Total Maximum Daily Load Document
Lake Swamp and Lower Sparrow Swamp
Stations: RS-12084, PD-345, and PD-332
(Hydrologic Unit Codes: 030402020401, 030402020402, 030402020403, 030402020404, 030402020405, 030402020406, 030402020407 and 030402020408)
Escherichia coli Bacteria,
Indicator for Pathogens

April 2017

Prepared for: Bureau of Water

SCDHEC Technical Document Number 0712-17

Healthy People. Healthy Communities.

Prepared by:

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Photographs on Title Page

Photograph in the foreground: proximity of the South Carolina Department of Health and Environmental Control's (SCDHEC) Water Quality Monitoring Station PD-332 in Sparrow Swamp at County Route S-21-55 (Meadow Prong Road) near Johnsons Crossroads in Florence County, SC (date of photography: July 12, 2016). Photograph in the background: proximity of the SCDHEC's Water Quality Monitoring Station PD-345 in Lake Swamp at County Route S-21-38 in Florence County, SC (date of photography: July 12, 2016).

Abstract

§303(d) of the federal *Clean Water Act (CWA)* and the United States Environmental Protection Agency's (USEPA) *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 all 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). 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 was listed for *Escherichia coli (E. coli)* bacteria. The following three (3) impaired water quality monitoring (WQM) stations in Lake Swamp and Sparrow Swamp in Florence County, SC are listed on the 2014 §303(d) list for *E. coli* bacteria: **a)** station RS-12084 in Lake Swamp; **b)** station PD-345 in Lake Swamp; and, **c)** station PD-332 in Sparrow Swamp. Fecal coliform (FC) bacteria TMDLs were developed for the aforementioned WQM stations using FC bacteria data collected between January 1999 and December 2012. These three (3) FC bacteria TMDLs were converted to *E. coli* bacteria TMDLs for purposes of implementation of the current *E. coli* bacteria water quality standard (WQS). Furthermore, all three (3) sites will be included on future §303(d) lists due to exceedances of the current *E. coli* bacteria WQS until such time such that sufficient *E. coli* bacteria data are collected that demonstrate the standard is attained, or until such time that these TMDLs are approved to address the parameter of concern.

Probable sources of fecal contamination include direct loading by livestock, failing septic systems, surrounding wildlife, and other agricultural activities. The load-duration curve methodology was used to calculate existing and TMDL loads for each impaired segment. 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 or dry depending on which condition demonstrated the highest load reductions necessary to meet WQSs. In order to achieve the target load (i.e., the TMDL minus a 5% MOS) for Lake Swamp and Sparrow Swamp, the following reductions in the existing loads at the respective WQM stations will be necessary: **a)** up to 61% at RS-12084; **b)** up to 58% at PD-345; and, **c)** up to 75% at PD-332. For the South Carolina Department of Transportation (SCDOT), existing and future NPDES municipal separate storm sewer system (MS4) permittees, compliance with terms and conditions of its NPDES permit is effective implementation of the WLA to the Maximum Extent Practicable (MEP) and demonstrates consistency with the assumptions and requirements of the TMDLs. For existing and future NPDES construction and Industrial stormwater permittees, compliance with terms and conditions of its permit is effective implementation of the WLA. Required load reductions in the LA portion of these TMDLs can be implemented through voluntary measures and are eligible for *CWA* §319 grants.

The Department recognizes that adaptive management/implementation of these TMDLs might be needed to achieve the WQS and the Department is committed towards targeting the load reductions to improve water quality in the Lake Swamp and Lower Sparrow Swamp watersheds. As additional data and/or information become available, it may become necessary to revise and/or modify these TMDLs targets accordingly.

Table Ab-1. Total Maximum Daily Loads for the Lake Swamp and Lower Sparrow Swamp Watershed
Loads are expressed as FC bacteria or *E. coli* bacteria count/day

	Existing FC Load (count/day)[1]	TMDL (count/day)		Margin of Safety (MOS) (count/day)		Waste Load Allocation (WLA)				Load Allocation (LA)		
						Continuous Source[3] (count/day)		Non-Continuous Sources[4,5] (% Reduction)	Non-Continuous SCDOT[5] (% Reduction)	Load Allocation (count/day)		% Reduction to Meet LA[5]
Station	FC (cfu/day)	FC (cfu/day)	*E. coli* (MPN/day)[2]	FC (cfu/day)	*E. coli* (MPN/day)[2]	FC (cfu/day)	*E. coli* (MPN/day)[2]	(Percent)	(Percent)	FC (cfu/day)	*E. coli* (MPN/day)[2]	(Percent)
RS-12084	1.25E+12	5.20E+11	*4.54E+11*	2.60E+10	*2.27E+10*	See Note Below	See Note Below	61	61[6]	4.94E+11	*4.31E+11*	61
PD-345	5.18E+11	2.30E+11	*2.01E+11*	1.15E+10	*1.00E+10*	See Note Below	See Note Below	58	0[7]	2.19E+11	*1.91E+11*	58
PD-332	1.82E+12	9.99E+11	*8.71E+11*	4.99E+10	*4.36E+10*	3.03E+10	*2.64E+10*	49	49[6]	9.19E+11	*8.01E+11*	49

Table Notes:

1. Existing fecal coliform loads were determined from the 90 percentile instream fecal coliform concentrations and stream flows during critical flow conditions. Fecal coliform concentrations were determined during the Department's water quality monitoring program.
2. Expressed as *E. coli* bacteria (MPN/day). Loadings are developed by applying a conversion factor to values calculated for FC bacteria. This conversion is derived from an established relationship between FC bacteria and *E. coli* bacteria water quality standards in freshwaters.
3. WLAs are expressed as a daily maximum. Existing and future continuous discharges are required to meet the prescribed loading for the pollutant of concern. For the purposes of NPDES permitting, continuous discharges may be required to meet a loading equivalent of FC bacteria, based upon permitted flow and an allowable permitted maximum FC bacteria concentration of 400 cfu/100 ml, until such time that *E. coli* bacteria limits are incorporated into individual permits. *E. coli* limits will be developed based upon permitted flow and an allowable permitted maximum *E. coli* bacteria concentration of 349 MPN/100 ml.
4. 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.
5. Percent reduction applies to existing instream FC bacteria or *E. coli* bacteria.
6. 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* bacteria, the SCDOT will comply with these TMDLs and its applicable WLA to the MEP as required by its MS4 permit.
7. As long as the conditions within the SCDOT MS4 area remain the same the Department deem the current contributions from SCDOT negligible and no reduction of FC bacteria or *E. coli* bacteria is necessary. SCDOT must continue to comply with the provisions of its approved NPDES stormwater permit.

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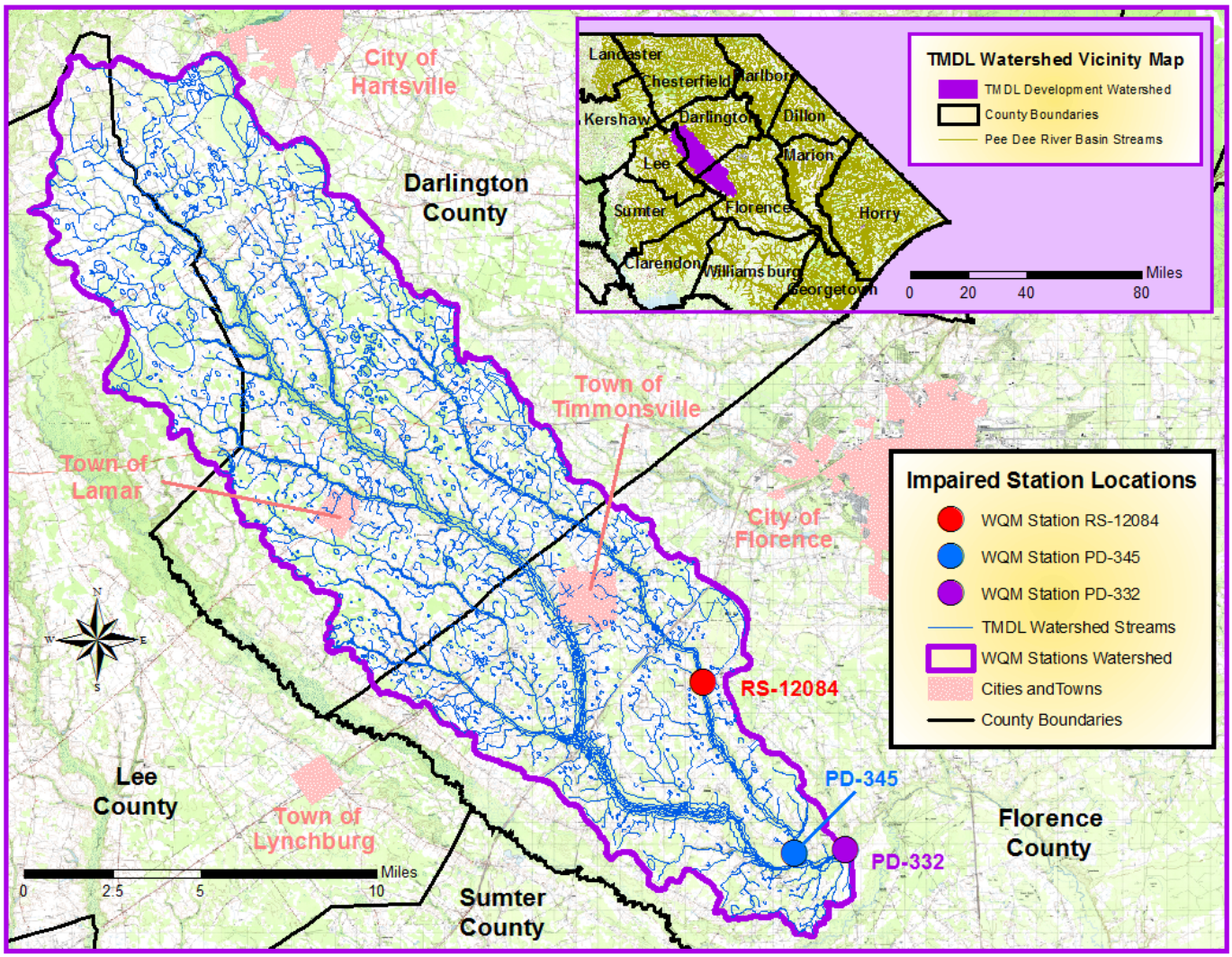
1.0 Introduction

1.1 Background

The federal *Clean Water Act (CWA)* directs each state to review the quality of its waters every two (2) years to determine if water quality standards (WQSs) are being met. If it is determined that the WQS is not being met, the states are to list the impaired water bodies under §303(d) of the *CWA*. 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 was listed for *Escherichia coli (E. coli)* bacteria. The South Carolina Department of Health and Environmental Control (SCDHEC) placed the following three (3) impaired water quality monitoring (WQM) stations in Lake Swamp and Sparrow Swamp in Florence County, SC on the 2014 §303(d) list for *E. coli* bacteria: **a)** station RS-12084 in Lake Swamp; **b)** station PD-345 in Lake Swamp; and, **c)** station PD-332 in Sparrow Swamp. These three (3) WQM stations are identified in Figure 1 and Table 1.

Figure 1. Location of Water Quality Monitoring Stations RS-12084, PD-345, and PD-332 Impaired for Freshwater Recreational Use



A Total Maximum Daily Load (TMDL) is a written plan and analysis to determine the maximum pollutant load a waterbody can receive and still meet applicable WQSs. The TMDL process includes estimating pollutant loadings from all sources, linking pollutant sources to their impacts on water quality, allocation of pollutant sources to each source and establishment of control mechanisms to achieve WQSs (USEPA, 1999).

Table 1. Lake Swamp and Lower Sparrow Swamp Watershed Recreational Use Impaired Waters

Waterbody	Station Number	Description
Lake Swamp	RS-12084	Lake Swamp at County Route S-21-106, second bridge west of the intersection with S-21-45, first bridge coming east from S-21-83
Lake Swamp	PD-345	Lake Swamp at County Route S-21-38
Sparrow Swamp	PD-332	Sparrow Swamp at County Route S-21-55 (Meadow Prong Road) near Johnsons Crossroads

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). TMDLs are required to be developed for each waterbody and pollutant combination on the States' §303(d) lists by 40 CFR 130.31(a) (USEPA, 1999).

E. coli bacteria are members of the Fecal Coliform (FC) group of bacteria and are part of the normal flora of the gastrointestinal tract of warm-blooded animals including humans. These harmless bacteria play an important role in preventing the growth of harmful bacteria, vitamin K production, and lactose digestion as well as producing compounds necessary for fat metabolism (Starr and Taggart, 1992; Wolfson and Harrigan, 2010). Some verotoxin producing strains of *E. coli*, such as 0157:H7, a major cause of foodborne illnesses, can cause gastrointestinal illnesses, kidney failure and death (Nadakavukaren, 1995; Wolfson and Harrigan, 2010).

E. coli bacteria in surface waters are indicators of recent human or animal waste contamination and originate from failing septic systems, agricultural runoff, leaking sewers among other sources. Section §303(d) of the *CWA* and the U.S. Environmental Protection Agency's (USEPA) Water Quality Planning and Management Regulations (40 CFR Part 130) require states to develop TMDLs for water bodies that are not meeting designated uses under technology-based pollution controls. The TMDL process establishes the allowable loading of pollutants or other quantifiable parameters for a water body based on the relationship between pollution sources and in stream water quality conditions so that states can establish water quality-based controls to reduce pollution and restore and maintain the quality of water resources (USEPA 1991).

This document documents the development of *E. coli* bacteria TMDLs for the following three (3) WQM stations in Florence County using FC bacteria data collected between January 1999 and December 2012: **a)** station RS-12084 in Lake Swamp; **b)** station PD-345 in Lake Swamp; and, **c)** station PD-332 in Sparrow Swamp. The FC bacteria TMDLs for these three (3) WQM stations were converted to *E. coli* bacteria TMDLs for the purposes of implementation of the current *E. coli* bacteria WQS.

1.2 Watershed Descriptions

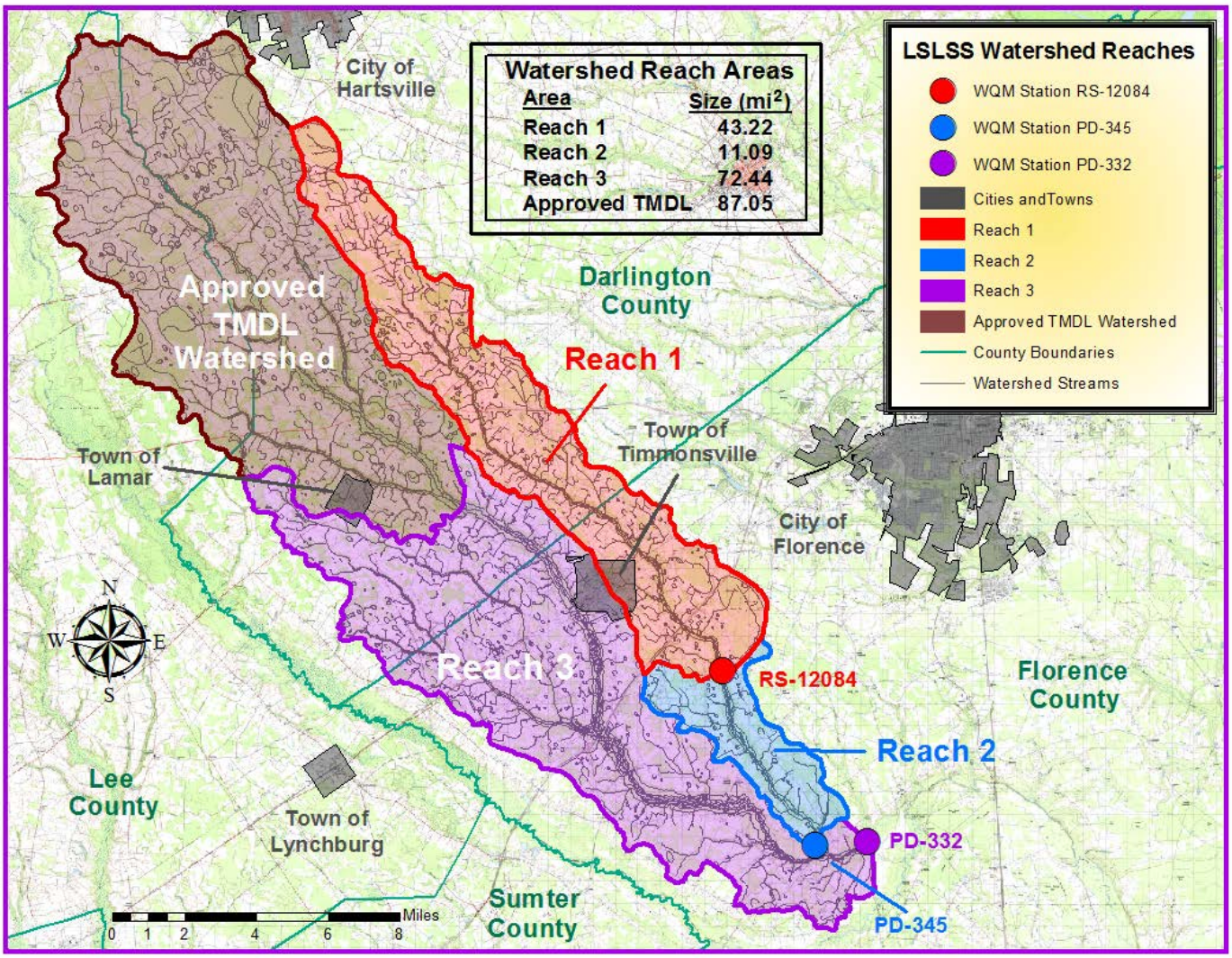
The watersheds for the three (3) aforementioned WQM stations that were placed on South Carolina's 2014 §303(d) list for impairment due to *E. coli* bacteria are addressed in this TMDL development document. In addition to the watersheds for the three aforementioned WQM stations, the watershed for WQM Station PD-072 in Sparrow Swamp in Darlington County is addressed. In September 2011, the USEPA approved a FC bacteria TMDL that was developed internally by the SCDHEC for WQM Station PD-072. The watershed for WQM Station PD-072 is contiguous with, and is located above (i.e., northwest) of the watershed for WQM Station PD-332 in Sparrow Swamp. All four watersheds are hydrologically connected. Drainage from all four watersheds ultimately flows through WQM Station PD-332. Collectively, the four (4) watersheds are referred to as the Lake Swamp and Lower Sparrow Swamp (LSLSS) Watershed in this TMDL development document.

The LSLSS Watershed is 213.79 mi^2 (136,863.47 acres) in size, is located in Darlington and Florence Counties in South Carolina, and lies in both the Southeastern Plains and Middle Atlantic Coastal Plains ecoregions of the State. The general stream flow direction in the LSLSS Watershed is in the southeastern direction. The upper northwestern part of the watershed is located at the City of Hartsville in Darlington County, and the lower southeastern part of the LSLSS Watershed is located in Florence County approximately nine (9) miles south-southwest of the City of Florence. According to the 2011 National Land

Cover Database (NLCD), land use in the watershed is predominately Cultivated Crops (46.30%), and Woody Wetlands (30.77%).

As mentioned above, collectively the aforementioned four (4) contiguous, hydrologically connected watersheds, including the watershed for the existing TMDL for WQM Station PD-072, are referred to as the LSLSS Watershed. However, the three (3) watersheds under TMDL development in this document will be referred to as reaches of the LSLSS Watershed. These three (3) reaches are: **a)** Reach 1 – the reach draining through WQM Station RS-12084; **b)** Reach 2 – the reach draining through WQM Station PD-345; and, **c)** Reach 3 – the reach draining through WQM Station PD-332. The reaches of the LSLSS Watershed are shown in Figure 2. The description of the watershed for the existing TMDL for WQM Station PD-072 is given in Section 1.3.1 of this TMDL development document.

Figure 2. Location of the Lake Swamp and Lower Sparrow Swamp Watershed Reaches

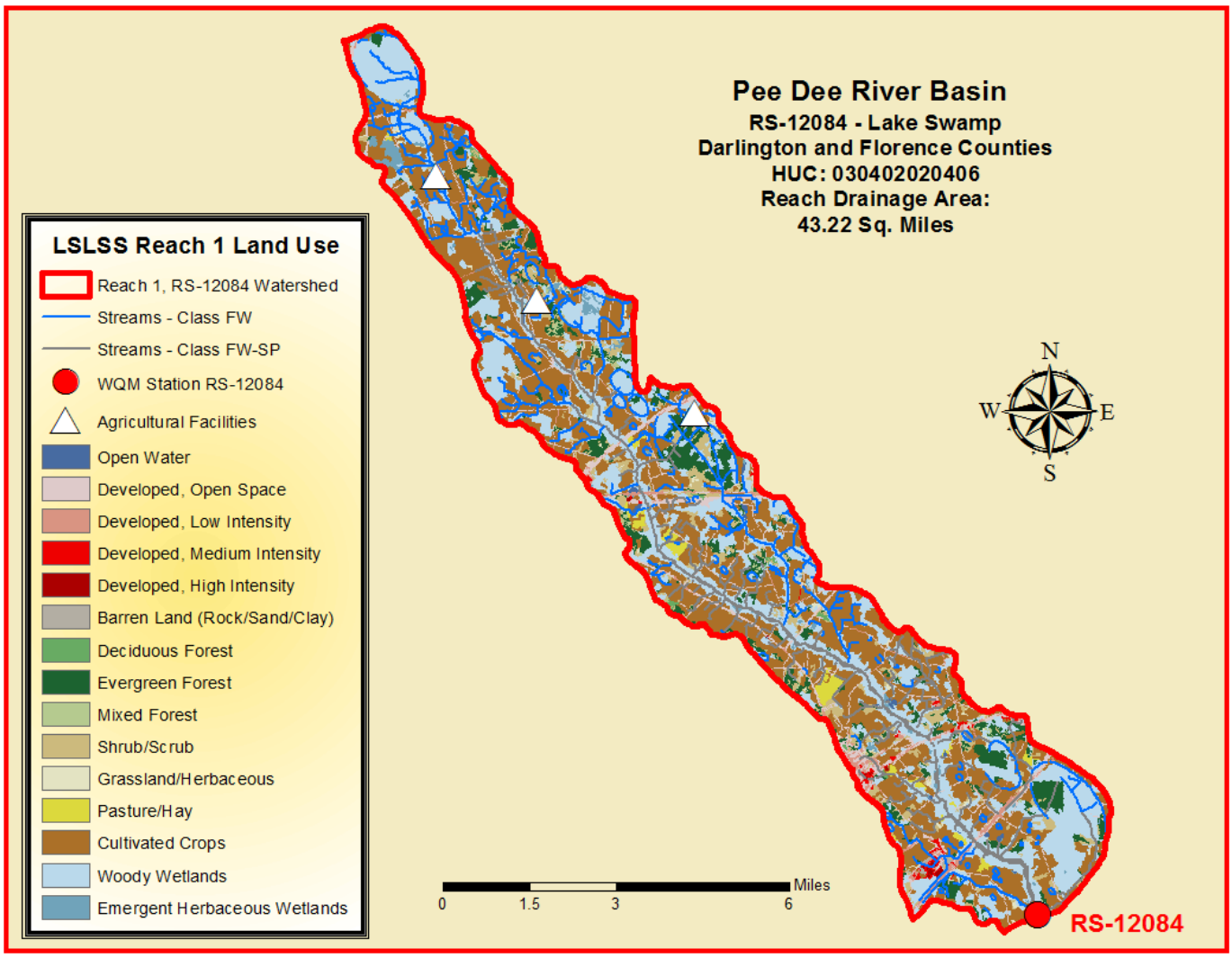


1.2.1 Reach 1 of the LSLSS Watershed; Terminal WQM Station RS-12084

Reach 1 of the LSLSS Watershed covers a drainage area of 43.22 mi² (27,668.48 acres) in size that drains into Lake Swamp and its tributaries from an area approximately two (2) miles south of the City of Hartsville in Darlington County, in a general southeastern fashion to impaired station RS-12084 in Lake Swamp at County Route S-21-106, approximately three (3) miles southeast of the Town of Timmonsville in Florence County (Figure 2). The reach lies in the Southeastern Plains and Middle Atlantic Coastal Plains ecoregions of the State.

Land use within Reach 1 of the LSLSS Watershed is predominately Cultivated Crops (42.84%), and Woody Wetlands (30.81%) (Figure 3a, Table 2a). Developed lands (residential, commercial, industrial, or open

Figure 3a. Land Use Diagram for Reach 1 of the Lake Swamp and Lower Sparrow Swamp Watershed



urban space) comprise 8.06% of the reach (Table 3). At the time of the development of these TMDLs, there were three (3) active animal feeding operations in the reach (Figure 3a).

According to Geographic Information System (GIS) information (available at time of TMDL development), there are approximately two hundred and fifty-six (256) miles of streams within Reach 1 of the LSLSS Watershed. The streams are all classified as freshwater (FW or FW-SP). From WQM Station RS-12084, Lake Swamp flows for approximately six (6) stream miles to Sparrow Swamp in Florence County approximately 8.7 miles southeast of Town of Timmonsville.

1.2.2 Reach 2 of the LSLSS Watershed; Terminal WQM Station PD-345

Reach 2 of the LSLSS Watershed covers a drainage area of 11.09 mi^2 (7096.81 acres) in size that drains into Lake Swamp and its tributaries from an area approximately three (3) miles southeast of the Town of Timmonsville in Florence County, in a general southeastern fashion to impaired station PD-345 in Lake Swamp at County Route S-21-32, approximately eight (8) miles southeast of the Town of Timmonsville in Florence County (Figure 2). The reach lies in the Middle Atlantic Coastal Plains ecoregion of the State.

Land use within Reach 2 of the LSLSS Watershed is predominately Cultivated Crops (43.32%), and Woody Wetlands (29.76%) (Figure 3b, Table 2b). Developed lands (residential, commercial, industrial, or open urban space) comprise 3.07% of the reach (Table 3). At the time of the development of this TMDL, there were no animal feeding operations in the reach.

Table 2a. Lake Swamp and Lower Sparrow Swamp Watershed: Land Use in Reach 1 (WQM Station RS-12084) (Derived from National Land Cover Database (NLCD) 2011)

Description	Area (Acres)	Area ($Mile^2$)	Percent
Cultivated Crops	11,852.49	18.51	42.84%
Woody Wetlands	8523.92	13.32	30.81%
Evergreen Forest	2228.39	3.48	8.05%
Developed, Open Space	1578.77	2.47	5.71%
Shrub/Scrub	1540.30	2.41	5.57%
Developed, Low Intensity	484.60	0.76	1.75%
Emergent Herbaceous Wetlands	435.89	0.68	1.58%
Pasture/Hay	347.82	0.54	1.26%
Grassland/Herbaceous	203.27	0.32	0.73%
Developed, Medium Intensity	135.22	0.21	0.49%
Mixed Forest	118.76	0.19	0.43%
Open Water	88.74	0.14	0.32%
Deciduous Forest	72.06	0.11	0.26%
Developed, High Intensity	32.47	0.05	0.12%
Barren Land (Rock/Sand/Clay)	25.80	0.04	0.09%
Totals	**27,668.48**	**43.22**	**100.00%**

Table 3. Developed Areas in the Lake Swamp and Lower Sparrow Swamp Watershed Reaches

Reach	Reach Description	Reach Area (mi^2)	Developed Area (mi^2)	Percent Developed
Reach 1 of the LSLSS Watershed	From an area approximately 2 miles south of the City of Hartsville in Darlington County to impaired station RS-12084 in Lake Swamp at County Route S-21-106, approximately 4 miles southeast of the Town of Timmonsville in Florence County.	43.22	3.49	8.06%
Reach 2 of the LSLSS Watershed	From an area approximately 4 miles southeast of the Town of Timmonsville in Florence County to impaired station PD-345 in Lake Swamp at County Route S-21-38, approximately 8 miles southeast of the Town of Timmonsville in Florence County.	11.09	0.34	3.07%
Reach 3 of the LSLSS Watershed	From an area at the Town of Lamar in Darlington County to impaired station PD-332 in Sparrow Swamp at County Route S-21-55 (Meadow Prong Road) near Johnsons Crossroads, approximately 7 miles south-southeast of the City of Florence in Florence County.	72.44	4.10	5.66%
Total Area in the Lake Swamp and Lower Sparrow Swamp Reaches		126.75	7.93	6.26%

According to GIS information, there are approximately sixty-one (61) miles of streams within Reach 2 of the LSLSS Watershed. The streams are all classified as FW or FW-SP. From WQM Station PD-345, Lake Swamp flows for approximately 0.3 stream miles to Sparrow Swamp in Florence County approximately 8 miles southeast of Town of Pamplico in Florence County.

