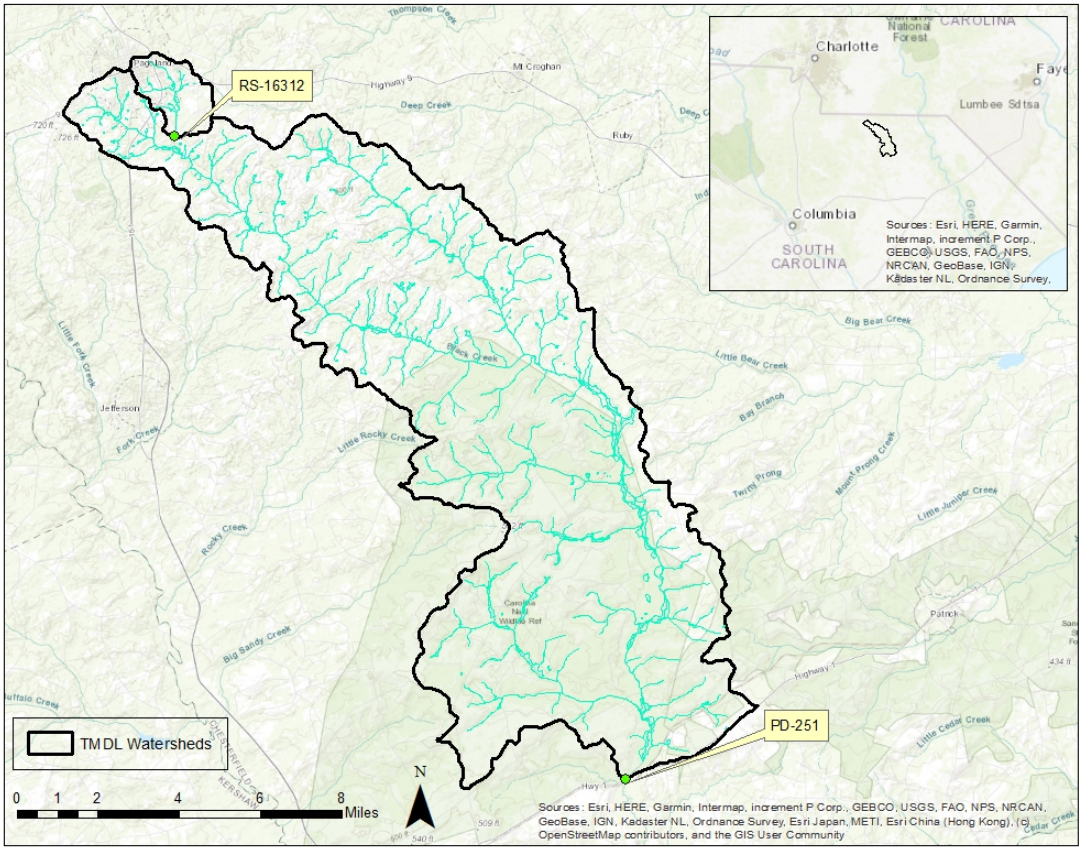
This document details the development of *E. coli* bacteria TMDLs for two water quality monitoring (WQM) stations. Cattail Branch (RS-16312) and Black Creek (PD-251) were included on South Carolina's final 2018 303(d) list by the South Carolina Department of Health and Environmental Control (SCDHEC) for impairment due to *E. coli* bacteria exceedances. RS-16312 is a random site that was sampled in 2016 and 2018 and PD-251 is an active site that has been sampled from 2001 through the present.

Until 2013, SCDHEC used fecal coliform bacteria as a pathogen indicator. In 2013, SCDHEC changed the pathogen indicator used to determine support of recreational uses from fecal coliform bacteria to *E. coli.* Beginning with the development of South Carolina's 2014 §303(d) list, any site that had been determined to be impaired for freshwater recreational use based on the previous standard was listed for *E. coli* bacteria rather than fecal coliform bacteria. In this analysis only *E. coli* data were used.

Table 1. Impaired WQM Stations

Stream Name	WQM Station	Description
Cattail Branch	RS-16312	Cattail Branch at S-13-54 Evans Mill Road
Black Creek	PD-251	Black Creek at US 1

Figure 1. Cattail Branch and Black Creek Watersheds with Locations of Impaired WQM Stations



1.2 Watershed Descriptions

For purposes of analyses of pollutant loads, sources, and subsequent allocation, the drainage areas associated with both impaired stations analyzed in this TMDL document will be addressed individually as subwatersheds. Subwatershed 16312 is the area that drains to RS-16312, and subwatershed 251 drains to PD-251. Subwatershed 251 excludes the smaller area draining to RS-16312 (Figure 1).

1.2.1 Subwatershed 16312

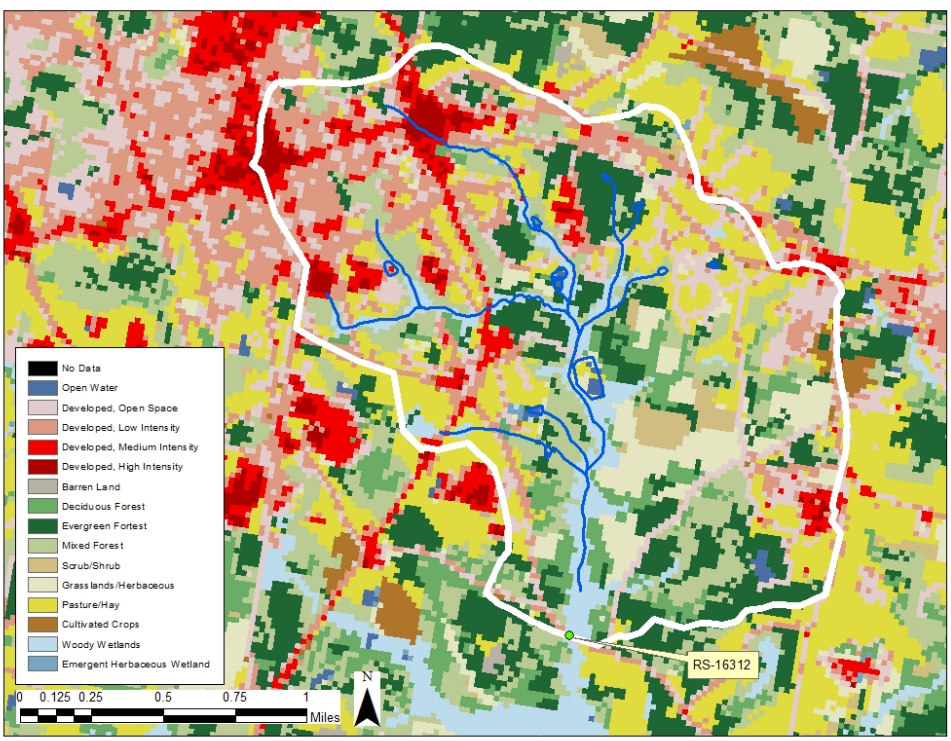
Impaired station RS-16312 is located in the northwestern extent of the Headwaters Black Creek Watershed (hydrologic unit code (HUC 12) 030402010602) and its drainage area lies entirely within Chesterfield County. Cattail Branch originates in the urbanized area associated with the Town of Pageland and flows south until joining Black Creek approximately three tenths of a mile beyond RS-16312. The area draining to RS-16312 measures 2.8 square miles.

Subwatershed 16312 is in the Sandhills ecoregion. The predominant land use categories are developed spaces (34.5%), forested (40.6%) and agriculture (15%). A significant portion (40.6%) of the subwatershed is considered urbanized, as defined by the 2010 U.S. Census, and much of it is within the city limits of Pageland. There is little potential for growth in this subwatershed.

Table 2. Land Use in Subwatershed 16312 (National Land Cover Database (NLCD), 2016)

Land Use Description	Area (square miles)	% of Total
Open Water	0.01	0.5%
Developed Open Space	0.34	12.2%
Developed Low Intensity	0.40	14.6%
Developed Medium Intensity	0.15	5.5%
Developed High Intensity	0.06	2.2%
Barren	0.00	0.0%
Deciduous Forest	0.16	5.9%
Evergreen Forest	0.39	14.1%
Mixed Forest	0.39	14.1%
Shrub/Scrub	0.05	1.8%
Grassland/Herbaceous	0.20	7.3%
Pasture/Hay	0.40	14.6%
Cultivated Crops	0.01	0.5%
Woody Wetlands	0.18	6.5%
Emergent Herbaceous Wetlands	0.01	0.2%
Total	2.8	100.0%

Figure 2. Land Use in Subwatershed 16312 (NLCD, 2016)



1.2.2 Subwatershed 251

The drainage area of impaired station PD-251 occupies the upper two thirds of Upper Black Creek HUC 10 (0304020106) and lies entirely within Chesterfield County. A total area of 107.3 square miles drains to WQM station PD-251. This drainage area includes subwatershed 16312 (Figure 1). When the area associated with subwatershed 16312 is subtracted, the drainage area for subwatershed 251 is 104.6 square miles.

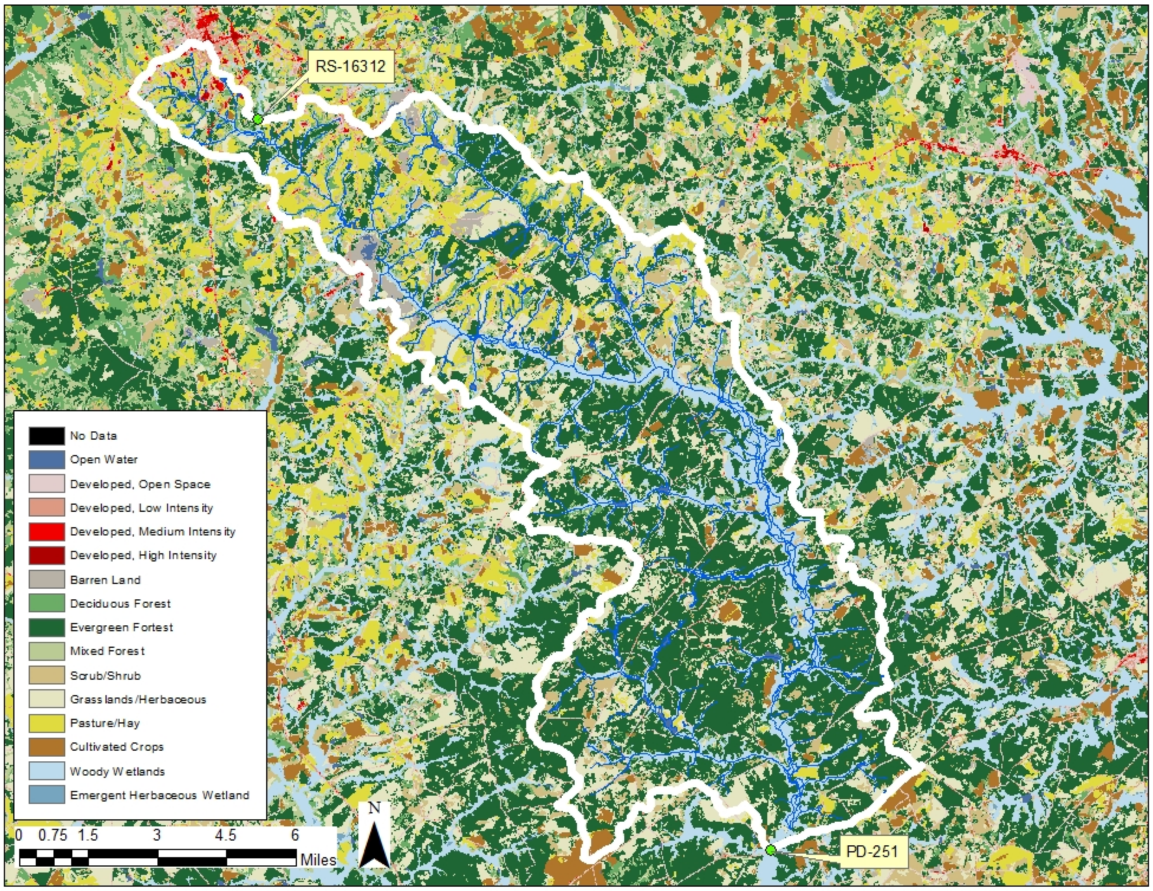
Black Creek originates in the outskirts of Pageland and flows in a southeasterly direction. It accepts flow from Cattail Branch and several additional small tributaries before its confluence with Little Black Creek. The creek then flows approximately three miles before entering the boundary of the Carolina Wildlife Refuge. Within the wildlife refuge several small tributaries join before the creek reaches PD-251.

Land use in the watershed is predominantly forested (63.9%) with a small amount of agriculture (10.5%) and even less developed land (6.0%) (Table 3). The subwatershed is within the Sandhills ecoregion. The Town of Pageland is in the northwestern extent of the drainage area and there is a small amount of urbanized area associated with it (1.6% of the total drainage area: U.S. Census 2010). There is little potential for growth in this watershed due to the presence of the Carolina Sandhills National Wildlife Refuge and Sandhills State Forest. These public lands occupy a little over 50% of the drainage area.

Table 3. Land Use in Subwatershed 251 (NLCD, 2016)

Land Use Description	Area (square miles)	% of Total
Open Water	0.84	0.8%
Developed Open Space	4.03	3.8%
Developed Low Intensity	1.87	1.8%
Developed Medium Intensity	0.26	0.3%
Developed High Intensity	0.06	0.1%
Barren	1.31	1.3%
Deciduous Forest	3.75	3.6%
Evergreen Forest	42.25	40.4%
Mixed Forest	7.38	7.1%
Shrub/Scrub	3.59	3.4%
Grassland/Herbaceous	14.70	14.0%
Pasture/Hay	9.23	8.8%
Cultivated Crops	1.78	1.7%
Woody Wetlands	13.42	12.8%
Emergent Herbaceous Wetlands	0.17	0.2%
Total	104.6	100.0%

Figure 3. Land Use in Subwatershed 251 (NLCD, 2016)



1.3 Water Quality Standard

The impaired streams addressed by this TMDL document are designated as Class Freshwater (FW) (Cattail Branch, Black Creek, and tributaries upstream of S.C. Highway 145) and FW* (Black Creek downstream of SC Highway 145). Both are defined in South Carolina Regulation 61-69 (2012):

"Freshwaters are 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 aquatic community of fauna and flora. Suitable also for industrial and agricultural uses."

South Carolina's water quality standard (WQS) for recreational use in freshwater is *E. coli* (R.61-68, 2014):

"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."

Prior to February 28, 2013, South Carolina's WQS for recreational use was fecal coliform (FC) bacteria:

"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 400/100mL."

In 1986, the United States Environmental Protection Agency (EPA) documented that *E. coli* and enterococcal species are better indicators than the FC bacteria group for predicting the presence of gastroenteritis-causing pathogens in freshwaters. The EPA study was based on data collected in areas where swimmers were directly exposed in freshwater lakes with established public swimming areas. The results indicated that *Enterococcus* and *E. coli* are more specific to sewage and other fecal sources than the FC bacteria group. In light of this information, EPA recommended the use of either *E. coli* or *Enterococcus* as the pathogen indicator for freshwaters.

To determine which of these pathogen indicators was better suited in South Carolina as the recreational use water quality standard in freshwaters, SCDHEC designed a pathogen indicator study, conducted in 2009. Weekly water samples were collected from 73 stations statewide and analyzed for *E. coli*, *Enterococcus*, and for FC bacteria. The study confirmed a statistically significant relationship between the concentrations of FC and *E. coli* bacteria in freshwater, supporting the decision to change the pathogen indicator to *E. coli*.

During 2012, following the public participation and public comment period and legislative processes, SCDHEC submitted a proposed amendment to EPA to change the pathogen indicator from FC bacteria to *E. coli* in R. 61-68. The proposed amendment was approved by EPA on February 28, 2013. Beginning on this date, *E. coli* as a pathogen indicator was promulgated in R. 61-68 and is now the applicable water quality standard for recreational use in freshwaters.

Beginning with the 2014 303(d) list of impaired waters, sites that had previously been listed as impaired for recreational use by FC bacteria exceedances would now be listed as impaired by *E. coli*. Once sufficient *E. coli* data are collected from impaired stations, future TMDLs will be calculated based on *E. coli* data. Until this time, TMDLs for FC impaired stations can be calculated using FC data. These FC TMDLs can then be converted to *E. coli* TMDLs by multiplying the FC TMDL by 0.8725. This ratio was derived by dividing the current single sample maximum WQS for *E. coli*, 349 MPN/100 ml, by the former single sample maximum WQS for FC bacteria, 400 cfu/100 ml.

