FECAL COLIFORM TMDL AND LOAD REDUCTION MANAGEMENT PLAN
BIG SWAMP, SOUTH CAROLINA

SANTEE-WATEREE RESOURCE CONSERVATION AND DEVELOPMENT COUNCIL

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PROMOTE PROTECT PROSPER

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EXECUTIVE SUMMARY

This report represents a Load Reduction Management Plan supporting implementation of the fecal coliform bacteria total maximum daily load (TMDL) for the impaired sections of Big Swamp upstream of the Highway 378 and Route 51 Bridge, approximately 7.5 miles south of the Town of Pamplico in Florence County (Ambient Water Quality Monitoring Station PD-169). The project watershed area (approximately 56.24 square miles) is located entirely in Florence County, South Carolina. The Big Swamp main stem flows in a southern direction and discharges into the Lynches River, outside of the project watershed area.

FECAL COLIFORM BACTERIA IMPAIRMENT

Water quality data collected at the PD-169 ambient water quality monitoring station, the downstream-most point of the project watershed area on the Big Swamp main-stem, shows that fecal coliform bacteria concentrations have routinely exceeded the water quality criterion. The water quality criterion stipulate that no more than ten percent of samples collected contain fecal coliform concentrations of 400 colony forming units (cfu) per 100 mL. Due to the record of fecal coliform bacteria excursions, recreational uses are not supported. Therefore, the State of South Carolina has placed Big Swamp and its tributaries upstream of the US Hwy 378/SC Hwy 51 Bridge (Ambient Water Quality Monitoring Station PD-169) on the 303(d) impairment list. Under the Clean Water Act, a TMDL is required to identify the load allocations, wasteload allocations, and a margin of safety that will bring Big Swamp into compliance with the fecal coliform standard.

SOURCES OF FECAL COLIFORM BACTERIA

The Waste Water Treatment Plant (WWTP) for the Town of Pamplico is the only permitted discharge facility is located in the Big Swamp project watershed area. Records available in the USEPA Envirofacts database indicate the WWTP has been a significant source of fecal coliform; however the Town of Pamplico is in the process of upgrading the treatment system and transferring all discharge to the adjacent Pee Dee River. Therefore, this Load Reduction Management Plan has focused predominately on nonpoint sources of fecal coliform bacteria. The non-point sources contributing to the Big Swamp impairment include: wildlife, grazing livestock, and malfunctioning or “straight-pipe” septic systems.

AGRICULTURAL LAND USE CHARACTERIZATION

A Geographic Information System (GIS) Database was developed to characterize potential fecal coliform bacteria loading sources from agricultural land uses. A GIS datalayer of every United States Department of Agriculture Farm Service Agency (FSA) recognized farm field in the project watershed area was acquired from the United States Department of Agriculture (USDA). Additional attribute information was incorporated in the datalayer including the location of pastures, fox and dog pens, septic system failures, and other information pertinent to fecal coliform bacteria loading. Information was compiled for approximately 2,584 farm fields from interviews with local agricultural agency experts, field surveys, and reviews of aerial photographs. The database will be used during TMDL implementation planning to

identify and prioritize viable pasture and other types of farm field sites for agricultural BMP and conservation practice implementation.

WATER QUALITY ASSESSMENT

The load-duration curve methodology was used to calculate the existing and TMDL loads for Big Swamp at water quality monitoring station PD-169. This method develops TMDLs based on a frequency analysis of the historic hydrologic record and pollutant concentration data. Water quality data were obtained from the DHEC monitoring stations PD-169 (located at the US Hwy 378/SC Hwy 51 bridge over Big Swamp). Big Swamp at water quality monitoring station PD-169 is not gauged; however, the USGS does maintain a stream gauge (02135300) on Scape Ore Swamp approximately 48 miles northwest of station PD-169. Data from this gauge were used in a paired watershed approach to estimate stream-flow at station PD-169. Fecal coliform loads contributed by various non-point sources were estimated by using a mass balance approach, and load reduction estimates were determined using a combination of the results obtained from the mass balance approach and the calculated loads from the load duration curve method.

LOAD REDUCTION ALLOCATION SCENARIO

The existing load for the Big Swamp at the impaired ambient water quality monitoring station (PD-169) was estimated to be 3.39 x 1011 counts/day. The planned transfer of Pamplico WWTP discharge from Big Swamp to the Pee Dee River required the development of two appropriate TMDLs. The first TMDL (scenario a) covers interim discharge from the Pamplico WWTP during construction of the new plant and infrastructure upgrades. The scenario ‘a’ TMDL was determined to be 2.06 x 1011counts/day; consisting of a waste load allocation of 3.03 x 109 counts/day, load allocation of 1.93 x 1011 counts/day and margin of safety of 9.67 x 109 counts/day. The second TMDL (scenario b), covers the period after transfer of the Pamplico WWTP discharge to the Pee Dee River. The scenario ‘b’ TMDL was determined to be 2.03 x 1011counts/day; consisting of zero waste load allocation, a load allocation of 1.93 x 1011 counts/day and margin of safety of 9.67 x 109 counts/day. To achieve compliance with water quality standards, it is recommended that fecal coliform bacteria loads be reduced by approximately 67.6% from livestock sources, 84.2% from the WWTP during the interim discharge period, and 100% from failing septic systems. Eventual implementation of the scenario ‘b’ TMDL and associated load reduction allocation scenarios would result in an overall reduction of fecal coliform bacteria loading of 43.0% percent at PD-169.