Figure 3b. Land Use Diagram for Reach 2 of the Lake Swamp and Lower Sparrow Swamp Watershed

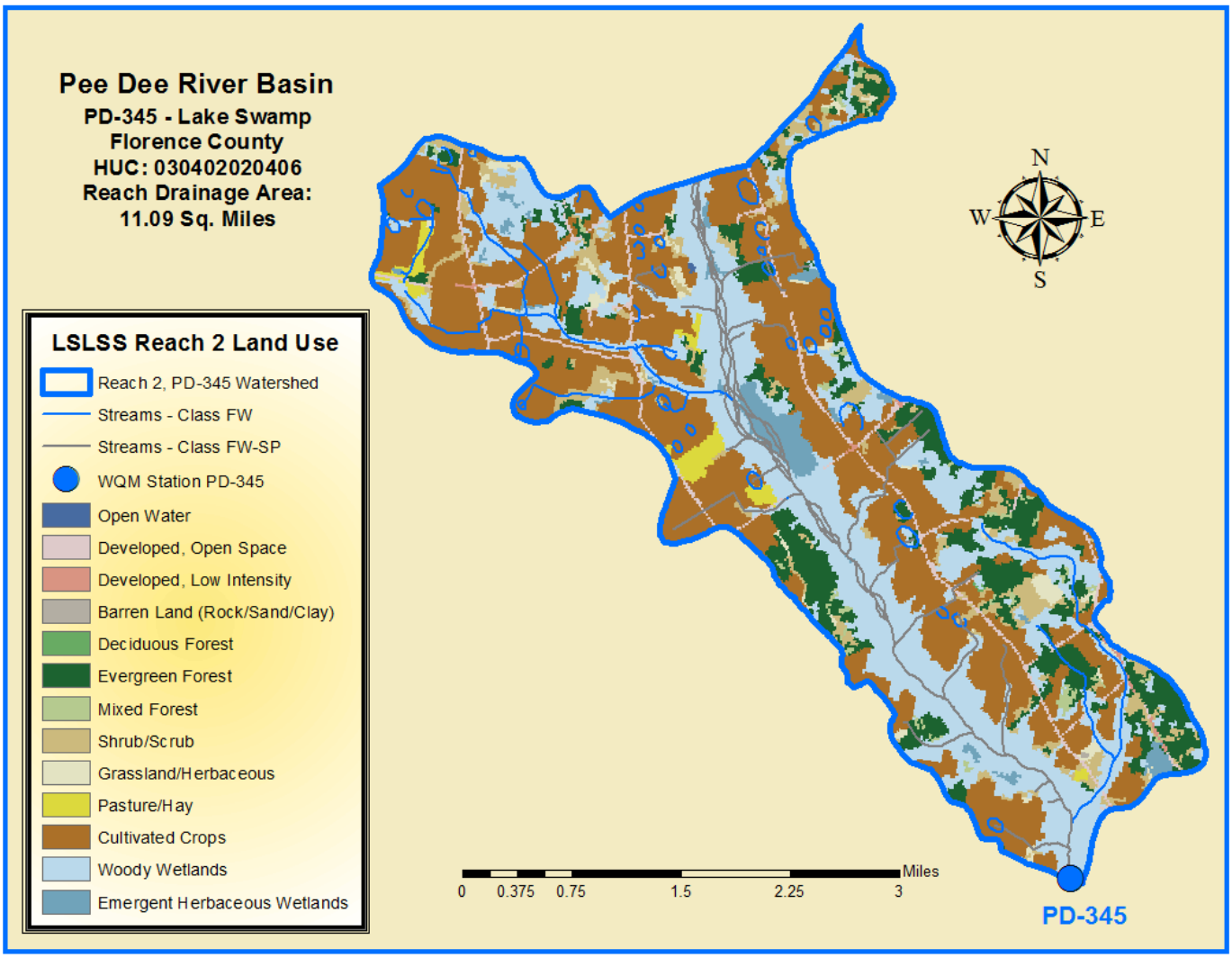


Table 2b. Lake Swamp and Lower Sparrow Swamp Watershed: Land Use in Reach 2 (WQM Station PD-345) (Derived from National Land Cover Database (NLCD) 2011)

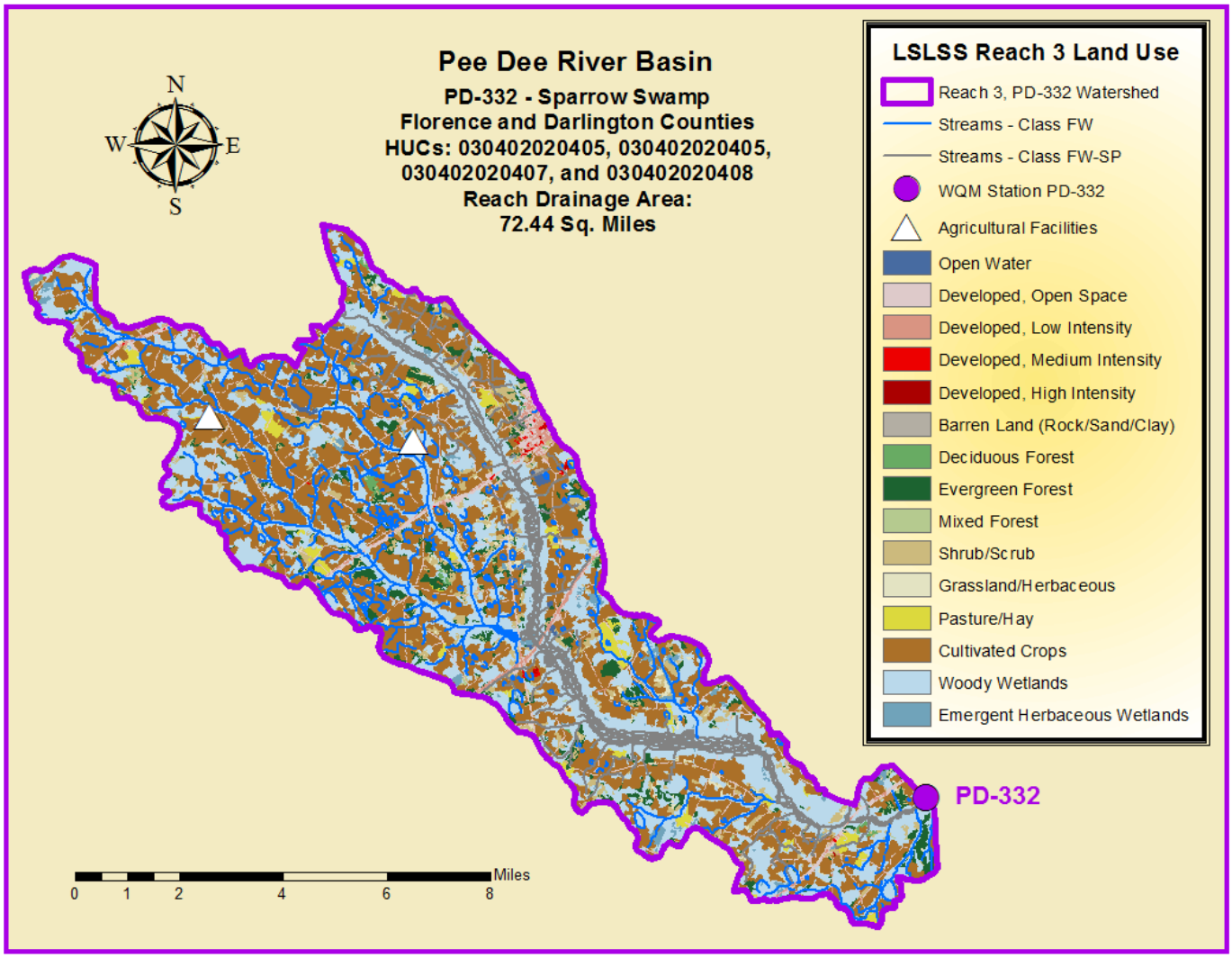
Description	Area (Acres)	Area (Mile^2)	Percent
Cultivated Crops	3074.37	4.80	43.62%
Woody Wetlands	2111.85	3.30	29.76%
Evergreen Forest	816.41	1.28	11.50%
Shrub/Scrub	420.32	0.66	5.92%
Developed, Open Space	201.49	0.31	2.84%
Emergent Herbaceous Wetlands	184.36	0.29	2.60%
Pasture/Hay	105.41	0.16	1.49%
Grassland/Herbaceous	103.64	0.16	1.46%
Mixed Forest	58.04	0.09	0.82%
Developed, Low Intensity	16.46	0.03	0.23%
Open Water	1.78	0.00	0.03%
Barren Land (Rock/Sand/Clay)	1.33	0.00	0.02%
Deciduous Forest	1.33	0.00	0.02%
Totals	**7096.81**	**11.09**	**100.00%**

1.2.3 Reach 3 of the LSLSS Watershed; Terminal WQM Station PD-332

Reach 3 of the LSLSS Watershed covers a drainage area of 72.44 mi^2 (46,372.03 acres) in size that drains into Sparrow Swamp and its tributaries from an area at the Town of Lamar in Florence County, in a general southeastern fashion to impaired station PD-332 in Sparrow Swamp at County Route S-21-55 (Meadow Prong Road) near Johnsons Crossroads, approximately seven (7) miles south-southeast of the City of Florence in Florence County (Figure 2). The reach lies in the Southeastern Plains and Middle Atlantic Coastal Plains ecoregion of the State.

Land use within Reach 3 of the LSLSS Watershed is predominately Cultivated Crops (43.27%), and Woody Wetlands (35.66%) (Figure 3c, Table 2c). Developed lands (residential, commercial, industrial, or open urban space) comprise 5.66% of the reach (Table 3). At the time of the development of this TMDL, there were two (2) active animal feeding operations in the reach (Figure 3c).

Figure 3c. Land Use Diagram for Reach 3 of the Lake Swamp and Lower Sparrow Swamp Watershed



According to GIS information, there are approximately 431 miles of streams within Reach 3 of the LSLSS Watershed. The streams are all classified as FW or FW-SP. From WQM Station PD-332, Sparrow swamp flows for approximately two (2) stream miles to the Lynches River on the Florence and Marion County border approximately 5.8 miles south of City of Florence in Florence County

1.3 The Existing Sparrow Swamp Total Maximum Daily Load

1.3.1 Description of the Sparrow Swamp TMDL Watershed (WQM Station PD-072)

The watershed for the approved TMDL for WQM Station PD-072 is contiguous with, and is located above (i.e., northwest) of the watershed for Reach 3 of the LSLSS (WQM Station PD-332) (Figure 2). The

Table 2c. Lake Swamp and Lower Sparrow Swamp Watershed: Land Use in Reach 3 (WQM Station PD-332) (Derived from National Land Cover Database (NLCD) 2011)

Description	Area (Acres)	Area (Mile^2)	Percent
Cultivated Crops	20,065.94	31.34	43.27%
Woody Wetlands	16,535.88	25.83	35.66%
Shrub/Scrub	2316.90	3.62	5.00%
Evergreen Forest	2231.06	3.49	4.81%
Developed, Open Space	2091.84	3.27	4.51%
Pasture/Hay	937.17	1.46	2.02%
Emergent Herbaceous Wetlands	789.28	1.23	1.70%
Grassland/Herbaceous	453.68	0.71	0.98%
Developed, Low Intensity	448.57	0.70	0.97%
Open Water	130.99	0.20	0.28%
Deciduous Forest	128.77	0.20	0.28%
Mixed Forest	128.10	0.20	0.28%
Developed, Medium Intensity	68.72	0.11	0.15%
Barren Land (Rock/Sand/Clay)	29.13	0.05	0.06%
Developed, High Intensity	16.01	0.03	0.03%
Totals	**46,372.03**	**72.44**	**100.00%**

watershed covers a drainage area of 87.05 mi^2 (55,726.14 acres) in size that drains into Sparrow Swamp and its tributaries from an area approximately two (2) miles west of the City of Hartsville in Darlington County, in a general southeastern fashion to WQM Station PD-072 in Sparrow Swamp at County Route S-16-697, approximately 2.5 miles east of the Town of Lamar in Florence County (Figure 2). The approved TMDL watershed lies in the Southeastern Plains ecoregion of the State. According to the 2011 NLCD, current land use within the approved TMDL watershed is predominately Cultivated Crops (50.93%), and Woody Wetlands (26.82%).

1.3.2 The 2011 TMDL Development for Sparrow Swamp (WQM Station PD-072)

The SCDHEC placed WQM Station PD-072 in Sparrow Swamp in Darlington County on the State's 2010 §303(d) list due to excessive FC bacteria. On September 6, 2011, the USEPA approved a FC bacteria TMDL that was developed internally by the SCDHEC for WQM Station PD-072 based on water quality monitoring data from 1999 through 2008 (SCDHEC Technical Report No.: 9S20-11) (SCDHEC, 2011). Table 4 summarizes the sampling data supporting the USEPA approved 2011 TMDL for WQM Station PD-072.

Table 4. FC Bacteria Observed at WQM Station PD-072 (1999-2008)[1]

Station	Waterbody	Number of Samples	Maximum Concentration cfu/100 mL	Number of Samples >400/100 mL	% Samples Exceed WQS
PD-072	Sparrow Swamp	34	1200	7	21%

[1]Source: SCDHEC. 2011

The 2011 TMDL for WQM Station PD-072 in Sparrow Swamp identified dry stream flows as the critical conditions, i.e., the stream flow conditions requiring the greatest percentage of FC bacteria loading reduction to meet the LA in the TMDL (see Section 5.1 of this TMDL development document). A 19% reduction was established to meet the LA. Extreme high and low flow conditions were not evaluated during the 2011 TMDL for WQM Station PD-072. Table 5 gives the components of the 2011 TMDL.

Congress amended the *CWA* in 1987 to establish the §319 Nonpoint Source Management Program. Under §319, States receive grant money to support a wide variety of activities including the restoration of impaired

Table 5. Total Maximum Daily Load for Sparrow Swamp (WQM Station PD-072), September 2011[1]

Station	Existing FC Load (cfu/day)[2]	TMDL (cfu/day)	Margin of Safety (MOS) (cfu/day)	Load Allocation (LA) (cfu/day)	Reduction To Meet LA (Percent)	Reduction to Meet LA (cfu/day)	Critical Condition
PD-072	5.54E+11	4.72E+11	7.34E+08	4.49E+11	19	1.05E+11	Dry

[1]Source: SCDHEC. 2011

[2]Existing FC Bacteria Load (cfu/day) at the time of TMDL approval in September 2011

waters. TMDL implementation projects are given a high priority for 319 funding. *CWA* §319 grants are not available for implementation of the WLA component of TMDLs, but may be available for the LA component of a TMDL within permitted municipal separate storm sewer system (MS4) jurisdictional boundaries. According to the SCDHEC's Nonpoint Source Coordinator, as of the time of the development of these TMDLs, no *CWA* §319 grants had been awarded for activities in the watershed for WQM Station PD-072.

1.4 Water Quality Standard

The impaired stream segments of the LSLSS Watershed basins are designated as Class Freshwater (FW or FW-SP), which is defined in SC Regulation 61-69 (2012) as:

> "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 current WQS for recreational use in freshwater is *E. coli* (R.61-68):

> "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 (SCDHEC, 2012)."

Prior to February 28, 2013, South Carolina's WQS for recreational use in freshwaters was FC bacteria (R.61-68):

> "Not to exceed a geometric mean of 200/100 mL, based on five consecutive samples during any 30 day period; nor shall more than 10% of the total samples during any 30 day period exceed 400/100 mL." (R.61-68).

Primary contact recreation is not limited to large streams and lakes. Even streams that are too small to swim in, will allow small children the opportunity to play and immerse their hands and faces. Essentially all perennial streams should therefore be protected from pathogen impairment.

2.0 WATER QUALITY ASSESSMENT

In 1986, the USEPA documented that *E. coli* and *Enterococcus* bacteria are better indicators than FC bacteria group in predicting the presence of human gastroenteritis (upset stomach, nausea, diarrhea, vomiting) causing pathogenic bacteria in fresh waters. The USEPA study was based on data collected when swimmers were directly exposed in freshwater lakes with established public swimming areas. In almost all cases of water-borne illnesses, pathogens come from inadequately treated waste of humans or other warm-blooded animals. Also, *Enterococcus* and *E. coli* are more specific to sewage and fecal sources than the FC bacteria group. In light of this information, USEPA has recommended the use of either *E. coli* or *Enterococcus* as the pathogen indicator for fresh waters.

In order to determine which pathogen indicator bacteria is better suited in South Carolina as the recreational use WQS in fresh waters, the SCDHEC designed a PIS and conducted the study during 2009. Weekly water samples were collected from seventy-three (73) stations statewide and analyzed for *E. coli, Enterococcus* and for FC bacteria group. PIS results showed *E. coli* (a member of the FC bacteria group) is a better indicator for predicting the presence of pathogens in South Carolina freshwaters.

During 2012 and following the public participation, public comment period and legislative processes, the SDHEC 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 the USEPA on February 28, 2013 and *E. coli* has been promulgated in R. 61-68. *E. coli* is the applicable WQS for recreational use in fresh waters.

Beginning with the 2014 §303(d) list of impaired waters, sites included as impaired for recreational use due to FC bacteria on the 2012 §303(d) lists was listed as impaired for *E. coli.* bacteria. Once sufficient *E. coli* bacteria data are collected from impaired stations, future TMDLs will be calculated based on *E. coli* bacteria data. Until sufficient data are collected, TMDLs for currently FC bacteria impaired stations can be calculated using FC bacteria data. Then, these FC bacteria TMDLs can be converted to *E. coli* bacteria TMDLs by multiplying the FC bacteria TMDL number by 0.8725. A 0.8725 ratio was derived by dividing the current single sample maximum (SSM) WQS for *E. coli* bacteria, 349 MPN/100 ml by former SSM WQS for FC bacteria, 400 cfu/100 ml.

The SCDHEC currently has three (3) monitoring locations within the LSLSS Watershed described earlier in this TMDL development document. These three (3) WQM stations in Lake Swamp and in Sparrow Swamp in Florence County, SC which the SCDHEC listed on the 2014 §303(d) list as impaired for recreational use due to *E. coli* bacteria are: **a)** station RS-12084 in Lake Swamp; **b)** station PD-345 in Lake Swamp; and, **b)** station PD-332 in Sparrow Swamp. 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 there are not an adequate number of monthly samples to calculate a geometric mean, then the available sample results are compared against the 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 impaired for recreational use. These stations will be included on future §303(d) lists due to exceedances of the current *E. coli* bacteria WQS until such time such time that sufficient *E. coli* bacteria data are collected and demonstrate the WQS is attained or such time that TMDLs are developed and approved to address the parameter of concern.

As discussed previously, this TMDL development document addresses the development of FC bacteria TMDLs for the three (2) aforementioned WQM stations in the LSLSS Watershed listed on the 2014 §303(d) list as impaired for recreational use, using FC bacteria data collected between January 1999 and December 2012. These three (3) FC bacteria TMDLs were converted to *E. coli* bacteria TMDLs for the purposes of implementation of the current *E. coli* bacteria WQS. Table 6 provides a summary of number of samples collected, number of exceedences and exceedence percentages.

Table 6. FC Bacteria WQS Exceedence Summary for Impaired Stations (1999-2012)

Station	Waterbody	Number of Samples	Number of Samples >400/100 mL	% Samples Exceed WQS
RS-12084	Lake Swamp	11	4	36%
PD-345	Lake Swamp	60	11	18%
PD-332	Sparrow Swamp	103	11	11%

Figure 4 illustrates precipitation and FC bacteria by data and date for WQM Station PD-332. The graph and Table 7 show that there is a moderate positive correlation between the amount of precipitation and the temporal FC bacteria exceedences of WQSs (r = 0.357). The graphs for precipitation and FC bacteria by data and date for the other two (2) WQM stations in the LSLSS Watershed are shown in Appendix A. Like for WQM Station PD-332, Table 7 and the graphs (in Appendix A) show that there is a moderate positive correlation between the amount of precipitation and the temporal FC bacteria exceedences of WQSs for WQM Station RS-12084. However, Table 8 and the graphs show that there is little or no correlation between the amount of precipitation and the temporal FC bacteria exceedences of WQSs for WQM Station PD-345.

Figure 4. Precipitation and FC Bacteria Data by Date for Water Quality Monitoring Station PD-332

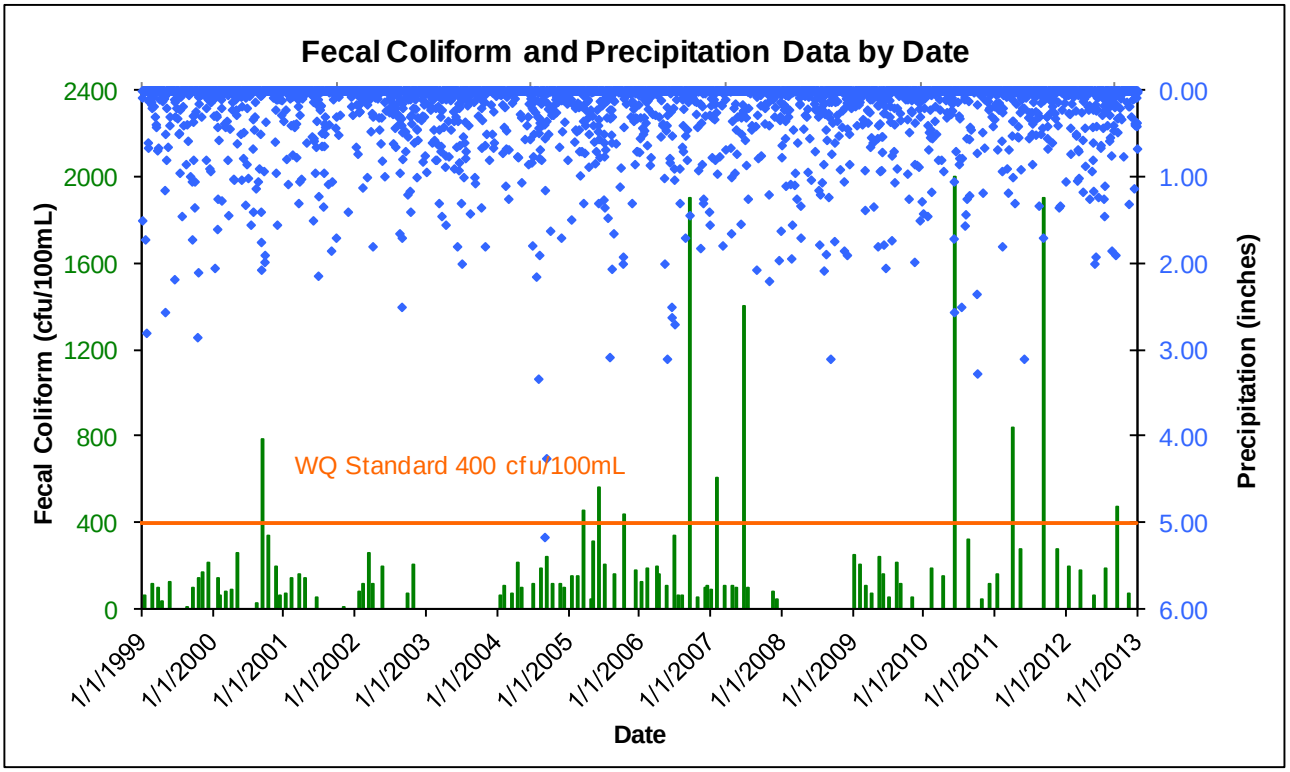


Table 7. Correlations Between Rainfall and FC Bacteria in the Lake Swamp and Lower Sparrow Swamp Watershed

Station	Waterbody	Correlation Coefficient (r)	Coefficient of Determination (r^2)
RS-12084	Lake Swamp	0.310	0.096
PD-345	Lake Swamp	0.079	0.006
PD-332	Sparrow Swamp	0.357	0.127

3.0 SOURCE ASSESSMENT AND LOAD ALLOCATION

The SCDHEC has adopted a change of its pathogen indicator from FC bacteria to *E. coli* bacteria during 2012. The new WQS were approved by the USEPA on February 28, 2013. Starting with the effective date of February 28, 2013, *E. coli* bacteria is the new pathogen indicator for recreational use in freshwaters.

Even though there are tests for specific pathogens, it is difficult to determine beforehand which organism may be present, and test for those specific organisms. Indicators such as FC bacteria, enteroccoci, or *E. coli* bacteria, which are indicators for human pollution, are easier to measure, have similar sources as pathogens, and persist in surface waters for a similar or longer length of time (Tchobanoglous & Schroeder, 1987). These bacteria are not in themselves disease causing, but indicate the potential presence of organisms that may result in illness.

E. coli bacteria is used by the State of South Carolina as the indicator for pathogens in surface waters. Pathogens, which are usually difficult to detect, cause disease and make full body contact recreation in lakes and streams a risk to public health.

There are many sources of pathogen pollution 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 (WWTF), has been greatly reduced. These point sources are required by the *CWA* to obtain a NPDES permit. In South Carolina NPDES permits require that dischargers of sanitary wastewater must meet the state standard for the relevant pathogen indicator at the point of discharge. Municipal and private sanitary WWTFs may occasionally be sources of pathogens. However, if these facilities are discharging wastewater that meets their permit limits, then the facilities are not causing impairment. If any of these facilities is not meeting its permit limits, enforcement actions/mechanisms are required.

Other non-continuous point sources required to obtain NPDES permits that may be a source of pathogens include MS4s and stormwater discharges from construction or industrial sites. MS4s may require NPDES discharge permits for industrial and construction activities under the NPDES stormwater regulations. These sources 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 WQS as prescribed in Section 5 of this TMDL development document and required in their MS4 permits, then the MS4s should not be causing or contributing to an instream pathogen impairment.

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 WWTFs, industrial waste treatment facilities, or regulated stormwater 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 only one *E. coli* bacteria related continuous point source in the LSLSS Watershed authorized under an NPDES permit issued by the SCDHEC. The Town of Timmonsville has a domestic WWTF located at 706 South Hill Street in Timmonsville, approximately one-tenth of a mile south of the town in Florence County. The facility is authorized under the SCDHEC's NPDES Permit No. SC0025356 to discharge to Sparrow Swamp in Reach 3 of the LSLSS Watershed (Figure 5 and Table 8). Under the terms and conditions of the permit, the facility has limitations on the discharge of *E. coli* bacteria, and is authorized to discharge a daily maximum of 349 MPN/100 ml. The permit was issued on October 6, 2014, and will expire on November 30, 2019. At the time of the development of these TMDLs, there were no other NPDES permitted FC bacteria or *E. coli* bacteria related continuous point sources in the LSLSS Watershed.

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 permits numbered SCS and SCR and/or regulated under South Carolina Water Pollution Control Permits: R61-9, §122.26(b)(4),(7),(14) - (21) (SCDHEC, 2011). All regulated MS4 entities have the potential to contribute *E. coli* bacteria and other FC bacteria pollutant loadings in the delineated drainage area used in the development of this TMDL.

There are three (3) regulated MS4s in the LSLSS Watershed: **a)** The South Carolina Department of Transportation (SCDOT); **b)** Darlington County; and, **c)** Florence County. The SCDOT is the only large MS4 in the watersheds. There are no medium MS4s in the watersheds. The other two (2) MS4s are small MS4s. The SCDOT operates under the SCDHEC's NPDES MS4 Permit SCS040001 and owns and operates roads within all of the reaches in the LSLSS Watershed (Figure 6 and Table 9). However, the Department recognizes that SCDOT is not a traditional MS4 in that it does not possess statutory taxing or has enforcement powers. SCDOT does not regulate land use or zoning, issue building or development permits.

Current developed land use for the LSLSS Watershed range from 3.07% to 5.66% (Table 3). Based on GIS information, there are no SCDOT facilities in the LSLSS Watershed. And, based on the SCDOT website, there are no highway rest areas in the watershed.

Small MS4s that discharge stormwater in urbanized areas, as designated by the U.S. Bureau of Census, are regulated under SC *Water Pollution Control Permits* Regulation 122.26(b)(16) and 122.32. Urbanized areas in the LSLSS Watershed are shown in Figure 7. Darlington County, a small MS4, is responsible for

Figure 5. NPDES Permitted *E. coli* Bacteria Discharge in the Lake Swamp and Lower Sparrow Swamp Watershed

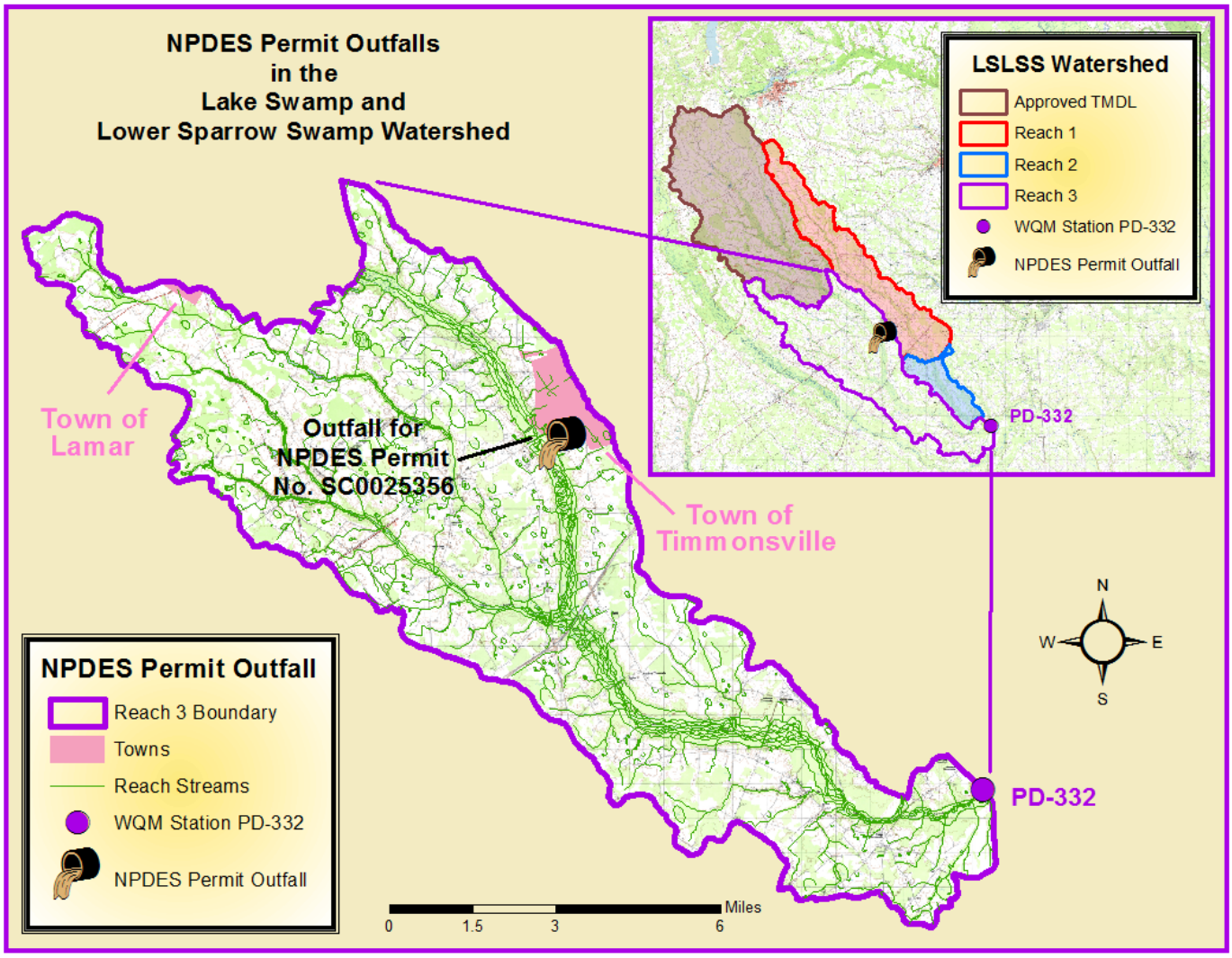


Table 8. NPDES Permitted *E. coli* Bacteia Discharge in the Lake Swamp and Lower Sparrow Swamp Watershed

Impaired Station Watershed	Permitted Facility	NPDES Permit Number	Permit Type	Permit Limitation (*E. coli* x Unit/Volume)	Permitted Flow (MGD)	Outfall Stream
PD-332	Town of Timmonsville WWTF	SC0025356	Major	349 MPN/100 mL	2.0	Sparrow Swamp

regulated stormwater discharges in urbanized areas in the watershed for the approved TMDL for PD-072 in Sparrow Swamp in the LSLSS Watershed (Figure 7). The county operates under the SCDHEC's NPDES MS4 Permit SCR033101.

In addition to stormwater discharges from small MS4s regulated under Regulation 122.26(b)(16) and 122.32, the SCDHEC may designate stormwater discharges from small MS4s for regulation under Regulation 122.26(a)(1)(v) and 122.32(f) and (g). Florence County, also a small MS4, is responsible for regulated stormwater discharges in urbanized areas in Reach 1 and Reach 3 of the LSLSS Watershed, and is responsible for regulated discharges in SCDHEC designated areas in all three reaches of the watershed (Figure 7). The county operates under the SCDHEC's NPDES MS4 Permit SCR034102. At the time of the development of these TMDLs, there were no regulated medium MS4 discharges in the LSLSS Watershed.