2.0 Water Quality Assessment

Two WQM stations are addressed in this TMDL document. One of these (PD-251) is an active site at which monthly sampling is ongoing. This site has been sampled monthly or bimonthly since 2001. Only data collected beginning in February 2013 through January 2020 at PD-251 were used for this TMDL analysis, since during this period *E. coli* was being measured rather than FC bacteria. The other site is a random site (RS-16312) that was sampled monthly for two separate years (2016 and 2018). Station PD-251 was included on the state's 303(d) list for the first time in 2016 for *E. coli* exceedances. Station RS-16312 was included on the state's final 303(d) list for the first time in 2018 for *E. coli* exceedances.

For recreational use, if greater than 10% of the monthly geometric mean of available data collected during an assessment period exceeds the criterion, the station is included on South Carolina's §303(d) list. If sufficient data are not available to calculate a monthly geometric mean, then the available sample results are compared against the single sample maximum (SSM) criterion. If greater than 10% of these samples exceed this criterion then the station is included on South Carolina's §303(d) list as not supporting recreational use. Table 4 provides a summary of the number of samples collected, number of exceedances, and the percentage of samples exceeding the standard.

Table 4. Exceedance Summary for WQM Stations E-050 and E-100

Station	Waterbody	Number of Samples	Number Exceeding	Percent Exceeding	Years Sampled
RS-16312	Cattail Branch	22	11	50.0%	2016 and 2018
PD-251	Black Creek	57	14	24.6%	2013-2020

3.0 Source Assessment

While there are assays available for specific human pathogens that may be present in surface water, it is not possible to test for every potential pathogenic organism. For this reason, indicator bacteria (such as *E. coli*) are used to indicate the possible presence of human pathogens. Indicator bacteria are easy to measure, persist in surface waters for a similar or longer length of time, and have similar sources as pathogens of concern. There are also pathogenic forms of *E. coli*. These may be found in the gastrointestinal tracts of ruminant animals such as cattle, goats, sheep, deer, and elk, and can produce toxins (Shiga toxin-producing *E. coli* or STEC). Of these, cattle are the major source for human illnesses. A STEC infection may occur through accidental ingestion of water (through recreational contact) contaminated with feces.

There are many potential sources of pathogens in surface waters. In general, these sources may be classified as point and nonpoint sources. With the implementation of technology-based controls, pollution from continuous point sources, such as factories and wastewater treatment facilities, has been greatly reduced. These point sources are required by the CWA to obtain NPDES permits and in South Carolina, NPDES permits require that dischargers of sanitary wastewater meet the state standard for the relevant pathogen indicator at the point of discharge. Municipal and private sanitary wastewater treatment facilities may occasionally be sources of pathogens. However, if these facilities are discharging wastewater that meets their permit limits, they cannot be causing an impairment. If any of these facilities are not meeting their permit limits, enforcement actions/mechanisms are required.

Municipal Separate Storm Sewer Systems (MS4s) and stormwater discharges from regulated construction or industrial sites are considered non-continuous point sources. These sources are required to obtain NPDES discharge permits for industrial and construction activities under the NPDES stormwater regulations. They are also required to comply with the state standard for the pollutant(s) of concern. If MS4s and discharges from construction sites meet the percentage reduction or the water quality standard as prescribed in Section 5 of this TMDL development document and required in their MS4 permits, they should not be causing or contributing to an instream pathogen impairment.

Nonpoint sources of pollution come from many sources. Nonpoint source pollution is usually the result of overland runoff and as such, it may be the predominate source in wet conditions. Malfunctioning septic tanks, sanitary sewer overflows, pet waste, and poorly managed livestock operations are some of the potential sources of pathogens in surface water.

3.1 Point Sources

Point sources are defined as pollutant loads discharged at a specific location from pipes, outfalls, and conveyance channels from either municipal wastewater treatment plants, industrial waste treatment facilities, or regulated storm water discharges. Point sources can also include pollutant loads contributed by tributaries to the main receiving water stream or river. Point sources can be further broken down into continuous and non-continuous.

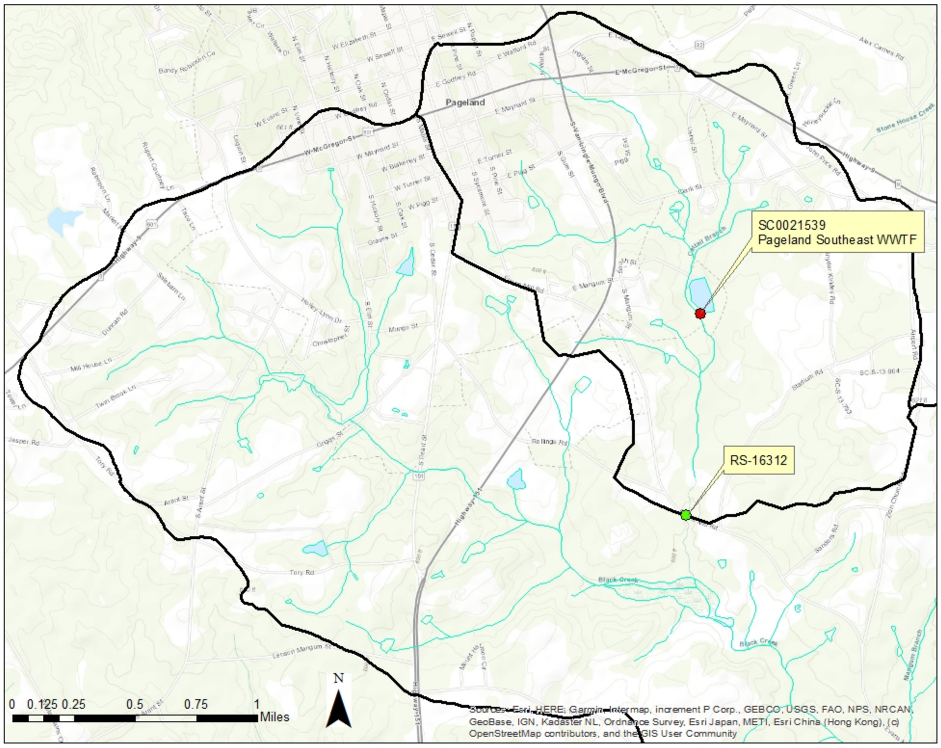
3.1.1 Continuous Point Sources

There is one NPDES-permitted continuous point source in the watershed draining to RS-16312 that can be expected to discharge *E. coli* bacteria. The Pageland Southeast Wastewater Treatment Facility (WWTF), NPDES permit number SC0021539, is a municipal wastewater treatment plant serving the Town of Pageland in subwatershed 16312. This facility is permitted to discharge up to 1.5 MGD of treated sanitary wastewater to Cattail Branch (Figure 4).

As with any other NPDES permitee discharging sanitary wastewater, the Pageland facility must meet the water quality criterion for *E. coli* bacteria at the point of discharge (a daily maximum of 349 MPN/100ml, and a 30-day maximum geometric mean of no more than 126 MPN/100ml). If it is meeting its discharge limits, it will not cause a violation in the stream.

Any future NPDES-permitted dischargers of *E. coli* and other FC bacteria in this watershed will be required to implement the WLA and demonstrate consistency with the assumptions and requirements of this TMDL.

Figure 4. Location of NPDES Permitted Municipal Wastewater Treatment Plant



3.1.2 Non-Continuous Point Sources

Non-continuous point sources include all NPDES-permitted stormwater discharges, including current and future MS4s, construction and industrial discharges covered under permit numbers beginning with SCS and SCR and regulated under SC *Water Pollution Control Permits* Regulation R61-9, §122.26(b)(4),(7),(14) - (21)(SCDHEC, 2011). All regulated MS4 entities have the potential to contribute FC bacteria loadings, including *E. coli* and other pathogens in the delineated drainage area used in the development of these TMDLs and as such may be subject to the WLA portion of the TMDL. A high percentage of developed land within a watershed suggests the potential for impacts from non-continuous point sources (as well as other sources). Developed land use in subwatershed 16312 is 34.5% of the total area. In subwatershed 251 developed land only makes up 6.0% of the total area (Table 5).

The South Carolina Department of Transportation (SCDOT) is currently the only designated MS4 within both subwatersheds. The SCDOT operates under NPDES MS4 Permit SCS040001 and owns and operates facilities and roads within the watershed. However, the Department recognizes that SCDOT is not a traditional MS4 in that it does not possess statutory taxing or enforcement powers. SCDOT does not regulate land use or zoning, issue building or development permits. Based on information available at the time of this TMDL development there is one SCDOT facility in the TMDL drainage area located in Pageland.

Industrial facilities that have the potential to cause or contribute to a violation of a water quality standard due to storm water discharge are covered by the NPDES Storm Water Industrial General Permit (SCR000000). Construction activities are usually covered by the NPDES Storm Water Construction General

Permit SCR100000. Where construction has the potential to affect the water quality of a water body with a TMDL, the Storm Water Pollution Prevention Plan (SWPPP) for the site must address any pollutants of concern and adhere to any waste load allocations in the TMDL. There may be other stormwater discharges not covered under permits numbered SCS and SCR that occur in the watersheds. These activities are not subject to the WLA portion of the TMDL.

Sanitary sewer overflows (SSOs) are considered non-continuous point sources. SSOs to surface waters have the potential to severely impact water quality. It is the responsibility of the NPDES wastewater discharger, or collection system operator (for non-permitted 'collection only' systems), to ensure that releases do not occur. Unfortunately, releases to surface waters from SSOs are not always preventable or reported. Portions of subwatersheds 16312 and 251 are served by municipal wastewater treatment plants (WWTP). Sewer lines are present and therefore the potential for SSOs exists.

The Department acknowledges that progress with the assumptions and requirements of the TMDL by MS4s is expected to take one or more permit iteration. Progress towards achieving the WLA reduction for the TMDL may constitute MS4 compliance with its SWMP, provided the Maximum Extent Possible (MEP) definition is met, even where the numeric percent reduction may not be achieved in the interim.

Table 5. Developed Area within Each Subwatershed

WQM Station	Drainage Area (Square Miles)	Total Developed Area (Square Miles)	Percent Developed Area
RS-16312	2.8	0.95	34.5%
PD-251*	104.6	6.2	6%

*Drainage area excludes subwatershed 16312

3.2 Nonpoint Sources

Nonpoint source pollution is defined as pollution that is not released through pipes but rather originates from multiple sources over a relatively large area. Nonpoint source pollution may result from failing septic tanks, improper animal-keeping practices, agriculture, forestry practices, wildlife, and urban and suburban runoff. These and other nonpoint source contributors located within unregulated areas (outside any regulated MS4 areas) may contribute to *E. coli* in the Cattail Branch and Black Creek watershed. Nonpoint sources located in unregulated areas are subject to the LA and not the WLA of the TMDL.

Nonpoint source contributions to in-stream *E. coli* may be expected to increase in response to rainfall as rainwater runoff washes pollutants from the land into waterways. Because of this, a strong positive correlation between rainfall and bacteria concentrations may indicate that nonpoint sources are predominantly responsible for bacteria exceedances (Table 6). In subwatershed 16312 there was a weak positive relationship between precipitation and bacteria concentration with a coefficient of determination (r^2) of 0.247 and a correlation coefficient (r) of 0.497 (Figures 5 and 6). At WQM station PD-251, there was a stronger positive correlation between rainfall and bacteria amounts with a coefficient of determination of 0.369 and a correlation coefficient of 0.607 (Figures7and 8).