STAKEHOLDER PARTICIPATION

Stakeholder recruitment and participation from a number of working group partners was prioritized throughout the development of this Load Reduction Management Plan. The final working group of stakeholders and community participants included:

- The Santee-Wateree Resource Conservation and Development (RC&D) Council
- The Florence Soil and Water Conservation District
- The Florence Natural Resources Conservation Service (NRCS) field office
- The South Carolina Department of Natural Resources

- The Florence Farm Service Agency (FSA) field office
- Consulting firms

A stakeholder kick-off meeting was held on August 16, 2005, in the Florence County, South Carolina USDA Office Building, to detail the steps required to achieve a comprehensive Load Reduction Management and TMDL Plan. Field surveys of the watershed and interviews with local agricultural BMP and conservation practice experts were conducted during August 2005. A final presentation of the Load Reduction Management Plan and land use characterization approach and results will be presented in early 2006 to the South Carolina Department of Health and Environmental Control (SCDHEC), an assortment of local agricultural agency personnel, local growers from the project watershed area including Soil and Water Conservation District Commissioners and Farm Bureau representatives.

RECOMMENDATIONS FOR TMDL IMPLEMENTATION

This Load Reduction Management Plan supporting fecal coliform bacteria TMDL development for Big Swamp provides the framework and management tools for making informed decisions about the strategic selection, placement, and implementation of effective BMPs in the project watershed area. The long-term goal of the Load Reduction Management Plan is to develop a TMDL that can be met through BMP implementation. To achieve this goal, three watershed planning components have been developed. Consultation with watershed stakeholders, including NRCS District Conservationists, has resulted in the development of a load reduction allocation scenario that can be both reasonably implemented and addresses the main sources of fecal coliform bacteria loading. In addition, a GIS database has been provided to watershed management decision makers that will assist to identify potential sources of fecal coliform bacteria loading, and target ideal farm field sites for BMP implementation. Finally, a group of agency and farming organizations in South Carolina have been recruited to provide advocacy assistance during the implementation planning phase of the project.

These three watershed planning components provide a starting point for developing effective implementation strategies. Results from load-duration curves and monitoring assessments show, for the most part, that periods of low flow (summer months) are the most critical for water quality. The results point out primary needs to reduce runoff of fecal coliform bacteria to the stream from livestock fields and ameliorate the NPDES permit exceedances at the Pamplico WWTP. Secondary needs include the complete elimination of failing and “straight pipe” residential septic systems. To meet these needs, implementation funding must be acquired from a variety of sources. The Pamplico WWTP currently has design plans and financial means to upgrade facilities and transfer discharge to the Pee Dee River. The remaining needs will be addressed through periodic and sporadic acquisition of public funds. In these cases, a phased implementation planning approach is recommended where an iterative process for implementation is adhered to. Sets of farm fields would be targeted and prioritized for implementation as funds are obtained. A continued review of sampling results acquired at the ambient water quality monitoring stations PD-168 and PD-169 would occur following the implementation of prioritized farm field sets to measure (i.) the effectiveness of these implementation strategies, (ii.) the need for amending these strategies, and/or (iii.) progress toward the eventual removal of the impairment from the 303(d) list.

SECTION 1.0

INTRODUCTION

1.1 BACKGROUND

Section 303(d) of the Clean Water Act and EPA's Water Quality Planning and Management Regulations (40 CFR Part 130) requires states to develop total maximum daily loads (TMDLs) for water bodies that are not meeting designated uses under technology-based pollution controls. The TMDL process establishes the allowable loadings 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).

The South Carolina Department of Health and Environmental Control (DHEC) has identified the Big Swamp watershed (03040202-130) upstream of ambient water quality monitoring station PD-169 (located at the US-378/SC-51 Bridge one mile west of the Town of Salem) as being impacted by fecal coliform bacteria. Accordingly the station has been reported on the State of South Carolina 2004 303(d) list. An additional ambient water quality monitoring, PD-168, located on the mainstem of Big Swamp immediately upstream from the Town of Pamplico, has not been reported as showing a fecal coliform bacteria impairment.

Fecal coliform bacteria may be elevated in surface water as the result of both point and nonpoint sources of pollution. It is assumed that water bodies possessing high concentrations of fecal coliform bacteria my also be contaminated by pathogens, or disease producing bacteria or viruses, which may exist in fecal material. Some waterborne diseases associated with fecal material include typhoid fever, viral and bacterial gastroenteritis, and hepatitis A. The presence of fecal contamination is, therefore, an indicator that a potential health risk exists for individuals exposed to this water. The objective of this study is to develop a Load Reduction Management Plan in support of TMDL implementation efforts that will result in a reduction of fecal coliform bacteria concentrations to levels that do not present a health risk and that are below the state water quality standard.