Figure 6. SCDOT Owned and Maintained Roads in the Lake Swamp and Lower Sparrow Swamp Watershed Reaches

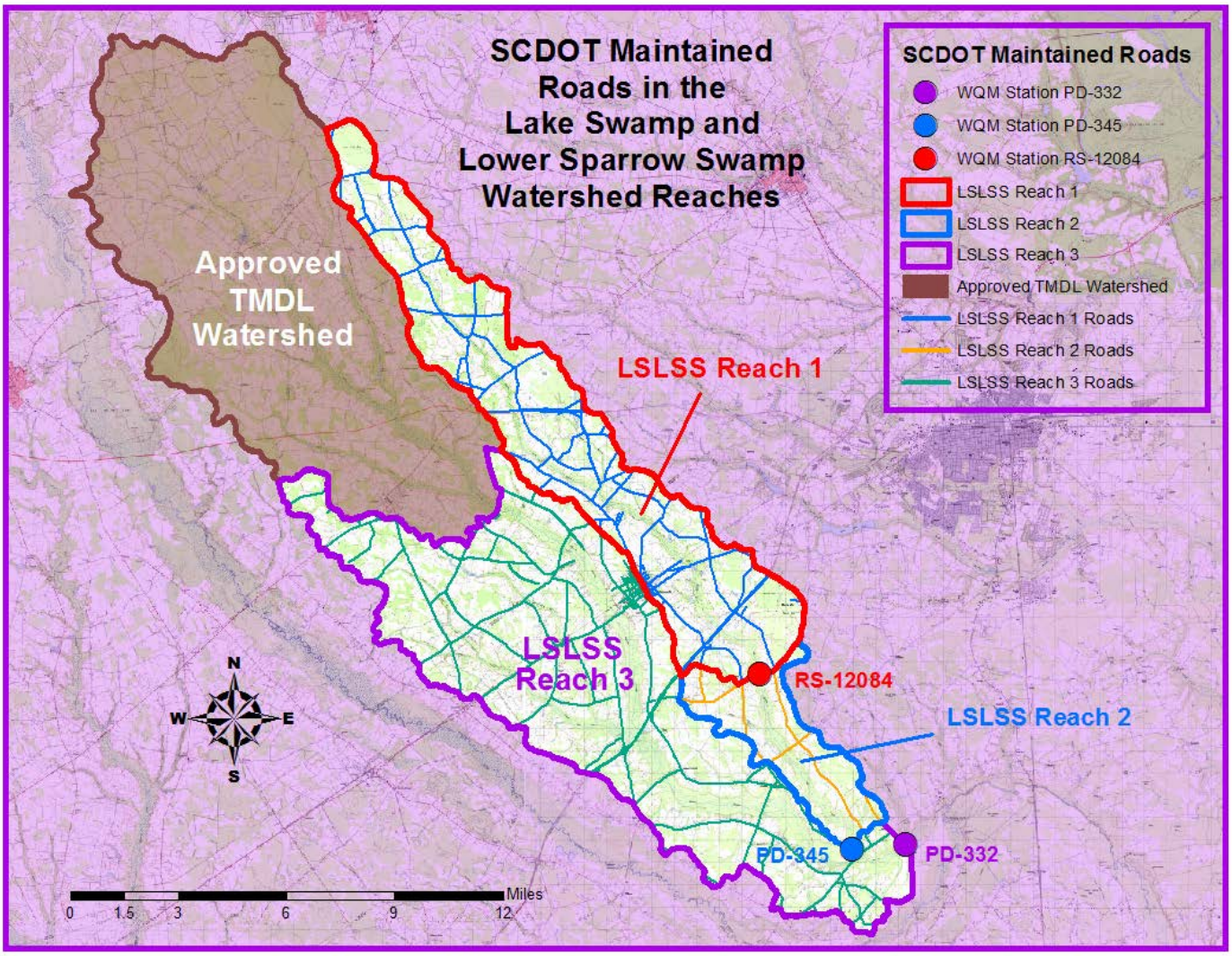


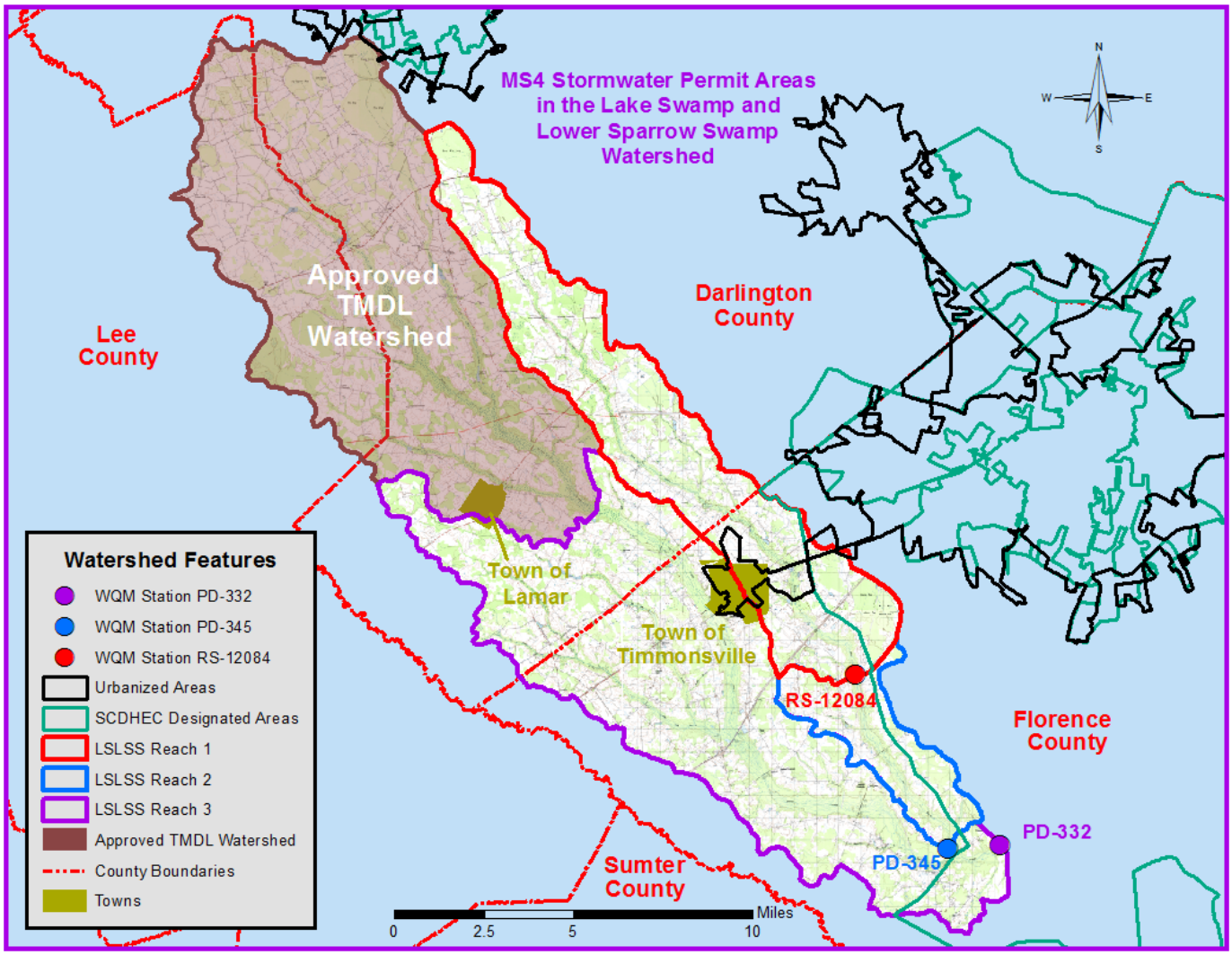
Table 9. SCDOT Maintained Road Miles in the Lake Swamp and Lower Sparrow Swamp Watershed Reaches

Watershed Reach	Station	Road Miles
Watershed Reach 1	RS-12084	94.7
Watershed Reach 2	PD-345	16.8
Watershed Reach 3	PD-332	125.4
Total Miles in the LSLSS Watershed Reaches:		236.9

Other than the abovementioned MS4 owned and/or operated stormwater sewer systems, there are currently no permitted stormwater systems that discharge into the LSLSS watershed. Future permitted sanitary sewer or stormwater systems in the referenced watersheds will be required to comply with the load reductions prescribed in the WLA and demonstrate consistency with the assumptions and requirements of the TMDLs in this TMDL development document.

Industrial facilities that have the potential to cause or contribute to a violation of a WQS are covered by the NPDES Storm Water Industrial General Permit (SCR000000). Construction activities are usually covered by the NPDES Storm Water Construction General Permit from the SCDHEC (SCR100000). Where the construction has the potential to affect water quality of a water body with a TMDL, the Storm Water Pollution Prevention Plan for the site must address any pollutants of concern and adhere to any WLAs in the TMDLs. Note that there may be other stormwater discharges not covered under permits numbered SCS and SCR that occur in the referenced watersheds. These activities are not subject to the WLA portion of the TMDLs.

Figure 7. MS4 Stormwater Permit Areas in the Lake Swamp and Lower Sparrow Swamp Watershed



Sanitary sewer overflows (SSOs) to surface waters have the potential to severely impact water quality. These untreated sanitary discharges result in violations of the WQS. It is the responsibility of the NPDES wastewater discharger, or sewer 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.

According to GIS information, community sewer collection systems serve portions of Reach 1 and Reach 2 in the LSLSS Watershed. The Town of Timmonsville's sewer collection system serves a small area in the southeastern portion of Reach 1 of the LSLSS Watershed (terminal WQM Station RS-12084). The area served is 2.99 mi^2 (1916.97 acres). This represents only 7% of the 43.22 mi^2 reach being served by a sewer collection system (Table 10).

According to GIS information, the Town of Lamar's sewer collection system serves 0.97 mi^2 (623.38 acres) in the northwestern portion of Reach 3 of the LSLSS Watershed (terminal WQM Station PD-332). And, the Town of Timmonville's sewer collection system serves 4.03 mi^2 (2579.41 acres) in the central portion of the reach. This represents only 7% of the 72.44 mi^2 reach being served by sewer collection systems (Table 10). There are no community sewer collection systems in Reach 2 of the LSLSS Watershed.

Similar to regulated MS4s, potentially designated MS4 entities (as listed in 64 FR, 235, P.68837) or other unregulated MS4 communities located in the LSLSS Watershed and surrounding watersheds may have the

Table 10. Areas Served by Community Sewer Collection Systems in the Lake Swamp and Lower Sparrow Swamp Watershed Reaches

WQM Station	Reach	Reach Area (mi^2)	Area Served by Sewer Collection Systems (mi^2)	% Reach Covered by Sewer Collection Systems
RS-12084	Reach 1	43.22	2.99	6.93%
PD-332	Reach 3	72.44	5.00	6.91%

potential to contribute FC bacteria in stormwater runoff. These unregulated entities are subject to the LA for the purposes of this TMDL

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

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 sources can be divided into source activities related either to land or water use including failing septic tanks, improper animal-keeping practices, agriculture, forestry practices, wildlife and urban and rural runoff.

The Department recognizes that there may be wildlife, agricultural activities, grazing animals, septic tanks, and/or other nonpoint source contributors located within unregulated areas (outside of NPDES permitted area) of the LSLSS Watershed. Nonpoint sources located in unregulated areas are subject to the load LA and not the WLA of the TMDL development document.

Pathogenic forms of *E. coli,* found in the guts of ruminant animals such as cattle, goats, sheep, deer and elk, produce toxins and are called “Shiga toxin-producing” *E. coli* or STEC. Of these ruminant animals, cattle are the major source for human illnesses. STEC infections start with ingestion of human or animal feces, contact with cattle, unpasteurized apple cider, soft cheeses made from raw milk, consumption of contaminated unpasteurized raw milk and water (CDC, n.d.).

3.2.1 Wildlife

Resident and migrant wildlife (mammals and birds) can be a significant contributor of *E. coli* bacteria and other FC bacteria. Wildlife in this area typically includes deer, squirrels, raccoons, and other mammals as well as a variety of birds. Wildlife wastes are carried into nearby streams by runoff following rainfall or deposited directly in streams. According to the SC Department of Natural Resources (SCDNR) 2013 deer population density map and GIS information, there are less than 15 deer/mi^2 in an approximately five (5) mi^2 area of Reach 1 of the LSLSS Watershed (terminal WQM Station RS-12084) approximately 4 miles northeast of the Town of Lamar in Darlington County (Figure 8, Table 11) (SCDNR, 2015). And, according to the SCDNR map and GIS information, there are 15 to 30 deer/mi^2 in the other approximately thirty-eight (38) mi^2 of the reach (Figure 8, Table 11). This translates into less than 15 deer/mi^2 in approximately 11% of the reach, and 15 to 35 deer/mi^2 in approximately 89% of the reach.

According to the SCDNR 2013 deer population density map and GIS information, there are 15 to 30 deer/mi^2 in an approximately nine (9) mi^2 east to northwest strip of Reach 2 of the LSLSS Watershed (terminal WQM Station PD-345) (Figure 8, Table 11). And, according to the SCDNR map and GIS information, there are 30 to 45 deer/mi^2 in the other approximately two (2) mi^2 southwestern strip of the reach (Figure 8, Table 11). This translates into 15 to 30 deer/mi^2 in approximately 85% of the reach, and 30 to 45 deer/mi^2 in approximately 15% of the reach.

And, according to the SCDNR 2013 deer population density map and GIS information, there are 15 to 30 deer/mi^2 in two areas totaling approximately twenty-five (25) mi^2 in Reach 3 of the LSLSS Watershed (terminal WQM Station PD-332). The first, larger, area lies in the northeastern part of the reach in

Figure 8. Deer Population Densities in the Lake Swamp and Lower Sparrow Swamp Watershed Reaches (based on the 2013 SCDNR South Carolina Deer Population Density Map)

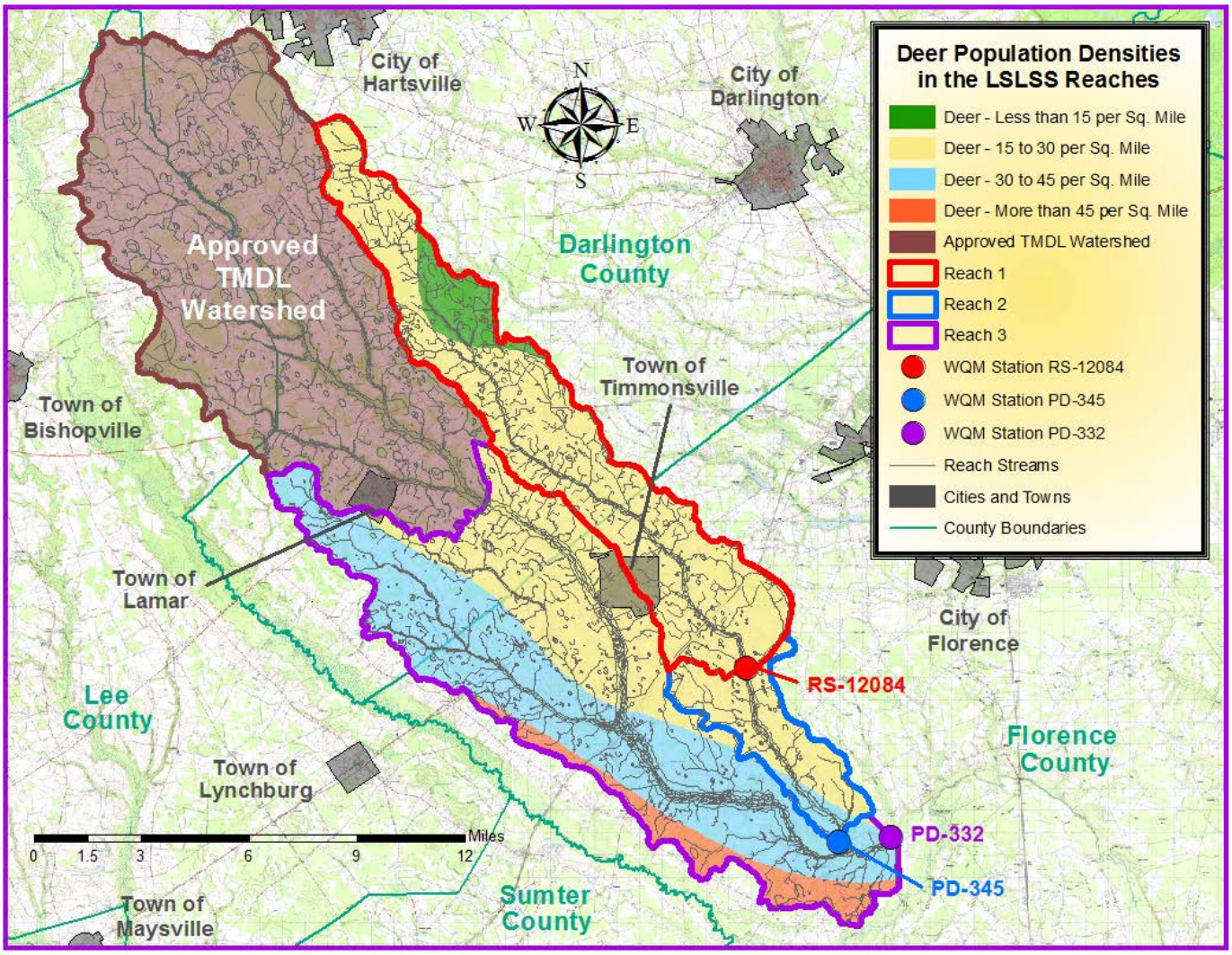


Table 11. Deer Population Densities in the Lake Swamp and Lower Sparrow Swamp Watershed Reaches (based on the 2013 SCDNR South Carolina Deer Population Density Map)

Reach WQM Station	Deer Population Densities in the Lake Swamp and Lower Sparrow Swamp Reaches							
	Mile² with <15 Deer	Areal Percent	Mile² with 15 to 30 Deer	Areal Percent	Mile² with 30 to 45 Deer	Areal Percent	Mile² with >45 Deer	Areal Percent
RS-12084	5	11%	38	89%	---	---	---	---
PD-345	---	---	9	85%	2	15%	---	---
PD-332	---	---	25	34%	40	55%	8	10%

Darlington and Florence Counties at the Town of Lamar and the Town of Timmonsville; and, the second, smaller, area is situated at WQM Station PD-332 in Florence County (Figure 8, Table 11). According to the SCDNR map and GIS information, there are 30 to 45 deer/mi² in an approximately forty (40) mi² strip of the reach running from the northwestern tip of the reach in Darlington County to the WQM station in Darlington County (Figure 8, Table 11). And, according to the SCDNR map and GIS information, there are more than 45 deer/mi² in an approximately eight (8) mi² strip along the western to southern border of the reach in Darlington County (Figure 8, Table 11). This translates into 15 to 30 deer/mi² in approximately 34% of the

reach, 30 to 45 deer/mi^2 in approximately 55% of the reach, and more than 45 deer/mi^2 in approximately 10% of the reach. A 2008 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 10^6 cfu/head-day in a study conducted by Yagow (1999), of which only a portion will enter the LSLSS Watershed. Wildlife may contribute a significant portion of the overall *E. coli* bacteria and other FC bacteria load within the watersheds.

3.2.2 Agricultural Activities

Agricultural activities that involve livestock or animal wastes are potential sources of pathogen contamination of surface waters. Fecal matter can enter the waterway via runoff from the land or by direct deposition into the stream. Unstabilized soil directly adjacent to surface waters can contribute to pollutant loading during periods of runoff after rain events. During these events, fertilizer and wildlife wastes can be transported into the creek and carried downstream. Agricultural activities may represent a contributing source in the LSLSS Watershed where agricultural activities constitute a greater portion of the land use.

3.2.2.1 Agricultural Animal Facilities

Owners/operators of most commercial animal growing operations are required by South Carolina 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, the Department has a reasonable assurance that facilities operating in compliance with this regulation should not contribute to downstream water quality impairments. South Carolina currently does not have any confined animal feeding operations (CAFOs) under NPDES coverage; 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 the SCDHEC.

At the time of the development of these TMDLs, there were five (5) active AFOs with regulated structures or activities in the reaches of the LSLSS Watershed (Figure 3a, Figure 3c, and Table 12). All of the facilities poultry facilities. Three (3) of the AFOs are located in Reach 1 of the LSLSS Watershed (terminal WQM station RS-08068) (Figures 3a); and, two (2) of the AFOs are located in Reach 3 of the watershed (terminal WQM station SV-352) (Figures 3c). These five (5) poultry operations are regulated according to Section 122.23 of SC Regulation 61-9, *Water Pollution Control Permits*. There may also be land application sites associated with these facilities. These facilities are routinely inspected for compliance. Permitted agricultural facilities that operate in compliance with their permit are not considered to be sources of impairment.

Table 12. Active Animal Feeding Operations with Regulated Structures or Activities Within the Lake Swamp and Lower Sparrow Swamp Watershed Reaches

Downstream Impaired Station	AFO Permit	Facility	Type of Livestock	Number of Permitted Animals
RS-12084	ND0074055	Brantley Norris Poultry	Poultry (Broilers)	120,000
RS-12084	ND0078034	Russell Howell Farms	Turkey	16,000
RS-12084	ND0078018	Tedder Brooder Turkey Facility	Turkey	45,000
PD-332	ND0077704	Gobble Hill Farm	Turkey	25,000
PD-332	ND0086941	Windham Farms	Turkey (Grow-Out)	52,000

3.2.2.2 Grazing Animals

Livestock, especially cattle, are frequently major contributors of FC bacteria or *E. coli* bacteria to streams. Cattle on average produce some 1.0E+11 cfu/day per animal of FC bacteria (ASAE 1998). Grazing cattle and other livestock may contaminate streams with FC bacteria (including *E. coli*) indirectly by runoff from pastures or directly by defecating into streams and ponds. Direct loading by cattle or other livestock to

surface waters within the LSLSS Watershed is likely to be a contributing source of *E. coli* bacteria and other FC bacteria. However, the grazing of unconfined livestock (in pastures) is not regulated by the SCDHEC.

The United States Department of Agriculture's (USDA) National Agricultural Statistics Service reported 3165 and 2812 cattle and calves in Darlington and Florence Counties, respectively, in 2012 (USDA 2014). According to the 2011 National Land Cover Database (NLCD), there are 5662.37 and 15,476.62 acres of pastureland in Darlington and Florence Counties, respectively. This relates to 0.56 and 0.18 cattle per acre of pastureland in Darlington and Florence Counties, respectively, assuming an even distribution of cattle across pastureland in the counties. Table 13 shows the number of acres of pastureland in the reaches of the LSLSS Watershed and, based on this acreage, an estimate of the number of cattle in the reaches. And, based on the number of cattle, the table shows an average of cfu/day of FC bacteria produced by cattle in the reaches. Based on the table, following is the average FC bacteria produced per day by the estimated total cattle and calves within each reach of the LSLSS Watershed: **a)** 1.16E+13 cfu/day by an estimated one hundred and sixteen (116) cattle and calves in Reach 1 (terminal WQM Station RS-12084); **b)** 1.92E+12 cfu/day by an estimated nineteen (19) cattle and calves in Reach 2 (terminal WQM Station PD-345); and, **c)** 2.63E+13 cfu/day by an estimated two hundred and sixty-three (263) cattle and calves in Reach 3 (terminal WQM Station PD-332).

Table 13. Cattle FC Bacteria per Day in the Lake Swamp and Lower Sparrow Swamp Watershed Reaches

Downstream Impaired Station	County	Pasture Area (Acre) per Watershed	Cattle per Watershed	Cattle Fecal Coliform, cfu/day
RS-12084	Darlington	139.23	78	7.78E+12
	Florence	207.74	38	3.77E+12
PD-345	Florence	105.41	19	1.92E+12
PD-332	Darlington	245.03	137	1.37E+13
	Florence	696.19	126	1.26E+13

3.2.3 Land Application of Industrial, Domestic Sludge or Treated Wastewater

NPDES-permitted industrial and domestic wastewater treatment processes may generate solid waste bi-products, also known as sludge. In some cases, facilities may be permitted to land apply sludge at designated locations and under specific conditions. There are also some NPDES-permitted facilities authorized to land apply treated effluent 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. It is recognized that there may be operating, regulated land application sites located in the LSLSS Watershed. If 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. Land applications sites can be a source of pathogen loadings and stream impairment if not properly managed. Similar to AFO land application sites, the permitted land application sites described in this section are not allowed to directly discharge to LSLSS Watershed. Direct discharges from land applications sites to surface waters of the State are illegal and are subject to enforcement actions by SCDHEC.

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 wastes to the surrounding environment. Quantifying these sources is extremely speculative without direct monitoring of the source because the magnitude is directly proportional to the volume and its proximity to the surface water.

Illicit sewer connections into storm drains result in direct discharges 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. Besides the SCDOT, Darlington County, and Florence County, there are currently no entities subject to an NPDES MS4 permit within or with impact to the LSLSS Watershed.

3.2.5 Failing Septic Systems

Failing, leaking or non-conforming septic systems, however, can be a major contributor of *E. coli* bacteria and other FC bacteria to the LSLSS Watershed. Wastes from failing septic systems enter 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.

3.2.5.1. Septic Systems in Reach 1 of the LSLSS Watershed (WQM Station RS-12084)

According to GIS information, sewer lines for the Town of Timmonsville extend into a small area of the southeastern portion of the 27,668.48-acre Reach 1 of the LSLSS Watershed. However, the vast majority of Reach 1 (approximately 93%) is not served by the Town of Timmonsville sewer systems, or any other community sewer system. Based on GIS information, 2015 USDA aerial photography of the watershed, and based on the 2010 U.S. population census, there are 1118 households within the reach not served by a community sewer system. Therefore, assuming one (1) septic tank per household, it is estimated that there are approximately 1118 septic tanks within the reach. This translates into 0.040 septic tanks per watershed acre. At the time of the development of these TMDLs, their status in relation to function was unknown.

3.2.5.2. Septic Systems in Reach 2 of the LSLSS Watershed (WQM Station PD-345)

According to GIS information, there are no community sewer systems serving Reach 2 of the LSLSS Watershed. Based on current GIS information, 2015 USDA aerial photography of the reach, and based on the 2010 U.S. population census, there are 353 households within the 7096.81-acre reach. Therefore, assuming one (1) septic tank per household, it is estimated that there are approximately 353 septic tanks within the reach. This translates into 0.050 septic tanks per reach acre. At the time of the development of these TMDLs, their status in relation to function was unknown.

3.2.5.3. Septic Systems in Reach 3 of the LSLSS Watershed (WQM Station PD-332)

And, according to GIS information, sewer lines for the Town of Lamar extend into a small area of the northwestern portion of the 46,372.03-acre Reach 3 of the LSLSS Watershed; and, sewer lines for the Town of Timmonsville extend into a small area in the central portion of the reach. However, the vast majority of Reach 1 (approximately 93%) is not served by the Town of Lamar or the Town of Timmonsville sewer systems, or any other community sewer system. Based on GIS information, 2015 USDA aerial photography of the watershed, and based on the 2010 U.S. population census, there are 1384 households within the reach not served by a community sewer system. Therefore, assuming one (1) septic tank per household, it is estimated that there are approximately 1384 septic tanks within the reach. This translates into 0.030 septic tanks per watershed acre. At the time of the development of these TMDLs, their status in relation to function was unknown.

3.2.6 Urban and Suburban Runoff

Dogs, cats, and other domesticated pets are the primary source of *E. coli* bacteria and other FC bacteria deposited on the urban landscape. There are also 'urban' wildlife, squirrels, raccoons, pigeons, and other birds, all of which contribute to the FC bacteria (including *E. coli*) load. A small percentage of urban areas lie within the LSLSS Watershed. Based on GIS information, some portion of two (2) incorporated areas lie within Reach 1 and Reach 2 of the LSLSS Watershed (Figure 2).

According to GIS information, 40.29% of the incorporated area of the Town of Timmonsville (i.e., 656.38 acres of 1629.04 acres) lie within in the southwestern portion of the 27,668.48-acre Reach 1 of the LSLSS Watershed (Figure 2). However, this translates to only 2.37% of the reach being incorporated areas.

Also, according to GIS information, 59.71% of the incorporated area of the Town of Timmonsville (i.e., 972.66 acres of 1629.04 acres) lie within in the northeastern portion of the 46,372.03-acre Reach 3 of the LSLSS Watershed; and, 11.74% of the incorporated area of the Town of Lamar (i.e., 85.56 acres of 728.69 acres) lie within in the northwestern portion of the reach (Figure 2). However, this translates to only 2.28% of the reach being incorporated areas. There are no incorporated areas in Reach 2 of the LSLSS Watershed.

Similar to regulated MS4s, potentially designated MS4 entities (as listed in FR 64, 235, p.68837) or other unregulated MS4 communities located in the LSLSS Watershed may have the potential to contribute pollutant loadings in stormwater runoff. According to GIS information, only 6.62% of the LSLSS Watershed, including the watershed for the approved TMDL for WQM Station PD-072, is developed. Therefore, there is potential for growth in the LSLSS Watershed.

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 flow data. Two (2) United States Geological Survey (USGS) gages were used for collecting "real-time" flow data for the LSLSS Watershed TMDLs, based primarily on the size of the drainage area to the downstream gage, and secondarily on the general land use in the drainage area. The USGS gage used for collecting flow data for Reaches 1 and 2 of the LSLSS Watershed (WQM Stations RS-12084 and PD-345) was the Bear Creek gage at Mays Store, NC (Gage Number: 0208925200). This gage has a drainage area of 57.7 square miles, began recording daily flows in 1987 and provides the flow data required to establish flow duration curves for these two (2) impaired stations.

And, the USGS gage used for collecting flow data for Reach 3 of the LSLSS Watershed (WQM Stations PD-332) was the Lumber River gage near Maxton, NC (Gage Number: 02133624). This gage has a drainage area of 365 square miles, began recording daily flows in 1987 and provides the flow data required to establish flow duration curves for this impaired station.

For example, flow data for a 14-year period (January 1, 1999 to December 31, 2012) from the USGS Maxton, NC gage was used to establish the flow duration curve for Reach 3 of the LSLSS Watershed (WQM Station PD-332). The records for this period were complete (i.e., no missing dates). The drainage area of the sampling station was delineated using USGS topographic maps using ArcMap software. The cumulative area drained was calculated and used to estimate flow based on the ratio of the monitoring station drainage area to the downstream USGS gage. For example, the Maxton, NC gage records flow from 365 square miles (sq mi). The cumulative drainage area for the Reach 3 of the LSLSS Watershed at WQM Station PD-332 (in Sparrow Swamp at County Route S-21-55 (Meadow Prong Road) near Johnsons Crossroads, approximately seven (7) miles south-southeast of the City of Florence in Florence County) is 213.79 sq mi, or 58.57% of the area drained at the Maxton, NC gage. Therefore, mean daily flow for the PD-332 monitoring location was assumed to be 58.57% of the daily flow at the Maxton, NC gage.

Figure 2 provides an illustration of monitoring and gage locations along with a summary of drainage area statistics used to establish flows at un-gaged monitoring stations in the LSLSS Watershed.

Flow duration curves were developed by ranking flows 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 curves were divided into five (5) hydrologic condition categories (High Flows, Moist Conditions, Mid-Range, Dry Conditions and Low Flows). Categorizing flow conditions can assist in determining which hydrologic conditions result in the greatest number of exceedences. A high number of exceedences under dry conditions might indicate a point source or illicit connection issue, whereas moist 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 their infrequency.

For those WQM stations where the target load-duration curves were created using existing FC bacteria data (i.e., stations RS-12084, PD-345, and PD-332), the curves were created by calculating the allowable load using daily flow, the former FC bacteria WQS concentration and a unit conversion factor. The water quality target was set at 380 cfu/100 ml for the instantaneous criterion, which is five (5) percent lower than the

former water quality criterion of 400 cfu/100 ml. A five (5) percent explicit MOS was reserved from the water quality criteria in developing target load-duration curves. The load-duration curve for station PD-332 is presented in Figure 9 as an example. The load-duration curves for stations RS-12084 and PD-345 are presented in Appendix B.

Target loads in freshwaters impaired for *E. coli* bacteria may alternatively be calculated as the ratio of *E.coli* bacteria MPN/100 ml to FC bacteria cfu/100 ml or (349/400=0.8725). This conversion is derived from an established relationship between FC bacteria and *E. coli* bacteria WQS in freshwaters determined during the SCDHEC's 2009 PIS. Accordingly, because SC has recently adopted a change from FC bacteria to *E. coli* bacteria as a recreational use standard in all freshwaters, this TMDL development document also includes converted *E. coli* bacteria TMDLs for WQM Stations RS-12084, PD-345, and PD-332, for purposes of implementation of the current recreational use standard. For these calculations, the daily flow and a unit conversion factor were used and the water quality target was set at 332 MPN/100 ml for the instantaneous criterion, which is five (5) percent lower than the current water quality criteria of 349 MPN/100 ml. A five (5) percent explicit MOS was reserved from the water quality criteria in developing target load-duration curves. For the purposes of establishing these three (3) TMDLs, FC bacteria percent reductions should also be representative of reductions necessary to meet the *E. coli* bacteria WQS.

For all curves, including Figure 9, the independent variable (X-Axis) represents the percentage of estimated flows greater than value x. The dependent variable (Y-Axis) represents the FC bacteria loading at each estimated flow expressed in terms of colony forming units per day (cfu/day), or most probable number per day (MPN/day). In each of the defined flow intervals for WQM Stations RS-12087 and PD-345, existing loads and LAs to achieve target loads were calculated by the following equations:

Existing Load (cfu/day) = Mid-Point Flow in Each Hydrologic Category (ft^3/s) x 90^{th} Percentile FC Concentration (cfu/100 ml) x Conversion Factor (24465758.4)

LA to Achieve Target Load (cfu/day) = Mid-Point Flow in Each Hydrologic Category (ft^3/s) x 380 (WQ criterion minus a 5% MOS) (cfu/100 ml) x Conversion Factor (24465758.4)

Percent Reduction = (Existing Load – LA to Achieve Target Load) / Existing Load

In each of the defined flow intervals for WQM Station PD-332, existing loads and *LAs to achieve* target load were calculated by the following equations:

Existing Load (cfu/day) = Mid-Point Flow in Each Hydrologic Category (ft^3/s) x 90^{th} Percentile FC Concentration (cfu/100 ml) x Conversion Factor (24465758.4)

LA to Achieve Target Load (cfu/day) = (Mid-Point Flow in Each Hydrologic Category (ft^3/s) x 380 (WQ criterion minus a 5% MOS) (cfu/100 ml) x Conversion Factor (24465758.4)) - (NPDES SC0025356 Permitted Flow (2.0 MGD = 3.094 ft^3/s) x 400 (WQ criterion minus) (cfu/100 ml) x Conversion Factor (24465758.4))

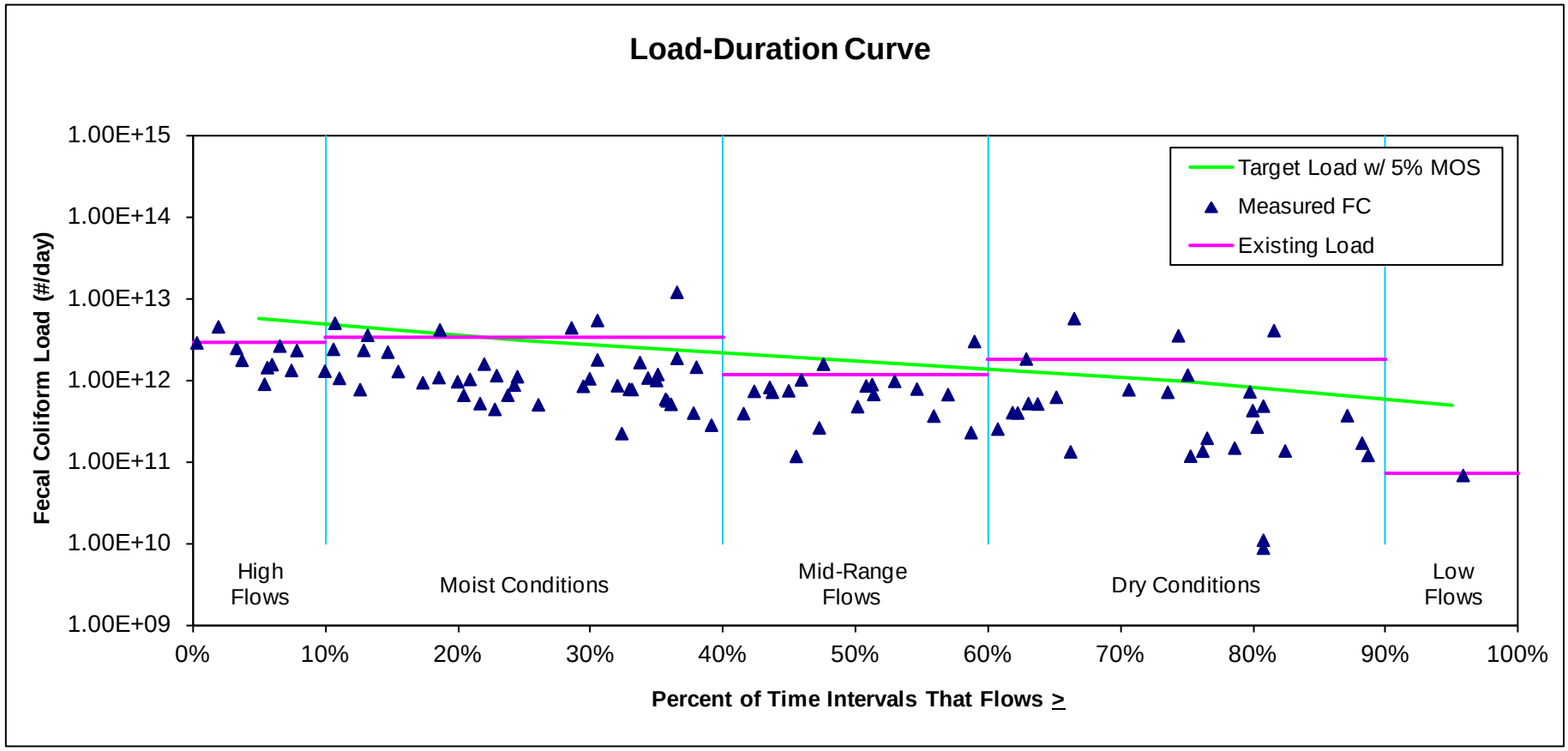
Percent Reduction = (Existing Load – LA to Achieve Target Load) / Existing Load

Instantaneous loads for each of the impaired stations were calculated. Measured FC bacteria concentrations from 1999 through 2012 were multiplied by measured (or estimated flow based on drainage area) flow on the day of sampling and a unit conversion factor. These data were plotted on the load-duration graph based on the flow duration interval for the day of sampling. Samples above the target line are violations of the WQS while samples below the line are in compliance (see Figure 9, for example). Only the instantaneous water quality criterion was targeted because there is insufficient data to evaluate against the 30-day geometric mean.