Figure 5. Correlation Between Rainfall and *E. coli* at RS-16312

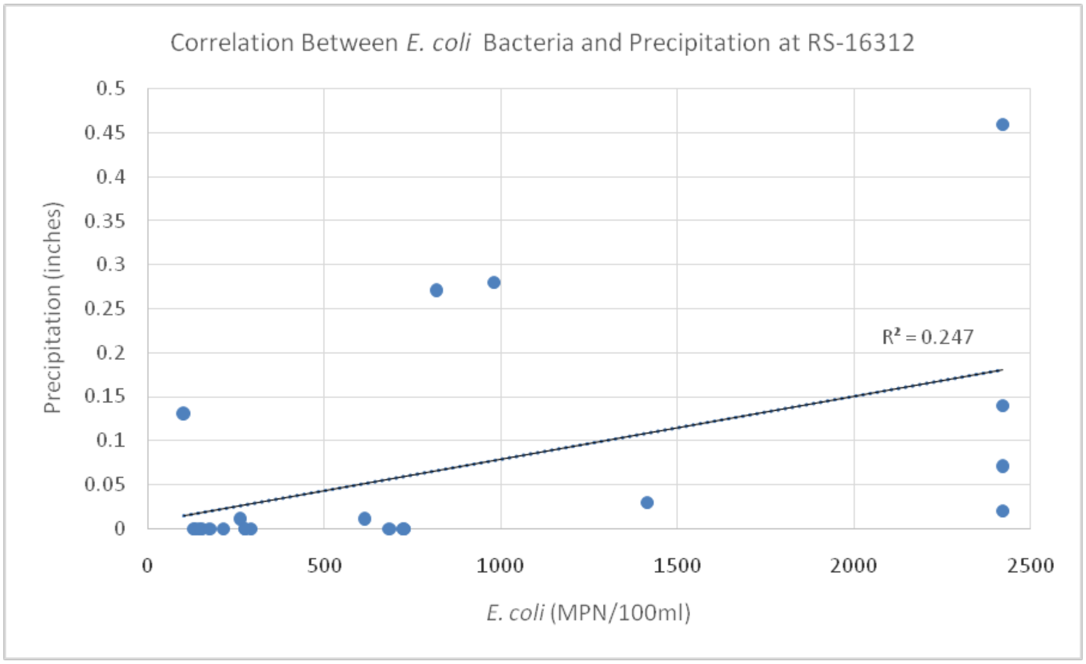


Figure 6. *E. coli* and Precipitation at RS-16312

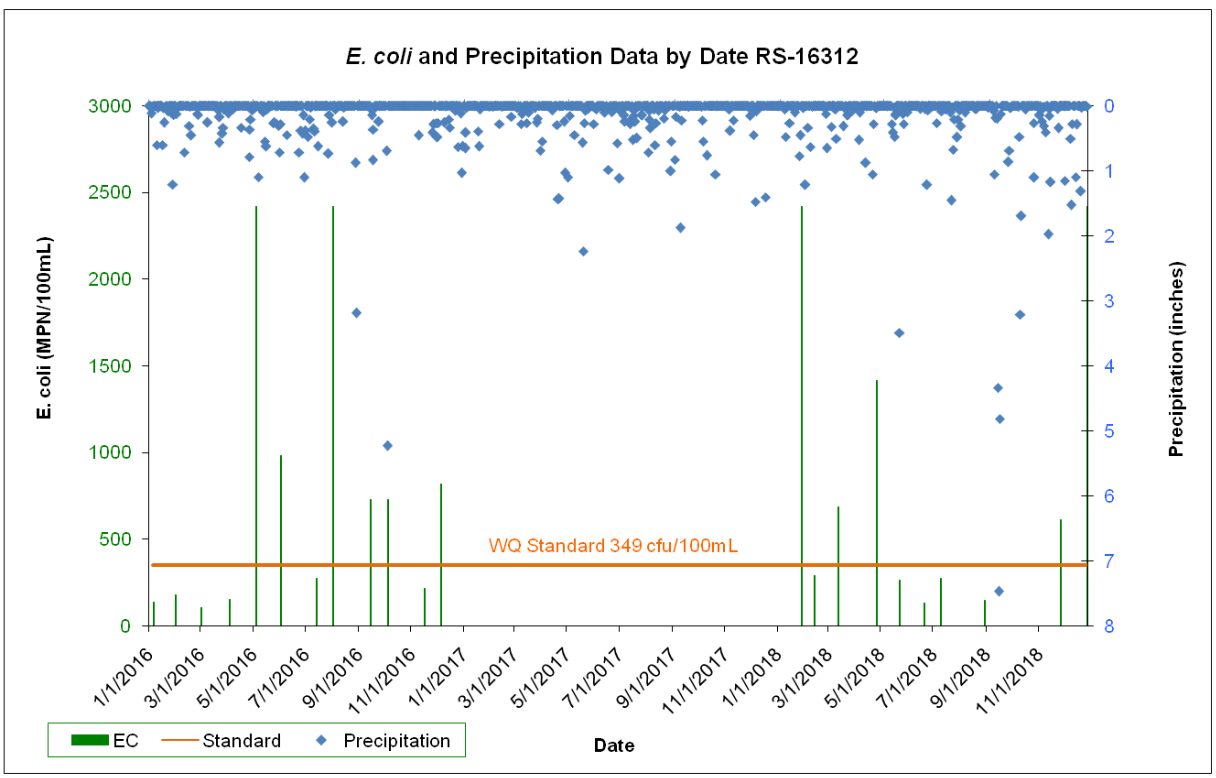


Figure 7. Correlation between Rainfall and *E. coli* at PD-251

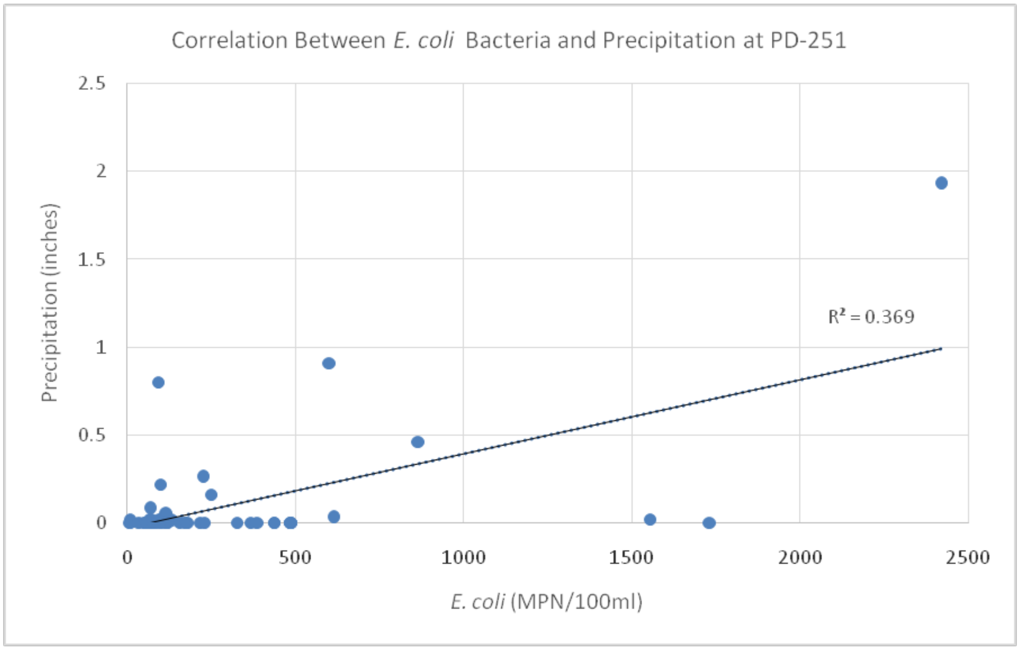


Figure 8. *E. coli* and Precipitation at PD-251

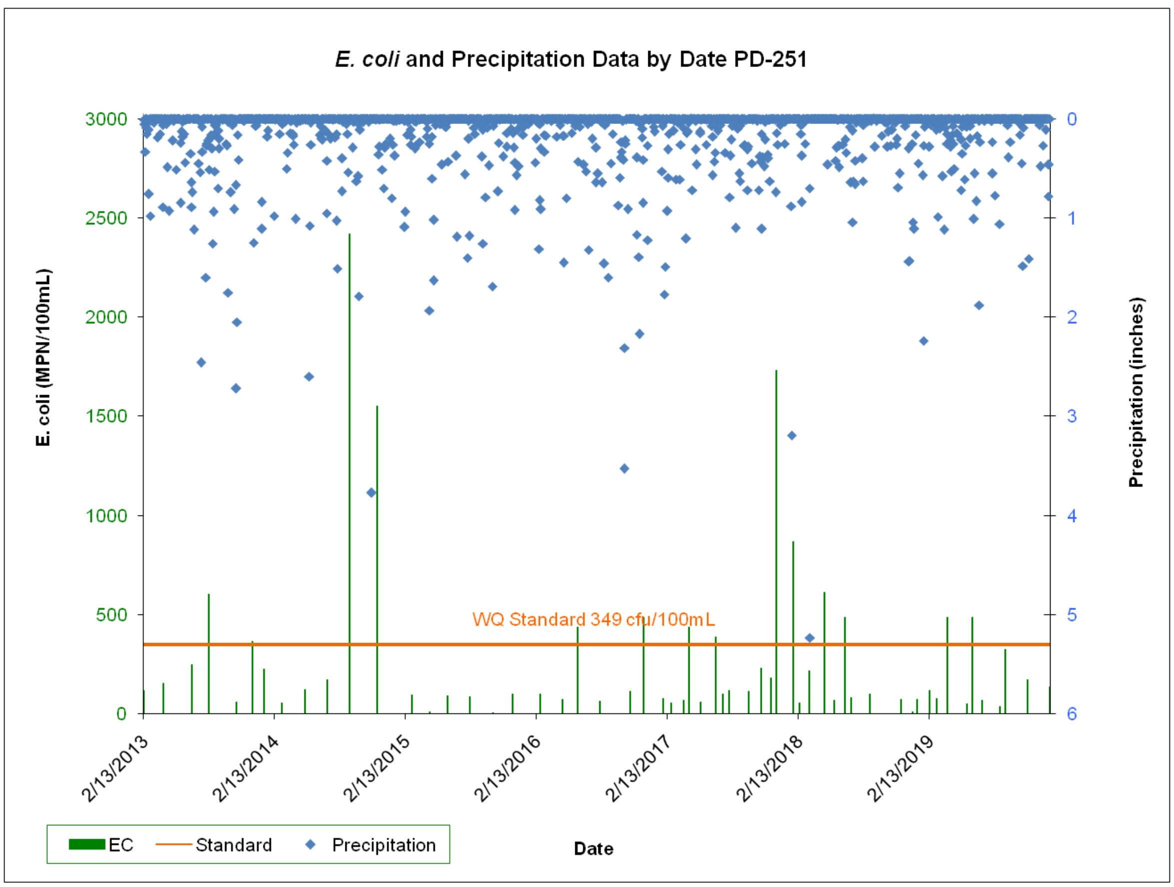


Table 6. Correlations Between Precipitation and Bacteria

Station	Waterbody	Correlation Coefficient (r)	Coefficient of Determination (r^2)
RS-16312	Cattail Branch	0.497	0.247
PD-251	Black Creek	0.607	0.369

3.2.1 Wildlife

Wildlife can contribute to *E. coli* and other fecal-borne pathogens found in waterways. Wildlife inhabiting this area includes deer, squirrels, raccoons, opossums, waterfowl and other birds. Wildlife feces may be deposited directly into surface waters or may be carried into nearby streams by runoff following rainfall. According to a study conducted by South Carolina Department of Natural Resources (SCDNR) in 2013 and GIS analysis, the deer population within subwatershed 16312 is between 41 and 83. The deer population of subwatershed 251 ranges from 1569 to 3137. The SCDNR study estimated deer density based on suitable habitat (forests, croplands, and pastures). The FC bacteria production rate for deer has been shown to be 347 x 10^6cfu/head-day in a study conducted by Yagow (1999), of which only a portion will enter the water. Wildlife may contribute a significant portion of the overall bacterial load, especially within subwatershed 251 since it is mostly rural and approximately 50% of the drainage area is state forest land and wildlife preserve. In particular, the Carolina Sandhills National Wildlife Conservation Area is managed for wildlife. There are many manmade impoundments in the area, some just upstream of PD-251, designed to attract waterfowl and other birds and mammals. Wildlife congregating in these areas can contribute to the *E. coli* loading to Black Creek.

3.2.2 Agriculture

Agricultural activities that involve livestock or animal wastes are potential sources of pathogen contamination of surface waters. Feces can enter the waterway via runoff from the land or by direct deposition into the stream. Agricultural activities may represent a significant source of bacteria due to the large numbers of bacteria associated with animal waste.

3.2.2.1 Agricultural Animal Facilities

Owners/operators of most commercial animal growing operations are required by SC Regulation 61-43, *Standards for the Permitting of Agricultural Animal Facilities*, to obtain permits for the handling, storage, treatment (if necessary) and disposal of the manure, litter and dead animals generated at their facilities (SCDHEC, 2002). The requirements of R. 61-43 are designed to protect water quality, therefore there is a reasonable assurance that facilities operating in compliance with this regulation would not contribute to downstream water quality impairments. The state of South Carolina does not have any confined animal feeding operations (CAFOs) under NPDES coverage at this time, however the state does have permitted animal feeding operations (AFOs) covered under R. 61-43. These permitted operations are not allowed to discharge to waters of the state and are covered under ‘no discharge’ (ND) permits. Discharges from these operations to waters of the state are illegal and are subject to enforcement actions by SCDHEC.

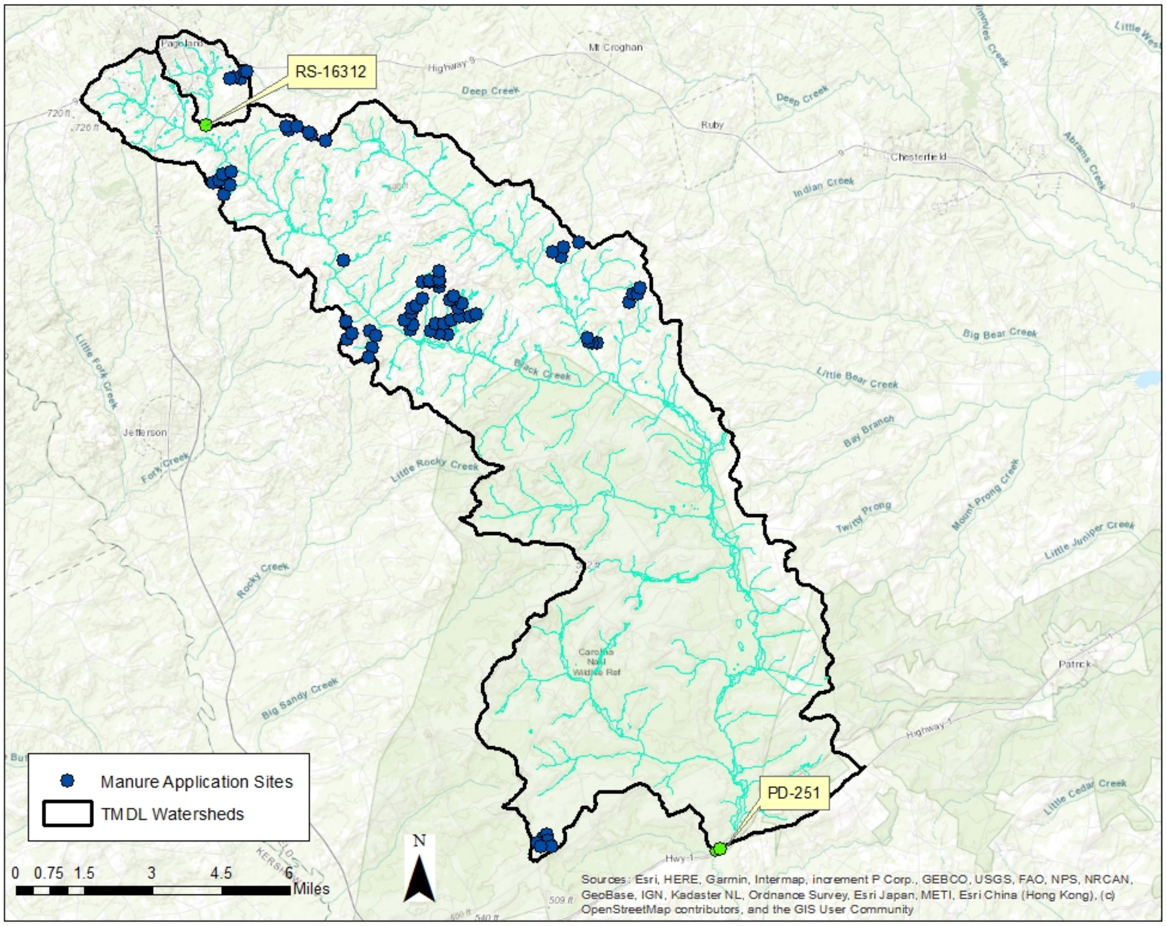
There are 13 animal feeding operations permitted to apply manure to land within the two subwatersheds evaluated in this document. They have the potential to spread manure from up to 650,600 chickens and turkeys on fields in the watershed (Figure 9, Table 7).

Table 7. AFO Permits in the TMDL Watersheds

Permit Number	**Animal Type**	**AFO Size**	**Number of Animals**
ND0062537	TURKEY	MEDIUM	24000
ND0066001	POULTRY	SMALL	80000
ND0066010	TURKEY	MEDIUM	54400
ND0066028	TURKEY	MEDIUM	54400
ND0066036	TURKEY	MEDIUM	54400
ND0066044	TURKEY	LARGE	81600
ND0066052	TURKEY	SMALL	12000
ND0070572	POULTRY	MEDIUM	60000
ND0075591	TURKEY	MEDIUM	45000
ND0076571	TURKEY	MEDIUM	45000
ND0078891	TURKEY	MEDIUM	48000
ND0073563	POULTRY	MEDIUM	50000
ND0062651	TURKEY	MEDIUM	41800
ND0087751*	NA	NA	NA
Total			650,600

* Permitted to apply manure within watershed, no AFO associated with permit

Figure 9. Locations of AFO Manure Land Application Sites



3.2.2.2 Grazing Livestock

Livestock, especially cattle, are frequent contributors of *E. coli* and other fecal-borne pathogens in streams. Cattle on average produce approximately 1.0E+11 cfu/day per animal of FC bacteria (ASAE 1998). Grazing cattle and other livestock may contaminate streams with bacteria indirectly by runoff from pastures or directly by defecating into streams and ponds. The grazing of livestock in pastures is not regulated by SCDHEC.

The United States Department of Agriculture's National Agricultural Statistics Service reported 9,624 cattle in Chesterfield County in 2017 (USDA 2019). Assuming an even distribution across the hay / pastureland in the county, subwatershed 16312 contains 66 head of cattle and subwatershed 251 contains 2,408 head of cattle. These cattle can be expected to contribute up to 2.5E+14 cfu fecal coliform bacteria per day to the entire watershed, some fraction of which may enter the waterways (Tables 8 and 9).

The NLCD land classification 'pasture / hay' includes grazing land (pasture) as well as land planted for seed or hay crops (hay). The latter will be harvested and is not grazed. Also, not all cattle counted by the USDA census are grazed. Dairy cattle and feedlot cattle are often confined and would therefore not be evenly distributed across the pasture / hay land. For these reasons, the calculations provide only a rough estimate of the cattle population.

Direct loading by cattle or other livestock to surface waters within the TMDL watersheds is a possible contributing source of *E. coli* and other FC bacteria. Aerial views reveal what appears to be grazing cattle just upstream of PD-251. During a site visit conducted in September 2020, no grazing cattle were observed in the watershed although there were many acres of land devoted to hay production. Only a few horses were seen near Black Creek and these were fenced well away from the stream bank.