1.2 WATERSHED DESCRIPTION

The Big Swamp project watershed area is a swamp stream system that extends from north of the Town of Pamplico, SC to the ambient water quality station PD-169 at US 378/SC 51 in Florence County, SC. The Big Swamp system contains 51.8 mile of stream and eventually discharges into Lynches River outside the project area. The project watershed covers approximately 56.24 square miles in the Lower Coastal Plain region, with slopes ranging from zero to six percent. Major tributaries to the impaired Big Swamp in the project area include Gum Branch, Buck Branch, Cypress Branch, and Little Swamp.

According to the National Pollutant Discharge Elimination System (NPDES) a permitted municipal effluent point source (Town of Pamplico Waste Water Treatment Plant- SC0021351) is located on the Big

Swamp main stem, 7.5 miles upstream from station PD-169. It is estimated that approximately 932 septic systems are currently in use in the project area. The lagoon system Pamplico Waste Water Treatment Plant (WWTP) is a documented point source of fecal coliform loading and failing septic systems are considered non-point sources of fecal coliform bacteria loading.

Agriculture is considered the largest contributor of fecal coliform bacteria to surface waters. Figure 1-1 delineates the location of approximately 2,584 farm fields in the 56.24 square mile Big Swamp project watershed area. According to the Natural Resource Conservation Service (NRCS) District Conservationist for Florence County (Lynette Savereno July 25, 2005), the types of agricultural practices that exist within the project watershed include soybean, tobacco, and corn row crop farms. Soybeans were the major cropland product and limited participation in the tobacco buyout program will perpetuate tobacco cultivation for the foreseeable future. Additionally, many producers do not plant cover crops on barren fields after harvest. This practice could create soil erosion and water quality problems. Excessive runoff from these unprotected fields can be contaminated with silt, chemicals, fecal coliform, and other harmful bacteria.

The MSD Associates field survey conducted in August 2005 documented data estimated 50 cattle, 186 horses, and 38 goats on pasture land. Pastures with stream access were observed in some areas and livestock watering in streams remains a concern.

Two SCDHEC ambient water quality monitoring stations are found in the Big Swamp project watershed area (Figure 2-1). The station listed for fecal coliform bacteria impairment (PD-169) is located at the downstream-most point of the project watershed area on the US 378/SC 51 Bridge. The second ambient water quality monitoring station (PD-168) is located upstream 1 mile northwest of Pamplico and is not currently listed for coliform impairment.

As described in the Pee Dee River Basinwide Plan (2000), the Big Swamp project watershed area is located in the Lower Coastal Plains regions of South Carolina. The predominant soil types consist of an association of the Rains-Norfolk-Lynchburg-Wagram series. The erodability of the soil (k) averages 0.15; and the slope of the terrain averages 2 % with a range of 0-6 %. The predominant Big Swamp project watershed land uses from the National Land Cover Dataset are cropland (27.5%) pasture (3.7%) and forest (62%). The remaining land use in the watershed is water or developed/transitional land (6.74%) (See Table 1-1 and Figure 1-2).

INTRODUCTION

TABLE 1-1
Land Use Classification (NLCD) in the Big Swamp Watershed above Water Quality Monitoring Station PD-169

LULC broad class	LULC Specific Use	Upper Mainstem Sub-watershed (acres)	Lower Mainstem Sub-watershed (acres)	Little Swamp Sub-watershed (acres)	Cypress Branch Sub-watershed (acres)	Buck Branch Sub-watershed (acres)	Big Swamp Branch Sub-watershed (acres)	**Total Big Swamp Watershed Area Above PD-169 (acres)**	**% of Total Watershed Area Above PD-169**
Vegetated; Natural Forested Upland	Deciduous Forest	528.9	429.6	449.1	457.7	367.4	634.5	2,873	7.97%
Vegetated; Natural Forested Upland	Evergreen Forest	1340.3	1888.7	1508.4	2924.5	1230.6	1717.5	10,630	29.48%
Vegetated; Natural Forested Upland	Mixed Forest	546.0	391.3	367.5	412.3	458.4	709.5	2,891	8.02%
Wetlands	Woody Wetlands	1477.5	1338.5	946.2	831.5	458.1	896.9	5,960	16.53%
Wetlands	Emergent Herbaceous Wetlands	0.4	2.0	3.3	0.6	0.4	1.6	8	0.02%
	Subtotal	***3,893***	***4,050***	***3,275***	***4,627***	***2,515***	***3,960***	***22,361***	***62.01%***
Barren	Bare Rock/Sand/Clay	8.6	6.7	5.3	2.1	7.7	6.8	37	0.10%
Water	Open Water	9.1	11.4	7.6	9.4	7.0	25.8	70	0.20%
Barren	Transitional	37.6	315.5	287.7	630.8	89.7	418.4	1,783	4.94%
Developed	Low Intensity Residential	266.3	---	14.2	---	1.2	8.5	291	0.81%
Developed	High Intensity Residential	20.8	---	1.1	---	---	---	22	0.06%
Developed	Commercial / Industrial / Transportation	168.3	---	10.4	0.6	0.6	9.8	190	0.53%
Herbaceous Planted/Cultivated	Urban/Recreational Grasses	31.1	---	2.7	---	---	2.3	36	0.10%
	Subtotal	***542***	***334***	***329***	***643***	***106***	***472***	***2,430***	***6.74%***
Herbaceous Planted/Cultivated	Row Crops	1902.7	1737.3	1806.7	1342.5	1324.1	1795.3	***9,927***	***27.53%***
Herbaceous Planted/Cultivated	Pasture/Hay	312.2	246.2	152.1	146.8	141.7	339.8	***1,341***	***3.72%***
	Totals	**6,650**	**6,367**	**5,562**	**6,759**	**4,087**	**6,567**	**36,060**	**100.00%**