An existing load was determined for each hydrologic category for the TMDL calculations. For the three (3) WQM stations in the LSLSS Watershed, the 90^{th} percentile of measured FC bacteria concentrations within each hydrologic category were multiplied by the flow at each category midpoint (i.e., flow at the 25% duration interval for the Moist Conditions, 50% interval for Mid-Range, and 75% for Dry Condition).

Existing loads are plotted on the load-duration curves presented in Appendix A as well as the example for WQM Station PD-332 in Figure 9. These values were compared to the target loads (which includes an explicit 5% MOS) at each hydrologic category midpoint to determine the percent load reduction necessary to achieve compliance with the WQS. These TMDLs assumes that if the highest percent reduction is achieved, then the WQS will be attained under all flow conditions.

Figure 9. Load Duration Curve for Reach 3 of the Lake Swamp and Lower Sparrow Swamp Watershed, Water Quality Monitoring Station PD-332



5.0 DEVELOPMENT OF TOTAL MAXIMUM DAILY LOAD

A TMDL for a given pollutant and water body is comprised of the sum of individual WLAs for point sources, and LAs for both nonpoint sources and natural background levels. In addition, the TMDL must include a MOS, either implicitly or explicitly, 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 WQS. In TMDL development, allowable loadings from all pollutant sources that cumulatively amount to no more than the TMDL must be established and thereby provide 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

The critical condition is identified as the stream flow condition requiring the greatest percentage of pollutant loading reduction to meet the LA in the TMDL. Data within the High Flow and Low Flow categories are generally not used in the development of a TMDL due to their infrequency. Accordingly, the TMDLs for the three (3) WQM stations in the LSLSS Watershed were based on the flow recurrence interval between 10% and 90% and excludes extreme high and low flow conditions; flows that are characterized as 'Low' or 'High.' The critical conditions for the LSLSS Watershed pathogen impaired segments are listed in Table 14. This data indicates that for WQM Station PD-332, dry conditions result in larger bacteria loads and is therefore the critical condition for that station. The following flow conditions result in larger bacteria loads, and are therefore the critical conditions, for the other two (3) WQM stations in the LSLSS Watershed: **a)** moist conditions for RS-12084; and, **b)** dry conditions for PD-345.

Table 14. Percent Reduction Necessary to Achieve Target Load by Hydrologic Category

WQM Station	Waterbody	Moist Conditions	Mid-Range Flow	Dry Conditions
RS-12084	Lake Swamp	61	NRN	23
PD-345	Lake Swamp	NRN	17	58
PD-332	Sparrow Swamp	10	NRN	49

Highlighted cells indicate critical condition
NRN = no reduction needed. Existing load below target load

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 development document. The existing load under the critical condition, described in Section 5.1 above was used in the TMDL calculations. Loadings from all sources are included in this value: cattle-in-streams, failing septic systems as well as wildlife. The existing load for the three (3) WQM stations in the LSLSS Watershed are provided in Appendix D.

5.3 Waste Load Allocation

The 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 active permitted domestic discharger of *E. coli* bacteria and other FC bacteria in the LSLSS Watershed. The facility is the Town of Timmonville's WWTF, which is discharging in Reach 3 of the

watershed (Figure 5) (see Section 3.1.1 of this TMDL development document). The Town is permitted under the SCDHEC's NPDES Permit No. SC0025356 to discharge *E. coli* bacteria from its WWTF to Sparrow Swamp. To determine the WLA for the WWTF, the average permitted flow for the facility was multiplied by an allowable permitted maximum concentration of 349 MPN/100 mL and a unit conversion factor. The WLA for the WWTF, based on a permitted daily maximum of 349 MPN/100 mL, is presented in Table 15. The WLA for the WWTF is 26.4 billion counts per day (2.64E+10 MPN/day) based on a permitted average design flow of 2.0 MGD.

Table 15. Average Permitted Flow and *E. coli* Bacteria WLA for the NPDES Wastewater Discharge in the Lake Swamp and Lower Sparrow Swamp Watershed

Impaired Station Watershed	Permitted Facility	Permit Number	Permitted Flow (MGD)	WLA *E. coli* (MPN/day)
PD-332	Town of Timmonsville's WWTF	SC0025356	2.0	2.64E+10

Because South Carolina has recently adopted a change from FC bacteria to *E. coli* bacteria as a recreational use standard in all freshwaters, future continuous discharges are required to meet the prescribed loading for *E. coli* bacteria based on permitted flow and an allowable permitted maximum concentration of 349MPN/100 mL.

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 SCS & SCR and regulated under SC *Water Pollution Control Permits* Regulation 122.26(b)(14) & (15) (SCDHEC, 2010. Illicit discharges, including SSOs, are not covered under any NPDES permit and are subject to enforcement mechanisms. All areas defined as "Urbanized Area" by the US Census are required under the NPDES Phase II Stormwater Regulations to obtain a permit for the discharge of stormwater. Figure 7 shows the urbanized areas in the LSLSS Watershed. Other non-urbanized areas may be required under the NPDES Phase II Stormwater Regulations to obtain a permit for the discharge of stormwater.

WLAs 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 percent reduction is based on the maximum percent reduction (critical condition) within any hydrologic category necessary to achieve target conditions. Table 16 presents the reduction needed for each impaired segment in the LSLSS Watershed. The reduction percentages in these TMDLs also apply to the FC bacteria or *E. coli* bacteria waste load attributable to those areas of the watershed that are covered or will be covered under NPDES MS4 permits.

Table 16. Percent Reduction Necessary to Achieve Target Load

WQM Station	Waterbody	% Reduction
RS-12084	Lake Swamp	61
PD-345	Lake Swamp	58
PD-332	Sparrow Swamp	49

As appropriate information is made available to further define the pollutant contributions for the permitted MS4, an effort can 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.

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 these TMDLs. However, the Department recognizes that the SCDOT is not a traditional MS4 in that it does not possess statutory taxing or enforcement powers. The SCDOT does not regulate land use of zoning, issue building or development permits.

5.4 Load Allocation

The LA applies to the nonpoint sources of *E. coli* bacteria and other FC bacteria and is expressed both as a load and as a percent reduction. The LA is calculated as the difference between the target load (i.e., the TMDL minus a 5% MOS) under the critical condition and the point source WLA. The LA is listed in Table 17. There may be other unregulated MS4s located in the LSLSS Watershed 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, these entities will be required to meet load reductions prescribed in the WLA component of these TMDLs. 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 take into account the seasonal variability in watershed loading. The variability in these TMDLs is accounted for by using a 14-year hydrological and water quality sampling data set.

5.6 Margin of Safety

The MOS may be explicit and/or implicit. The explicit MOS is 5% of the TMDL, or, in the case of FC bacteria TMDLs, 20 cfu/100 mL of the instantaneous criterion of 400 cfu/100 mL (380 cfu/100 mL); and, in the case of *E. coli* bacteria TMDLs, 17 MPN/100 mL of the instantaneous criterion of 349 MPN/100 mL (332 MPN/100 mL). Target loads are therefore 95% of the assimilative capacity (i.e.,TMDL) of the waterbody. 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* bacteria may be calculated as the ratio of *E.coli* bacteria MPN/100 mL to FC bacteria cfu/100 mL or 20*0.8725 = 17 MPN/100 mL of the instantaneous *E. coli* bacteria criterion of 349 MPN/100 mL (332 MPN/100 mL). This conversion is deemed appropriate by the Department and derived from an established relationship between FC bacteria and *E. coli* bacteria WQS in freshwaters determined during the 2009 PIS.

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 organism counts (or resulting concentration), in accordance with 40 CFR 130.2(l). Only the instantaneous water quality criterion was targeted for the LSLSS Watershed because there is 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 segment can receive while meeting the WQS. The TMDL value is the mid-point target load within the critical condition (i.e., the middle value within the hydrologic category that requires the greatest load reduction) and MOS.

While TMDL development was primarily 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 FC bacteria 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 17 indicates the percentage reduction or WQS required for each watershed (or reach) in the LSLSS Watershed. Note that all future regulated NPDES-permitted stormwater discharges will also be required to meet the prescribed percentage reductions, or the WQS. It should be noted that that in order to meet the WQS for FC bacteria or *E. coli* bacteria 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 LSLSS Watershed that drain directly to a regulated MS4 and that drain through the unregulated MS4 has 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, the regulated MS4 is assigned the same percent reduction as the non-regulated sources in the watershed. Compliance with the MS4 permit in regards to this TMDL development 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 development document.

6.0 IMPLEMENTATION

The implementation of both point (i.e., WLA) and non-point (i.e., LA) source components of the TMDLs are necessary to bring about the required reductions in FC bacteria or *E. coli* bacteria loading to Lake Swamp and Lower Sparrow Swamp in order to achieve WQSs. Using existing authorities and mechanisms, an implementation plan providing information on how point and non point sources of pollution are being abated or may be abated in order to meet WQSs is provided. Sections 6.1.1-6.1.7 presented below correspond with sections 3.1.1-3.2.5 of the source assessment presented in the TMDL development document. As the implementation strategy progresses, the 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 *CWA's* primary point source control program is the NPDES. Point sources can be broken down into continuous and non-continuous point sources. Some examples of a continuous point source are WWTFs and industrial facilities. Non-continuous point sources are related to stormwater and include MS4, construction activities, etc. Current and future NPDES discharges in the referenced watersheds are required to comply with the load reductions prescribed in the 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 the LSLSS Watershed are subject to the LA and not the WLA of the TMDL development 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 for interested parties to control pollution and prevent water quality degradation in the LSLSS Watershed would be the establishment and administration of a program of BMPs. BMPs 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 FC bacteria or *E. coli* bacteria loading to Lake Swamp and Lower Sparrow Swamp. TMDL implementation projects are given highest priority for 319 funding. *CWA* §319 grants are not available for implementation of the WLA component of this TMDL but may be available for the LA component within

Table 17. Total Maximum Daily Loads for the Lake Swamp and Lower Sparrow Swamp Watershed
Loads are expressed as FC bacteria or *E. coli* bacteria count/day

	Existing FC Load (count/day)[1]	TMDL (count/day)		Margin of Safety (MOS) (count/day)		Waste Load Allocation (WLA)				Load Allocation (LA)		
						Continuous Source[3] (count/day)		Non-Continuous Sources[4,5] (% Reduction)	Non-Continuous SCDOT[5] (% Reduction)	Load Allocation (count/day)		% Reduction to Meet LA[5]
Station	FC (CFU/day)	FC (CFU/day)	*E. coli* (MPN/day)[2]	FC (CFU/day)	*E. coli* (MPN/day)[2]	FC (CFU/day)	*E. coli* (MPN/day)[2]	(Percent)	(Percent)	FC (CFU/day)	*E. coli* (MPN/day)[2]	(Percent)
RS-12084	1.25E+12	5.20E+11	*4.54E+11*	2.60E+10	*2.27E+10*	See Note Below	See Note Below	61	61[6]	4.94E+11	*4.31E+11*	61
PD-345	5.18E+11	2.30E+11	*2.01E+11*	1.15E+10	*1.00E+10*	See Note Below	See Note Below	58	0[7]	2.19E+11	*1.91E+11*	58
PD-332	1.82E+12	9.99E+11	*8.71E+11*	4.99E+10	*4.36E+10*	3.03E+10	*2.64E+10*	49	49[6]	9.19E+11	*8.01E+11*	49

Table Notes:

1. Existing fecal coliform loads were determined from the 90 percentile instream fecal coliform concentrations and stream flows during critical flow conditions. Fecal coliform concentrations were determined during the Department's water quality monitoring program.
2. Expressed as *E. coli* bacteria (MPN/day). Loadings are developed by applying a conversion factor to values calculated for FC bacteria. This conversion is derived from an established relationship between FC bacteria and *E. coli* bacteria water quality standards in freshwaters.
3. WLAs are expressed as a daily maximum. Existing and future continuous discharges are required to meet the prescribed loading for the pollutant of concern. For the purposes of NPDES permitting, continuous discharges may be required to meet a loading equivalent of FC bacteria, based upon permitted flow and an allowable permitted maximum FC bacteria concentration of 400 cfu/100 ml, until such time that *E. coli* bacteria limits are incorporated into individual permits. *E. coli* limits will be developed based upon permitted flow and an allowable permitted maximum *E. coli* bacteria concentration of 349 MPN/100 ml.
4. 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.
5. Percent reduction applies to existing instream FC bacteria or *E. coli* bacteria.
6. By implementing the best management practices that are prescribed in either the SCDOT annual SWMP or the SCDOT MS4 Permit to address fecal coliform or *E. coli* bacteria, the SCDOT will comply with these TMDLs and its applicable WLA to the MEP as required by its MS4 permit.
7. As long as the conditions within the SCDOT MS4 area remain the same the Department deem the current contributions from SCDOT negligible and no reduction of FC bacteria or *E. coli* bacteria is necessary. SCDOT must continue to comply with the provisions of its approved NPDES stormwater permit.

permitted MS4 jurisdictional boundaries. Additional resources are provided in Section 7.0 of this TMDL development document.

The SCDHEC will also work with the existing agencies in the area to provide nonpoint source education in the LSLSS Watershed. Local sources of nonpoint source education and assistance include the Natural Resource Conservation Service (NRCS), the Barnwell, Bamberg, and Colleton County Soil and Water Conservation Services, the Clemson University Cooperative Extension Service, and the South Carolina Department of Natural Resources.

The Department recognizes that adaptive management/implementation of these TMDLs might be needed to achieve the WQS and the Department is committed towards targeting the load reductions to improve water quality in the LSLSS Watershed. As additional data and/or information become available, it may become necessary to revise and/or modify the TMDL targets accordingly.

6.1 Implementation Strategies

The strategies presented in this document for implementation of the referenced TMDLs 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 for the referenced watersheds while demonstrating consistency with the assumptions and requirements of the TMDLs. Application of certain strategies provided within may be voluntary and are not a substitute for actual NPDES permit conditions.

6.1.1 Continuous Point Sources

Continuous point source WLA reductions will be implemented through NPDES permits. 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 TMDLs. FC bacteria loadings are developed based upon permitted flow and an allowable permitted maximum concentration of 400 cfu/100 mL. *E. coli* bacteria loadings are developed based upon permitted flow and an allowable permitted maximum *E. coli* bacteria concentration of 349 MPN/100 mL.

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 SWMP or any other plan is TMDL and watershed specific. Hence, it is expected that NPDES permit holders 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 staff (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 C which provides additional information as it relates to evaluating the effectiveness of an MS4 Permit as it related to compliance with approved TMDLs. For the SCDOT, existing and future NPDES MS4 permittees, compliance with terms and conditions of its NPDES permit is effective implementation of the WLA to the MEP and demonstrates consistency with the assumptions and requirements of the TMDLs. For existing and future NPDES construction and Industrial stormwater permittees, compliance with terms and conditions of its permit is effective implementation of the WLA. Required load reductions in the LA portion of these TMDLs 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 TMDLs by MS4s is expected to take one or more permit iteration. Achieving the WLA reduction for the TMDLs 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 criterion depending on the type of NPDES MS4 permit that applies. 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 web sites, 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. These discharges enter 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 USEPA 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 of the US they discharge for instance. If not already in place, an ordinance prohibiting non-stormwater discharges into a MS4 with appropriate enforcement procedures may also 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://www.scdhec.gov/Environment/WaterQuality/Stormwater/BMPHandbook/

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/good housekeeping is also a key element of stormwater management programs. Generally this requires the MS4 entity to examine and alter their programs or activities to ensure reductions

in pollution are occurring. It is recommended that a plan be developed to prevent or reduce pollutant runoff from municipal operations into the storm sewer system and it is encouraged to include employee training on how to incorporate and document pollution prevention/good housekeeping techniques. To minimize duplication of effort and conserve resources, the MS4 operator can use training materials that are available from the USEPA or relevant organizations (USEPA, 2005).

MS4 communities are encouraged to utilize partnerships when developing and implementing a stormwater management program. Watershed associations, educational organizations, and state, county, and city governments are all examples of possible partners with resources that can be shared. For additional information on partnerships contact the SCDHEC Watershed Manager for the waterbody of concern online at: http://www.scdhec.gov/HomeAndEnvironment/Water/Watersheds/Contacts/ For additional information on stormwater discharges associated with MS4 entities please see the SCDHEC's NPDES web page online at https://www.scdhec.gov/environment/WaterQuality/Stormwater/RegulatedMS4s/ as well as the USEPA NPDES website online at http://cfpub.epa.gov/npdes/home.cfm?program_id=6 for information pertaining to the National Menu of BMPs, Urban BMP Performance Tool, Outreach Documents, etc.

Clemson Carolina Clear and the Florence Darlington Stormwater Consortium are currently two organizations working cooperatively with regulated MS4s in the LSLSS watershed to address permit requirements and reduce FC bacteria or *E. coli* bacteria loadings from non-continuous point sources.

6.1.3 Wildlife

Suggested forms of implementation for wildlife will vary widely due to geographic location and species. There are many forms of acceptable wildlife BMPs in practice and development at the present time. For example, contiguous forested areas could be set up and managed to keep wildlife from bedding down and defecating near surface waters. This management practice relies on concentrating wildlife away from water bodies to minimize their impact to pollutant loading. Additionally, contributions from wildlife could be reduced in protected areas by developing a management plan which would allow hunting access during certain seasons. Although this strategy might not work in all situations, it would decrease FC bacteria or *E. coli* bacteria loading from wildlife in areas where wildlife may be a significant contributor to the overall watershed. According to the 2011 NLCD, the LSLSS Watershed is 60.50 percent forest or otherwise vegetated (non-cultivated). On June 23rd, June 28th, July 12th, September 13th, and September 20th in 2016, the SCDHEC conducted site visits in the LSLSS Watershed to assess pollutant sources potentially contributing to water quality impairment in the watershed. All potential pollutant sources in the watershed found during the 2016 site visits are identified in Tables Ap-1 through Ap-3 (see Appendix E).

According to the SCDNR 2013 deer population density map and GIS information, the estimated population of deer in Darlington and Florence Counties in the areas of the LSLSS Watershed range from less than fifteen (15) deer per square mile to more than forty-five (45) deer per square mile (see Section 3.2.1 of this TMDL development document) (SCDNR 2015). During the 2016 potential pollutant source assessment visits in the LSLSS Watershed, the SCDHEC actually found live deer in Reach 1 of the watershed (Figure F-1). Besides finding live deer, the SCDHEC found evidence of their presence in the form of deer stands in Reaches 1 and 3 of the watershed (e.g., Figures F-2, F-3, and F-4).

Deterrents may also be used to keep wildlife away from docks and lawns in close proximity to surface waters. Non-toxic spray deterrents, decoys, eagles, kites, noisemakers, scarecrows, and plastic owls are a sample of what is currently available. During the SCDHEC's potential pollutant source assessment visits in 2016, the department found waterfowl the LSLSS Watershed. Geese were found near a stream-fed pond in Reach 1 of the LSLSS Watershed (Figure F-5); and, a flock of egrets were found in a pasture with cattle in Reach 3 of the watershed (Figure F-6). Many waterfowl species are deterred by foreign objects on lawns and the planting of a shrub buffer along greenways adjacent to impoundments may also be effective.

In addition, homeowners and the hunting community should be educated on the impacts of feeding wildlife or planting wildlife food plots in close proximity to surface waters. Please check local and federal laws before applying deterrents or harassing wildlife. Additional information may be obtained from the "Managing Pet and Wildlife Waste to Prevent Contamination of Drinking Water" bulletin provided by the USEPA (2001).

6.1.4 Agricultural Activities

Suggested forms of implementation for agricultural activities will vary based on the activity of concern. 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. Therefore, for BMPs to be effective, the transport mechanism of the pollutant, FC bacteria or *E. coli* bacteria, needs to be identified. For livestock in the referenced watersheds, 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. During the 2016 potential pollutant source assessment visits in the LSLSS Watershed, the SCDHEC found several cattle pastures in Reaches 1 and 3 the LSLSS Watershed (e.g., Figures F-7, F-8, F-9, and F-10). And, the SCDHEC found a sheep farm in Reach 3 of the watershed (Figure F-11).

During the potential pollutant source assessment visits in 2015 and 2016, the SCDHEC also found numerous hobby farms within the LSLSS Watershed. Horses were found throughout the LSLSS Watershed (e.g., Figures F-12, F-13, F-14, and F-15). Goats were also found throughout the watershed (e.g., Figures F-16, F-17, F-18, and F-19). Donkeys were found in Reaches 2 and 3 of the watershed (e.g., Figures F-20 and F-21). And, chickens were found in Reaches 1 and 3 of the watershed (e.g., Figures F-22, F-23, and F-24).

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% (ASABE 1997). An indirect result of this was a 77% reduction in stream bank erosion by providing an alternative to accessing the stream directly for water supply.

For row crop farms in the referenced watersheds, many common practices exist to reduce FC bacteria or *E. coli* bacteria contributions. Unstabilized soil directly adjacent to surface waters can contribute to FC bacteria or *E. coli* bacteria loading during periods of runoff after rain events. Agricultural field borders and filter strips (vegetative buffers) can provide erosion control around the border of planted crop fields. These borders can provide food for wildlife, may possibly be harvested (grass and legume), and also provide an area where farmers can turn around their equipment (SCDNR, 1997). A study conducted in 1998 by the American Society of Agricultural and Biological Engineers (ASABE 1998) has shown that a vegetative buffer measuring 6.1 meters in width can reduce fecal runoff concentrations from 2.0E+7 to an immeasurable amount once filtered through the buffer. A buffer of this width was also shown to reduce phosphorous and nitrogen concentrations by 75%.

The agricultural BMPs listed above are 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 LSLSS Watershed. Education should be provided to local farmers on these methods as well as acceptable manure spreading and holding (stacking sheds) practices.

For additional information on accepted agricultural BMPs you can obtain a copy of the “Farming for Clean Water in South Carolina” handbook by contacting Clemson University Cooperative Extension Service at (864) 656-1550. In addition, Clemson Extension Service offers a ‘Farm-A-Syst’ package to farmers. Farm-A-Syst allows the farmer to evaluate practices on their property and determine the nonpoint source impact they may be having. It recommends best management practices (BMPs) to correct nonpoint source problems on the farm. You can access Farm-A-Syst by going onto the Clemson Extension Service website: http://www.clemson.edu/waterquality/FARM.HTM.

NRCS provides financial and technical assistance to help South Carolina landowners address natural resource concerns, promote environmental quality, and protect wildlife habitat on property they own or control. The cost-share funds are available through the 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. EQIP also assists eligible small-scale farmers who have historically not participated in or ranked high enough to be funded in previous sign ups. Please visit www.sc.nrcs.usda.gov/programs/ for more information, including eligibility requirements.

Also available through NRCS, the Grassland Reserve Program (GRP) is a voluntary program offering landowners the opportunity to protect, restore and enhance grasslands on their property. NRCS and the Farm Service Agency (FSA) coordinate implementation of the GRP, which helps landowners restore and protect grassland, rangeland, pastureland, shrubland and certain other lands and provides assistance for rehabilitating grasslands. The program will conserve vulnerable grasslands from conversion to cropland or other uses and conserve valuable grasslands by helping maintain viable grazing operations. A grazing management plan is required for participants. NRCS has further information on their website for the GRP as well as additional programs such as the Conservation Reserve Program, Conservation Security Program, Farm and Ranch Lands Protection Program, etc. You can visit the NRCS website by going to: www.sc.nrcs.usda.gov/programs/.

6.1.5 Leaking Sanitary Sewers and Illicit Discharges

Leaking sanitary sewers and illicit discharges, although illegal and subject to enforcement, may be occurring in regulated or unregulated portions of the LSLSS Watershed at any time. 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.

The SCDHEC recognizes illicit discharge detection and elimination activities are conducted by regulated MS4 entities as 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* bacteria. It is the intent of the SCDHEC to work with the MS4 entities to recognize FC bacteria or *E. coli* bacteria load reductions as they are achieved. The 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, the 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 water contains disease-causing bacteria and viruses, as well as unhealthy amounts of nitrate and other chemicals. Failed septic systems can allow untreated sewage to seep into wells, groundwater, and surface water bodies, where people get their drinking water and recreate. Pumping a septic tank is probably the single most important thing that can be done to protect the system. If the buildup of solids in the tanks becomes too high and solids move to the drainfield, this could clog and strain the system to the point where a new drainfield will be needed.

The SCDHEC's Office of Coastal Resource Management (OCRM) has created a toolkit for homeowners and local governments which includes tips for maintaining septic systems. These septic system Do's and Don'ts's are as follows:

Do's:

- Conserve water to reduce the amount of wastewater that must be treated and disposed of by your system. Doing laundry over several days will put less stress on your system.
- Repair any leaking faucets or toilets. To detect toilet leaks, add several drops of food dye to the toilet tank and see if dye ends up in the bowl.
- Divert down spouts and other surface water away from your drainfield. Excessive water keeps the soil from adequately cleansing the wastewater.
- Have your septic tank inspected yearly and pumped regularly by a licensed septic tank contractor.

Don'ts:

- Don't drive over your drainfield or compact the soil in any way.

- Don't dig in your drainfield or build anything over it, and don't cover it with a hard surface such as concrete or asphalt.
- Don't plant anything over or near the drainfield except grass. Roots from nearby trees and shrubs may clog and damage the drain lines.
- Don't use your toilet as a trash can or poison your system and the groundwater by pouring harmful chemicals and cleansers down the drain. Harsh chemicals can kill the bacteria that help purify your wastewater.

For additional information on how septic systems work, how to properly plan and maintain a septic system, or to link to the OCRM toolkit mentioned above, please visit the SCDHEC Environmental Health Onsite Wastewater page at the following link: http://www.scdhec.gov/HomeAndEnvironment/YourHomeEnvironmentalandSafetyConcerns/SepticTanks/

6.1.7 Urban Runoff

Urban runoff is surface runoff of rainwater created by urbanization outside of regulated areas which may pick up and carry pollutants to receiving waters. Pavement, compacted areas, roofs, reduced tree canopy and open space increase runoff volumes that rapidly flow into receiving waters. This increase in volume and velocity of runoff often causes stream bank erosion, channel incision and sediment deposition in stream channels. In addition, runoff from these developed areas can increase stream temperatures that along with the increase in flow rate and pollutant loads negatively affect water quality and aquatic life (USEPA 2017). This runoff can pick up FC bacteria or *E. coli* bacteria along the way. Many strategies currently exist to reduce FC loading from urban runoff and the USEPA nonpoint source pollution website provides extensive resources on this subject, which can be accessed online at: 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).

Some additional urban BMPs that can be adopted in public parks are doggy dooleys and pooch patches. Doggy dooleys are disposal units, which act like septic systems for pet waste, and are installed in the ground where decomposition can occur (USEPA, 2001). This requires that pet owners place the waste into the disposal units. During the SCDHEC potential pollutant source assessment visits in 2016, unattended dogs were found throughout the LSLSS Watershed (e.g., Figures F-25, F-26, F-27, and F-28).

Although the LSLSS Watershed is primarily rural in nature, many of the urban runoff practices discussed in this section can be applied to individual households in the watersheds. Education should be provided to individual homeowners in the referenced watersheds on the contributions to FC bacteria or *E. coli* 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 Runoff Pollution homepage at: https://www.scdhec.gov/HomeAndEnvironment/Docs/Watershed/Nonpoint%20Source%20Management%20Program.pdf

Clemson Extension's Home-A-Syst handbook can also help homeowners reduce sources of NPS pollution on their property. This document guides homeowners through a self-assessment of their property and can be accessed online at: http://www.clemson.edu/waterquality/HOMASYS.HTM

7.0 RESOURCES FOR POLLUTION MANAGEMENT

This section provides a listing of available resources to aid in the mitigation and control of pollutants. There are examples from across the nation, most of which are easily accessible on the world wide web.

7.1 General for Urban and Suburban Stormwater Mitigation

- National Management Measures to Control Nonpoint Source Pollution from Urban Areas – Draft. 2002. EPA842-B-02-003. Available at: http://link.library.in.gov/portal/National-management-measures-to-control-nonpoint/qhy7Z_3SYM0/
- Stormwater Management Volume Two: Stormwater Technical Manual. Massachusetts Department of Environmental Management. 1997. Available at: http://www.mass.gov/dep/brp/stormwtr/stormpub.htm
- Fact Sheets for the six (6) minimum control measures for storm sewers regulated under Phase I or Phase II. Available at: https://www3.epa.gov/npdes/pubs/fact2-0.pdf
- A Current Assessment of Urban Best Management Practices. 1992. Metropolitan Washington Council of Governments. Washington, DC
- Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs. 1987. Metropolitan Washington Council of Governments. Washington, DC
- 2004 Stormwater Quality Manual. Connecticut Department of Environmental Protection 2004. Available at: http://www.ct.gov/deep/cwp/view.asp?a=2721&q=325704
- Stormwater Treatment BMP New Technology Report. California Department of Transportation. 2004. SW-04-069-.04.02. http://www.dot.ca.gov/hq/env/stormwater/special/newsetup/_pdfs/new_technology/CTSW-RT-04-069.pdf
- Moonlight Beach Urban Runoff Treatment facility: Using Ultraviolet Disinfection to Reduce Bacteria Counts. Rasmus, J. and K. Weldon. 2003. StormWater, May/June 2003.
- Operation, Maintenance, and Management of Stormwater Management Systems. Livingston, Shaver, Skupien, and Horner. August 1997. Watershed Management Institute. Call: (850) 926-5310.
- Stormwater O & M Fact Sheet Preventive Maintenance. USEPA 1999. 832-F-99-004. Available at: http://www.fxbrowne.com/html/gs-facts/prevmain.pdf
- The Mass Highway Stormwater Handbook. Massachusetts Highway Department. 2004. Available at: https://www.massdot.state.ma.us/Portals/8/docs/environmental/wetlands/Stormwater_Handbook.pdf
- University of New Hampshire Stormwater Center: Dedicated to the protection of water resources through effective stormwater management. Available at: https://www.unh.edu/unhsc/
- USEPA's Stormwater website: https://www.epa.gov/npdes/npdes-stormwater-program

7.2 Illicit Discharges

- Illicit Discharge Detection and Elimination Manual - A Handbook for Municipalities. 2003. New England Interstate Water Pollution Control Commission. Available at: http://www.neiwpcc.org/neiwpcc_docs/iddmanual.pdf

7.3 Pet Waste

- National Management Measure to Control Non Point Source Pollution from Urban Areas – Draft. USEPA 2002. EPA 842-B-02-2003.