Table 8. Grazing Cattle per Acre of Pasture/Hay County-wide

County	Number of Cattle	Acres Pasture-Hay	Cattle/Acre Pasture-Hay
Chesterfield	9,624	37,538	0.256

Table 9.Grazing Cattle and Bacteria Produced in Each Subwatershed

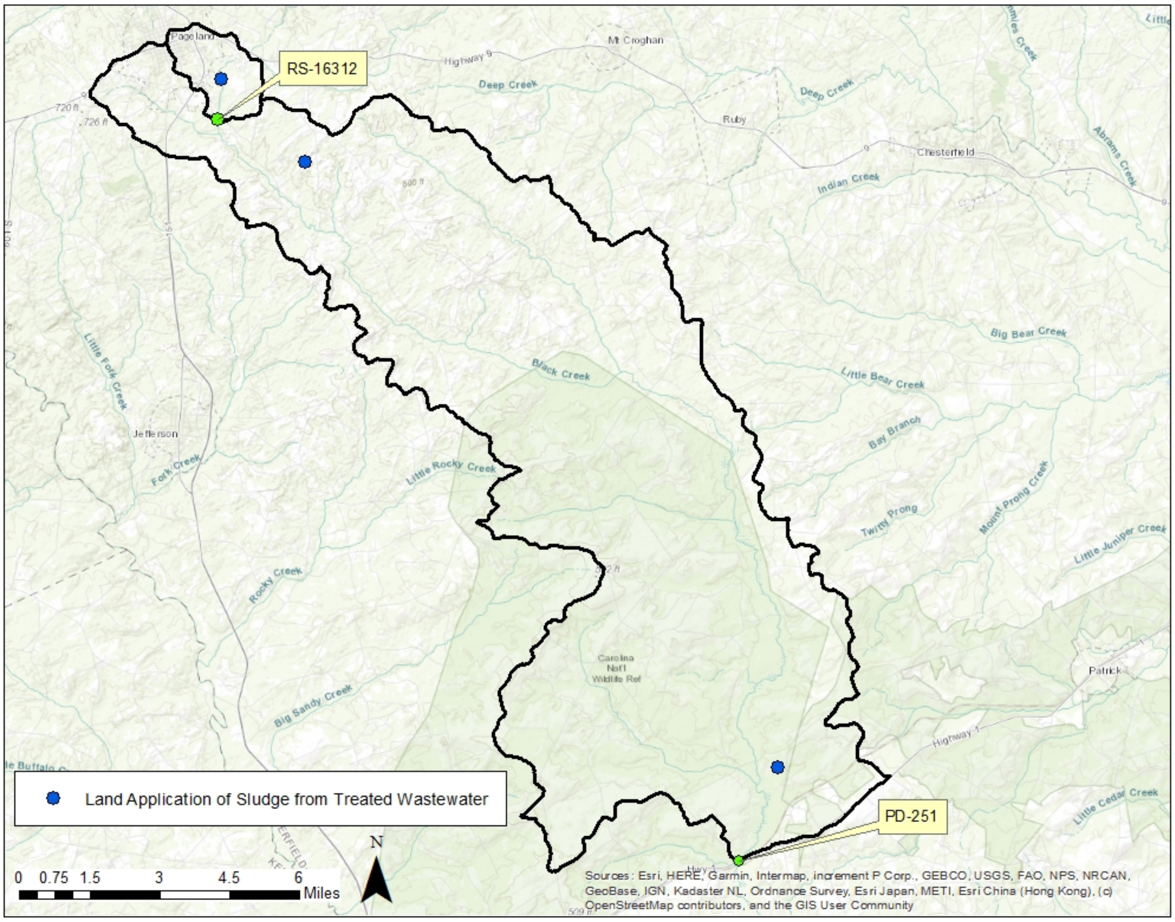
WQM Station	Pasture-Hay Acres	Cattle /Acre Pasture-Hay	Number of Cattle Grazing in Subwatershed	Bacteria Produced in Subwatershed (cfu/day)
RS-16312	257.9	0.256	66	6.6E+12
PD-251	9407.3	0.256	2408	2.4E+14

3.2.3 Land Application of Industrial, Domestic Sludge, or Treated Wastewater

NPDES-permitted industrial and domestic wastewater treatment processes may generate solid waste byproducts (sludge). In some cases, facilities may be permitted to apply sludge to land at designated locations and under specific conditions. There are also some NPDES-permitted facilities authorized to apply treated effluent to land at designated locations and under specific conditions. Land application permits for industrial and domestic wastewater facilities may be covered under SC Regulation 61-9, Sections 503, 504, or 505. When properly managed, waste is applied at a rate that ensures pollutants will be incorporated into the soil or plants and pollutants will not enter streams or groundwater. Land applications sites can be a source of fecal pathogens and stream impairment if not properly managed. Similar to AFO land application sites, land application sites are not allowed to directly discharge to the waterways. Direct discharges from land applications sites to surface waters of the State are illegal and are subject to enforcement actions by SCDHEC.

There are three facilities permitted to apply sludge from treated wastewater to land in the TMDL watersheds. Terra Renewal Services (ND0086479) applies sludge from food processing industries, and the Towns of Jefferson (SC0024767) and Pageland (SC0021539) are permitted to apply treated sludge from their wastewater treatment plants to fields in the watershed (Figure 10). Sludge application rates vary based on field conditions and facility production rates.

Figure 10. Sites of Land Application of Sludge from Treated Wastewater

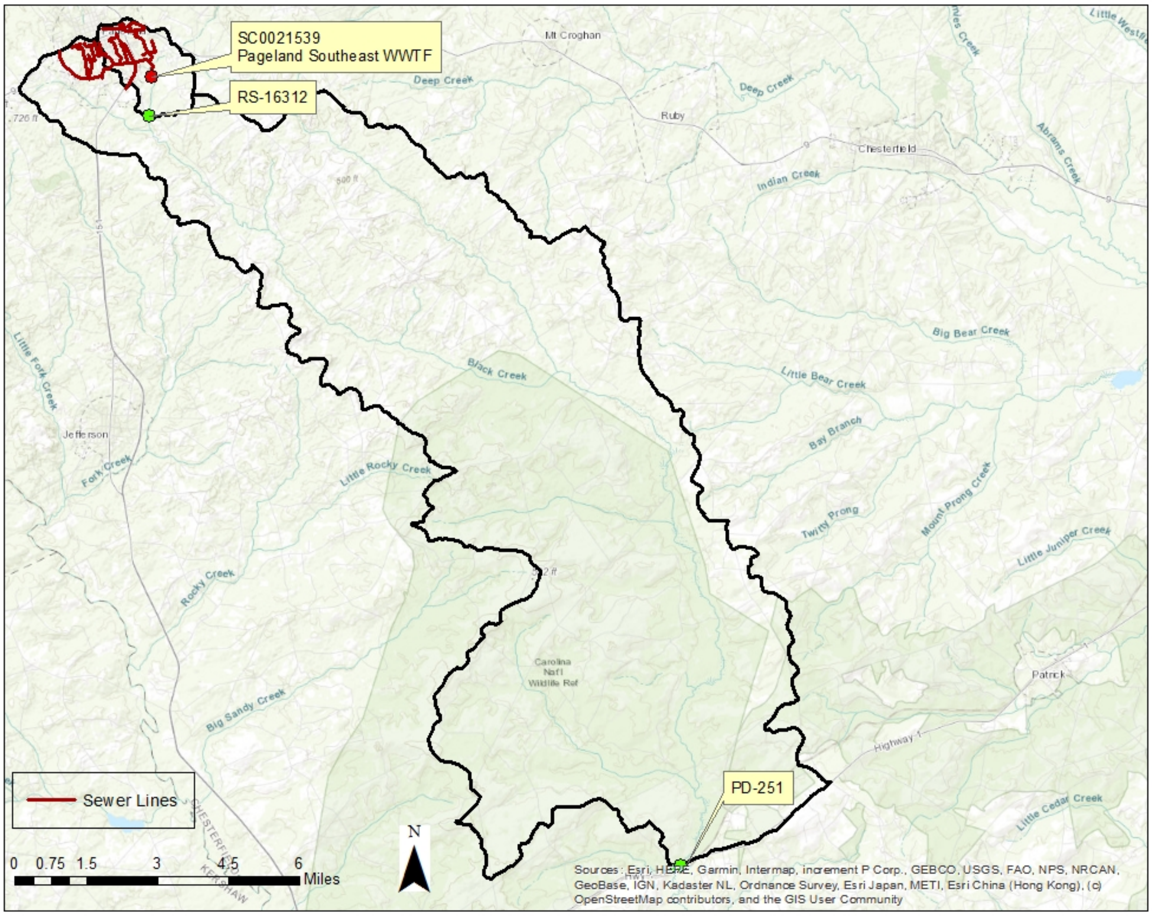


3.2.4 Leaking Sanitary Sewers and Illicit Discharges

Leaking sewer pipes and illicit sewer connections represent a direct threat to public health since they result in discharge of partially treated or untreated human waste to the surrounding environment. Quantifying these sources is highly speculative without direct monitoring of the source since the magnitude is directly proportional to the volume and proximity to the surface water. Typical values of FC bacteria in untreated domestic wastewater range from 10^4 to 10^6 MPN (Most Probable Number)/100mL (Metcalf and Eddy 1991). According to GIS coverage there are areas of the TMDL drainage area served by a sanitary sewer system so the possibility for leakage exists (Figure 11).

Illicit sewer connections into storm drains result in direct discharge of sewage via the storm drainage system outfalls. Monitoring of storm drain outfalls during dry weather is needed to document the presence or absence of sewage in the drainage systems.

Figure 11. Location of Sewer Lines in the TMDL Watersheds



3.2.5 Failing Septic Systems

Studies demonstrate that groundwater located four feet below properly functioning septic systems contains on average less than one FC bacteria organism per 100 mL (Ayres Associates 1993). Failed or non-conforming septic systems, however, can be a major contributor of *E. coli* and other pathogens to the Cattail Branch and Black Creek watershed. Waste from failing septic systems enters surface waters either as direct overland flow or via groundwater. Although loading to streams from failing septic systems is likely to be a continual source, wet weather events can increase the rate of transport of pollutants from failing septic systems because of the wash-off effect from runoff and the increased rate of groundwater recharge.

Based on the 2010 U.S. census and GIS analysis, there are an estimated 1806 households in subwatershed 251, only 12% of which are served by a sewer system. In subwatershed 16312 there are 532 households with as many as 65% located in an area with sewer lines. So while a majority of households in subwatershed 16312 are likely to be served by a sewer system, the majority (76%) of the households within the entire area covered by this TMDL are using septic tanks and some number of these are likely to be failing and contributing to bacteria in the streams (Table 10).

Table 10. Census Data (2010) and Septic Tank Estimate

Subwatershed	Number of People	Number of Households	Number of Households on Septic Tanks*
251	3877	1806	1586
16312	1220	532	184
Entire Drainage Area	5097	2338	1770

*Assumes one septic tank per household not served by municipal WWTP

The available GIS layer for sewer lines in this area includes only large trunk lines and may not include newer sewer lines or smaller branch lines. For these reasons, the proportion of the watershed served by wastewater treatment plants may be underrepresented and septic tank usage may be overestimated in this document.

3.2.6 Urban and Suburban Runoff

Dogs, cats, and other domesticated pets are the primary source of *E. coli* and other FC bacteria deposited on the urban and suburban landscape. There are also 'urban' wildlife sources: deer, squirrels, raccoons, opossums, and birds, all of which contribute to the bacteria load. Urban runoff is likely negligible within most of the TMDL watershed since there is little developed land present. The exception to this is the upper portion of subwatershed 251 and most of subwatershed 16312 which contain much of the small town of Pageland. Approximately 40.6% of subwatershed 16312 is considered urbanized while only 1.6% of subwatershed 251 is urbanized.

Unregulated MS4 communities, such as the town of Pageland, have the potential to contribute *E. coli* and other bacteria in stormwater runoff. The unregulated entities are subject to the LA for the purposes of this TMDL document.

4.0 Load-Duration Curve Method

The load-duration curve method was developed as a means of incorporating natural variability, uncertainty, and risk assessment into TMDL development (Bonta and Cleland 2003). The analysis is based on the range of hydrologic conditions for which there are appropriate water quality data. The load-duration curve method uses the cumulative frequency distribution of stream flow and pollutant concentration data to estimate existing and TMDL loads for a water body. Development of the load-duration curve is described in this chapter.

The load-duration curve method depends on an adequate period of record for stream flow data with which to create a flow-duration curve. There is an active United States Geological Survey (USGS) flow gauge on Black Creek (02130840 located on Angelus Road) with data available from September 2007 to present (Figure 12). These flow data from the gauge were used to construct a flow duration curve for the TMDL sites. Because the gauge is located downstream of the WWTP, flows measured here account for the actual recorded discharge flow.

The drainage areas for the WQM stations were delineated using USGS topographic maps and ArcGIS (Figure 1). Flows at the impaired WQM stations were estimated based on the ratio of the WQM station drainage area to the entire drainage area of the USGS gauge. For example, 02130840 records flow from

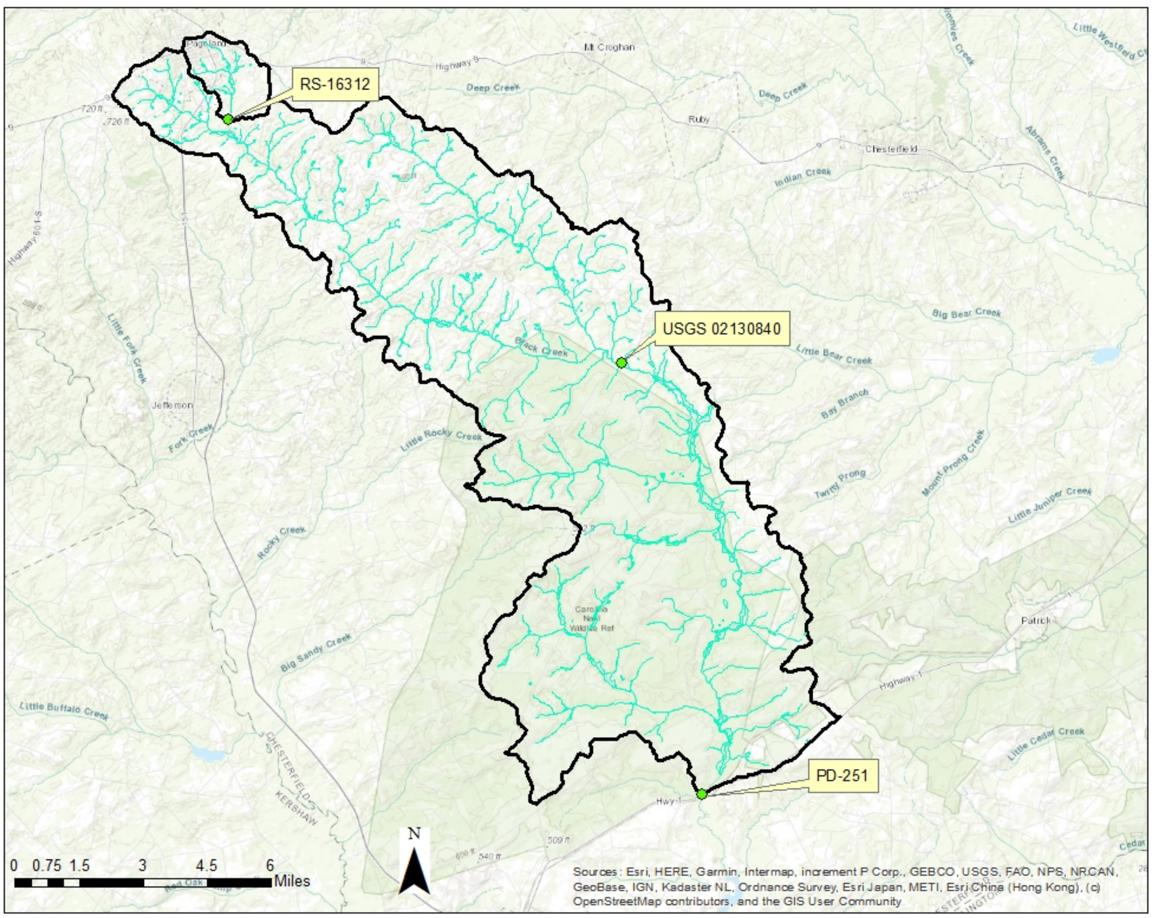
51.7 square miles. The drainage area for PD-251 is 107.3 square miles, or 207.8% of the drainage area at 02130840. Daily flows at the gauge were multiplied by 2.078 to arrive at an estimated flow at PD-251. Table 11 contains a summary of drainage area statistics used to establish flows at the WQM stations and Figure 12 provides an illustration of monitoring and gauge locations.