INTRODUCTION

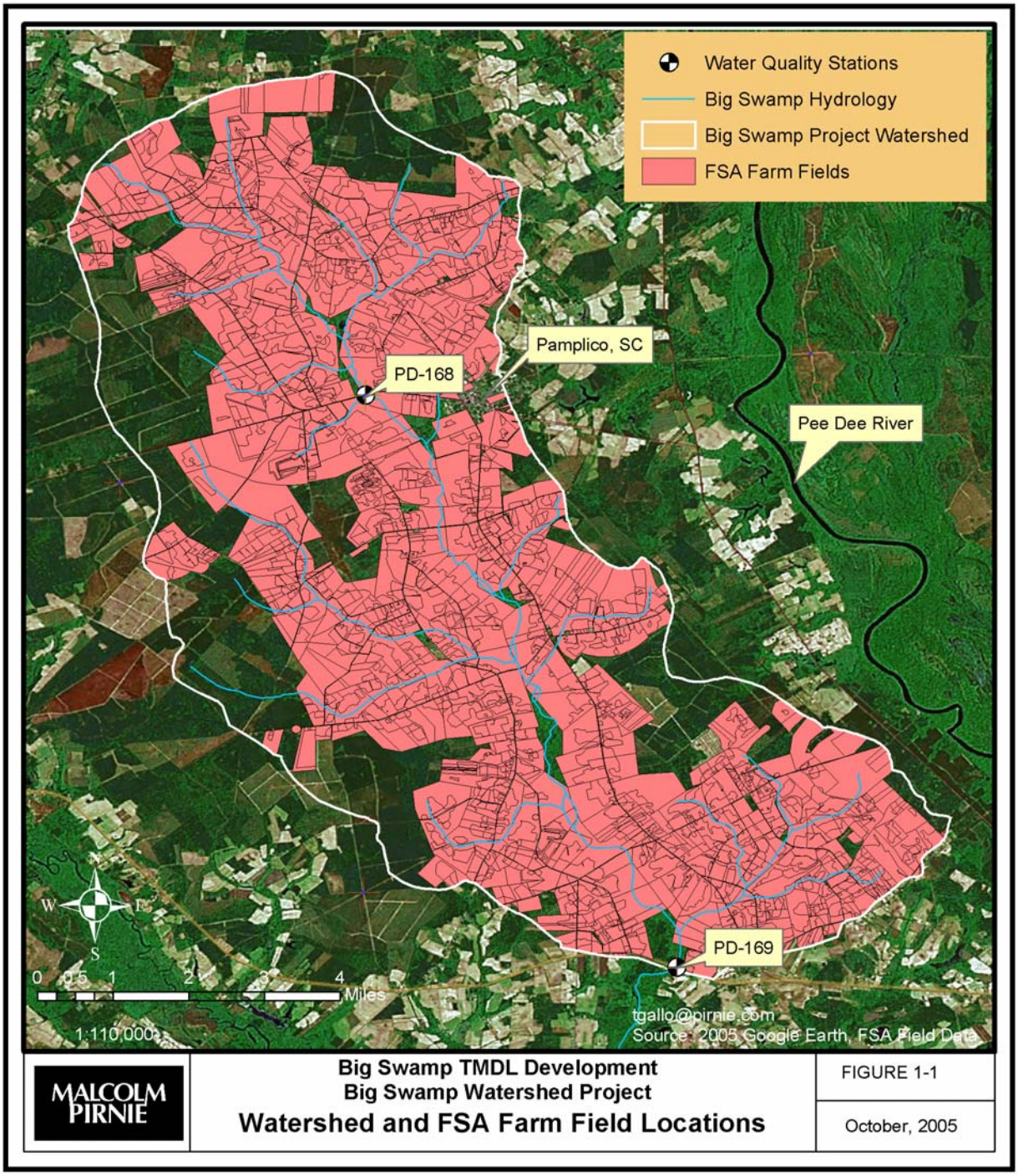
1.3 WATER QUALITY STANDARD

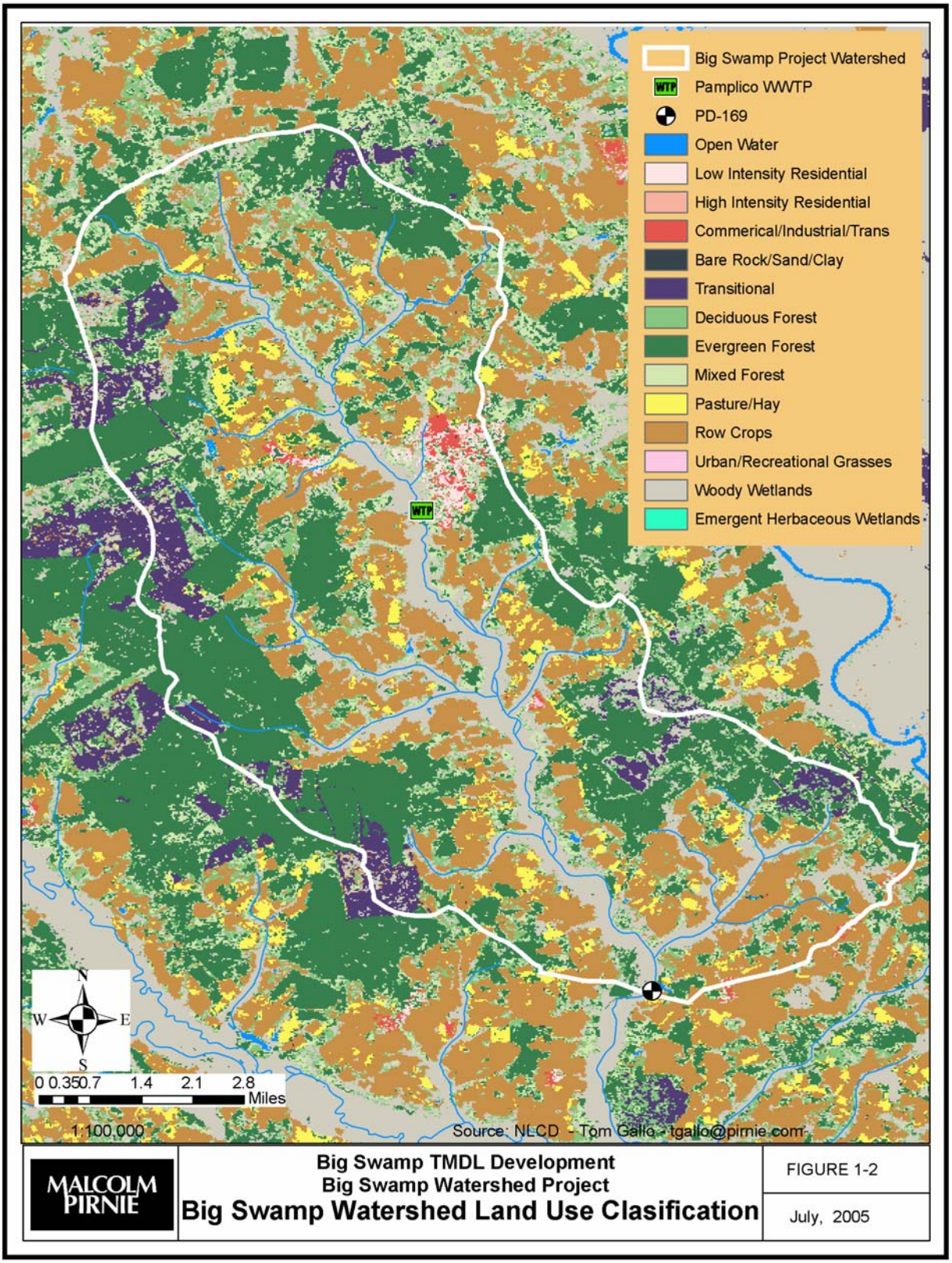
The impaired stream, Big Swamp above PD-169, is designated as Class Freshwater. Waters of this class are described as follows:

> *Freshwaters suitable for primary and secondary contact recreation and as a source for drinking water supply after convenient treatment in accordance with the requirements of the Department. Suitable for fishing and the survival and propagation of a balanced indigenous aquatic community of fauna and flora. Suitable also for industrial and agricultural uses. (R.61-68).*

The South Carolina standard for fecal coliform bacteria in Freshwater is:

> *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 percent of the total samples during any 30-day period exceed 400/100 ml. (R.61-68).*


Water Quality Stations
Big Swamp Hydrology
Big Swamp Project Watershed
FSA Farm Fields
Pamplico, SC
PD-168
Pee Dee River
PD-169
W
E
S
0 0.5 1 2 3 4
Miles
1:110,000
tgallo@pirnie.com
Source: 2005 Google Earth, FSA Field Data
MALCOLM PIRNIE
Big Swamp TMDL Development
Big Swamp Watershed Project
Watershed and FSA Farm Field Locations
FIGURE 1-1
October, 2005