- Septic Systems for Dogs? Nonpoint Source News-Notes 63. Pet Waste: Dealing with a Real Problem in Suburbia. Kemper, J. 2000. New Jersey Department of Environmental Protection. Available from: nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=2000E9C4.TXT (Copy and paste URL address).

- Stormwater Manager's Resource Center. Schueler, T., Center for Watershed Protection, Inc. http://www.stormwatercenter.net

- Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters. USEPA, Office of Water 1993. Washington, DC.

- National Menu of Best Management Practices for Stormwater Phase II. USEPA. 2002. Available at: https://www.epa.gov/npdes/national-menu-best-management-practices-bmps-stormwater#edu

- Welcome to NVRC'S Four Mile Run Program. NVRC 2001. Available at: http://www.novaregion.org/fourmilerun.htm

- Boston's ordinance on dog waste. City of Boston Municipal Codes, Chapter XVI. 16-1.10A Dog Fouling. Available at: https://law.resource.org/pub/us/code/city/ma/Boston/chapter16.rtf

- Pet Waste and Water Quality. Hill, J.A., and D. Johnson. 1994. University of Wisconsin Extension Service.

- Long Island Sound Study. Pet Waste Poster. USEPA.

- Source Water Protection Practices Bulletin: Managing Pet and Wildlife Waste to Prevent Contamination of Drinking Water. USEPA. 2001. EPA 916-F-01-027. Available at: nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=901V1N00.TXT (Copy and paste URL address).

7.4 Wildlife

- An example of a bylaw prohibiting the feeding of wildlife: Prohibiting Feeding of Wildlife. Town of Bourne Bylaws Section 3.4.3. Available at: http://www.townofbourne.com/sites/bournema/files/file/file/14_town_bylaw_thru_2014_oct_stm.pdf

- Integrated Management of Urban Canadian Geese. M Underhill. 1999. Conference Proceedings, Waterfowl Information Network.

- Urban Canadian Geese in Missouri. Missouri Conservationist Online. Available at: https://mdc.mo.gov/conmag/2004/02/urban-canada-geese-missouri

7.5 Septic Systems

- National Management Measures to Control Nonpoint Source Pollution from Urban Areas – Draft. Chapter 6. New and Existing Onsite Wastewater Treatment Systems. USEPA 2002. EPA842-B-02-003. Available at: nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=P10004FY.TXT (Copy and paste URL address).
- Septic Systems. USEPA Webpage: https://www.epa.gov/septic

7.6 Field Application of Manure

- Conservation Standard Practice-Irrigation Water Management. Number 449. United States Department of Agriculture (USDA) Natural Resources Conservation Service. 2003. Available at: https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1046888.pdf
- Conservation Standard Practice-Filter Strip. Number 393. USDA Natural Resources Conservation Service (NRCS). 2003. Available at: https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1241319.pdf
- Buffer Strips: Common Sense Conservation. USDA Natural Resource Conservations Service. No Date. Website. Available at: https://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/home/?cid=nrcs143_023568
- Conservation Standard Practice-Riparian Forest Buffer. Number 391. USDA Natural Resource Conservation Service. 2003. Available at: https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs143_026098.pdf
- Conservation Standard Practice-Riparian Herbaceous Cover. Number 390 USDA Natural Resource Conservation Service. 2003. Available at: https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs143_026183.pdf

7.7 Grazing Management

- Conservation Standard Practice-Stream Crossing. Number 578. USDA Natural Resource Conservation Service. 2003. Available at: https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1046923.docx
- Guidance Specifying Management Measures for Nonpoint Source Pollution in Coastal Waters. Chapter 2. Management Measures for Agricultural Sources. Grazing Management. USEPA. Available at: https://www.epa.gov/sites/production/files/2015-09/documents/czara_chapter2_agriculture.pdf

7.8 Animal Feeding Operations and Barnyards

- National Management Measures to Control Nonpoint Source Pollution from Agriculture. USEPA 2003. Report: EPA 841-B-03-004. Available at: https://www.epa.gov/nps/national-management-measures-control-nonpoint-source-pollution-agriculture
- Livestock Manure Storage. Software designed to asses the threat to ground and surface water from manure storage facilities. USEPA.
- National Engineering Handbook Part 651. Agricultural Waste Management Field Handbook. NRCS. Available At: https://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/water/?&cid=stelprdb1045935

- Animal Waste Management. NRCS website: https://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/landuse/crops/npm/?cid=stelprdb1044732

- Animal Waste Management Software. A tool for estimating waste production and storage requirements. Available at: https://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/technical/ecoscience/mnm/?cid=stelprdb1045812

- Manure Management Planner. Software for creating manure management plans. Available at: http://www.purdue.edu/agsoftware/mmp/

- Animal Feeding Operations Virtual Information Center. USEPA.

7.9 Federal Agriculture Resources: Program Overviews, Technical Assistance, and Funding

- USDA-NRCS assists landowners with planning for the conservation of soil, water, and natural resources. Local, state, and federal agencies and policymakers also rely on NRCS expertise. Cost shares and financial incentives are available in some cases. Most work is done with local partners. The NRCS is the largest funding source for agricultural improvements. To find out about potential funding, see: http://www.ma.nrcs.usda.gov/programs/. To pursue obtaining funding, contact a local NRCS coordinator. Contact information is available at: https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/contact/ .

- NRCS provides a wealth of information and BMP fact sheets tailored to agricultural and conservation practices through the NRCS Electronic Field Office Technical Guide at: http://efotg.nrcs.usda.gov/efotg_locator.aspx?map=SC.

- The 2014 USDA Farm Bill (https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/farmbill/) provides a variety of programs related to conservation. Information can be found at: https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/. The following programs can be linked to from the USDA Farm Bill website:

  - Conservation Security Program (CSP): https://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/programs/?&cid=stelprdb1047061
  - Conservation Reserve Program (CRP): https://www.fsa.usda.gov/programs-and-services/conservation-programs/conservation-reserve-program/index
  - Wetlands Reserve Program (WRP): https://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/programs/easements/wetlands/?cid=nrcs143_008419
  - Environmental Quality Incentives Program (EQIP): http://www.nrcs.usda.gov/programs/eqip/
  - Grassland Reserve Program (GRP): http://www.nrcs.usda.gov/programs/GRP/
  - Conservation of Private Grazing Land Program (CPGL): http://www.nrcs.usda.gov/programs/cpgl/
  - Wildlife Habitat Incentives Program (WHIP): https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/whip/
  - Farm and Ranch Land Protection Program (FRPP): http://www.nrcs.usda.gov/programs/frpp/
  - Resource Conservation and Development Program (RC&D): https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/16/stelprdb1042393.pdf

- CORE4 Conservation Practices. The common sense approach to natural resource conservation. USDA-NRCS (1999). This manual is intended to help USDA-NRCS personnel and other conservation and nonpoint source management professionals implement effective programs using four core conservation practices: conservation tillage, nutrient management, pest management, and conservation buffers, available at: https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs143_025540.pdf

- County soil survey maps are available from NRCS at: https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx

- Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters. USEPA, Office of Water (1993). Developed for use by State Coastal Nonpoint Pollution Control Programs, Chapter 2 of this document covers erosion control, animal feeding operation management, grazing practices, and management of nutrients, pesticides, and irrigation water, available at: https://www.epa.gov/nps/guidance-specifying-management-measures-sources-nonpoint-pollution-coastal-waters

- Farm-A-Syst is a partnership between government agencies and private business that enables landowners to prevent pollution on farms, ranches, and in homes using confidential environmental assessments, available at: https://www.nrcs.usda.gov/wps/portal/nrcs/detail/vt/technical/dma/?cid=nrcs142p2_010561

- State Environmental Laws Affecting South Carolina Agriculture: A comprehensive assessment of regulatory issues related to South Carolina agriculture has been compiled by the National Association of State Departments.

- Waterborne Pathogens in Agricultural Wastewater. Rosen, B. H., 2000. USDA, NRCS, Watershed Science Institute. Available at: https://wmc.ar.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1044366.pdf

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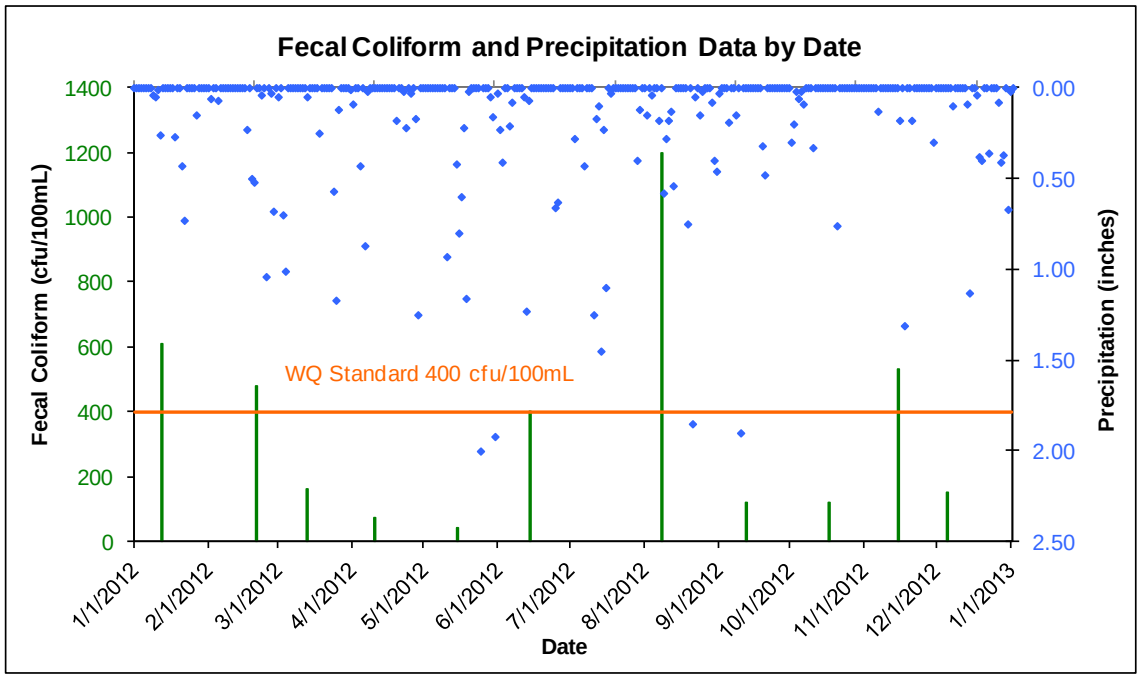
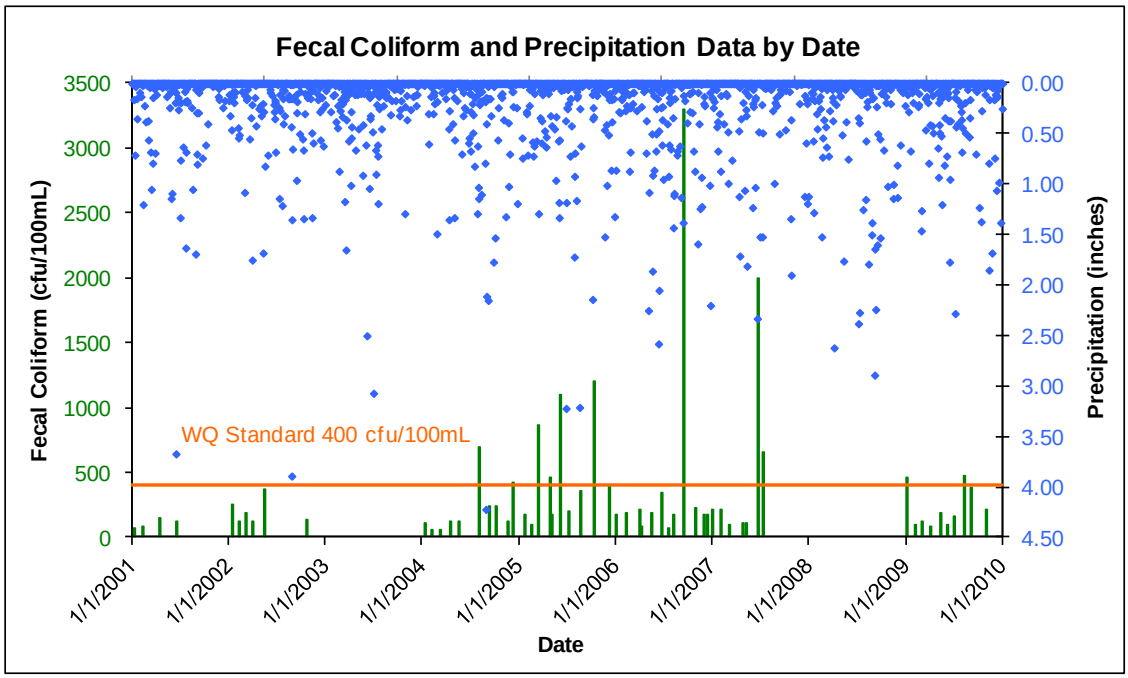
APPENDIX A
ADDITIONAL RAIN CHARTS BY STATION

Precipitation and FC Data by Date for Monitoring Station RS-12084

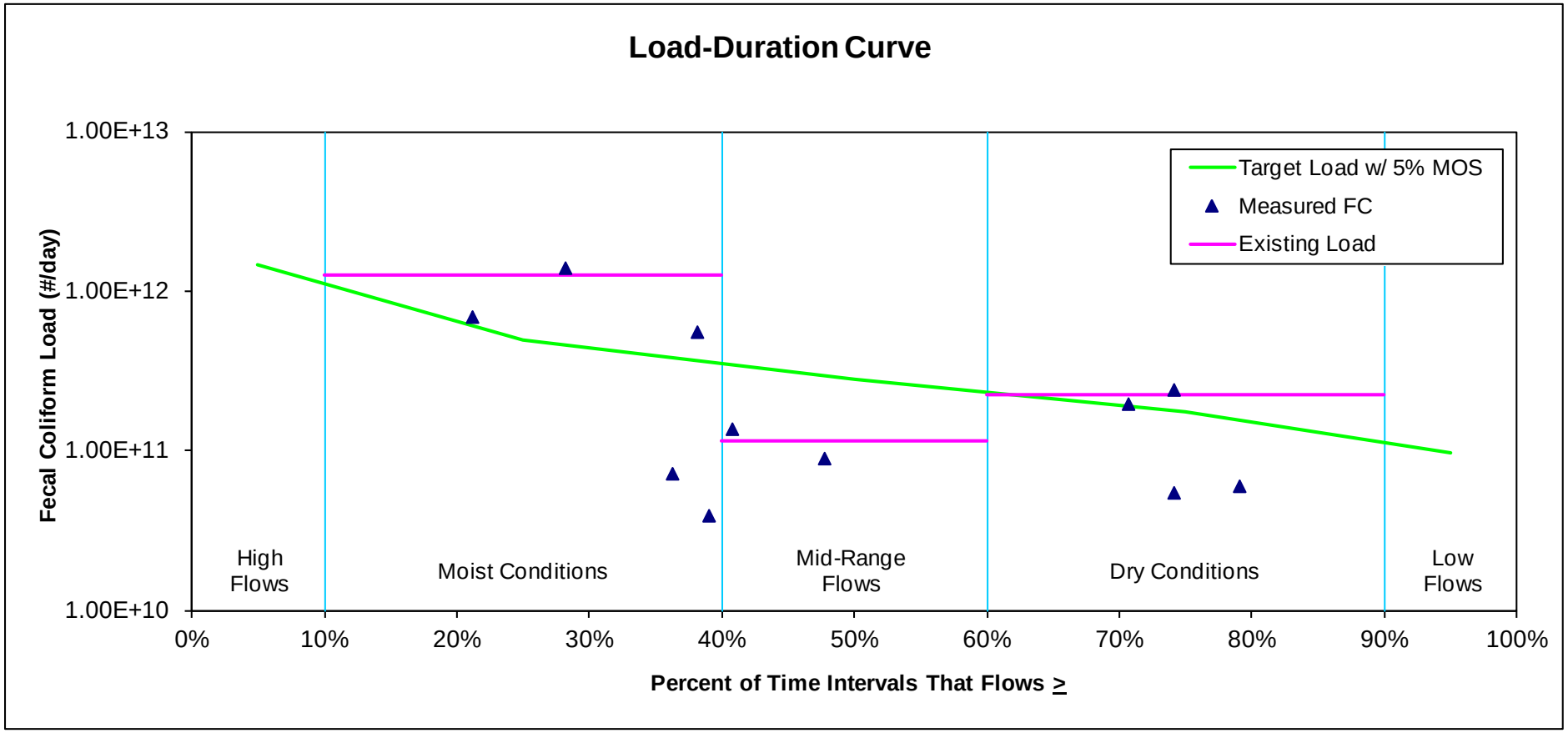


Precipitation and FC Data by Date for Monitoring Station PD-345

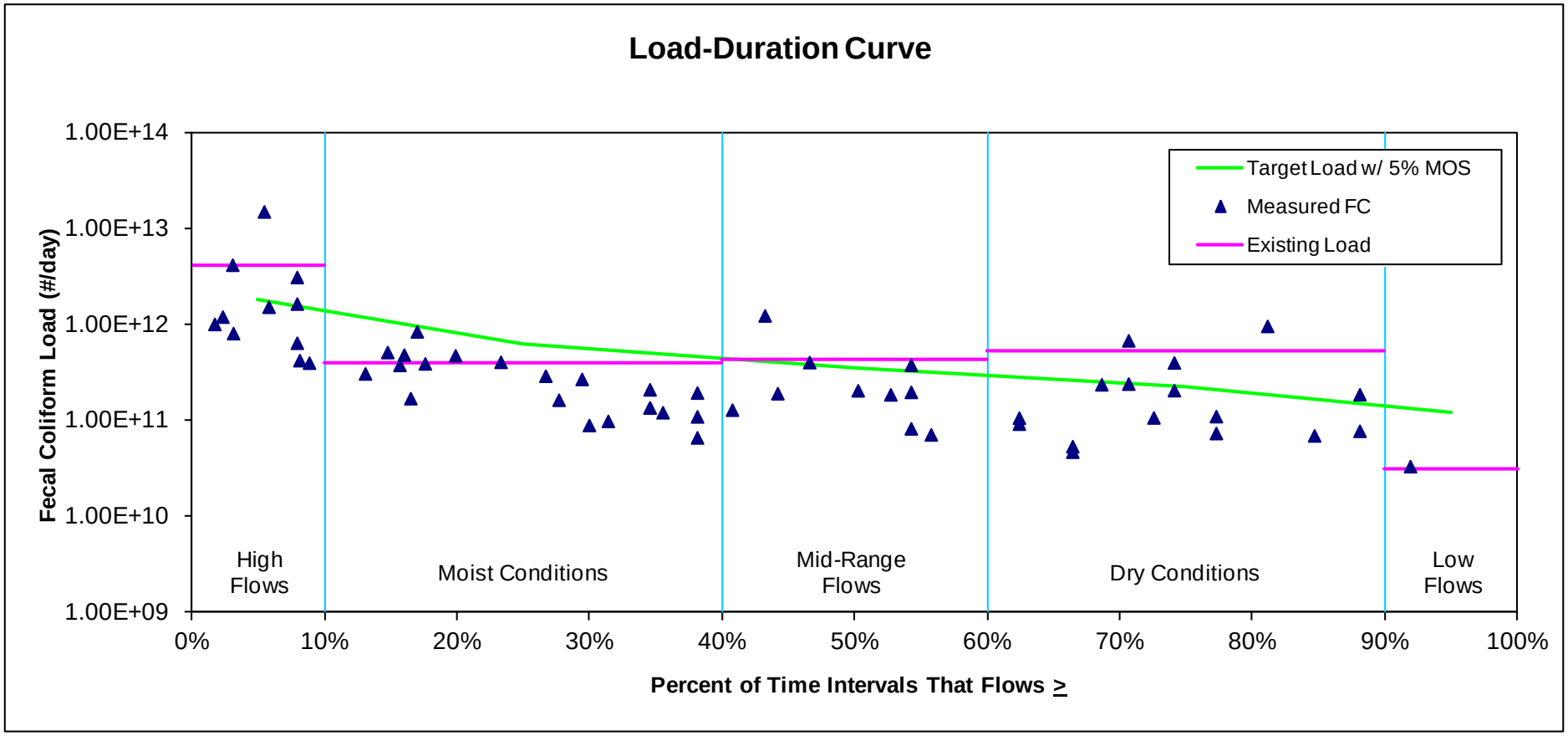


APPENDIX B
ADDITIONAL LOAD-DURATION CURVES BY STATION

Load Duration Curve for Reach 1 of the Lake Swamp and Lower Sparrow Swamp Watershed, WQM Station RS-12084



Load Duration Curve for Reach 2 of the Lake Swamp and Lower Sparrow Swamp Watershed, WQM Station PD-345



Appendix C

EVALUATING THE PROGRESS OF MS4 PROGRAMS

Evaluating the Progress of MS4 Programs:
Meeting the Goals of TMDLs and Attaining Water Quality Standards

Bureau of Water

August 2008

Described below are potential approaches that may be used by MS4 permit holders. These are recommendations and examples only, as the 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

5. Links:

- Evaluating the Effectiveness of Municipal Stormwater Programs. September 2007. EPA 833-F-07-010
- The BMP database - http://www.bmpdatabase.org/BMPPerformance.htm (this link is specifically to the BMP performance page, and lot more)
- USEPA's STORET data warehouse - http://www.epa.gov/storet/dw_home.html
- USEPA, Region 5: STEPL – Spreadsheet tool for estimating pollutant loads http://it.tetratech-ffx.com/stepl/
- Measurable goals guidance for Phase II Small MS4 - http://cfpub.epa.gov/npdes/stormwater/measurablegoals/index.cfm
- Environmental indicators for sotrmwater program- http://cfpub.epa.gov/npdes/stormwater/measurablegoals/part5.cfm
- National menu of stormwater best management practices (BMPs) - http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm
- SCDHEC – BOW: 319 grant program has attempted to calculate the load reductions for the following BMPs:

    - Septic tank repair or replacement
    - Removing livestock from streams (cattle, horses, mules)
    - Livestock fencing
    - Waste Storage Facilities (aka stacking sheds)
    - Strip cropping
    - Prescribed grazing
    - Critical Area Planting
    - Runoff Management System
    - Waste Management System
    - Solids Separation Basin
    - Riparian Buffers

Appendix D
DATA TABLES

Fecal Coliform WQS Exceedence Summary for Impaired Station RS-12084 by Date

Date	FC (cfu/100 mL)
1/12/2012	**610**
2/21/2012	**480**
3/13/2012	160
4/10/2012	76

Date	FC (cfu/100 mL)
5/15/2012	44
6/14/2012	400
8/8/2012	**1200**
9/12/2012	120

Date	FC (cfu/100 mL)
10/17/2012	120
11/15/2012	**530**
12/5/2012	150

____ **WQS Exceeded**

90th Percentile FC Concentrations (#/100 mL)

Hydro Category Range	High Flow 0-10	Moist Cond. 10-40	Mid Range 40-60	Dry Flow 60-90	Low Flow 90-100	Samples
RS-12084	NS	964	156	491	NS	11

NS = No samples

Mid Point Hydrologic Category Flow (cfs)

Hydro Categ (Mid-Point)	High Flow (5)	Moist Cond. (25)	Mid Range (50)	Dry (75)	Low Flow (95)
RS-12084	156.55	53.18	29.96	18.73	10.49

Existing Load (#/day)

Hydro Categ (Mid-Point)	High Flow (5)	Moist Cond. (25)	Mid Range (50)	Dry (75)	Low Flow (95)
RS-12084	NM	1.25E+12	1.14E+11	2.25E+11	NM

NM = Not measured

LA to Achieve Target Load (#/day)

Hydro Categ (Mid-Point)	High Flow (5)	Moist Cond. (25)	Mid Range (50)	Dry (75)	Low Flow (95)
RS-12084	1.46E+12	4.94E+11	2.79E+11	1.74E+11	9.75E+10

Load Reduction Necessary (#/day)

Hydro Categ (Mid-Point)	High Flow (5)	Moist Cond. (25)	Mid Range (50)	Dry (75)	Low Flow (95)
RS-12084	N/A	7.60E+11	NRN	5.09E+10	N/A

NRN = no reduction needed. Existing load below target load.

% Load Reduction Necessary

Hydro Categ (Mid-Point)	High Flow (5)	Moist Cond. (25)	Mid Range (50)	Dry (75)	Low Flow (95)
RS-12084	N/A	61	NRN	23	N/A

NRN = no reduction needed. Existing load below target load.

Fecal Coliform WQS Exceedence Summary for Impaired Station PD-345 by Date

Date	FC (cfu/100 mL)
1/10/2001	71
2/8/2001	89
3/15/2001	0
4/17/2001	150
6/18/2001	120
1/15/2002	250
2/7/2002	120
3/8/2002	190
4/1/2002	120
5/16/2002	370
10/21/2002	140
1/14/2004	110
2/5/2004	64
3/9/2004	58
4/15/2004	120
5/19/2004	130
8/5/2004	**700**
9/8/2004	240
10/7/2004	240
11/18/2004	120

Date	FC (cfu/100 mL)
12/6/2004	**420**
1/20/2005	170
2/17/2005	100
3/17/2005	**870**
4/26/2005	**460**
5/5/2005	180
6/2/2005	**1100**
7/6/2005	200
8/22/2005	360
10/13/2005	**1200**
12/8/2005	400
1/4/2006	180
2/9/2006	190
3/30/2006	220
4/6/2006	81
5/17/2006	190
6/22/2006	350
7/17/2006	73
8/9/2006	170
9/14/2006	**3300**

Date	FC (cfu/100 mL)
10/26/2006	230
11/27/2006	170
12/11/2006	170
1/3/2007	220
2/1/2007	220
3/7/2007	100
4/23/2007	110
5/10/2007	110
6/21/2007	**2000**
7/11/2007	**660**
1/7/2009	**460**
2/4/2009	96
3/4/2009	130
4/1/2009	79
5/12/2009	190
6/3/2009	97
7/1/2009	160
8/6/2009	**480**
9/3/2009	390
11/3/2009	210

____ WQS Exceeded

90th Percentile FC Concentrations (#/100 mL)

Hydro Category Range	High Flow 0-10	Moist Cond. 10-40	Mid Range 40-60	Dry Flow 60-90	Low Flow 90-100	Samples
PD-345	870	240	460	900	97	60

Mid Point Hydrologic Category Flow (cfs)

Hydro Categ (Mid-Point)	High Flow (5)	Moist Cond. (25)	Mid Range (50)	Dry (75)	Low Flow (95)
PD-345	196.72	66.83	37.65	23.53	13.18

Existing Load (#/day)

Hydro Categ (Mid-Point)	High Flow (5)	Moist Cond. (25)	Mid Range (50)	Dry (75)	Low Flow (95)
PD-345	4.19E+12	3.92E+11	4.24E+11	5.18E+11	3.13E+10

LA to Achieve Target Load (#/day)

Hydro Categ (Mid-Point)	High Flow (5)	Moist Cond. (25)	Mid Range (50)	Dry (75)	Low Flow (95)
PD-345	1.83E+12	6.21E+11	3.50E+11	2.19E+11	1.23E+11

Load Reduction Necessary (#/day)

Hydro Categ (Mid-Point)	High Flow (5)	Moist Cond. (25)	Mid Range (50)	Dry (75)	Low Flow (95)
PD-345	N/A	NRN	7.37E+10	2.99E+11	N/A

NRN = no reduction needed. Existing load below target load.

% Load Reduction Necessary

Hydro Categ (Mid-Point)	High Flow (5)	Moist Cond. (25)	Mid Range (50)	Dry (75)	Low Flow (95)
PD-345	N/A	NRN	17	58	N/A

NRN = no reduction needed. Existing load below target load.

Fecal Coliform WQS Exceedence Summary for Impaired Station PD-332 by Date

Date	FC (cfu/100 mL)
1/12/1999	66
2/24/1999	120
3/24/1999	100

Date	FC (cfu/100 mL)
4/15/1999	34
5/18/1999	130
8/18/1999	5

Date	FC (cfu/mL)
9/20/1999	100
10/14/1999	140
11/2/1999	170

Fecal Coliform WQS Exceedence Summary for Impaired Station PD-332 by Date (continued)

Date	FC (cfu/100 mL)
12/2/1999	220
1/20/2000	140
2/3/2000	62
3/9/2000	82
4/5/2000	92
5/3/2000	260
7/5/2000	0
8/10/2000	24
9/7/2000	**790**
10/4/2000	340
11/16/2000	200
12/11/2000	68
1/10/2001	73
2/8/2001	140
3/15/2001	160
4/17/2001	140
6/18/2001	54
10/31/2001	4
1/15/2002	84
2/7/2002	120
3/8/2002	260
4/1/2002	120
5/16/2002	200
9/23/2002	74

Date	FC (cfu/100 mL)
10/21/2002	210
1/13/2004	62
2/5/2004	110
3/9/2004	72
4/15/2004	220
5/6/2004	100
7/1/2004	120
8/5/2004	190
9/8/2004	240
10/7/2004	120
11/18/2004	120
12/6/2004	96
1/20/2005	150
2/17/2005	150
3/17/2005	**460**
4/26/2005	50
5/5/2005	310
6/2/2005	**560**
7/6/2005	210
8/22/2005	160
10/13/2005	**440**
12/8/2005	180
1/4/2006	130
2/9/2006	190

Date	FC (cfu/100 mL)
3/30/2006	200
4/6/2006	160
5/17/2006	110
6/22/2006	340
7/17/2006	65
8/9/2006	64
9/14/2006	**1900**
10/26/2006	56
11/27/2006	100
12/11/2006	110
1/3/2007	94
2/1/2007	**610**
3/7/2007	110
4/23/2007	110
5/10/2007	96
6/21/2007	**1400**
7/11/2007	96
11/19/2007	81
12/4/2007	48
1/7/2009	250
2/4/2009	210
3/4/2009	110
4/1/2009	76
5/12/2009	240

____ WQS Exceeded

Fecal Coliform WQS Exceedence Summary for Impaired Station PD-332 by Date (continued)

Date	FC (cfu/100 mL)
6/3/2009	160
7/1/2009	56
8/6/2009	220
9/3/2009	120
11/3/2009	56
2/1/2010	190
4/7/2010	150
6/3/2010	**2000**

Date	FC (cfu/100 mL)
8/11/2010	320
10/20/2010	44
12/1/2010	120
1/5/2011	160
3/28/2011	**840**
5/4/2011	280
9/8/2011	**1900**
11/9/2011	280

Date	FC (cfu/100 mL)
1/12/2012	200
3/13/2012	180
5/15/2012	64
7/18/2012	190
9/12/2012	**470**
11/14/2012	69

____ **WQS Exceeded**

90th Percentile FC Concentrations (#/100 mL)

Hydro Category Range	High Flow 0-10	Moist Cond. 10-40	Mid Range 40-60	Dry Flow 60-90	Low Flow 90-100	Samples
PD-332	190	420	260	728	56	103

Mid Point Hydrologic Category Flow (cfs)

Hydro Categ (Mid-Point)	High Flow (5)	Moist Cond. (25)	Mid Range (50)	Dry (75)	Low Flow (95)
PD-332	609.16	322.74	179.23	102.06	52.72

Existing Load (#/day)

Hydro Categ (Mid-Point)	High Flow (5)	Moist Cond. (25)	Mid Range (50)	Dry (75)	Low Flow (95)
PD-332	2.83E+12	3.32E+12	1.14E+12	1.82E+12	7.22E+10

LA to Achieve Target Load (#/day)

Hydro Categ (Mid-Point)	High Flow (5)	Moist Cond. (25)	Mid Range (50)	Dry (75)	Low Flow (95)
PD-332	5.63E+12	2.97E+12	1.64E+12	9.19E+11	4.60E+11

Load Reduction Necessary (#/day)

Hydro Categ (Mid-Point)	High Flow (5)	Moist Cond. (25)	Mid Range (50)	Dry (75)	Low Flow (95)
PD-332	N/A	3.46E+11	NRN	8.99E+11	N/A

NRN = no reduction needed. Existing load below target load.

% Load Reduction Necessary

Hydro Categ (Mid-Point)	High Flow (5)	Moist Cond. (25)	Mid Range (50)	Dry (75)	Low Flow (95)
PD-332	N/A	10	NRN	49	N/A

NRN = no reduction needed. Existing load below target load.