Table 11. Drainage Area Statistics

Site	Area (square miles)	Ratio Used to Estimate Flow at WQM Sites
USGS Gauge 02130840	51.7	
PD-251	107.3*	107.3/51.7=2.078
RS-16312	2.8	2.8/51.7=0.054

*Area includes that of subwatershed 16312 for the purpose of estimating flow at the WQM station

Figure 12. Location of USGS Gauge Used in Load Duration Analysis



Flow duration curves were created by ranking estimated flows at each WQM site from highest to lowest and calculating the probability of occurrence (presented as a percentage or duration interval), where zero corresponds to the highest flow. The duration interval can be used to determine the percentage of time a given flow is achieved or exceeded, based on the period of record. The flow duration curve was divided into five hydrologic condition categories (High Flows, Moist Conditions, Mid-Range, Dry Conditions and

Low Flows). Categorizing flow conditions and plotting sampling data on the same graph can assist in determining which hydrologic condition results in the greatest number of exceedances. A high number of exceedances under dry conditions may indicate a point source or illicit connection issue, whereas exceedances occurring during wet conditions may indicate nonpoint sources. Data within the High Flow and Low Flow categories are generally not used in the development of a TMDL due to the infrequency of these flow conditions.

Load duration curves for both impaired stations were created using only *E. coli* bacteria data. The allowable load was determined using daily flow and the *E. coli* water quality criterion. The water quality target was set at 332 MPN/100ml which is 5% lower than the instantaneous water quality criterion of 349 MPN/100ml. This allows a 5% explicit margin of safety (MOS) to be reserved from the water quality criterion. The load duration curve for PD-251 is presented in Figure 13, and RS-16312 in Figure 14.

Figure 13. Load Duration Curve PD-251

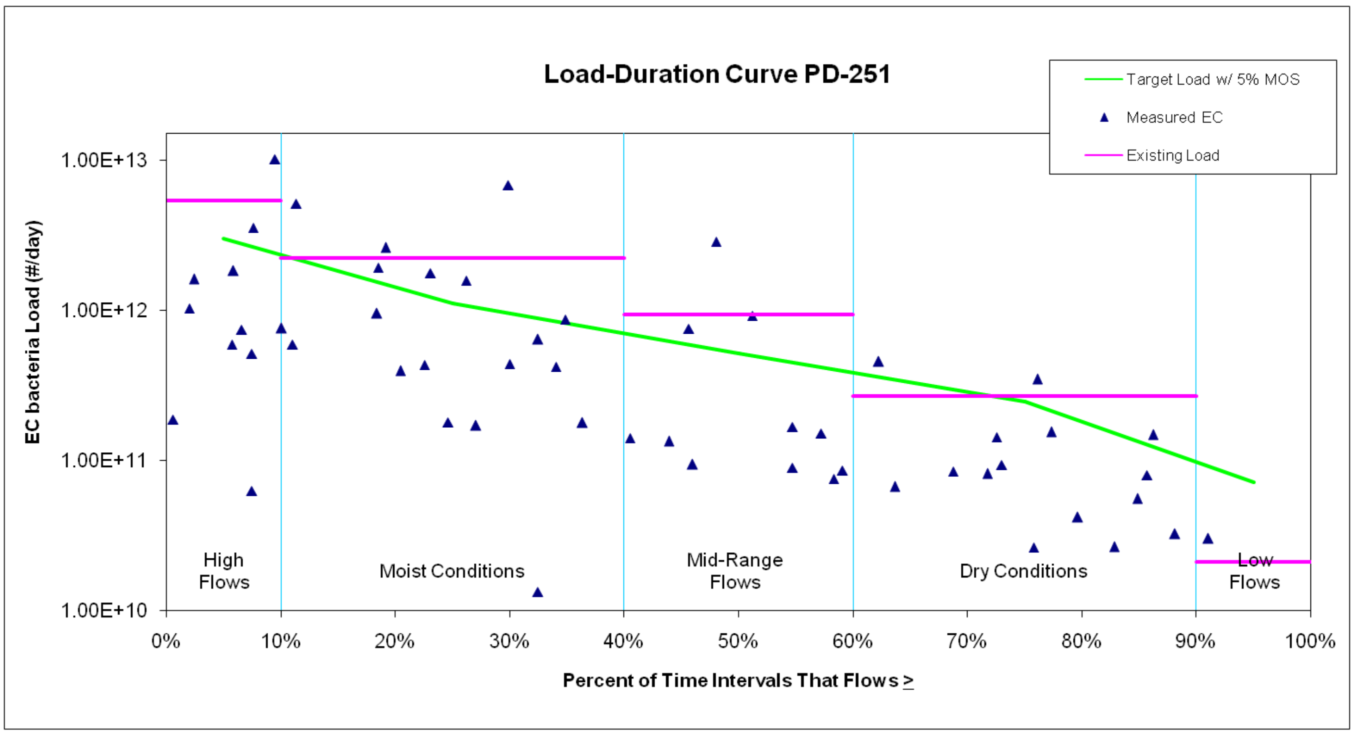
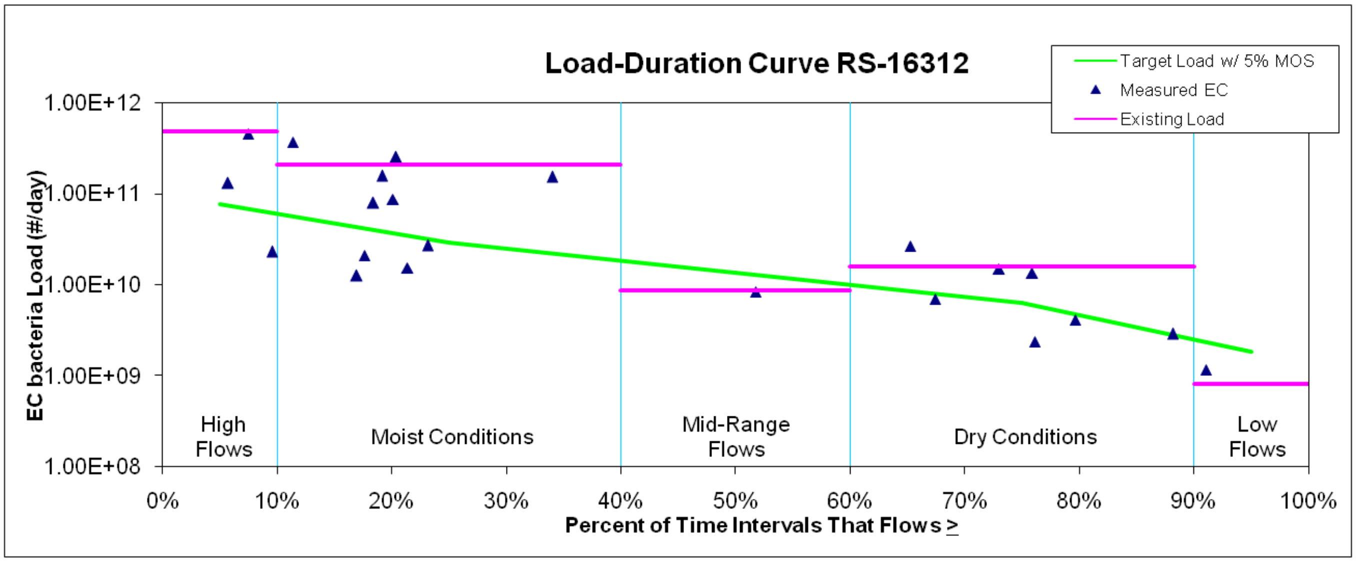


Figure 14. Load Duration Curve for RS-16312



In a load-duration curve, the independent variable (X axis) represents the percentage of time that the estimated flow would be greater than X. In this case flows are represented by categories: high, moist, mid-range, dry, and low. The dependent variable (Y axis) represents the bacteria load (MPN/day) at each flow. For instance, in each of the flow ranges represented on the graph, existing and target loads for PD-251 were calculated by the following:

Existing Load (MPN/day) = Mid-Point Flow in Each Hydrologic Category (ft^3/s) x 90^{th} Percentile *E. coli* Concentration x Conversion Factor (24465758.4)

Load Allocation to Meet Target Load (*E. coli* bacteria MPN/day) = Mid-Point Flow in Each Hydrologic Category (ft^3/s) x 332 (*E. coli* Bacteria WQ criterion minus a 5% MOS (MPN/100 ml)) x Conversion Factor (24465758.4)

Percent Reduction = (Existing Load – Load Allocation to meet Target Load) / Existing Load

Because there is a point source in subwatershed 16312 requiring a WLA, the calculations for this site are different. A WLA is calculated using the facility's permitted design flow. In constructing the flow duration curve, the design flow for the facility was added to the gauge flow and then the actual recorded facility flows (derived from reported monthly averages) were subtracted from the daily gauge flows to avoid counting them twice (since actual flows are being recorded by the downstream gauge). The WLA was calculated using the design flow, the *E. coli* WQ criterion and a conversion factor.

Existing Load (MPN/day) = Mid-Point Flow in Each Hydrologic Category (ft^3/s) x 90^{th} Percentile *E. coli* Concentration x Conversion Factor (24465758.4)

Load Allocation to Meet Target Load (*E. coli* bacteria MPN/day) =[Mid-Point Flow in Each Hydrologic Category (includes NPDES SC0021539 design flow – reported flow (ft^3/s)] x 332 (*E. coli* Bacteria WQS minus a 5% MOS (MPN/100 ml)) x Conversion Factor (24465758.4)] – [NPDES design flow (2.32ft^3/s) x 349 (E. coli WQ criterion MPN/day) x Conversion Factor (24465758.4)].

Percent Reduction = (Existing Load – Load Allocation to meet Target Load) / Existing Load

Instantaneous loads were calculated for each sampling station by converting measured bacteria concentrations into loads, or number of bacteria per day (see section 2.0 for data details). *E. coli* samples (MPN/100ml) were multiplied by the estimated in-stream flow on the day of sampling. This value was then multiplied by a conversion factor to determine loading. Load data were plotted on the load-duration graph based on the flow duration interval for the day of sampling. Samples that lie below the target line (green line) on the load-duration curve are in compliance with the water quality standard (blue triangles in Figures 13 and 14). Only the instantaneous WQS was targeted because there were insufficient data to evaluate against the 30-day geometric mean.

An existing load was determined for each hydrologic category for the TMDL calculations. The 90th percentile of measured bacteria concentrations within each of the hydrologic categories was multiplied by the flow at each category midpoint (i.e., flow at the 25% duration interval for moist conditions, 50% interval for mid-range, and 75% for dry conditions). Existing loads were then plotted on the load-duration curve (pink line in Figures 13 and 14). These values were compared to the target load (which includes an explicit 5% MOS) at each hydrologic category midpoint to determine the percent load reduction necessary to achieve compliance with the WQS. The TMDL assumes that if the highest percent reduction is achieved then the WQS will be attained under all flow conditions.

5.0 Development of the Total Daily Maximum Load

A TMDL for a given pollutant and water body is comprised of the sum of individual waste load allocations (WLAs) for point sources, and load allocations (LAs) for both nonpoint sources and natural background levels. In addition, the TMDL must include a margin of safety (MOS), either implicit or explicit, to account for the uncertainty in the relationship between pollutant loads and the quality of the receiving water body. Conceptually, this definition is represented by the equation:

$$TMDL = \sum WLAs + \sum LAs + MOS$$

The TMDL is the total amount of pollutant that can be assimilated by the receiving water body while still achieving compliance with the WQS. In TMDL development, allowable loadings from all pollutant sources that cumulatively amount to no more than the TMDL must be established and this provides the basis to establish water quality-based controls.

For most pollutants, TMDLs are expressed as a mass load (e.g., kilograms per day). For bacteria, however, TMDLs are expressed in terms of number, colony forming units (cfu), organism counts (or resulting concentration), or MPN, in accordance with 40 CFR 130.2(l).

5.1 Critical Conditions

These TMDLs are based on flow intervals between 10% and 90% and exclude extreme high and low flow conditions. Flows that were categorized as 'Low' or 'High' in the flow duration curve were not included in the analysis. The critical condition for each monitoring station is identified as the flow condition requiring the largest percent reduction, within the 10-90% duration intervals. Critical conditions for the WQM stations are listed in Table 12. These data indicate that for both WQM site RS-16312 and PD-251, moist conditions result in the largest bacteria loads and this is the critical condition for both stations.

5.2 Existing Load

An existing load was determined for each hydrologic category for the TMDL calculations as described in Section 4.0 of this TMDL document. The existing load under the critical condition described in Section 5.1 was used in the TMDL calculations. Loadings from all potential sources are included in this value such as cattle, failing septic systems as well as wildlife. The existing loads for both stations are provided in Appendix A.

Table 12. Percent Reduction Necessary to Achieve Target Load by Hydrologic Category

WQM Site	Stream	Moist Conditions	Mid-Range Flow	Dry Conditions
PD-251	Black Creek	50%	45%	8%
RS-16312	Cattail Branch	89%	0%*	60%

*There were no exceedances during this flow condition

Highlighted cells indicate critical conditions.

5.3 Waste Load Allocation

The waste load allocation (WLA) is the portion of the TMDL allocated to NPDES-permitted point sources (USEPA 1991). Note that all illicit dischargers, including SSOs, are illegal and not covered under the WLA of these TMDLs.

5.3.1 Continuous Point Sources

There is one NPDES-permitted municipal wastewater treatment plant with *E. coli* limits within the TMDL watersheds. The Town of Pageland operates under NPDES permit number SC0021539 which allows a discharge of up to 1.5 million gallons per day (2.32 cfs) into Cattail Branch. To determine the WLA for the Town of Pageland, the design flow (cfs) was multiplied by the allowed permitted maximum *E. coli* concentration (349 MPN/100ml) and a unit conversion factor (24465758.4) (Table 13).

Table 13.Waste Load Allocation for Subwatershed 16312

Subwatershed	Facility Name	Permit Number	Flow (MGD/cfs)	WLA *E. coli* (MPN/day)
16312	Town of Pageland Southeast WWTP	SC0021539	1.5 / 2.32	1.98E+10

Any future continuous discharges will be required to meet the prescribed loading for *E. coli* based on permitted flow and an allowable permitted maximum concentration of 349MPN/100mL.

5.3.2 Non-continuous Point Sources

Non-continuous point sources include all NPDES-permitted stormwater discharges, including current and future MS4s, construction and industrial stormwater discharges covered under permits numbered SCS000000 & SCR100000 regulated under SC *Water Pollution Control Permits* Regulation 122.26(b)(14) & (15). Illicit discharges, including SSOs, are not covered under any NPDES permit and are subject to enforcement mechanisms. Other non-urbanized areas may be required under the NPDES Phase II Stormwater Regulations to obtain a permit for the discharge of stormwater.

The South Carolina Department of Transportation (SCDOT) is currently the only designated MS4 within the Cattail Branch and Black Creek Watersheds. SCDOT operates under NPDES MS4 Permit SCS040001 and owns and operates roads within the watershed. However, the Department recognizes that SCDOT is not a traditional MS4 in that it does not possess statutory taxing or enforcement powers. SCDOT does not regulate land use or zoning, issue building or development permits.

Waste load allocations for stormwater discharges are expressed as a percentage reduction instead of a numeric loading due to the uncertain nature of stormwater discharge volumes and recurrence intervals. All current and future stormwater discharges are required to meet the percentage reduction or the existing instream standard for the pollutant of concern. The percentage reduction is based on the maximum percent reduction (critical condition) within any hydrologic category necessary to achieve target conditions. Table 14 presents the reduction needed for the impaired stations. The reduction percentages in these TMDLs also apply to the *E. coli* waste load attributable to those areas of the watershed that are covered or will be covered under NPDES MS4 permits.

As appropriate information is made available to further define the pollutant contributions for the permitted MS4, an effort may be made to revise these TMDLs. This effort will be initiated as resources permit and if deemed appropriate by the Department. For the Department to revise these TMDLs the following information should be provided, but not limited to:

1) An inventory of service boundaries of the MS4 covered in the MS4 permit, provided as ArcGIS compatible shape files.

2) An inventory of all existing and planned stormwater discharge points, conveyances, and drainage areas for the discharge points, provided as ArcGIS compatible shape files. If drainage areas are not known, any information that would help estimate the drainage areas should be provided. The percentage of impervious surface within the MS4 area should also be provided.

3) Appropriate and relevant data should be provided to calculate individual pollutant contributions for the MS4 permitted entities. At a minimum, this information should include precipitation, water quality, and flow data for stormwater discharge points.