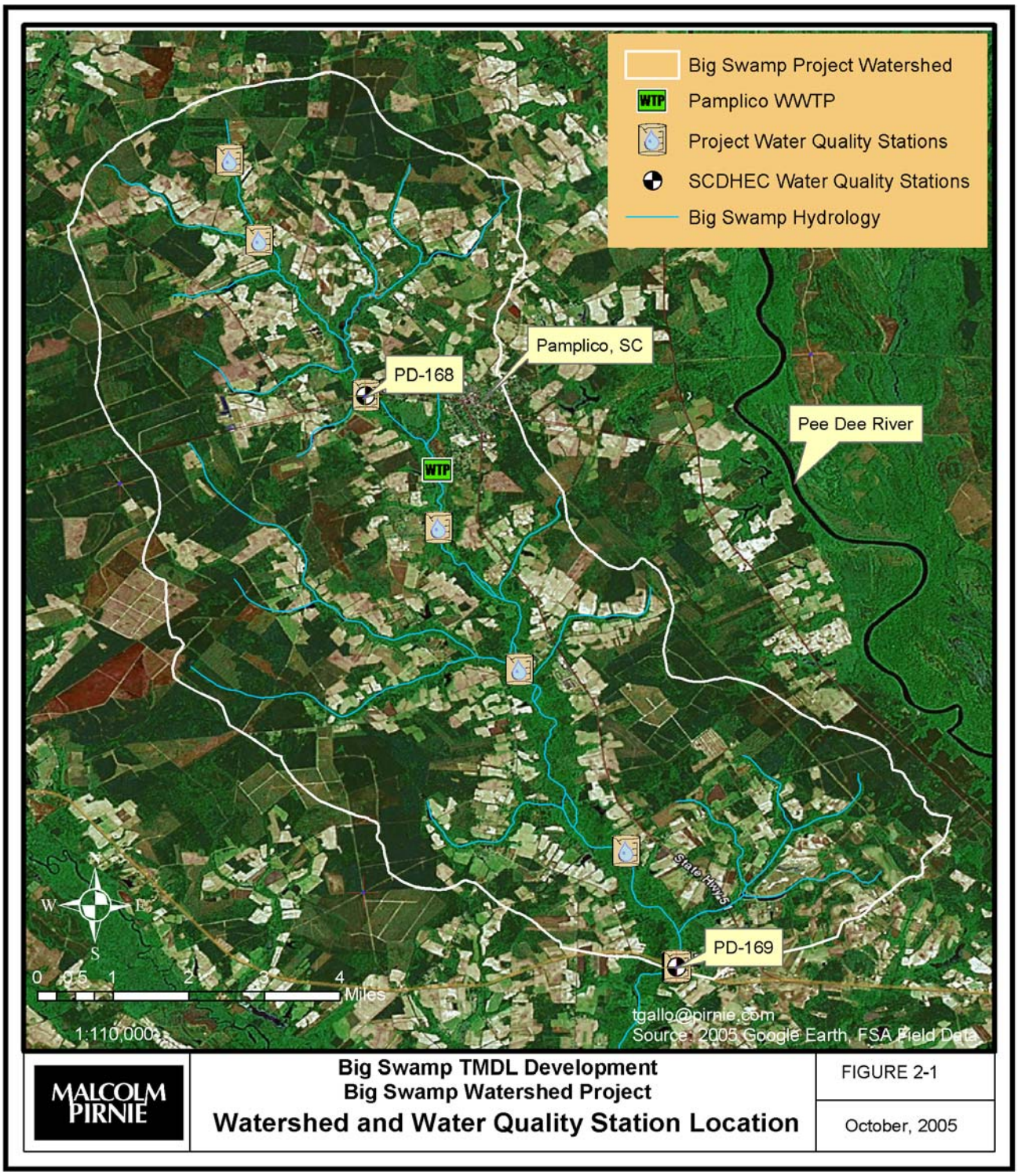

Big Swamp Project Watershed
Pamplico WWTP
PD-169
Open Water
Low Intensity Residential
High Intensity Residential
Commerical/Industrial/Trans
Bare Rock/Sand/Clay
Transitional
Deciduous Forest
Evergreen Forest
Mixed Forest
Pasture/Hay
Row Crops
Urban/Recreational Grasses
Woody Wetlands
Emergent Herbaceous Wetlands
WTP
N
W
E
S
0 0.35 0.7 1.4 2.1 2.8
Miles
1:100,000
Source: NLCD - Tom Gallo - tgallo@pirnie.com
MALCOLM PIRNIE
Big Swamp TMDL Development
Big Swamp Watershed Project
Big Swamp Watershed Land Use Clasification
FIGURE 1-2
July, 2005

SECTION 2.0

WATER QUALITY ASSESSMENT

The seasonal and hydrologic variability of fecal coliform data collected from 1990-2003 at ambient water quality monitoring station PD-169 were examined to provide insights into the contributing factors of high fecal coliform loading to the stream prior to conducting a detailed source assessment and TMDL analysis. For example, high concentrations during low flow conditions would be consistent with in-stream sources, whereas high concentrations only during storm events would indicate land-based sources.