Appendix E

POTENTIAL POLLUTANT SOURCE IDENTIFICATION

Table Ap-1. Potential FC and *E. coli* Pollutant Sources in Reach 1 of the Lake Swamp and Lower Sparrow Swamp Watershed (WQM Station RS-12084)

Reach Station	Source	Vicinity of Road/Street	County	Location in Watershed	Latitude	Longitude	Date Observed	Source Notes
RS-12084	Cats	Branch Road	Florence	Southeast	34.15746	-79.93236	6/28/2016	Unattended cat in yard
RS-12084	Cattle	South Sansbury Road	Darlington	Central	34.19671	-79.99497	6/23/2016	Pastured cattle near Lake Swamp
RS-12084	Cattle	Sunnyhill Road	Darlington	Central	34.17704	-79.95453	6/23/2016	Pastured cattle
RS-12084	Cattle	North Brockingham Street	Florence	Southeast	34.15612	-79.95217	6/28/2016	Pastured cattle
RS-12084	Cattle	Mount Carmel Road	Florence	Southeast	34.15401	-79.91601	6/28/2016	Pastured cattle
RS-12084	Chickens	Mayford Road	Darlington	Northwest	34.27144	-80.04826	6/23/2016	Fighting rosters in huts near Lake Swamp
RS-12084	Chickens	County Route S-16-483	Darlington	Northwest	34.22178	-80.02997	6/23/2016	Chickens in yard
RS-12084	Chickens	SC 403	Darlington	Central	34.18045	-79.98828	9/13/2016	Chickens in yard
RS-12084	Chickens	East Clifford Street	Florence	Southeast	34.13983	-79.93812	6/28/2016	Chickens in pen in the Town of Timmonsville
RS-12084	Chickens	Mount Carmel Road	Florence	Southeast	34.15404	-79.91524	6/28/2016	Guinea hens in pen
RS-12084	Deer	Indian Branch Road	Darlington	Northwest	34.27910	-80.06344	6/23/2016	Deer stand on edge of field near Lake Swamp
RS-12084	Deer	Indian Branch Road	Darlington	Northwest	34.28011	-80.04623	6/23/2016	Deer stand in field
RS-12084	Deer	Cinnamon Creek Road	Darlington	Northwest	34.22663	-80.03994	6/23/2016	Deer in field
RS-12084	Deer	Hanna Hyman Road	Darlington	Central	34.19494	-80.00407	6/23/2016	Deer stand in woods near Lake Swamp
RS-12084	Deer	Leisure Road	Darlington	Central	34.19876	-80.01077	6/23/2016	Deer stand on edge of field
RS-12084	Deer	East St Paul Road	Darlington	Southeast	34.16130	-79.96427	9/13/2016	Deer stand on edge of field
RS-12084	Dogs	Mayford Road	Darlington	Northwest	34.27191	-80.04458	6/23/2016	Unattended dog in yard
RS-12084	Dogs	Mayford Road	Darlington	Northwest	34.27193	-80.04446	6/23/2016	Unattended dog in yard
RS-12084	Dogs	Vapor Road	Darlington	Northwest	34.25300	-80.03690	6/23/2016	Unattended dog in road near Lake Swamp
RS-12084	Dogs	County Route S-16-483	Darlington	Northwest	34.22178	-80.03003	6/23/2016	Unattended dog in yard
RS-12084	Dogs	Rustic Way Drive	Darlington	Central	34.21039	-79.99735	6/23/2016	Unattended dogs in yard near Lake Swamp
RS-12084	Dogs	East Clifford Street	Florence	Southeast	34.13825	-79.94091	6/28/2016	Restrained dog in the Town of Timmonsville
RS-12084	Dogs	Tara Drive	Florence	Southeast	34.15171	-79.91967	6/28/2016	Unattended dog in road near Lake Swamp
RS-12084	Dogs	Mount Carmel Road	Florence	Southeast	34.15401	-79.91524	6/28/2016	Unattended dog in yard
RS-12084	Dogs	Steeple Drive	Florence	Southeast	34.14259	-79.90933	6/28/2016	Unattended dog in yard near Lake Swamp
RS-12084	Geese	Calvary Road	Darlington	Northwest	34.26769	-80.04996	6/23/2016	Geese near a stream-fed pond near Lake Swamp
RS-12084	Goats	US 401	Darlington	Central	34.22245	-80.00340	6/23/2016	Pastured goats near Lake Swamp
RS-12084	Herons	East Seven Pines Street	Darlington	Northwest	34.26399	-80.04821	6/23/2016	Grey heron in Lake Swamp

Table Ap-1 (continued). Potential FC and *E. coli* Pollutant Sources in Reach 1 of the Lake Swamp and Lower Sparrow Swamp Watershed (WQM Station RS-12084)

Reach Station	Source	Vicinity of Road/Street	County	Location in Watershed	Latitude	Longitude	Date Observed	Source Notes
RS-12084	Horses	Mayford Road	Darlington	Northwest	34.27214	-80.04289	6/23/2016	Pastured horses
RS-12084	Horses	Vapor Road	Darlington	Northwest	34.24754	-80.03626	6/23/2016	Horse in pasture near Lake Swamp
RS-12084	Horses	Philadelphia Street	Darlington	Northwest	34.24468	-80.03349	6/23/2016	Pastured horses near Lake Swamp
RS-12084	Horses	Lawson Grove Road	Darlington	Northwest	34.23813	-80.02266	6/23/2016	Esquestrian Center near Lake Swamp
RS-12084	Horses	Sunnyhill Road	Darlington	Central	34.17715	-79.95463	6/23/2016	Horse in pasture
RS-12084	Horses	SC 403	Darlington	Central	34.18770	-80.00209	6/28/2016	Pastured horses near Lake Swamp
RS-12084	Horses	Darlington Street	Florence	Southeast	34.15241	-79.94145	6/28/2016	Pastured horses
RS-12084	Horses	Darlington Street	Florence	Southeast	34.15404	-79.94132	6/28/2016	Pastured horses
RS-12084	Horses	River Bend Drive	Florence	Southeast	34.16978	-79.93584	6/28/2016	Pastured horse
RS-12084	Horses	River Bend Drive	Florence	Southeast	34.16969	-79.93590	6/28/2016	Horse under shed
RS-12084	Horses	Tara Drive	Florence	Southeast	34.15213	-79.91963	6/28/2016	Pastured horses near Lake Swamp
RS-12084	Horses	Mount Carmel Road	Florence	Southeast	34.15380	-79.91345	6/28/2016	Horse in pasture
RS-12084	Horses	North Sally Hill Road	Florence	Southeast	34.15484	-79.91043	6/28/2016	Pastured horses
RS-12084	Horses	North Sally Hill Road	Florence	Southeast	34.15822	-79.91138	6/28/2016	Pastured horse
RS-12084	Horses	Peniel Road	Florence	Southeast	34.10885	-79.88123	6/28/2016	Horse in pasture near Lake Swamp
RS-12084	Horses	Southern Aire Road	Florence	Southeast	34.13409	-79.88918	6/28/2016	Horse in pasture
RS-12084	Horses	Southern Aire Road	Florence	Southeast	34.13450	-79.88928	6/28/2016	Horse in pasture
RS-12084	Horses	Garner Road	Florence	Southeast	34.13650	-79.87484	6/28/2016	Horse in pasture
RS-12084	Rabbits	Vapor Road	Darlington	Northwest	34.25885	-80.03944	6/23/2016	Rabbit in a cage near Lake Swamp
RS-12084	Turtles	Mayberry Road	Darlington	Northwest	34.26285	-80.04884	6/23/2016	Turtle in road near Lake Swamp

Table Ap-2. Potential FC and *E. coli* Pollutant Sources in Reach 2 of the Lake Swamp and Lower Sparrow Swamp Watershed (WQM Station PD-345)

Reach Station	Source	Vicinity of Road/Street	County	Location in Watershed	Latitude	Longitude	Date Observed	Source Notes
PD-345	Dogs	Pearl Lane	Florence	South	34.05834	-79.85268	7/12/2016	Unattended dog in road near Lake Swamp
PD-345	Donkeys	Yarborough Lane	Florence	North	34.08365	-79.89049	6/28/2016	Donkey in pasture with Goats near Horse Branch
PD-345	Goats	Yarborough Lane	Florence	North	34.08365	-79.89049	6/28/2016	Goats in pasture with a donkey near Horse Branch
PD-345	Goats	Turnstone Road	Florence	North	34.09230	-79.87836	7/12/2016	Pastured goats near Lake Swamp
PD-345	Horses	Center Road	Florence	North	34.08974	-79.89233	6/28/2016	Pastured horses
PD-345	Horses	Center Road	Florence	North	34.08982	-79.89196	6/28/2016	Horse under shed
PD-345	Horses	Center Road	Florence	North	34.08280	-79.89330	6/28/2016	Pastured horses near Horse Branch
PD-345	Horses	Langston Road	Florence	North	34.08440	-79.87223	7/12/2016	Pastured horses
PD-345	Horses	Langston Road	Florence	North	34.09248	-79.87669	7/12/2016	Pastured horses near Lake Swamp
PD-345	Horses	W John Paul Jones Road	Florence	North	34.07520	-79.86125	7/12/2016	Pastured horses
PD-345	Horses	W John Paul Jones Road	Florence	North	34.07527	-79.86123	7/12/2016	Sign for the Carolina Marsh Tacky
PD-345	Horses	Langston Road	Florence	South	34.05208	-79.84877	7/12/2016	Pastured horses
PD-345	Horses	Langston Road	Florence	South	34.05168	-79.84833	7/12/2016	Pastured horses
PD-345	Horses	Langston Road	Florence	South	34.05087	-79.84757	7/12/2016	Pastured horses
PD-345	Horses	South Hill Road	Florence	South	34.03403	-79.85253	7/12/2016	Pastured horses

Table Ap-3. Potential FC and *E. coli* Pollutant Sources in Reach 3 of the Lake Swamp and Lower Sparrow Swamp Watershed (WQM Station PD-332)

Reach Station	Source	Vicinity of Road/Street	County	Location in Watershed	Latitude	Longitude	Date Observed	Source Notes
PD-332	Cattle	East St Paul Road	Darlington	Northwest	34.12523	-80.00728	9/13/2016	Pastured cattle
PD-332	Cattle	Seven Bridges Road	Darlington	Northwest	34.13576	-80.03507	9/13/2016	Pastured cattle
PD-332	Cattle	Cooters Crossing Road	Darlington	Northeast	34.17069	-79.99401	9/13/2016	Pastured cattle near Long Branch
PD-332	Cattle	Weaver Street	Darlington	Northeast	34.16358	-79.99091	9/13/2016	Pastured cattle
PD-332	Cattle	East St Paul Road	Florence	Northeast	34.13557	-79.98853	9/13/2016	Sign for cattle ranch and turkey farm
PD-332	Cattle	South Hill Road	Florence	Central	34.09777	-79.93772	9/20/2016	Pastured cattle near Sparrow Swamp
PD-332	Cattle	Twin Bridge Road	Florence	Central	34.06092	-79.92393	9/20/2016	Pastured cattle
PD-332	Cattle	West Ralph Lane Road	Florence	Southeast	34.02660	-79.88193	9/20/2016	Pastured cattle near Magnolia Branch
PD-332	Cattle	South Hill Road	Florence	Southeast	34.03457	-79.85598	9/20/2016	Pastured cattle
PD-332	Cattle	Hall Road	Florence	Southeast	34.01291	-79.84471	9/20/2016	Pastured cattle
PD-332	Chickens	Bosmith Road	Darlington	Northwest	34.14001	-80.07644	9/13/2016	Chickens in a pen
PD-332	Chickens	Weaver Street	Darlington	Northeast	34.16571	-79.98950	9/13/2016	Chickens in a pasture
PD-332	Chickens	Clyde McGee Road	Florence	Southeast	34.02429	-79.86707	9/20/2016	Chickens in pen near Magnolia Branch
PD-332	Chickens	Knight Road	Florence	Southeast	34.02056	-79.89061	9/20/2016	Guinea hens in yard
PD-332	Chickens	Creek Road	Florence	Southeast	34.02532	-79.90036	9/20/2016	Chichens in pasture with horses
PD-332	Deer	Hudson Stree	Darlington	Northwest	34.17374	-80.09406	9/13/2016	Deer stand on edge of field
PD-332	Deer	Joye Road	Darlington	Northwest	34.13840	-80.07085	9/13/2016	Deer stand on edge of field
PD-332	Deer	Seven Bridges Road	Darlington	Northwest	34.13703	-80.03423	9/13/2016	Deer stand on edge of field
PD-332	Deer	Seven Bridges Road	Darlington	Northwest	34.13773	-80.03379	9/13/2016	Deer stand on edge of field
PD-332	Deer	Piney Grove Road	Florence	Central	34.09689	-79.96720	9/20/2016	Deer stand on edge of field near Bay Branch
PD-332	Deer	East Twin Church Road	Florence	Central	34.08985	-79.92604	9/20/2016	Deer stand on edge of field
PD-332	Deer	East Old Middle Road	Florence	Central	34.07614	-79.92916	9/20/2016	Deer stand on edge of field
PD-332	Deer	Springs Road	Florence	Southeast	34.03982	-79.93180	9/20/2016	Deer stand in field
PD-332	Deer	Clyde McGee Road	Florence	Southeast	34.01977	-79.87811	9/20/2016	Deer stand on edge of field
PD-332	Deer	Oak Grove Road	Florence	Southeast	34.01306	-79.83863	9/20/2016	Deer stand in field
PD-332	Deer	Hall Road	Florence	Southeast	34.00458	-79.83895	9/20/2016	Deer stand on edge of field
PD-332	Deer	Gaymon Road	Florence	Southeast	34.00458	-79.84763	9/20/2016	Deer stand on edge of field
PD-332	Dogs	Carterville Highway	Darlington	Northwest	34.13786	-80.04986	9/13/2016	Unattended dog in yard near Deep Hole Swamp
PD-332	Dogs	Carterville Highway	Darlington	Northwest	34.13786	-80.04986	9/13/2016	Unattended dog in road near Deep Hole Swamp

Table Ap-3 (continued). Potential FC and *E. coli* Pollutant Sources in Reach 3 of the Lake Swamp and Lower Sparrow Swamp Watershed (WQM Station PD-332)

Reach Station	Source	Vicinity of Road/Street	County	Location in Watershed	Latitude	Longitude	Date Observed	Source Notes
PD-332	Dogs	Newberry Road	Darlington	Northwest	34.12026	-80.05586	9/13/2016	Dog chained in yard
PD-332	Dogs	Seven Bridges Road	Darlington	Northwest	34.13310	-80.03683	9/13/2016	Unattended dogs in road near Deep Hole Swamp
PD-332	Dogs	North Warren Street	Florence	Northeast	34.13572	-79.94307	9/13/2016	Unattended dog in yard in Timmonsville
PD-332	Dogs	South Keith Street	Florence	Northeast	34.13263	-79.94268	9/13/2016	Dogs in pen in Timmonsville
PD-332	Dogs	South Keith Street	Florence	Northeast	34.13255	-79.94261	9/13/2016	Dogs chained on porch in Timmonsville
PD-332	Dogs	Piney Grove Road	Florence	Central	34.10513	-79.97150	9/20/2016	Unattended dog in yard near Bay Branch
PD-332	Dogs	South Ham Road	Florence	Central	34.11709	-79.96120	9/20/2016	Dog in pen
PD-332	Dogs	Sardis Highway	Florence	Southeast	34.03193	-79.87515	9/20/2016	Dog in pen
PD-332	Dogs	Cussac Road	Florence	Southeast	34.01776	-79.86009	9/20/2016	Unattended dog on porch
PD-332	Dogs	Cussac Road	Florence	Southeast	34.01797	-79.85998	9/20/2016	Dog in pen
PD-332	Dogs	Victor White Road	Florence	Southeast	34.01198	-79.86053	9/20/2016	Unattended dog in yard
PD-332	Donkeys	W John Paul Jones Road	Florence	Southeast	34.05783	-79.89059	9/20/2016	Donkey in pasture
PD-332	Donkeys	West Ralph Lane Road	Florence	Southeast	34.02587	-79.88264	9/20/2016	Pastured donkeys near Magnolia Branch
PD-332	Egrets	Seven Bridges Road	Darlington	Northwest	34.13630	-80.03473	9/13/2016	Flock of egrets in pasture with cattle
PD-332	Goats	South Hill Road	Florence	Central	34.09159	-79.93879	7/12/2016	Goats in a pen near Sparrow Swamp
PD-332	Goats	Timmons Road	Florence	Central	34.06993	-79.96016	9/20/2016	Pastured goats near Deep Hole Swamp
PD-332	Goats	Dogwood Road	Florence	Central	34.05731	-79.94281	9/20/2016	Pastured goats
PD-332	Goats	Sardis Highway	Florence	Southeast	34.04032	-79.90291	9/20/2016	Pastured goats near Sparrow Swamp
PD-332	Horses	Sweetbriar Road	Darlington	Northwest	34.16402	-80.09571	9/13/2016	Pastured horses
PD-332	Horses	Joye Road	Darlington	Northwest	34.13903	-80.06926	9/13/2016	Pastured horses
PD-332	Horses	Carterville Highway	Darlington	Northwest	34.12325	-80.04188	9/13/2016	Horse in pasture
PD-332	Horses	Bay Branch Road	Darlington	Northwest	34.14720	-80.03243	9/13/2016	Pastured horses
PD-332	Horses	North Kershaw Street	Florence	Northeast	34.15028	-79.96152	9/13/2016	Pastured horses
PD-332	Horses	South Hill Road	Florence	Central	34.07671	-79.93451	7/12/2016	Pastured horses
PD-332	Horses	Timmons Road	Florence	Central	34.07042	-79.95970	9/20/2016	Pastured horses
PD-332	Horses	Cale Yarborough Highway	Florence	Central	34.08784	-79.95350	9/20/2016	Pastured horses
PD-332	Horses	W John Paul Jones Road	Florence	Southeast	34.05756	-79.89079	9/20/2016	Pastured horses
PD-332	Horses	South Hill Road	Florence	Southeast	34.05152	-79.87083	9/20/2016	Pastured horses
PD-332	Horses	West Ralph Lane Road	Florence	Southeast	34.02788	-79.88127	9/20/2016	Pastured horses near Magnolia Branch

Table Ap-3 (continued). Potential FC and *E. coli* Pollutant Sources in Reach 3 of the Lake Swamp and Lower Sparrow Swamp Watershed (WQM Station PD-332)

Reach Station	Source	Vicinity of Road/Street	County	Location in Watershed	Latitude	Longitude	Date Observed	Source Notes
PD-332	Horses	Oak Grove Road	Florence	Southeast	34.00736	-79.82729	9/20/2016	Horse in pasture
PD-332	Horses	Gaymon Road	Florence	Southeast	34.01286	-79.84719	9/20/2016	Horse in pasture
PD-332	Horses	US 301	Florence	Southeast	34.00849	-79.85609	9/20/2016	Horse in pasture
PD-332	Horses	US 301	Florence	Southeast	34.00733	-79.85767	9/20/2016	Horse in pasture
PD-332	Horses	Creek Road	Florence	Southeast	34.02532	-79.90036	9/20/2016	Horses in pasture with chickens
PD-332	Sheep	Weaver Street	Darlington	Northeast	34.16810	-79.99338	9/13/2016	Pastured sheep near Long Branch
PD-332	Sheep	Weaver Street	Darlington	Northeast	34.16423	-79.98981	9/13/2016	Pastured sheep near Long Branch
PD-332	Turkeys	East St Paul Road	Florence	Northeast	34.13557	-79.98853	9/13/2016	Sign for turkey farm and cattle ranch
PD-332	Turtles	Seven Bridges Road	Darlington	Northeast	34.16206	-80.01589	9/13/2016	Turtles on log in stream-fed pond

Appendix F

SOURCE ASSESSMENT PICTURES

Figure F-1

Deer at the edge of a field (location: 34.22663 N, -79.03994 W) on Cinnamon Creek Road in Darlington County. Found in Reach 1 of the LSLSS Watershed (Date of photography: June 23, 2016).

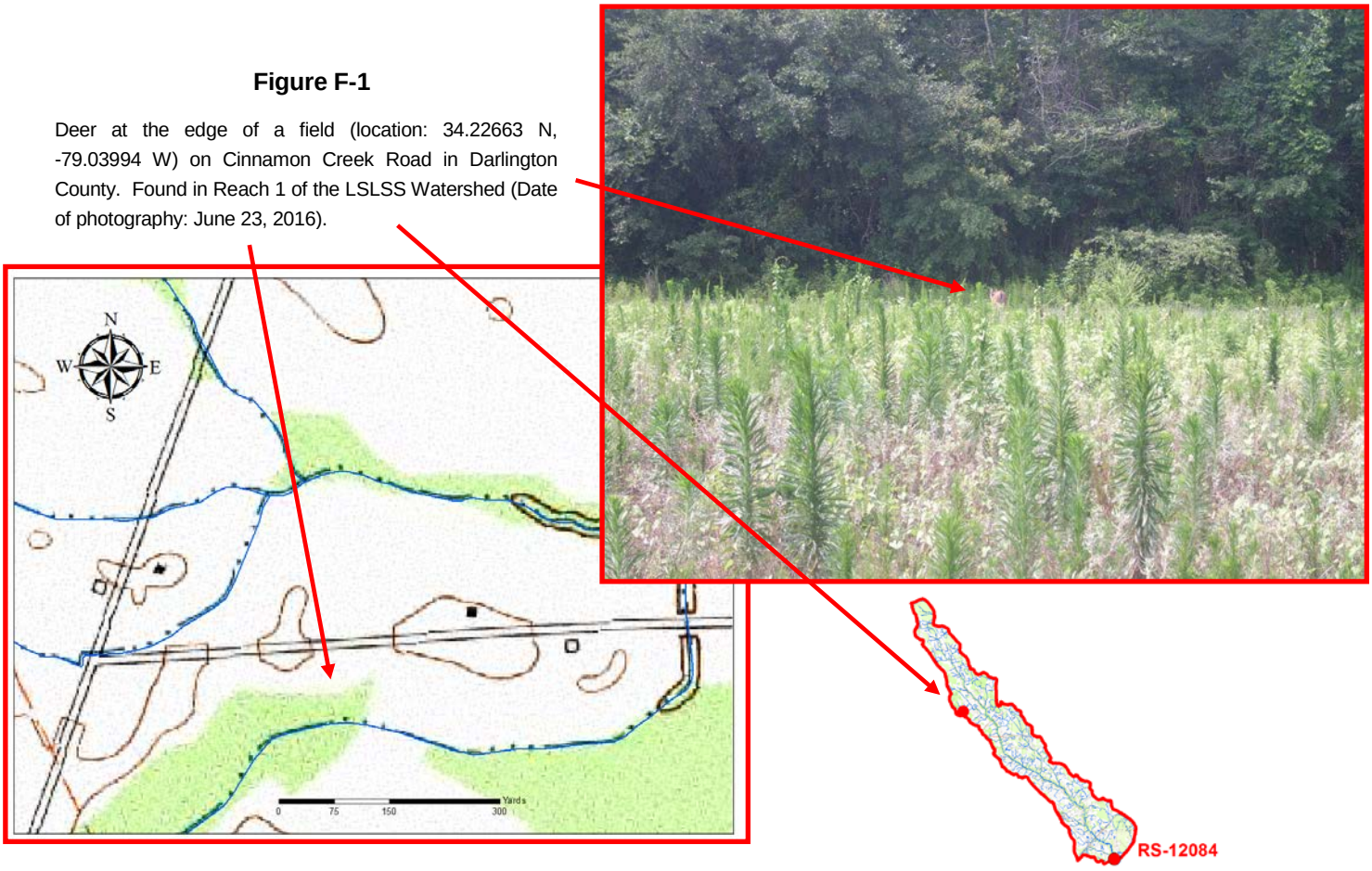


Figure F-2

Deer stand in woods near Lake Swamp (location: 34.19494 N, -80.00407 W) on Hanna Hyman Road in Darlington County. Found in Reach 1 of the LSLSS Watershed (Date of photography: June 23, 2016).

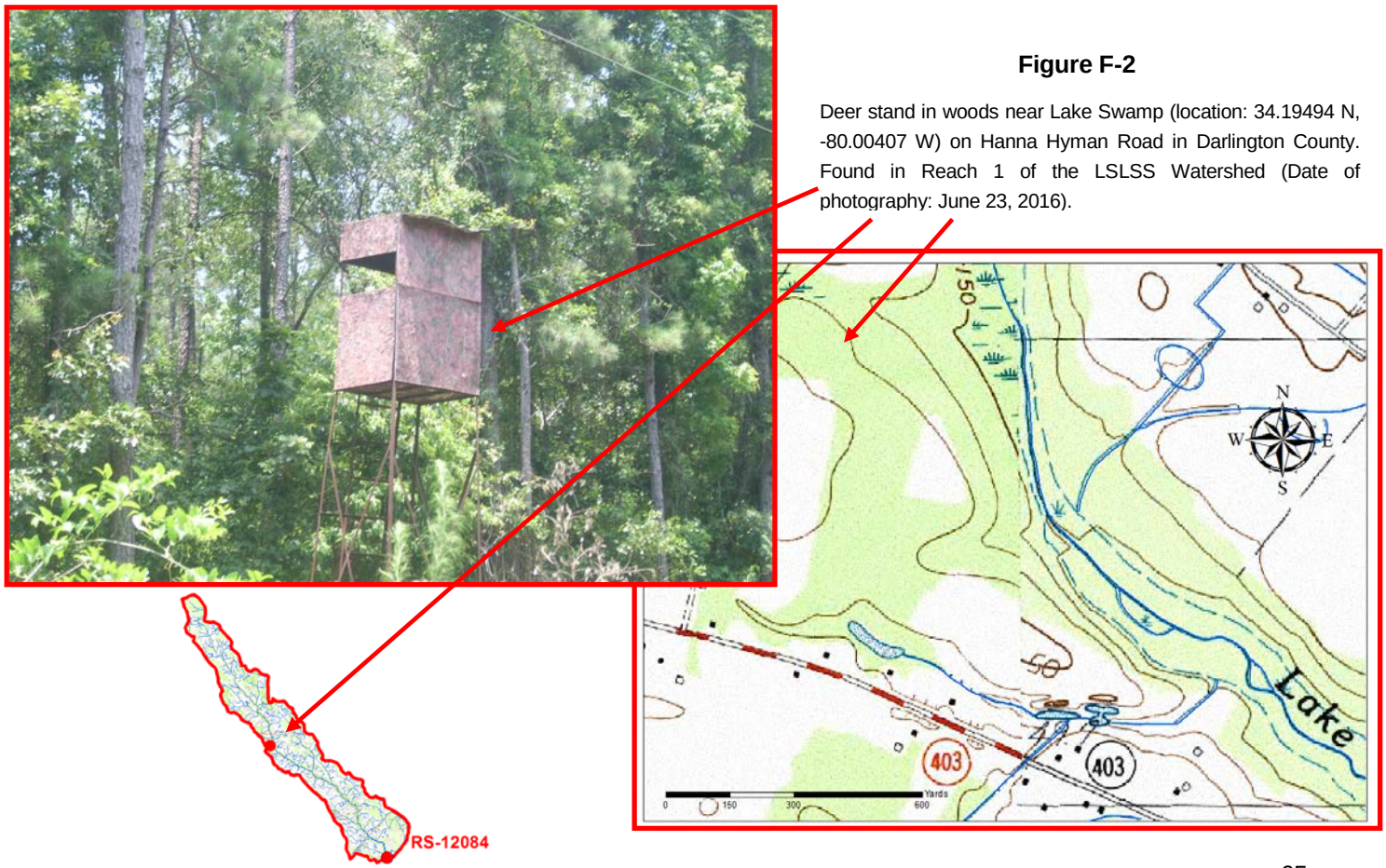


Figure F-3

Deer stand on edge of field (location: 34.07614 N, -79.92916 W) on East Old Middle Road in Florence County. Found in Reach 3 of the LSLSS Watershed (Date of photography: September 20, 2016).

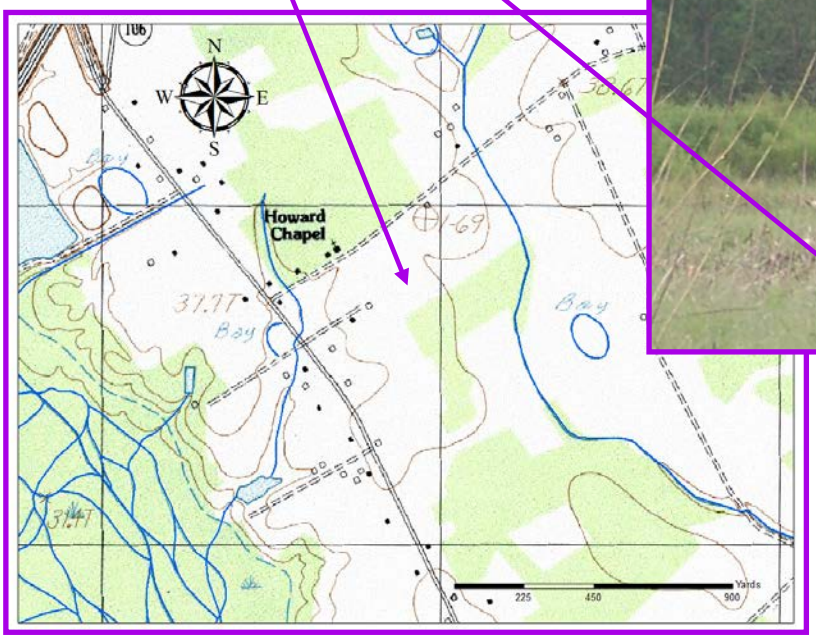


Figure F-4

Deer stand on edged of field (location: 34.00458 N, -79.84763 W) on Gaymon Road in Florence County. Found in Reach 3 of the LSLSS Watershed (Date of photography: September 20, 2016).

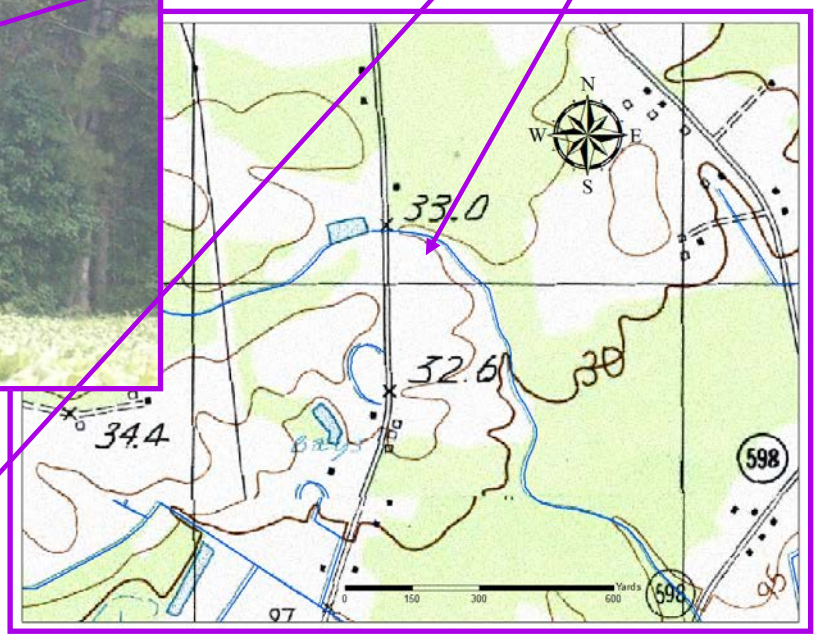


Figure F-5

Geese near a stream-fed pond near Lake Swamp (location: 34.26769 N, -80.04996 W) on Calvary Road in Darlington County. Found in Reach 1 of the LSLSS Watershed (Date of photography: June 23, 2016).

Figure F-6

Flock of egrets in a pasture with cattle (location: 34.13630 N, -80.03473 W) on Seven Bridges Road in Darlington County. Found in Reach 3 of the LSLSS Watershed (Date of photography: September 13, 2016).