Table 14. Percent Reduction Needed to Achieve Target Load for Non-Continuous Point Sources

WQM Site	Stream	% Reduction
PD-251	Black Creek	50%
RS-16312	Cattail Branch	89%

Compliance with terms and conditions of existing and future NPDES sanitary and stormwater permits (including all construction, industrial, and MS4) will effectively implement the WLA and demonstrate consistency with the assumptions and requirements of the TMDL.

5.4 Load Allocation

The Load Allocation applies to the nonpoint sources of *E. coli* and other FC bacteria and is expressed both as a load and as a percent reduction. The load allocation is calculated as the difference between the target load under the critical condition and the point source WLA. The load allocation is listed in Table 15. There may be other unregulated MS4s, such as the town of Pageland, located in the Cattail Branch and Black Creek Watersheds that are subject to the LA components of these TMDLs. At such time that the referenced entities, or other future unregulated entities become regulated NPDES MS4 entities and are subject to applicable provisions of SC Regulation 61-68D, they will be required to meet load reductions prescribed in the WLA component of the TMDL. This also applies to future discharges associated with industrial and construction activities that will be subject to SC R. 61-9 122.26(b)(14) & (15) (SCDHEC 2011).

5.5 Seasonal Variability

Federal regulations require that TMDLs consider the seasonal variability in watershed loading. The variability in these TMDLs is accounted for by using multi-year hydrological and water quality sampling data sets.

5.6 Margin of Safety

The margin of safety (MOS) may be explicit and/or implicit. The explicit margin of safety is 5% of the TMDL, or in the case of FC TMDLs, 20 cfu/100mL of the instantaneous criterion of 400 cfu/100 mL (380 cfu/100mL); and in the case of *E. coli* TMDLs, 17 MPN/100mL of the instantaneous criterion of 349 MPN/100 mL (332 MPN/100mL). The MOS is expressed as the value calculated from the critical condition defined in Section 5.1 and is the difference between the TMDL and the sum of the WLA and LA.

A 5% MOS in freshwaters impaired for *E. coli* may be calculated as the ratio of *E.coli* MPN/100 mL to FC bacteria cfu/100 mL or 20*0.8725 = 17 MPN/100 mL of the instantaneous *E. coli* criterion of 349 MPN/100 mL (332 MPN/100 mL). This conversion is deemed appropriate by the Department and was derived from an established relationship between FC bacteria and *E. coli* WQS in freshwaters determined during the 2009 Pathogen Indicator Study.

5.7 TMDL

For most pollutants, TMDLs are expressed as a mass load (e.g., kilograms per day). For bacteria, however, TMDLs are expressed in terms of cfu or MPN or organism counts, in accordance with 40 CFR 130.2(l). Only the instantaneous water quality criterion was targeted for the Cattail Branch and Black Creek because there are insufficient data to evaluate against the 30-day geometric mean. The target load is defined as the load (from point and nonpoint sources) minus the MOS that a stream station can receive while meeting the WQS. The TMDL value is the median target load within the critical condition (i.e., the median value within the hydrologic category that requires the greatest load reduction) plus the WLA and MOS.

While TMDL development was based on instantaneous water quality criterion, terms and conditions of NPDES permits for continuous discharges require facilities to demonstrate compliance with both geometric mean and instantaneous water quality criteria for *E. coli* in treated effluent. NPDES permits for continuous dischargers require data collection sufficient to monitor for compliance of both criteria at the point of outfall.

Table 15 indicates the percentage reduction or water quality standard required for both subwatersheds analyzed in this TMDL document. Note that all future regulated NPDES-permitted stormwater discharges will also be required to meet the prescribed percentage reductions, or the water quality standard. It should be noted that in order to meet the WQS for *E. coli,* prescribed load reductions must be targeted from all sources, including NPDES permitted and nonpoint sources.

Based on the available information at this time, the portions of the subwatersheds that drain directly to regulated MS4s and those that drain through unregulated MS4s have not been clearly defined within the MS4 jurisdictional area. Loading from both types of sources (regulated and unregulated) typically occurs in response to rainfall events, and discharge volumes as well as recurrence intervals are largely unknown. Therefore, where applicable, the regulated MS4 is assigned the same percent reduction as the non-regulated sources in the watershed. Compliance with the MS4 permit in regard to this TMDL document is determined at the point of discharge to waters of the state. The regulated MS4 entity is only responsible for implementing the TMDL WLA in accordance with their MS4 permit requirements and is not responsible for reducing loads prescribed as LA in this TMDL document.

Table 15. Total Maximum Daily Loads for Cattail Branch, Black Creek and Tributaries

	Existing Load	TMDL	Margin of Safety	Waste Load Allocation (WLA)			Load Allocation (LA)	
Station	*E. Coli* (MPN/day)	*E. coli* (MPN/day)	*E. coli* (MPN/day)	Continuous Source[1] (MPN/day)	Non-Continuous Sources[2,3] (% Reduction)	Non-Continuous SCDOT[3,4] (% Reduction)	*E. coli* (MPN/day)	% Reduction to Meet LA[3]
PD-251	2.24E+12	1.18E+12	5.74E+10	--- (see note 1)	50%	50%	1.12E+12	50%
RS-16312	2.10E+11	4.48E+10	2.18E+09	1.98E+10 (see note 1)	89%	89%	2.28E+10	89%

1. WLAs are expressed as a daily maximum. Existing and future continuous discharges are required to meet the prescribed loading for the pollutant of concern. Future loadings will be developed based upon permitted flow and an allowable permitted maximum *E. coli* concentration of 349 MPN/100ml.
2. Percent reduction applies to all NPDES-permitted stormwater discharges, including current and future MS4, construction and industrial discharges covered under permits numbered SCS & SCR. Stormwater discharges are expressed as a percentage reduction due to the uncertain nature of stormwater discharge volumes and recurrence intervals. Stormwater discharges are required to meet percentage reduction or the existing instream standard for pollutant of concern in accordance with their NPDES Permit.
3. Percent reduction applies to existing instream *E. coli.*
4. By implementing the best management practices that are prescribed in either the SCDOT annual SWMP or the SCDOT MS4 permit to address fecal coliform bacteria or *E. coli*, SCDOT will comply with these TMDLs and their applicable WLAs to the maximum extent practicable (MEP) as required by its MS4 permit.

5.8 Reasonable Assurance

NPDES permits are issued for regulated dischargers, including continuous and non-continuous sources of pathogenic bacteria. In freshwaters, the applicable recreational use water quality standard is *E. coli* bacteria. Continuous discharges are required to target the *E. coli* water quality standard at the point of discharge. For regulated non-continuous discharges, the *E. coli* standard should be targeted to the maximum extent practicable. There may be other regulated activities present that could contribute to *E. coli* loadings in the watershed. New septic tanks, animal feeding operations (AFOs), land application of treated sludge or wastewater also require permits that reduce the potential for runoff of bacteria into waters of the State.

Unregulated sources of *E. coli* loadings in the watershed may include wildlife, improper agricultural or silvicultural activities, urban, and suburban runoff. These sources may be reduced through means such as best management practices, local ordinances, and outreach educational efforts, as well as 319 grant funded opportunities. SCDHEC has fostered effective partnerships between other federal, state and local entities to help reduce the potential for runoff of bacteria into waters of the State. Once implemented, all these reduction mechanisms will provide reasonable assurance that the recreational use water quality standard will be attained in this watershed.

6.0 Implementation

Implementation of both point (WLA) and non-point (LA) source components of the TMDL are necessary to bring about the required reductions in *E. coli* bacteria loading to the Cattail Branch and Black Creek Watersheds. Using existing authorities and mechanisms, implementation guidance providing information on how point and non-point sources of pollution may be abated to meet water quality standards is provided. Sections 6.1.1-6.1.7 presented below correspond with sections 3.1.1-3.2.6 of the source assessment presented in the TMDL document. As the implementation strategy progresses, SCDHEC will continue to monitor the effectiveness of implementation measures and evaluate water quality where deemed appropriate.

Point sources are discernible, confined, and discrete conveyances of pollutants to a water body including but not limited to pipes, outfalls, channels, tunnels, conduits, man-made ditches, etc. The Clean Water Act's primary point source control program is the National Pollutant Discharge Elimination System (NPDES). Point sources can be broken down into continuous and non-continuous point sources. Some examples of a continuous point source are wastewater treatment facilities (WWTF) and industrial facilities. Some examples of non-continuous point sources include MS4s and construction activities. Current and future NPDES discharges in the referenced watershed are required to comply with the load reductions prescribed in the waste load allocation (WLA).

Nonpoint source pollution originates from multiple sources over a relatively large area. It is diffuse in nature and indistinct from other sources of pollution. It is generally caused by the pickup and transport of pollutants from rainfall moving over and through the ground. Nonpoint sources of pollution may include, but are not limited to wildlife, agricultural activities, illicit discharges, failing septic systems, and urban runoff. Nonpoint sources located in unregulated portions of subwatersheds 16312 and 251 are subject to the load allocation (LA) and not the WLA of the TMDL document.

South Carolina has several tools available for implementing the non-point source components of these TMDLs. The *Implementation Plan for Achieving Total Maximum Daily Load Reductions from Nonpoint Sources for the State of South Carolina* (SCDHEC 1998) document is one example. Another key component in controlling pollution and preventing water quality degradation in the TMDL watersheds would be the establishment and administration of a program of Best Management Practices (BMPs). Best management practices may be defined as a practice or a combination of practices that have been determined to be the most effective, practical means used in the prevention and/or reduction of pollution.

Interested parties (local stakeholder groups, universities, local governments, etc.) may be eligible to apply for CWA §319 grants to install BMPs that will implement the LA portions of these TMDLs and reduce nonpoint source *E. coli* loading to the TMDL watersheds. Congress amended the Clean Water Act (CWA) in 1987 to establish the Section 319 Nonpoint Source Management Program. Under Section 319, States receive grant money to support a wide variety of activities including the restoration of impaired waters. TMDL implementation projects are given highest priority for 319 funding. SCDHEC will also work with existing agencies in the area to provide nonpoint source education in the Cattail Branch and Black Creek Watersheds.

The Department recognizes that adaptive management/implementation of these TMDLs might be necessary to achieve the water quality standard and we are committed to targeting the load reductions needed to improve water quality in the Cattail Branch and Black Creek Watersheds. As additional data and/or information become available, it may become necessary to revise and/or modify the TMDL target accordingly.

6.1 Implementation Strategies

The strategies presented in this document for implementation of the Cattail Branch, Black Creek, and Tributaries Watershed TMDL are not inclusive and are to be used only as guidance. The strategies are informational suggestions that may lead to the required load reductions being met while demonstrating consistency with the assumptions and requirements of the TMDL. Application of certain strategies provided may be voluntary and are not a substitute for actual NPDES permit conditions.

6.1.1 Continuous Point Sources

Continuous point source WLA reductions are implemented through NPDES permitting. Existing and future continuous discharges are required to meet the prescribed loading for the pollutant of concern and demonstrate consistency with the assumptions and requirements of the TMDL. *E. coli* loadings are developed based upon permitted flow and an allowable permitted maximum *E. coli* concentration of 349 MPN/100mL.

6.1.2 Non-continuous Point Sources

An iterative BMP approach as defined in the general stormwater NPDES MS4 permit is expected to provide significant implementation of the WLA. Permit requirements for implementing WLAs in approved TMDLs will vary across waterbodies, discharges, and pollutant(s) of concern. The allocations within a TMDL can take many different forms – narrative, numeric, specific BMPs – and may be complimented by other special requirements such as monitoring.

The level of monitoring necessary, deployment of structural and non-structural BMPs, evaluation of BMP performance, and optimization or revisions to the existing pollutant reduction goals of the Storm Water Management Plan (SWMP) or any other plan is TMDL and watershed specific. Hence, it is expected that NPDES permit holders will evaluate their existing SWMP or other plans in a manner that would effectively address implementation of these TMDLs with an acceptable schedule and activities for their permit compliance. The Department (permit writers, TMDL project managers, and compliance staff) is willing to assist in developing or updating the referenced plan as deemed necessary. Please see Appendix B for additional information on evaluating the effectiveness of an MS4 Permit as it relates to compliance with approved TMDLs. For SCDOT, existing, and future NPDES MS4 permittees, compliance with terms and conditions of the NPDES permit is effective implementation of the WLA to the Maximum Extent Practicable (MEP) and demonstrates consistency with the assumptions and requirements of the TMDL. For existing and future NPDES construction and industrial stormwater permittees, compliance with terms and conditions of the permit is effective implementation of the WLA. Required load reductions in the LA portion of this TMDL can be implemented through voluntary measures and are eligible for CWA §319 grants.

The Department acknowledges that progress with the assumptions and requirements of the TMDL by MS4s is expected to take one or more permit iteration. Achieving the WLA reduction for the TMDL may constitute MS4 compliance with its SWMP, provided the MEP definition is met, even where the numeric percent reduction may not be achieved in the interim.

Regulated MS4 entities are required to develop a SWMP that includes the following: public education, public involvement, illicit discharge detection & elimination, construction site runoff control, post construction runoff control, and pollution prevention/good housekeeping. These measures are not exhaustive and may include additional criteria depending on the type of NPDES MS4 permit in question. The following examples are recognized as acceptable stormwater practices and may be applied to unregulated MS4 entities or other interested parties in the development of a stormwater management plan.

An informed and knowledgeable community is crucial to the success of a stormwater management plan (USEPA, 2005). MS4 entities may implement a public education program to distribute educational materials to the community or conduct equivalent outreach activities about the impacts of stormwater discharges on local waterbodies and the steps that can be taken to reduce stormwater pollution. Some appropriate BMPs may be brochures, educational programs, storm drain stenciling, stormwater hotlines, tributary signage, and alternative information sources such as websites, bumper stickers, etc. (USEPA, 2005).

The public can provide valuable input and assistance to a stormwater management program and they may have the potential to play an active role in both the development and implementation of the stormwater program where deemed appropriate by the entity. There are a variety of practices that can involve public participation such as public meetings/citizens panels, volunteer water quality monitoring, volunteer educators, community clean-ups, citizen watch groups, and "Adopt a Storm Drain" programs which encourage individuals or groups to keep storm drains free of debris and monitor what is entering local waterways through storm drains (USEPA, 2005).

Illicit discharge detection and elimination efforts are also necessary. Discharges from MS4s often include wastes and wastewater from non-stormwater sources. This enters the system through either direct connections or indirect connections. The result is untreated discharges that contribute high levels of pollutants, including heavy metals, toxics, oil and grease, solvents, nutrients, viruses, and bacteria to receiving waterbodies (USEPA, 2005). Pollutant levels from these illicit discharges have been shown in EPA studies to be high enough to significantly degrade receiving water quality and threaten aquatic, wildlife, and human health. MS4 entities may have a storm sewer system map which shows the location of all outfalls and to which waters they discharge. If not already in place, an ordinance prohibiting non-stormwater discharges into a MS4 with appropriate enforcement procedures may be developed. Entities may also have a plan for detecting and addressing non-stormwater discharges. The plan may include locating problem areas through infrared photography, finding the sources through dye testing, removal/correction of illicit connections, and documenting the actions taken to illustrate that progress is being made to eliminate illicit connections and discharges.

A program might also be developed to reduce pollutants in stormwater runoff to the MS4 area from construction activities. An ordinance or other regulatory mechanism may exist requiring the implementation of proper erosion and sediment controls on applicable construction sites. Site plans should be reviewed for projects that consider potential water quality impacts. It is recommended that site inspections should be conducted, and control measures enforced where applicable. A procedure might also exist for considering information submitted by the public (USEPA, 2005). For information on specific BMPs please refer to the SCDHEC Stormwater Management BMP Handbook online at: https://scdhec.gov/environment/water-quality/stormwater/bmp-handbook

Post-construction stormwater management in areas undergoing new development or redevelopment is recommended because runoff from these areas has been shown to significantly affect receiving waterbodies. Many studies indicate that prior planning and design for the minimization of pollutants in post-construction stormwater discharges is the most cost-effective approach to stormwater quality management (USEPA, 2005). Strategies might be developed to include a combination of structural and/or non-structural BMPs. An ordinance or other regulatory mechanism may also exist requiring the implementation of post-construction runoff controls and ensuring their long term-operation and maintenance. Examples of non-structural BMPs are planning procedures and site-based BMPs (minimization of imperviousness and maximization of open space). Structural BMPs may include but are not limited to stormwater retention/detention BMPs, infiltration BMPs (dry wells, porous pavement, etc.), and vegetative BMPs (grassy swales, filter strips, rain gardens, artificial wetlands, etc.).