Fecal coliform data were collected during every month of the year (January-December) by DHEC at ambient monitoring station PD-169, and results from this station were the primary basis for the 303(d) listing of the stream for bacteria impairment. Big Swamp fecal coliform data from DHEC monitoring station PD-169 are provided in Appendix A. Figures 1-2 and 2-1 show the location of monitoring station PD-169.


Big Swamp Project Watershed
Pamplico WWTP
Project Water Quality Stations
SCDHEC Water Quality Stations
Big Swamp Hydrology
Pamplico, SC
PD-168
Pee Dee River
WTP
PD-169
State Hwy 51
W
E
S
0 0.5 1 2 3 4 Miles
1:110,000
tgallo@pirnie.com
Source: 2005 Google Earth, FSA Field Data
MALCOLM PIRNIE
Big Swamp TMDL Development
Big Swamp Watershed Project
Watershed and Water Quality Station Location
FIGURE 2-1
October, 2005

2.2 SEASONAL VARIABILITY

As shown in Figure 2-2, the mean fecal coliform bacteria concentrations were highest in May and July. However, the monthly mean fecal coliform bacteria concentrations did not exceed the water quality criteria for fecal coliform bacteria (400 count/100 mL) during any month of the year. Generally, warmer months of the year (May-October) had higher mean fecal coliform bacteria concentrations than colder temperature months (November, December, and January). However, the high mean fecal coliform bacteria concentration was also observed during February in one of the two available observations.

The general seasonal pattern is due to several factors, including: (1) higher fecal coliform bacteria die-off rates occurring in colder temperatures leading to lower concentrations in the water column during colder periods of the year; and (2) chronic summer NPDES coliform permit exceedances at the Pamplico WWTP.

2.3 HYDROLOGIC VARIABILITY

To assess the hydrologic variability of fecal coliform bacteria concentrations, stream flow data were estimated from measured flow data at the USGS gauging station 02135300 located on the Scape Ore Swamp drainage in adjacent Lee County. The watersheds above PD-169 and USGS gauging station 02135300 share similar land use, topology, and single NPDES dischargers with flow limits less than 0.7 million gallons per day. Streamflow at station PD-169 was estimated by multiplying flow data from the USGS gauge station (USGS 02135300) by the ratio of the drainage area above PD-169 to the drainage area above the USGS gauge station.

The plot of fecal coliform concentration vs. flow demonstrates that higher fecal coliform bacteria concentrations tend to occur during low flow conditions (Figure 2-3). However, the water quality criterion was also exceeded under moderate flow conditions. This indicates that dry-weather sources of fecal coliform bacteria are predominant, but wet-weather sources of fecal coliform bacteria also contribute to standard exceedances. Thus, under dry weather conditions, sources such as livestock in streams, failing septic systems and direct wildlife deposition may provide fecal coliform bacteria loads to the stream. Under wet weather conditions, run-off related sources, such as livestock manure deposited on pastureland, WWTP capacity exceedance, and in-direct wildlife deposition may be more important.