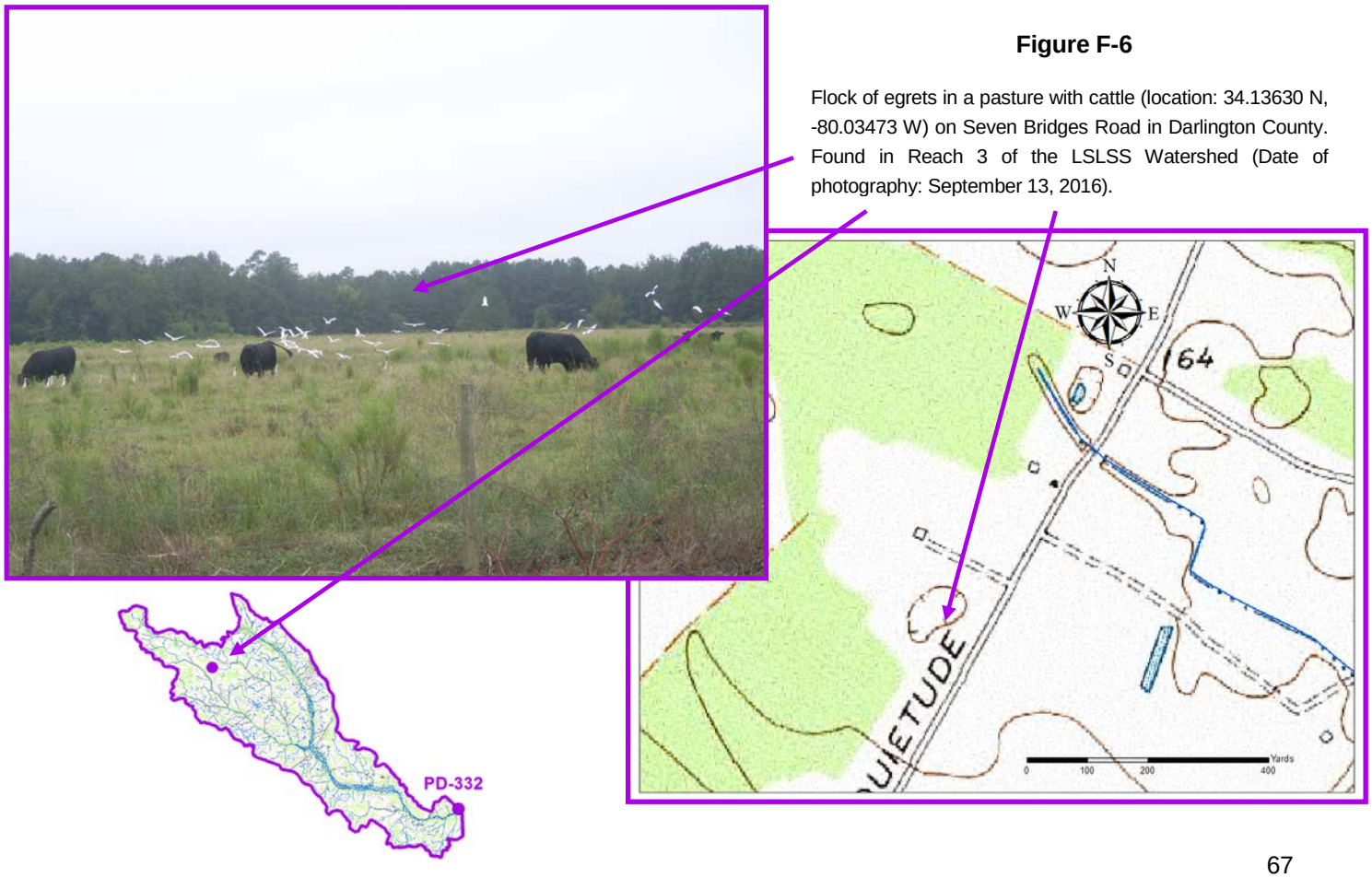


Figure F-7

Pastured cattle near Lake Swamp (location: 34.19671 N, -79.99497 W) on South Sansbury Road in Darlington County. Found in Reach 1 of the LSLSS Watershed (Date of photography: June 23, 2016).

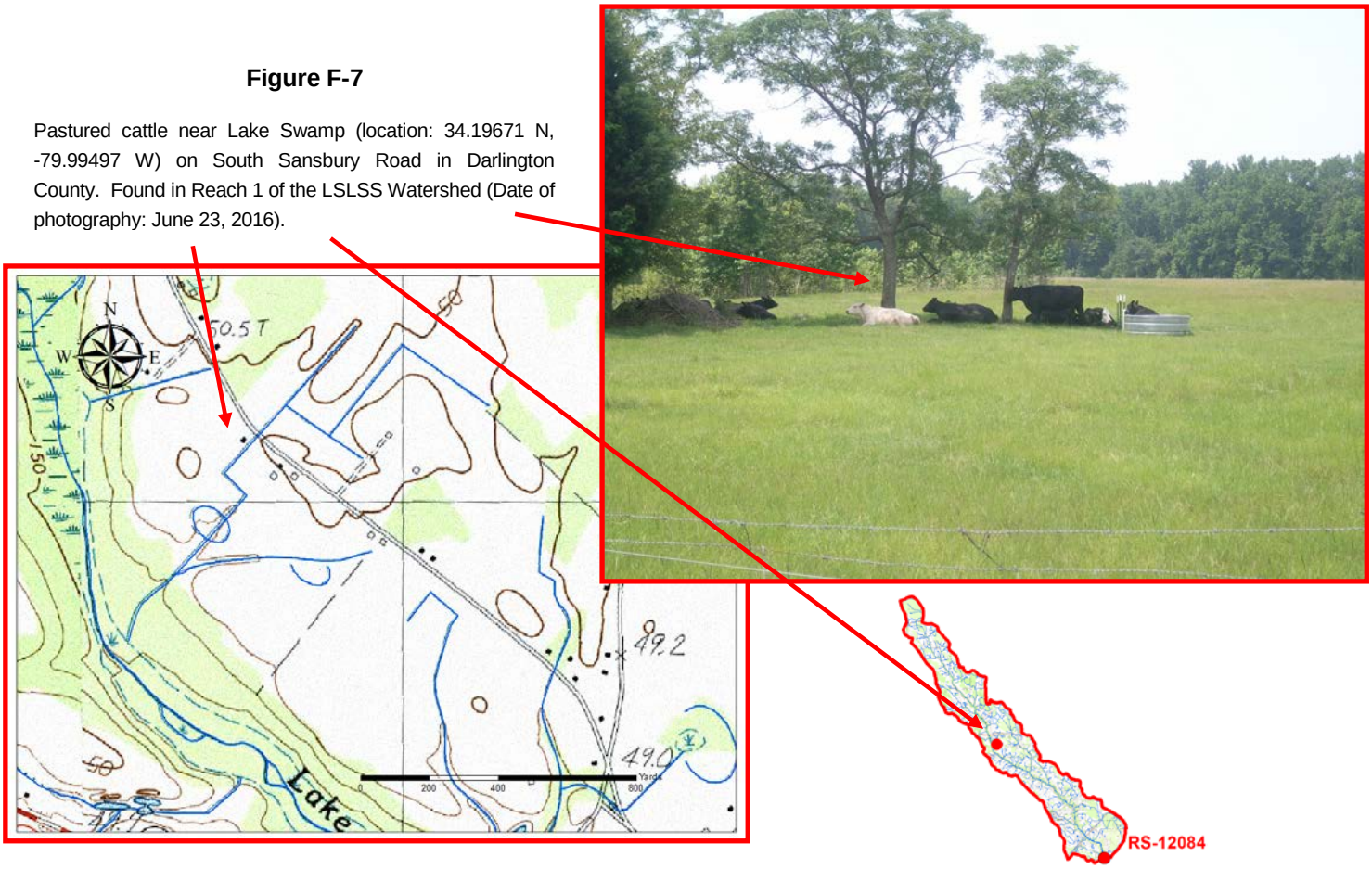


Figure F-8

Pastured cattle (location: 34.15401 N, -79.91601 W) on Mount Carmel Road in Florence County. Found in Reach 1 of the LSLSS Watershed (Date of photography: June 28, 2016).

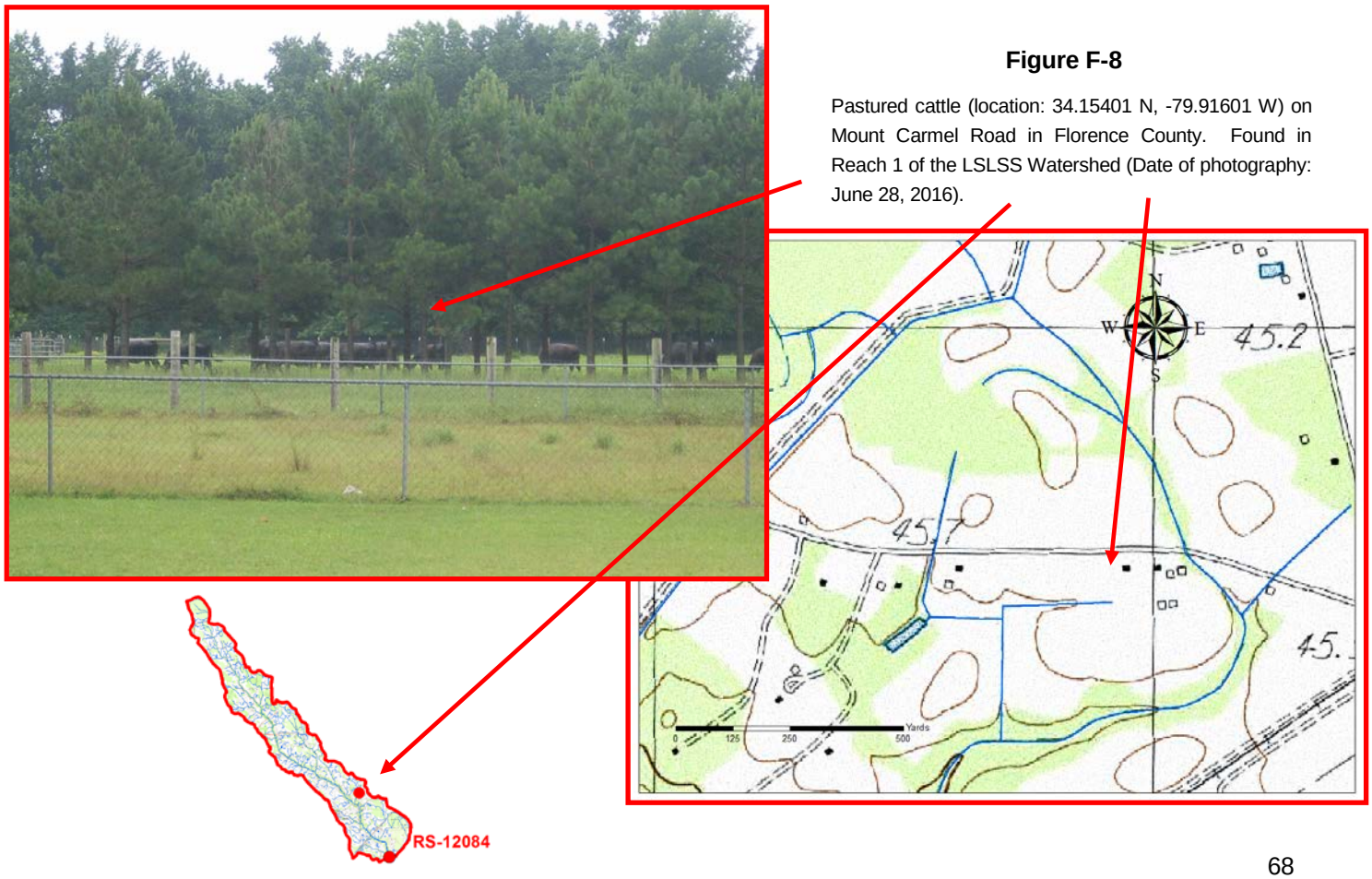


Figure F-9

Pastured cattle near Long Branch (location: 34.17069 N, -79.99401 W) on Cooters Crossing Road in Darlington County. Found in Reach 3 of the LSLSS Watershed (Date of photography: September 13, 2016).

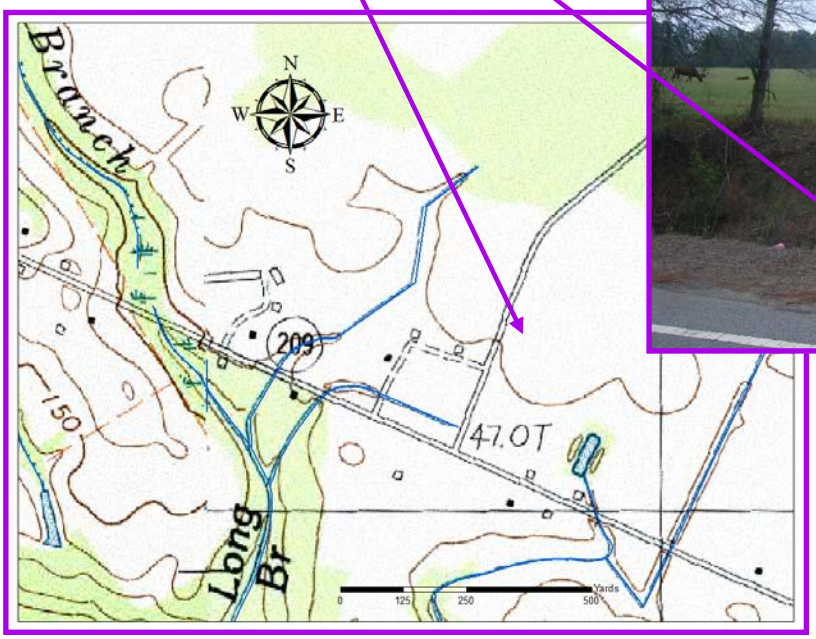


Figure F-10

Pastured cattle near Magnolia Branch (location: 34.02660 N, -79.88193 W) on West Ralph Lane Road in Florence County. Found in Reach 3 of the LSLSS Watershed (Date of photography: September 20, 2016).

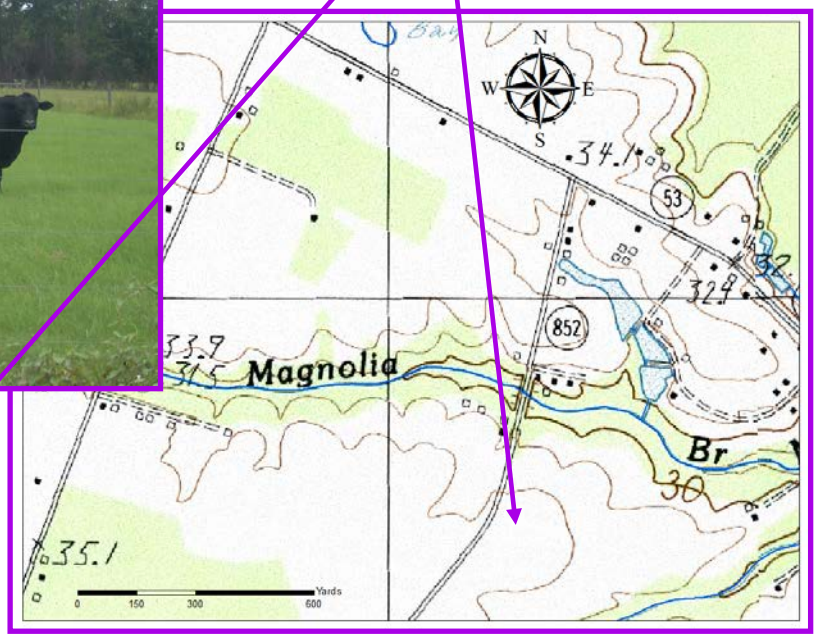


Figure F-11

Pastured sheep near Long Branch (location: 34.16423 N, -79.98981 W) on Weaver Street in Darlington County. Found in Reach 3 of the LSLSS Watershed (Date of photography: September 13, 2016).

Figure F-12

Pastured horses near Lake Swamp (location: 34.18770 N, -80.00209 W) on SC 403 in Darlington County. Found in Reach 1 of the LSLSS Watershed (Date of photography: June 28, 2016).

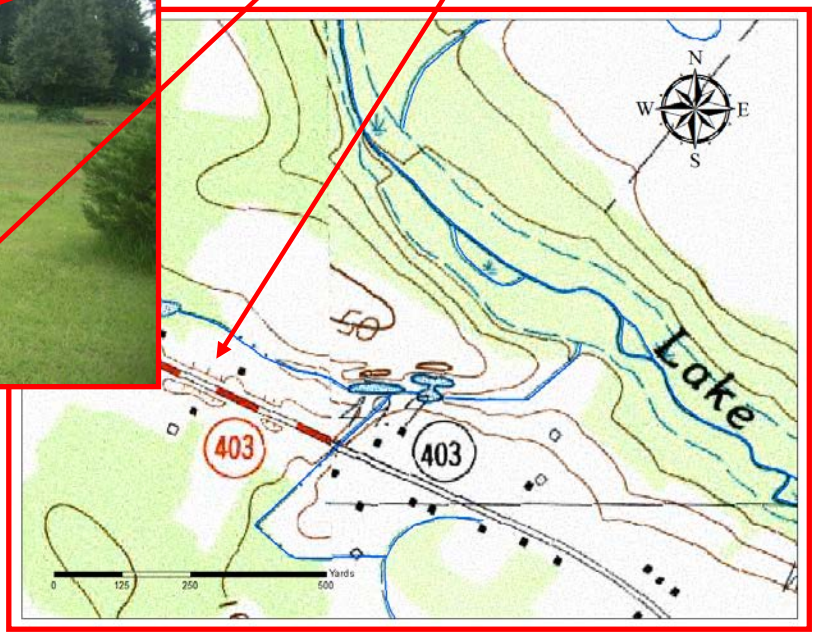


Figure F-13

Pastured horses near Lake Swamp (location: 34.09248 N, -79.87669 W) on Langston Road in Florence County. Found in Reach 2 of the LSLSS Watershed (Date of photography: July 12, 2016).

Figure F-14

Pastured horses (location: 34.05087 N, -79.84757 W) on Langston Road in Florence County. Found in Reach 2 of the LSLSS Watershed (Date of photography: July 12, 2016).

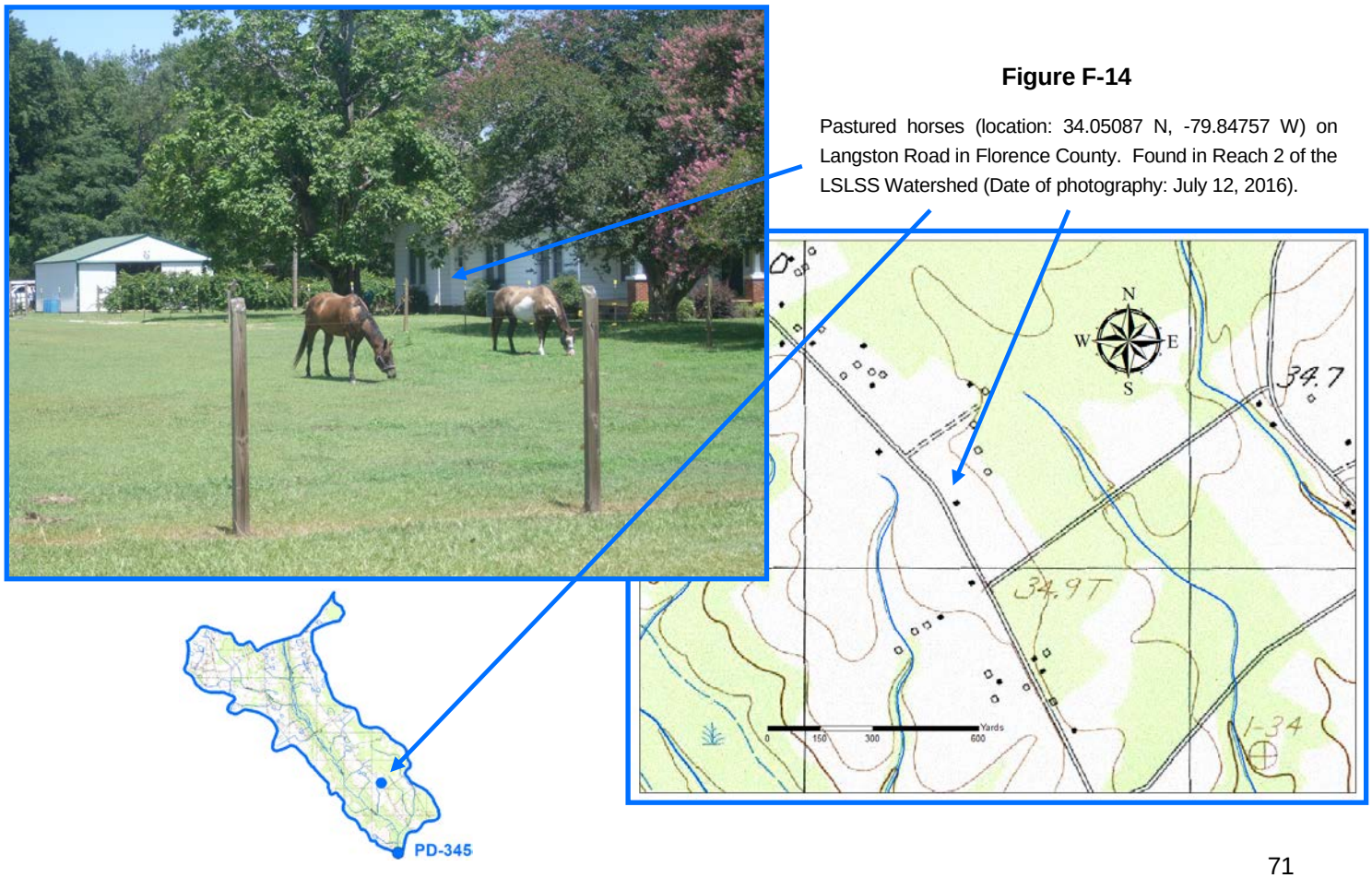


Figure F-15

Pastured horses near Magnolia Branch (location: 34.02788 N, -79.88127 W) on West Ralph Lane Road in Florence County. Found in Reach 3 of the LSLSS Watershed (Date of photography: September 20, 2016).

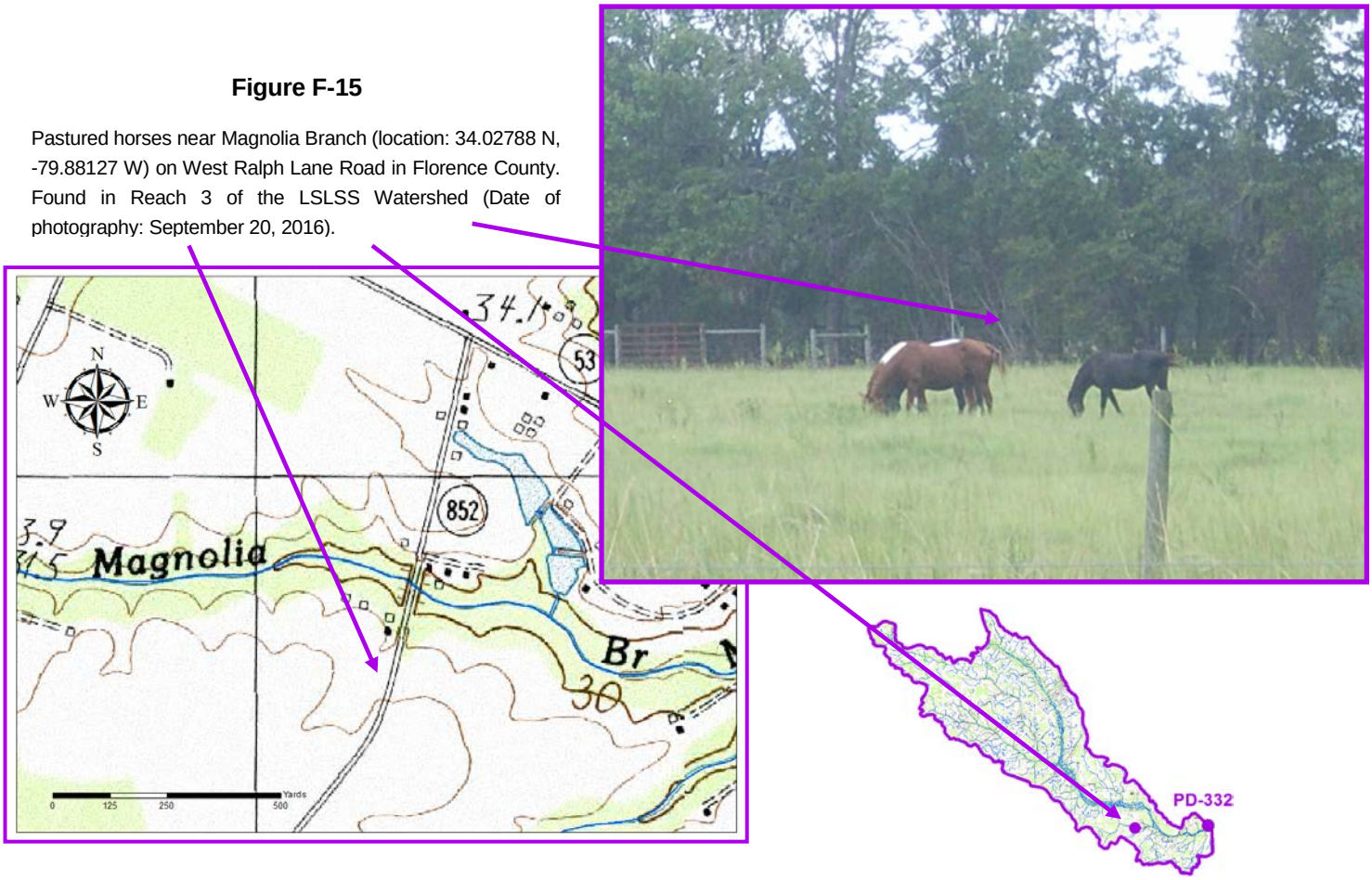


Figure F-16

Pastured goats near Lake Swamp (location: 34.22245 N, -80.00340 W) on US 401 in Darlington County. Found in Reach 1 of the LSLSS Watershed (Date of photography: June 23, 2016).

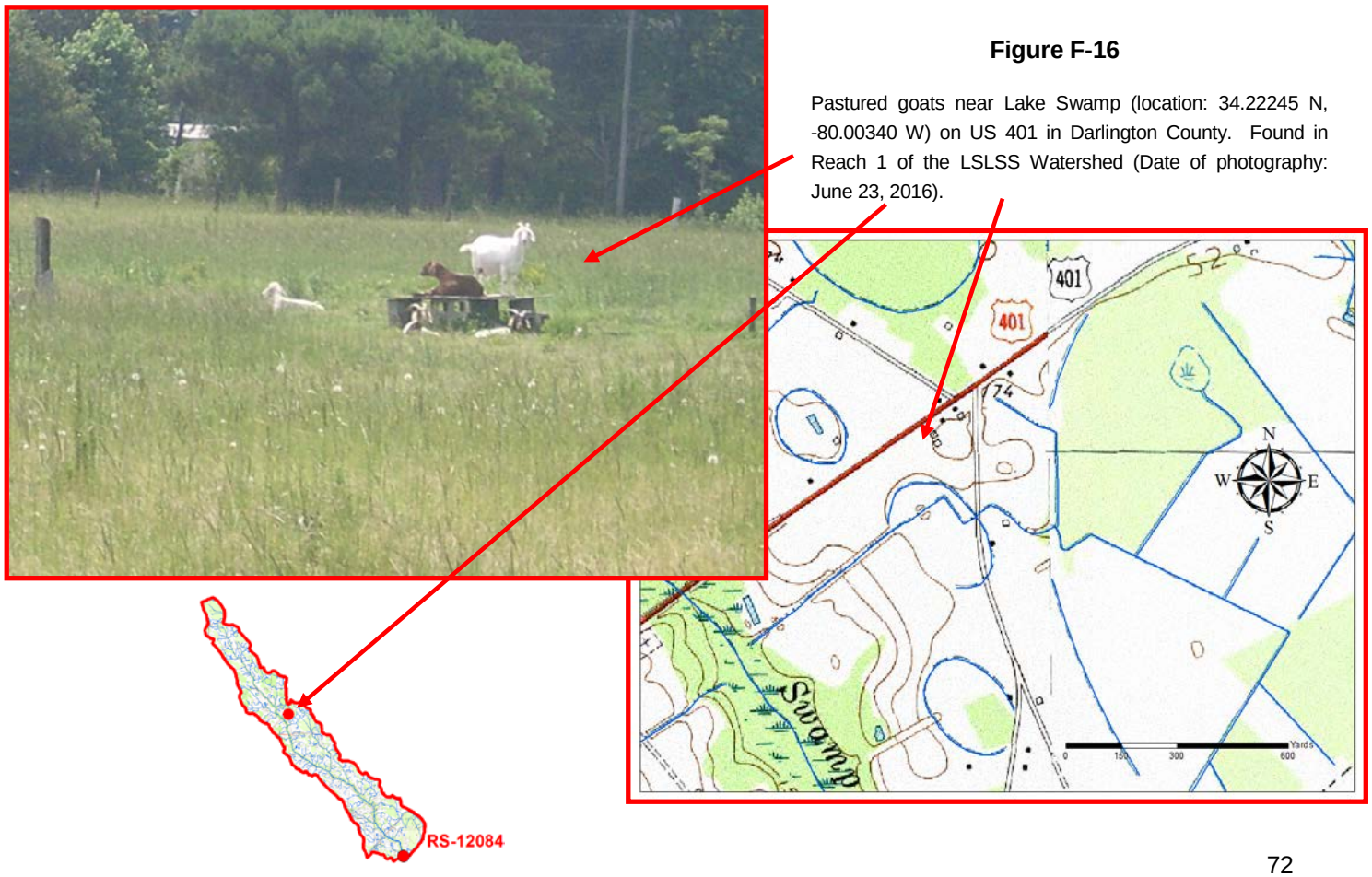


Figure F-17

Pastured goats near Lake Swamp (location: 34.09230 N, -79.87836 W) on Turnstone Road in Florence County. Found in Reach 2 of the LSLSS Watershed (Date of photography: July 12, 2016).

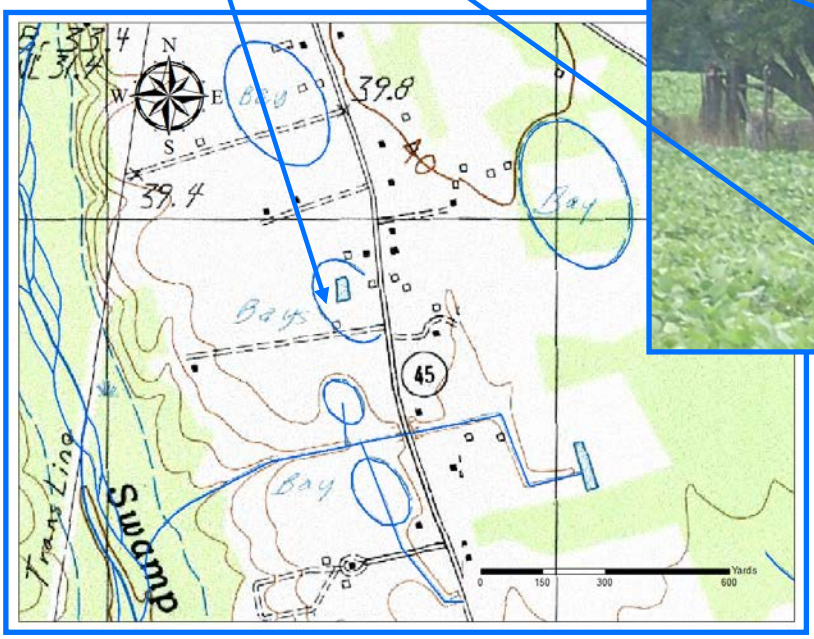


Figure F-18

Pastured goats near Deep Hole Swamp (location: 34.06993 N, -79.96016 W) on Timmons Road in Florence County. Found in Reach 3 of the LSLSS Watershed (Date of photography: September 20, 2016).

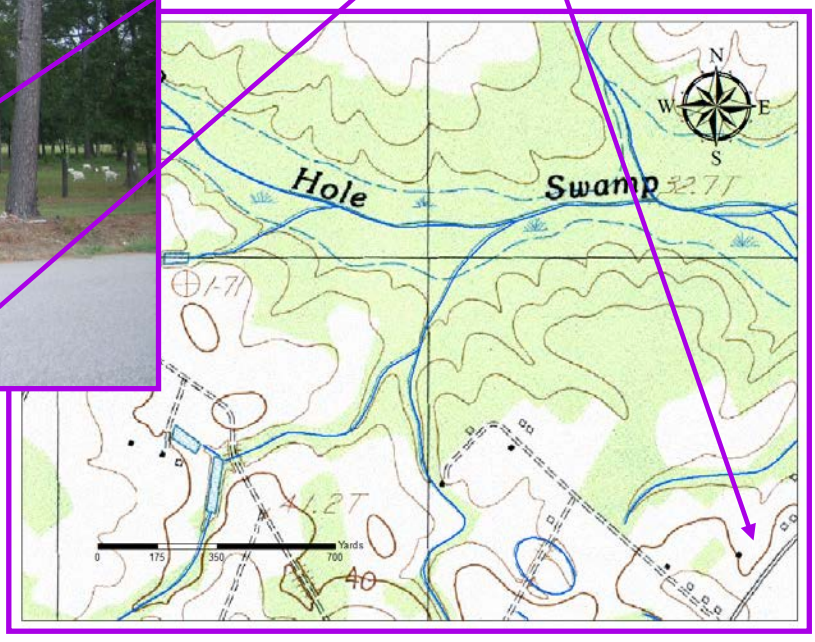


Figure F-19

Pastured goats near Sparrow Swamp (location: 34.04032 N, -79.90291 W) on Sardis Highway in Florence County. Found in Reach 3 of the LSLSS Watershed (Date of photography: September 20, 2016).