Pollution prevention is also a key element of stormwater management programs. This requires the MS4 entity to examine and alter their programs or activities to ensure reductions in pollution are occurring. A plan should be developed to prevent or reduce pollutant runoff from municipal operations into the storm sewer system and employees trained on ways to incorporate and document pollution prevention/good housekeeping techniques. The MS4 operator can use training materials that are available from EPA or relevant organizations (USEPA, 2005).

6.1.3 Wildlife

Methods for managing the bacteria contribution from wildlife will vary from location to location. In developed areas it may make sense to divert wildlife from sensitive areas by fencing, mowing, landscaping changes, and trimming trees to reduce bird roosting. Food sources for wildlife can be kept to a minimum by prohibiting feeding by the public, by removing trash, pet food, and palatable plant species. In rural, undeveloped areas, which includes much of the watershed evaluated for this TMDL document, these methods would not be practical.

Although there are many ways to discourage birds and other wildlife from waterways by removing attractants or harassing nuisance species, any plans to do so should be undertaken only with a good understanding of the animal populations in question. Federal and state permits may be required to interfere with wildlife, and some nuisance species such as Canada geese and other migratory birds are protected by federal law. It is recommended that the South Carolina Department of Natural Resources, USDA-APHIS, and the United States Fish and Wildlife Service be consulted prior to interfering with wildlife (USEPA, 2001). Approximately half of the area covered by this TMDL is managed for the benefit of wildlife, which may in turn be contributing to *E. coli* in the waterways. In this case, *E. coli* from other sources should be targeted.

6.1.4 Agricultural Activities

Suggested forms of implementation for agricultural activities will vary depending on location. Agricultural BMPs can be vegetative, structural, or management oriented. When selecting BMPs, it is important to keep in mind that nonpoint source pollution occurs when a pollutant becomes available, is detached, and then transported to nearby receiving waters. For BMPs to be effective, the transport mechanism of the pollutant, in this case *E. coli* bacteria, needs to be identified.

For livestock in the watershed, installing fencing along the streams within the watershed and providing an alternative water source where livestock are present would eliminate direct contact with the streams. When grazing animals have access to streams, they have a large impact on bacteria loads even if few in number. If fencing is not feasible, it has been shown that installing water troughs within a pasture area reduced the amount of time livestock spent drinking directly from streams by 92% (Sheffield et al.,1997). In addition to reducing bacteria in the stream, this BPM resulted in a 77% reduction in stream bank erosion.

Aside from hayfields, there was very little agricultural activity observed in the Cattail Branch and Black Creek Watersheds. Where row crops do exist, many practices exist to reduce nonpoint source pollution. Unstabilized soil directly adjacent to surface waters can contribute to bacteria loading during periods of runoff after rain events. Agricultural field borders and filter strips (vegetative buffers) can provide erosion control around fields. These borders may be harvested as hay and provide an area in which farmers can turn equipment around when working the field (SCDNR, 1997). A study conducted in 1998 by the American Society of Agricultural and Biological Engineers (ASABE 1998) demonstrated that a vegetative buffer measuring 6.1 meters in width can reduce fecal bacteria runoff concentrations to a non-detectable amount. A buffer of this width was also shown to reduce phosphorous and nitrogen concentrations in runoff by 75%.

The agricultural BMPs listed above are just a sample of the many accepted practices that are currently available. Many other techniques such as conservation tillage, responsible pest management, and precision agriculture also exist and may contribute to an improvement in overall water quality in the TMDL watersheds. Education should be provided to local farmers on these methods as well as acceptable manure spreading and holding practices. South Carolina-specific information on agriculture BMPs is available from the Clemson Cooperative Extension Service. http://www.clemson.edu/extension/water

The Natural Resources Conservation Service (NRCS, a division of USDA) provides financial and technical assistance to help landowners address natural resource concerns, promote environmental quality, and protect wildlife habitat on property they own or control. Their website contains a wealth of information on agriculture BMPs and water quality issues associated with agricultural practices. Cost-share funds are available through the NRCS's Environmental Quality Incentives Program (EQIP). EQIP helps farmers improve production while protecting environmental quality by addressing such concerns as soil erosion and productivity, grazing management, water quality, animal waste, and forestry concerns. More information about conservation and funding sources may be found at: https://www.farmers.gov/ and https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/eqip/ .

6.1.5 Leaking Sanitary Sewers

Leaking sanitary sewers and illicit discharges, although illegal and subject to enforcement, may be occurring the Cattail Branch and Black Creek Watershed. Due to the high concentration of pollutant loading that is generally associated with these discharges, their detection may provide a substantial improvement in overall water quality in the watershed. Detection methods may include, but are not limited to: dye testing, air pressure testing, static pressure testing, and infrared photography. SCDHEC recognizes illicit discharge detection and elimination activities are conducted by regulated MS4 entities pursuant to compliance with existing MS4 permits. Note that these activities are designed to detect and eliminate illicit discharges that may contain FC bacteria or *E. coli*. It is the intent of SCDHEC to work with the MS4 entities to recognize FC bacteria or *E. coli* load reductions as they are achieved. SCDHEC acknowledges that these efforts to reduce illicit discharges and SSOs are ongoing and some reduction may already be accountable (i.e., load reductions occurring during TMDL development process). Thus, the implementation process is an iterative and adaptive process. Regular communication between all implementation stakeholders will result in successful remediation of controllable sources over time. As designated uses are restored, SCDHEC will recognize efforts of implementers where their efforts can be directly linked to restoration.

6.1.6 Failing Septic Systems

A septic system, also known as an onsite wastewater system, is defined as failing when it is not treating or disposing of sewage in an effective manner. The most common reason for failure is improper maintenance by homeowners. Untreated sewage not only contains disease-causing bacteria and viruses, but also unhealthy amounts of nitrate and other chemicals. Failed septic systems can allow untreated sewage to seep into and pollute wells, groundwater, and surface water bodies. Pumping a septic tank is probably the single most important thing that can be done to protect the system. Information on how a septic tank works and proper maintenance is available here: https://scdhec.gov/environment/your-home/septic-tanks and tips on proper usage here:https://www.epa.gov/septic/dos-and-donts-homeowners-brochure

6.1.7 Urban and Suburban Runoff

Urban runoff is surface runoff of rainwater created by urbanization outside of regulated areas. Pavement, compacted areas, roofs, reduced tree canopy and open space increase runoff volumes that rapidly flow into receiving waters. The increase in volume and velocity of runoff may cause stream bank erosion, channel incision and sediment deposition in stream channels. In addition, runoff from these developed areas can increase stream temperatures. This, along with the increase in flow rate and pollutant loads negatively affect water quality and aquatic life (USEPA 2005). Runoff can pick up bacteria along the way. Many strategies currently exist to reduce bacteria loading from urban runoff and the USEPA nonpoint source pollution website provides extensive resources on this subject:

https://www.epa.gov/nps/nonpoint-source-urban-areas

Some examples of urban nonpoint source BMPs are street sweeping, stormwater wetlands, pet waste receptacles (equipped with waste bags), and educational signs which can be installed adjacent to receiving waters in the watershed such as parks, common areas, apartment complexes, trails, etc. Low impact development (LID) may also be effective. LID is an approach to land development (or re-development) that works with nature to manage stormwater as close to its source as possible. LID employs principles such as preserving and recreating natural landscape features, minimizing effective imperviousness to create functional and appealing site drainage that treats stormwater as a resource rather than a waste product. There are many practices that have been used to adhere to these principles such as bioretention facilities, rain gardens, vegetated rooftops, rain barrels, and permeable pavements (USEPA, 2009).

Education should be provided to individual homeowners in the referenced watershed on the contributions to bacteria loading from pet waste. Education to homeowners in the watershed on the fate of substances poured into storm drain inlets should also be provided. For additional information on urban runoff please see the SCDHEC nonpoint source program web page:

https://www.scdhec.gov/environment/your-water-coast/watersheds-program/section-319-nonpoint-source-program

7.0 Resources for Pollution Management

- Citizen's Guide to Protecting Our Water Resources from Runoff Pollution

  https://scdhec.gov/sites/default/files/media/document/CR-002358.pdf

- Polluted Runoff: Nonpoint Source (NPS) Pollution – EPA's landing page for all things NPS

  https://www.epa.gov/nps

- National Menu of Best Management Practices (BMPs) for Stormwater – Based on the six minimum control measures for Phase I and Phase II MS4s

  https://www.epa.gov/npdes/national-menu-best-management-practices-bmps-stormwater#edu

- South Carolina Forestry Commission Best Management Practices – Includes streamside management, stream crossings, and managing drainage to protect water quality

  https://www.state.sc.us/forest/refbmp.htm#contents

- Clemson Public Service and Agriculture – Center for Watershed Excellence offers professional training for managing stormwater ponds, assessing BMPs, and landscape managing to protect waterways

  https://www.clemson.edu/public/water/watershed/

- SCDOT Stormwater Management

  https://www.scdot.org/business/storm-water.aspx

- Agricultural Waste Management Field Handbook

  https://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/water/?&cid=stelprdb1045935

- Manure Management for Small Farms

  https://lpelc.org/manure-management-on-small-farms/

- Managing Canada Geese in Urban Environments

  https://ecommons.cornell.edu/handle/1813/66

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Appendix A: Data Tables for PD-251 and RS-16312

Data WQM Station PD-251

PD-251 *E. coli* Counts (exceedances highlighted)

Date	MPN/100ml
2/13/2013	116.9
4/8/2013	155.3
6/27/2013	248.9
8/12/2013	601.5
10/28/2013	59.4
12/12/2013	365.4
1/14/2014	224.7
3/4/2014	52.9
5/7/2014	119.8
7/8/2014	172.3
9/8/2014	2419.6
11/24/2014	1553.1
3/2/2015	95.9
4/20/2015	8.6
6/9/2015	90.9
8/10/2015	83.9
10/14/2015	5.2
12/7/2015	98.8
2/23/2016	98.5
4/26/2016	73.3
6/7/2016	435.2
8/8/2016	64.4
10/31/2016	114.5
12/7/2016	488.4
1/30/2017	77.6
2/22/2017	54.6
3/29/2017	69.7
4/13/2017	435.2
5/15/2017	58.3
6/26/2017	387.3
7/17/2017	98.8
8/3/2017	118.7
9/27/2017	114.5
10/30/2017	228.2
11/27/2017	178.5
12/12/2017	1732.9
1/29/2018	866.4

2/14/2018	54.8
3/13/2018	214.3
4/26/2018	613.1
5/23/2018	68.3
6/21/2018	488.4
7/10/2018	79.4
8/30/2018	98.7
11/26/2018	71.7
12/27/2018	8.6
1/9/2019	70.3
2/13/2019	118.7
3/5/2019	77.1
4/4/2019	488.4
5/29/2019	50.4
6/13/2019	488.4
7/8/2019	67.7
8/28/2019	36.4
9/11/2019	325.5
11/13/2019	172.5
1/15/2020	133.3

90th Percentile *E. coli* Concentration (MPN/100ml) by Hydrologic Category

WQM Site	**High Flow 0-10%**	**Moist Cond. 10-40%**	**Midrange 40-60%**	**Dry Cond. 60-90%**	**Low Flow 90-100%**	**Number of Samples**
PD-251	595	664	602	363	97	57

Flow (cfs) at Midpoint of Each Hydrologic Category

WQM Site	**High Flow (5%)**	**Moist Cond. (25%)**	**Midrange (50%)**	**Dry (75%)**	**Low Flow (95%)**
PD-251	369.5	138.1	64.2	30.5	8.9

Existing Load (number *E. coli*/day) at each Midpoint of Each Hydrologic Category Flow

WQM Site	**High Flow (5%)**	**Moist Cond. (25%)**	**Midrange (50%)**	**Dry (75%)**	**Low Flow (95%)**
PD-251	5.38E+12	2.24E+12	9.44E+11	2.71E+11	2.11E+10

TMDL (number *E. coli* bacteria/day) at Each Midpoint of Each Hydrologic Category Flow

WQM Site	High Flow (5%)	Moist Cond. (25%)	Midrange (50%)	Dry (75%)	Low Flow (95%)
PD-251	3.16E+12	1.18E+12	5.48E+11	2.61E+11	7.57E+10

Load Reduction Necessary (number *E. coli* bacteria/day) at Midpoint of Each Hydrologic Category Flow

WQM Site	High Flow (5%)	Moist Cond. (25%)	Midrange (50%)	Dry (75%)	Low Flow (95%)
PD-251	NA	1.06E+12	3.96E+11	1.00E+10	NA

Percent Reduction Necessary at Midpoint of Each Hydrologic Category Flow

WQM Site	High Flow (5%)	Moist Cond. (25%)	Midrange (50%)	Dry (75%)	Low Flow (95%)
PD-251	NA	50%	45%	8%	NA

Data WQM Station RS-16312

RS-16312 *E. coli* Bacteria Counts (exceedances highlighted)

Date	MPN/100ml
1/6/2016	137.4
2/1/2016	178.5
3/2/2016	104.3
4/4/2016	152.9
5/5/2016	2419.6
6/2/2016	980.4
7/14/2016	275.5
8/2/2016	2419.6
9/15/2016	727
10/5/2016	727
11/17/2016	214.3
12/6/2016	816.4
1/29/2018	2419.6
2/13/2018	290.9
3/13/2018	686.7
4/26/2018	1413.6
5/23/2018	261.3
6/21/2018	129.6
7/10/2018	275.5
8/30/2018	146.7
11/26/2018	613.1
12/27/2018	2419.6

90th Percentile *E. coli* Concentration (MPN/100ml) by Hydrologic Category

WQM Site	**High Flow 0-10%**	**Moist Cond. 10-40%**	**Midrange 40-60%**	**Dry Cond. 60-90%**	**Low Flow 90-100%**	**Number of Samples**
RS-16312	2058	2420	214	828	147	22

Flow (cfs) at Midpoint of Each Hydrologic Category

WQM Site	**High Flow (5%)**	**Moist Cond. (25%)**	**Midrange (50%)**	**Dry (75%)**	**Low Flow (95%)**
RS-16312	9.5	3.6	1.6	0.78	0.23

Existing Load (number *E. coli*/day) at Each Midpoint of Each Hydrologic Category Flow

WQM Site	High Flow (5%)	Moist Cond. (25%)	Midrange (50%)	Dry (75%)	Low Flow (95%)
RS-16312	4.78E+11	2.10E+11	8.65E+09	1.59E+10	8.18E+08

TMDL (number *E.coli*/day) at Each Midpoint of Each Hydrologic Category Flow

WQM Site	High Flow (5%)	Moist Cond. (25%)	Midrange (50%)	Dry (75%)	Low Flow (95%)
RS-16312	9.42E+10	4.48E+10	3.00E+10	2.33E+09	1.89E+09

Load Reduction Necessary (number *E. coli*/day) at Midpoint of Each Hydrologic Category Flow

WQM Site	High Flow (5%)	Moist Cond. (25%)	Midrange (50%)	Dry (75%)	Low Flow (95%)
RS-16312	NA	1.65E+11	NA*	1.36E+10	NA

*no exceedances occurred during this flow category so no reduction necessary

Percent Reduction Necessary at Midpoint of Each Hydrologic Category Flow

WQM Site	High Flow (5%)	Moist Cond. (25%)	Midrange (50%)	Dry (75%)	Low Flow (95%)
E-030	NA	89%	NA*	85%	NA

*no exceedances occurred during this flow category so no reduction necessary

Appendix B: Evaluating the Progress of MS4 Programs

Described below are approaches that may be used by MS4 permit holders and others implementing TMDLs. These are recommendations and examples only. SCDHEC-BOW recognizes that other approaches may be utilized or employed to meet compliance goals.