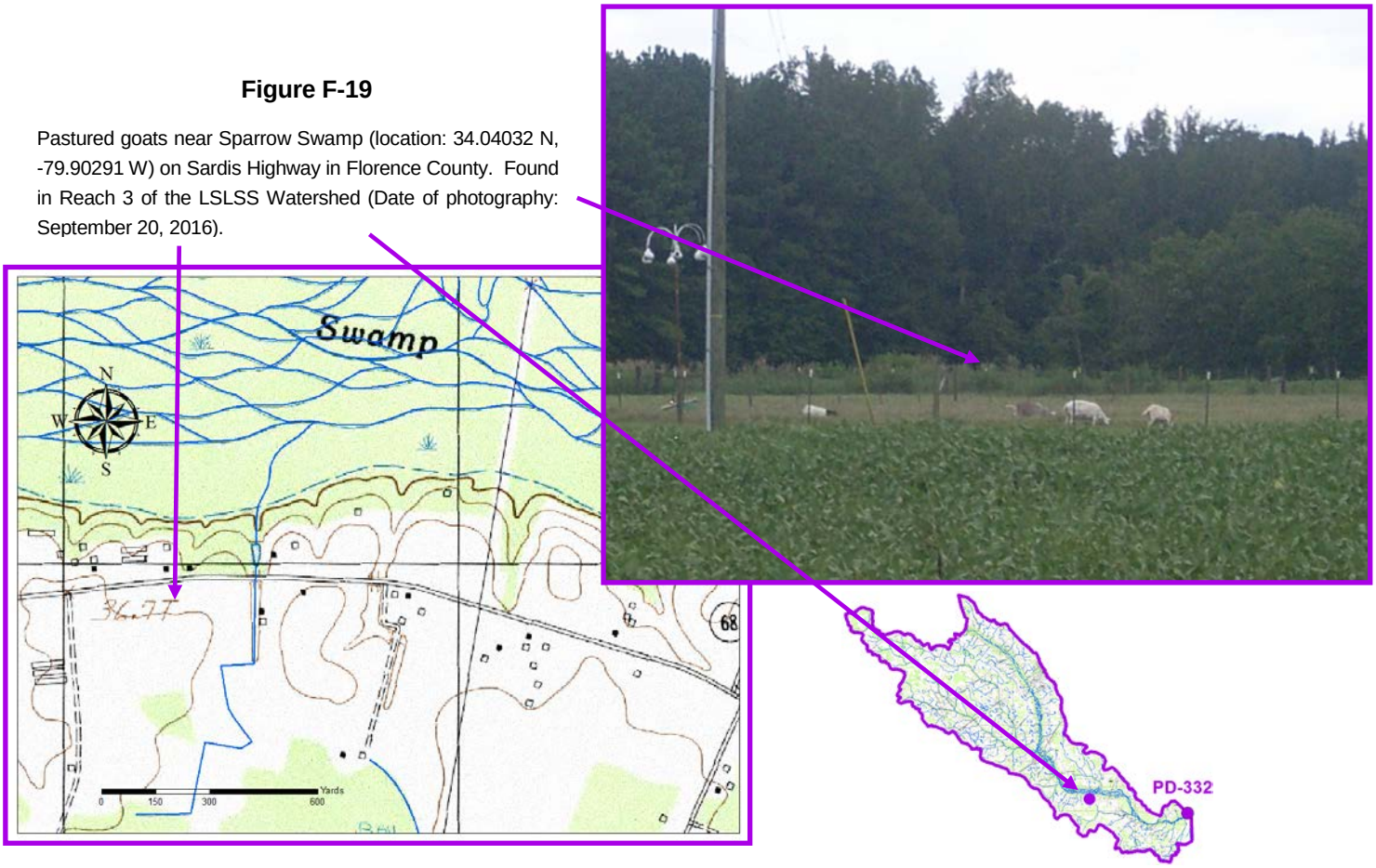


Figure F-20

Donkey in pasture with goats near Horse Branch (location: 34.08365 N, -79.89049 W) on Yarborough Lane in Florence County. Found in Reach 2 of the LSLSS Watershed (Date of photography: June 28, 2016).

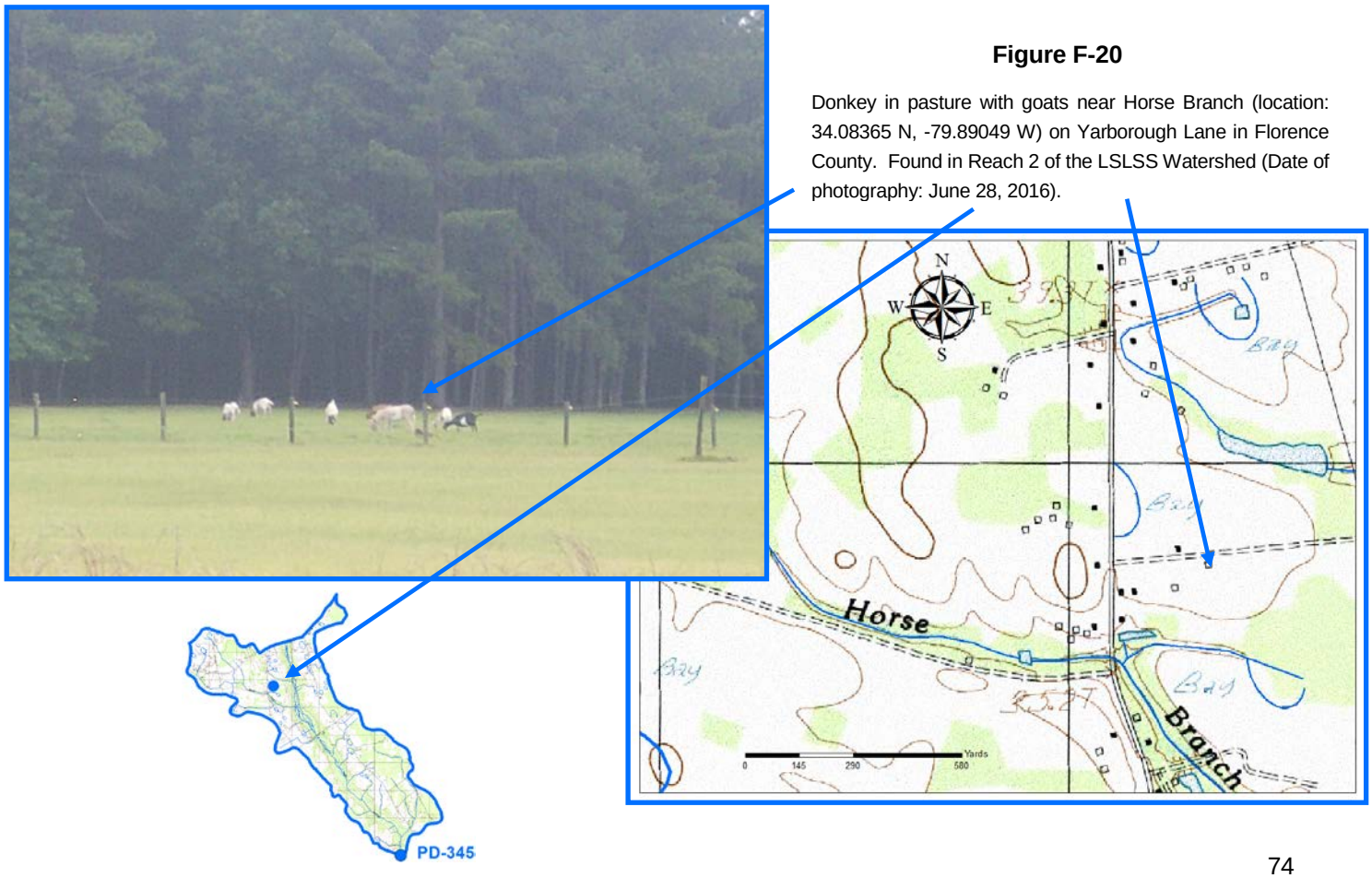


Figure F-21

Pastured donkeys near Magnolia Branch (location: 34.02587 N, -79.88264 W) on West Ralph Lane Road in Florence County. Found in Reach 3 of the LSLSS Watershed (Date of photography: September 20, 2016).

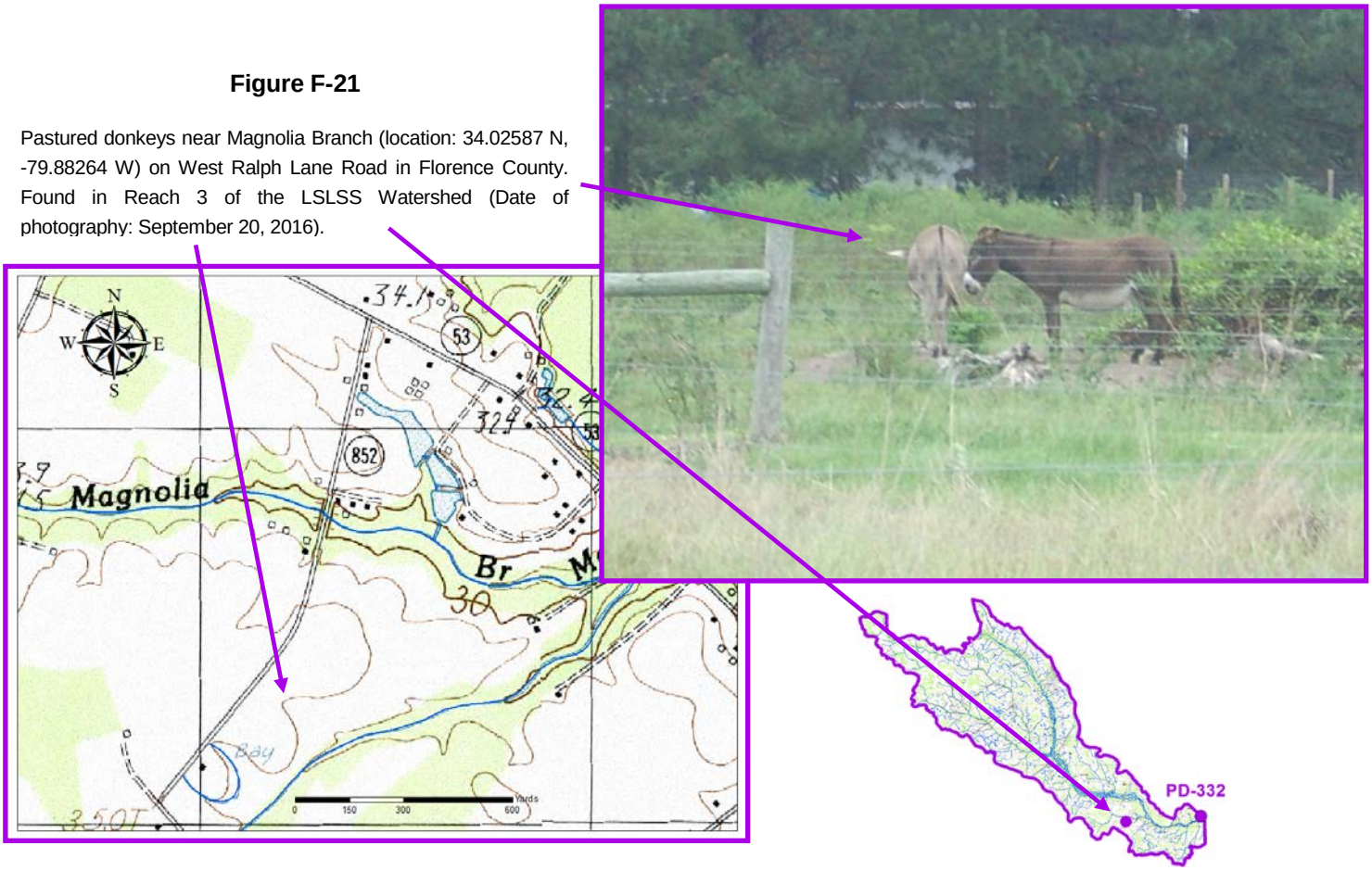


Figure F-22

Fighting roosters in huts near Lake Swamp (location: 34.27144 N, -80.04826 W) on Mayford Road in Darlington County. Found in Reach 1 of the LSLSS Watershed (Date of photography: June 23, 2016).

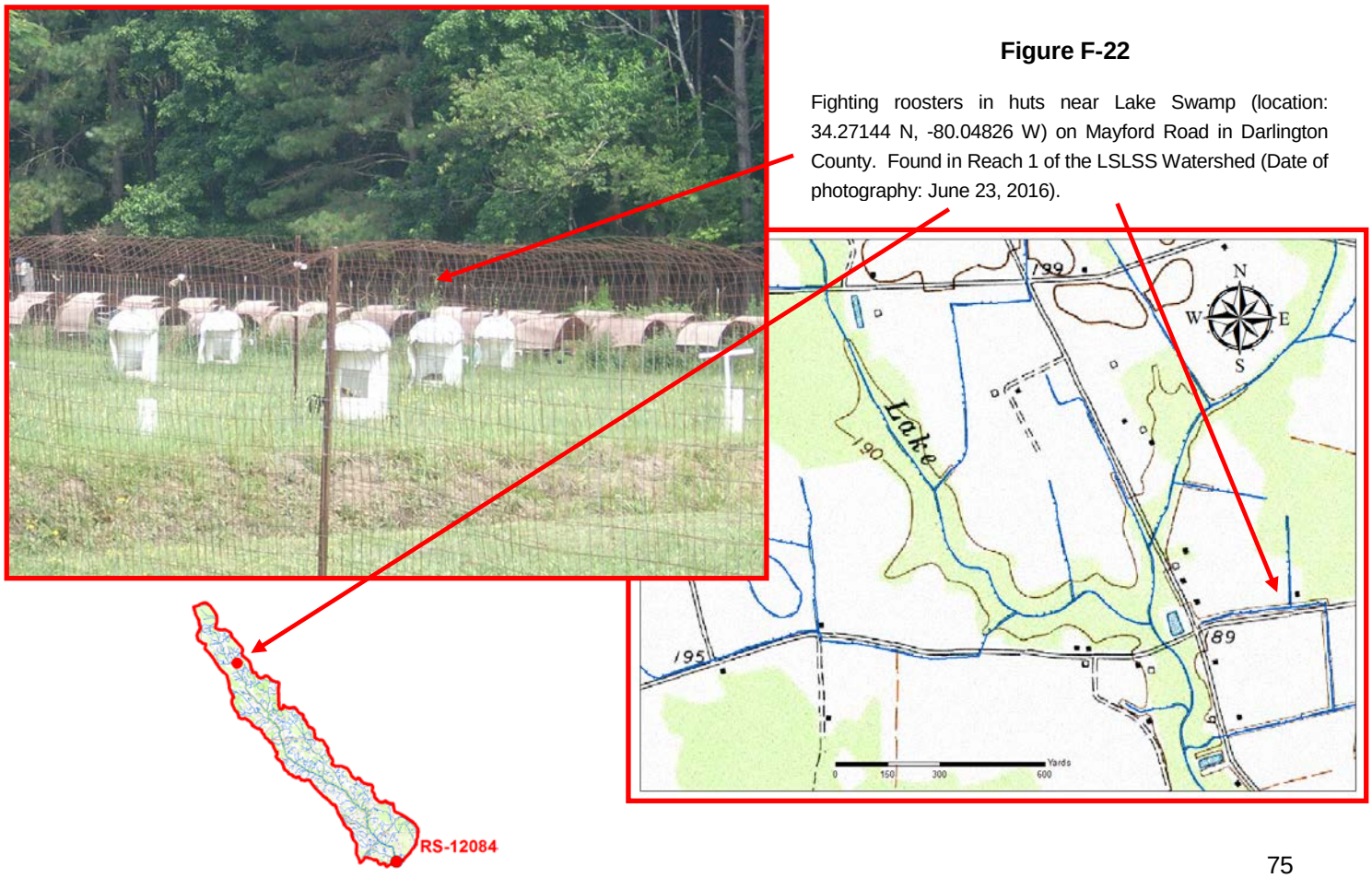
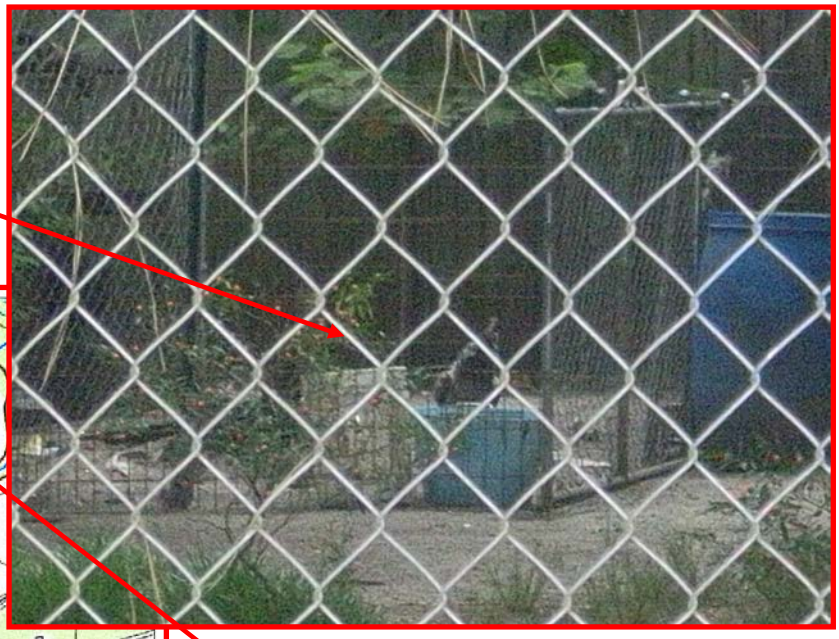


Figure F-23

Chickens in pen in the Town of Timmonsville (location: 34.13983 N, -79.93812 W) on East Clifford Street in Florence County. Found in Reach 1 of the LSLSS Watershed (Date of photography: June 28, 2016).



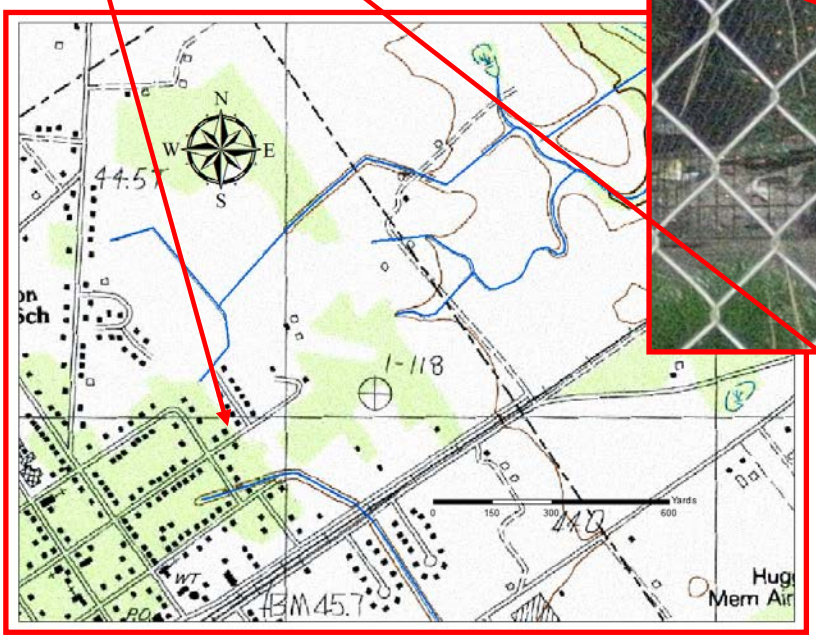
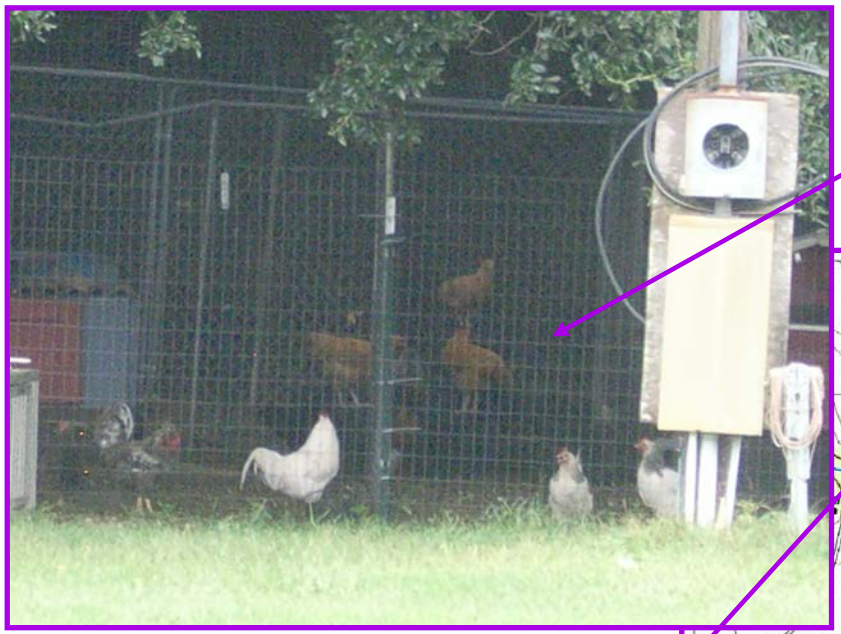


Figure F-24

Chickens in pen near Magnolia Branch (location: 34.02429 N, -79.86707 W) on Clyde McGee Road in Florence County. Found in Reach 3 of the LSLSS Watershed (Date of photography: September 20, 2016).



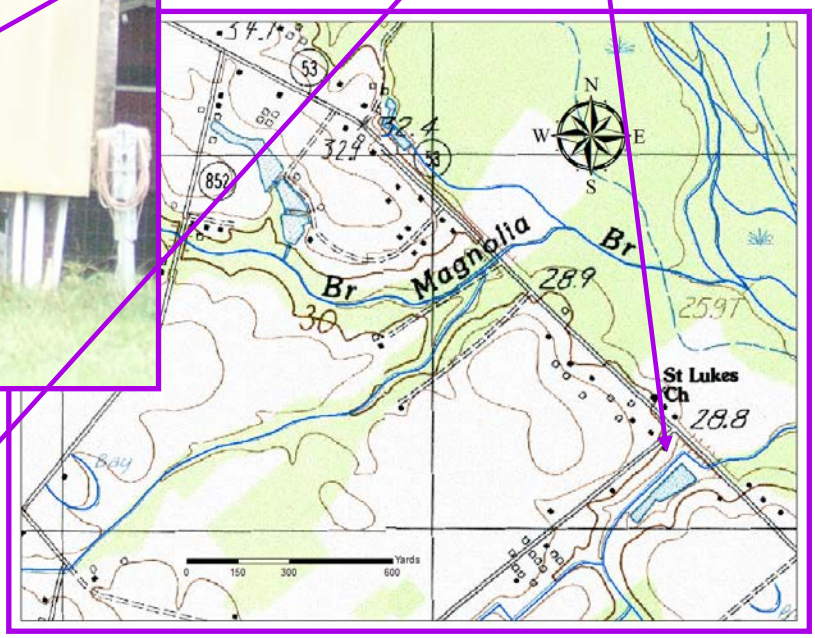


Figure F-25

Unattended dogs in yard near Lake Swamp (location: 34.21039 N, -79.99735 W) on Rustic Way Drive in Darlington County. Found in Reach 1 of the LSLSS Watershed (Date of photography: June 23, 2016).

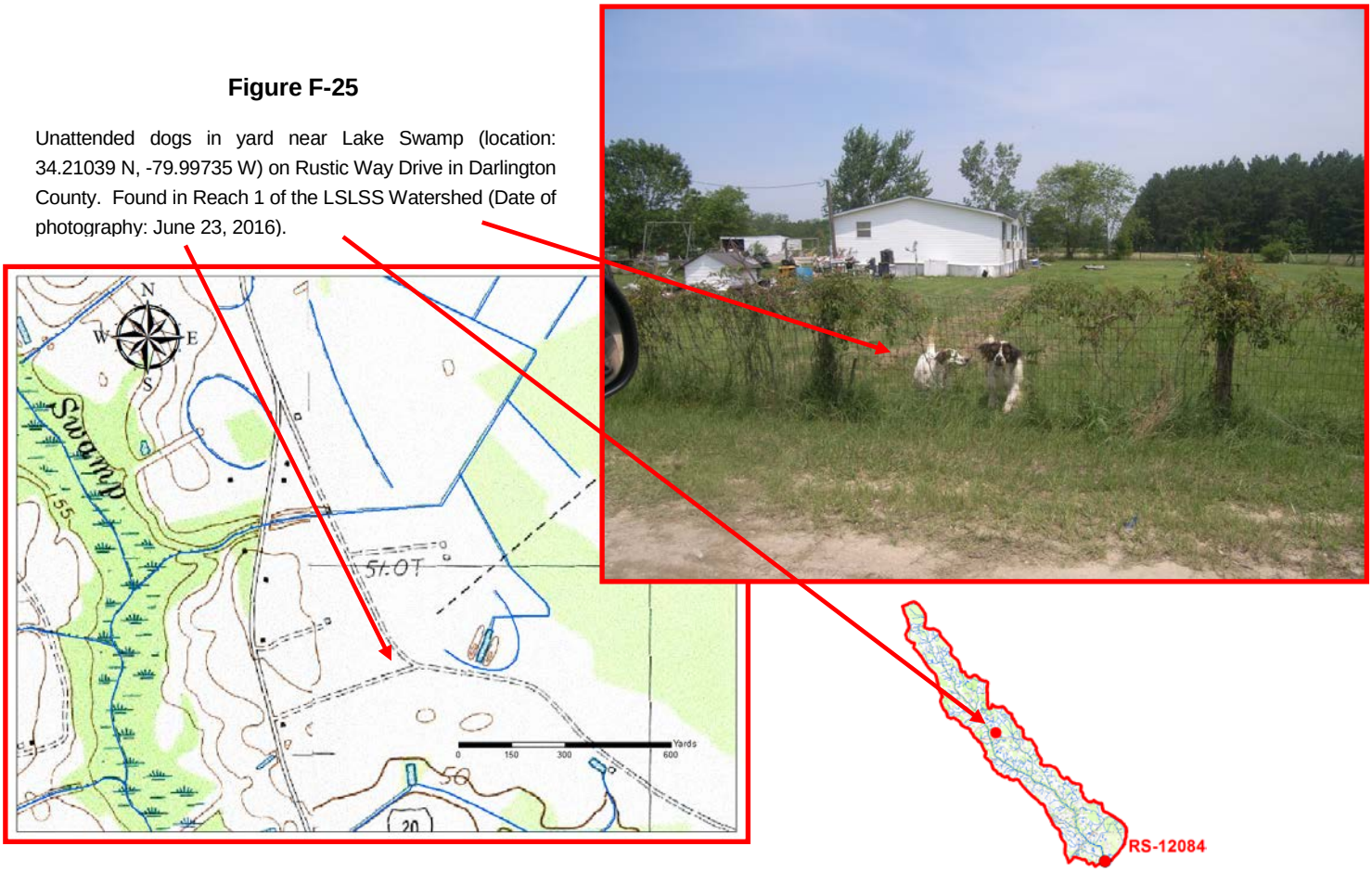


Figure F-26

Unattended dog in road near Lake Swamp (location: 34.05834 N, -79.85268 W) on Pearl Lane in Florence County. Found in Reach 2 of the LSLSS Watershed (Date of photography: July 12, 2016).

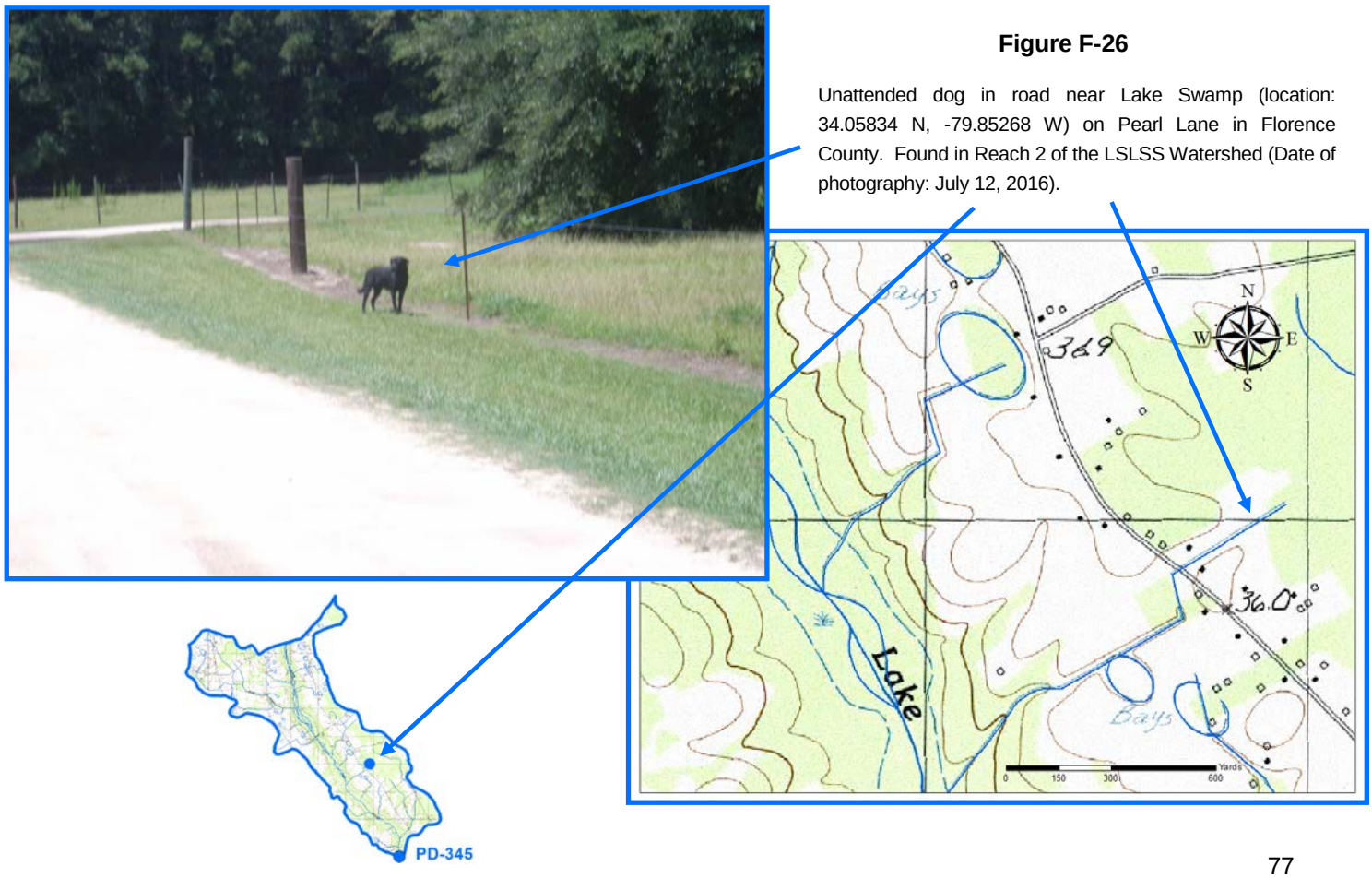


Figure F-27

Unattended dog in yard in Timmonsville (location: 34.13572 N, -79.94307 W) on North Warren Street in Florence County. Found in Reach 3 of the LSLSS Watershed (Date of photography: September 13, 2016).

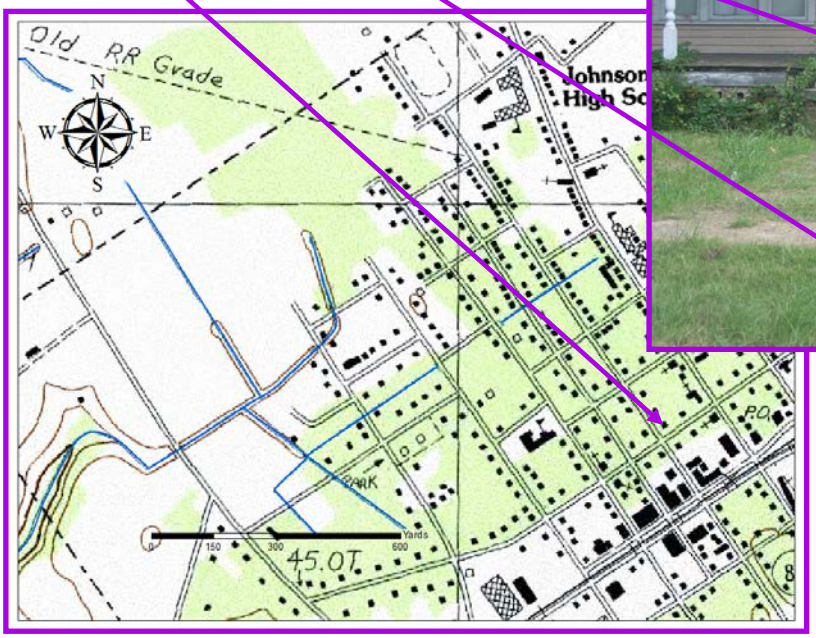


Figure F-28

Unattended dogs in road near Deep Hole Swamp (location: 34.13310 N, -80.03683 W) on Seven Bridges Road in Darlington County. Found in Reach 3 of the LSLSS Watershed (Date of photography: September 13, 2016).