1. Calculate pollutant load reduction for each best management practice (BMP) deployed:
    - Retrofitting stormwater outlets
    - Creation of green space
    - LID activities (e.g., creation of porous pavements)
    - Creations of riparian buffers
    - Stream bank restoration
    - Scoop the poop program (how many pounds of poop were scooped/collected)
    - Street sweeping program (amount of materials collected etc.)
    - Construction & post-construction site runoff controls
2. Description & documentation of programs directed towards reducing pollutant loading:
    - Document tangible efforts made to reduce impacts to urban runoff
    - Track type and number of structural BMPs installed
    - Parking lot maintenance program for pollutant load reduction
    - Identification and elimination of illicit discharges
    - Zoning changes and ordinances designed to reduce pollutant loading
    - Modeling of activities & programs for reducing pollutant reductions
3. Description & documentation of social indicators, outreach, and education programs:
    - Number/Type of training & education activities conducted and survey results
    - Activities conducted to increase awareness and knowledge – residents, business owners. What changes have been made based on these efforts? Any measured behavior or knowledge changes?
    - Participation in stream and/or lake clean-up events or activities
    - Number of environmental action pledges
4. Water quality monitoring: A direct and effective way to evaluate the effectiveness of stormwater management plan activities:
    - Use of data collected from existing monitoring activities (e.g., SCDHEC data for ambient monitoring program available through STORET; water supply intake testing; voluntary watershed group's monitoring, etc)
    - Establish a monitoring program for permitted outfalls and/or waterbodies within MS4 areas as deemed necessary– use a certified lab
    - Monitoring should focus on water quality parameters and locations that would both link pollutant sources and BMPs being implemented

Useful Links:

Evaluating the Effectiveness of Municipal Stormwater Programs.

https://www3.epa.gov/npdes/pubs/region3_factsheet_swmp.pdf

The International Stormwater Best Management Practices Database Project

http://www.bmpdatabase.org/

National Water Quality Monitoring Council - Water Quality Data

https://www.waterqualitydata.us/portal/

Spreadsheet Tool for Estimating Pollutant Loads (STEPL)

https://www.epa.gov/nps/spreadsheet-tool-estimating-pollutant-loads-stepl

Measurable Goals Guidance for Phase II Small MS4s

https://www3.epa.gov/npdes/pubs/measurablegoals.pdf

National Menu of BMPs for Stormwater

https://www.epa.gov/npdes/national-menu-best-management-practices-bmps-stormwater#edu

SCDHEC – BOW: The 319 grant program (**Error! Hyperlink reference not valid.**) can provide guidance on estimating load reductions for the following BMPs:

- Septic tank repair or replacement
- Removing livestock from streams
- Livestock fencing
- Waste Storage Facilities
- Strip cropping
- Prescribed grazing
- Critical Area Planting
- Runoff Management System
- Waste Management System
- Solids Separation Basin
- Riparian Buffers

Appendix C: Source Assessment Pictures

Figure 15. Stream characteristics in the Cattail Branch and Black Creek Watershed

The TMDL watersheds lie entirely within the Sandhills ecoregion. This region is characterized by rolling hills with excessively drained sandy soils that are generally unsuited for row crops due to poor moisture and nutrient content. Stream flow tends to be consistent because the sandy soil has a large capacity for infiltration and groundwater recharge. (left, Highway 145 near Rogers Branch; lower left Black Creek at Highway 265 illustrating sandy soil and creek bed). It is only toward the southeastern extent of the watershed that a wide, flat, inundated floodplain was noted (below, Black Creek at PD-251).

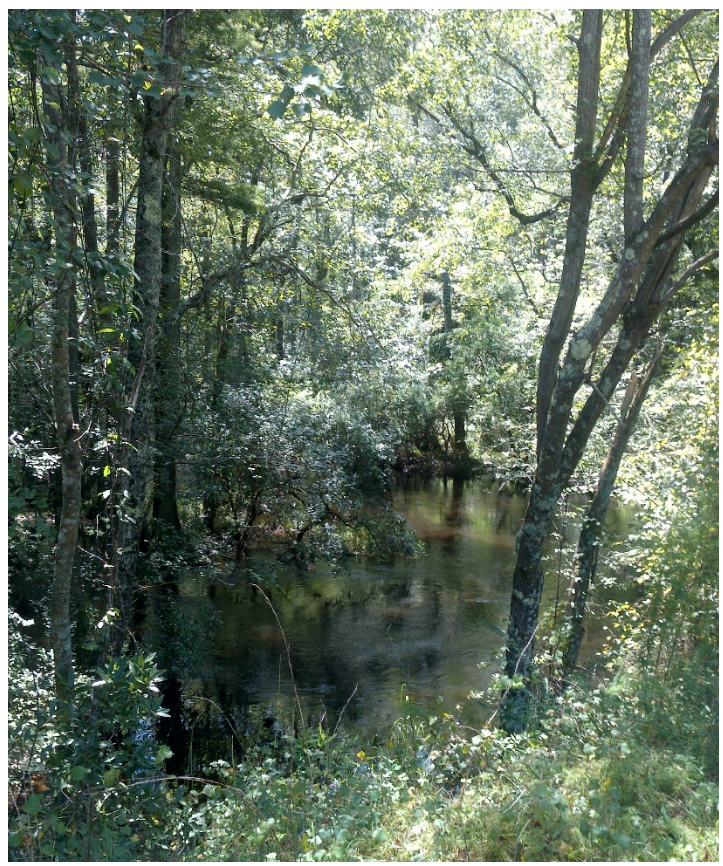


Figure 16. Developed Areas in the Watershed

Although less than 7% of the total area covered by this TMDL is considered developed land, the headwaters of Black Creek (below left and below right) and Cattail Branch originate near and within the Town of Pageland (left). The photo below is the first bridge over Black Creek with flow. Just upstream of this site are three small impoundments, the closest of which has been drained.

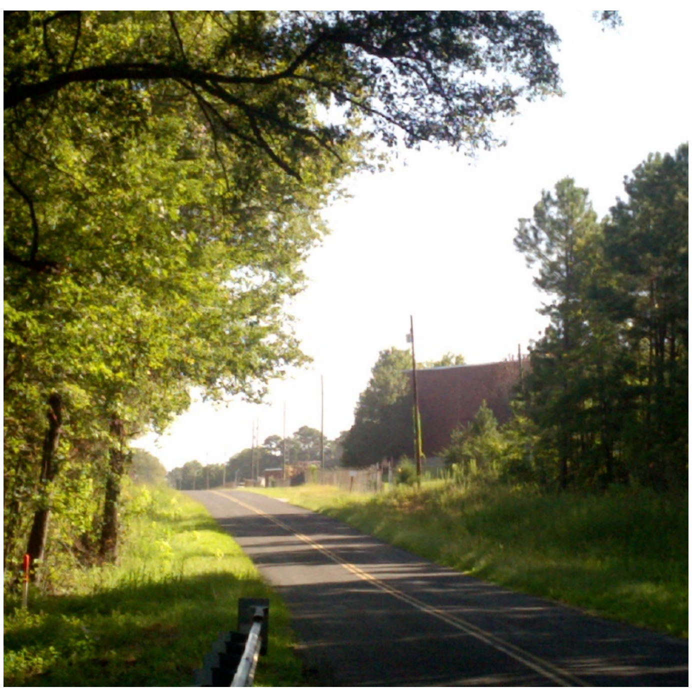


Figure 17. Silviculture

Most of the TMDL watershed is forested. Over 50% of the watershed consists of public lands (Carolina Sandhills National Wildlife Refuge and Sandhills State Forest). These areas are managed for wildlife and timber harvesting.

Figure 18. Wildlife

Land in the southeastern portion of the watershed nearest to PD-251 is mostly public, both state forest and national wildlife refuge. Human habitation is sparse in this area. There are many impoundments on the streams draining to Black Creek which are designed to attract wildlife. Meadows are maintained alongside wooded areas to attract deer and upland bird species, some of which are hunted with dogs. All of these may contribute to *E. coli* in the waterways.

Figure 19. Sewer and Onsite Wastewater Treatment

The Town of Pageland is served by a wastewater treatment plant that discharges to Cattail Branch (right, at RS-16312). Wastewater is handled by septic systems in the remainder of the watershed. Because septic systems in coarse sandy soils may drain too quickly, insufficiently treated wastewater may reach groundwater and streams. Groups of mobile homes and single family houses were noted near stream crossings (below right). As one travels south and east, there are fewer and fewer houses, and essentially none in the wildlife area. This is demonstrated in the aerial view of the lower half of the watershed (below). Areas that are cleared have been logged or are fields and meadows cultivated or kept clear for wildlife. Some of these receive treated sludge from wastewater treatment facilities (Section 3.2.3).

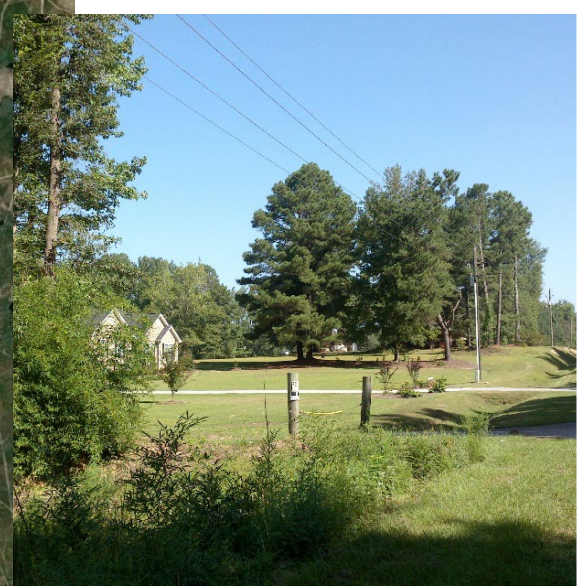


Figure 20. Subwatershed 16312 and Upper Subwatershed 251 Source Assessment

The upper third of subwatersheds 16312 and 251 are more developed than the rest of the TMDL area. There is a large area of impervious surfaces in the Town of Pageland and a fair amount of industry present. Runoff from this area has the potential to affect water quality in Cattail Branch and Black Creek. Moving to the southeast, the watershed quickly takes on a rural character with only a few scattered houses present.

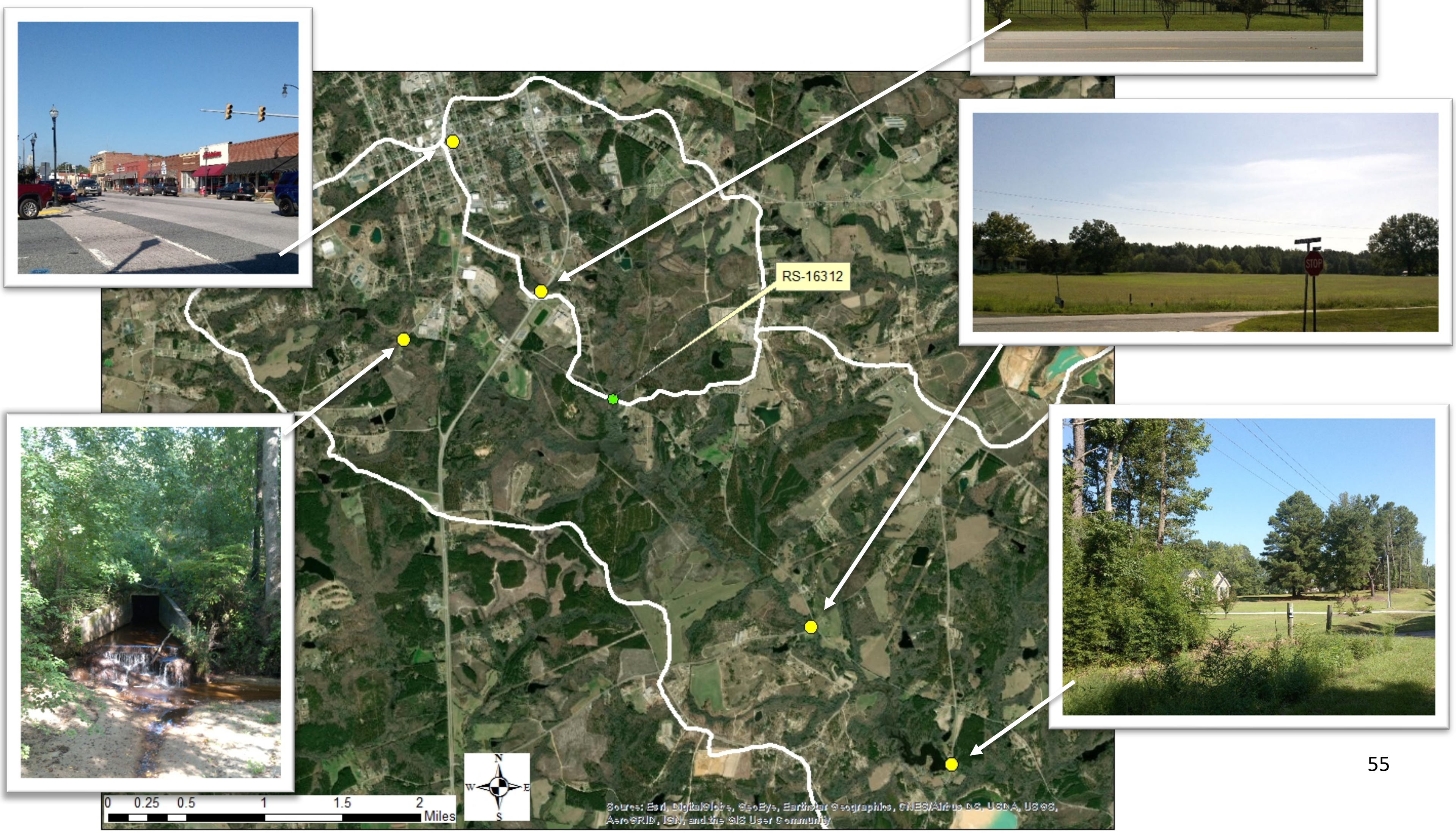
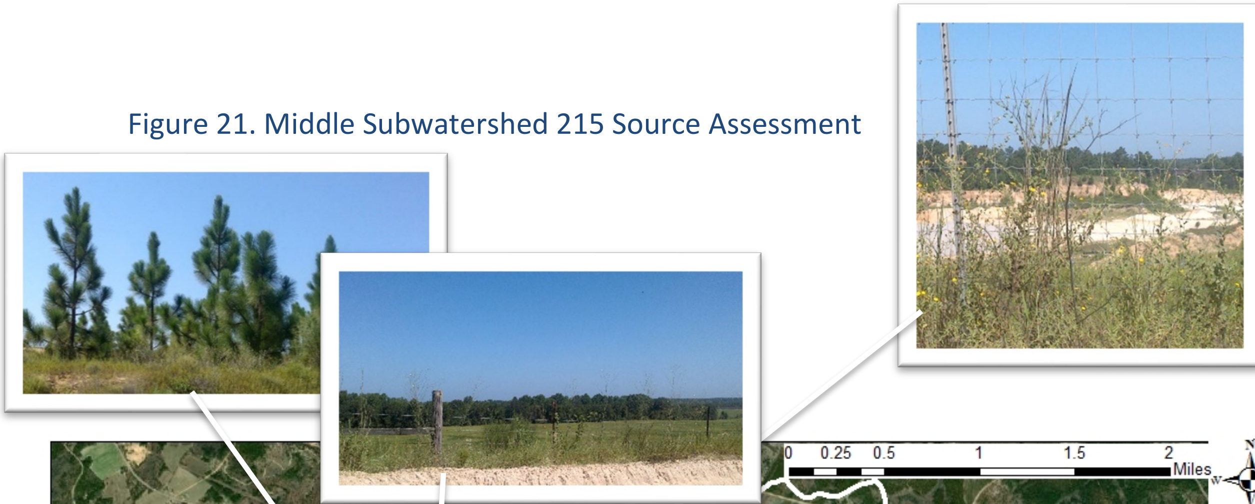


Figure 21. Middle Subwatershed 215 Source Assessment



The middle portion of the watershed is primarily forested, with some farmland and a few sand mining operations on hill tops (left). There was only one instance of grazing seen near waterways: horses which were fenced out of the stream. There are many impoundments on Little Black Creek, Black Creek, and tributaries.

Figure 22. Lower Subwatershed 251 Source Assessment

The lower third of the watershed is mostly forested and sparsely populated. The USGS gauge on Black Creek (right) used to create the flow duration curve is in the northernmost extent of this area. The creek starts to widen here and at the southern end of the watershed, a wooded floodplain develops. There are many impoundments present and large areas are devoted to wildlife habitat and timber harvesting.