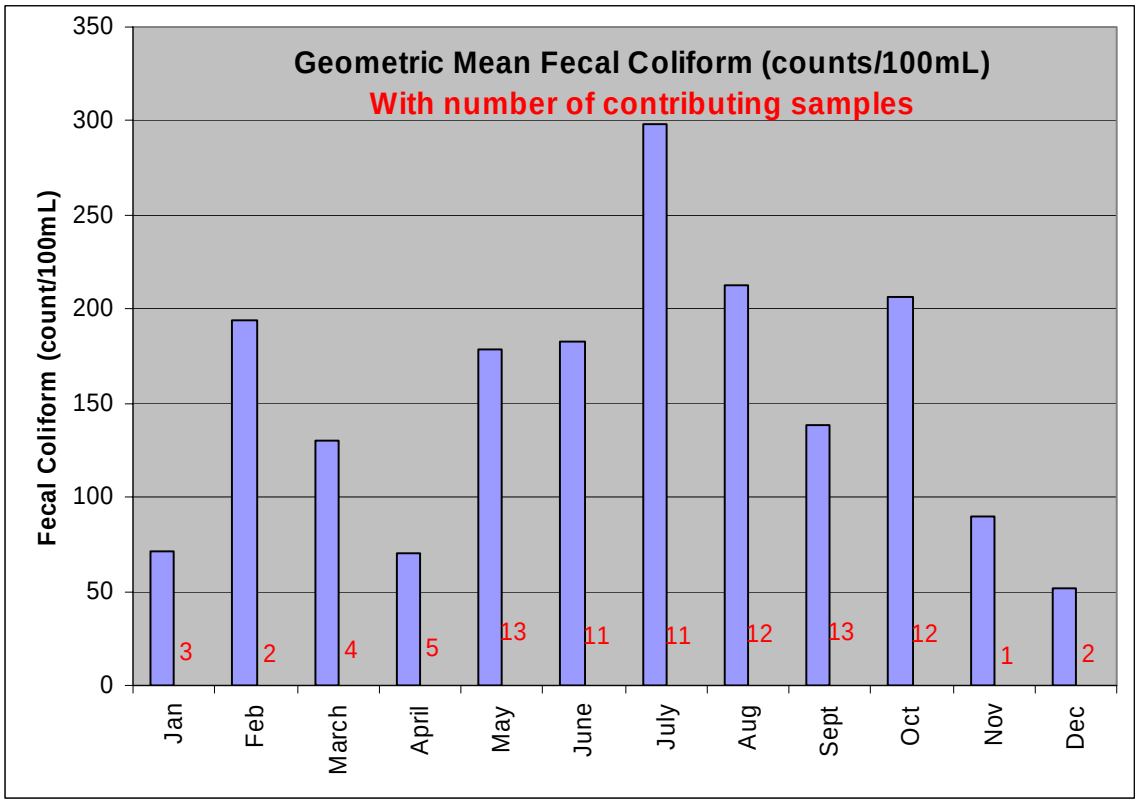


Figure 2-2: Mean fecal coliform concentration vs. month in Big Swamp at DHEC water quality monitoring station PD-169. Mean values were calculated using 1990-2003 data from DHEC water quality monitoring station PD-169.

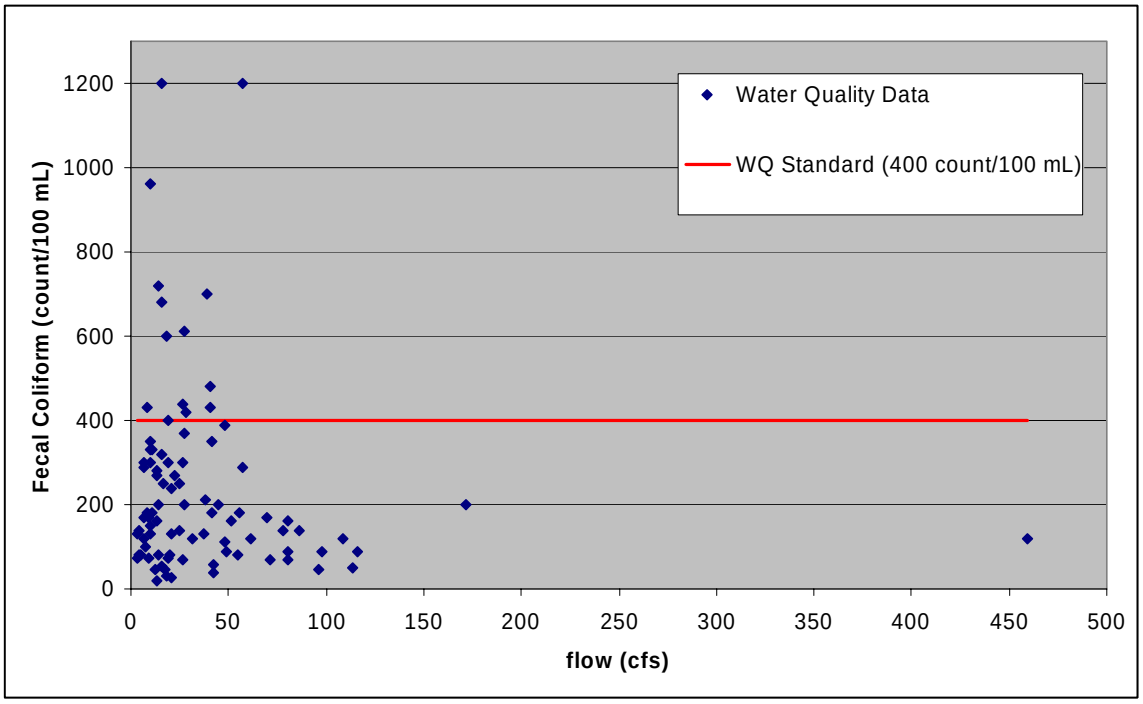


Figure 2-3: Fecal coliform concentration vs. estimated stream flow in Big Swamp at DHEC water quality monitoring station PD-169, 1990-2003.

SOURCE ASSESSMENT

Figure 1-2 and Table 1-1 show the distribution of land use categories in the Big Swamp project area, obtained from the Multi-Resolution Land Characteristics Consortium's (MRLC) National Land Cover Dataset 1992 (NLCD).

The source assessment phase of this study involved the identification and quantification of fecal coliform bacteria loads as applied to the land surface in the Big Swamp project area, or directly to the stream. The Bacterial Indicator Tool (BIT) developed by USEPA as part of its BASINS family of software was used to quantify the fecal coliform bacteria loading rates from various non-point sources (USEPA, 2000a). The BIT is a spreadsheet that calculates loading factors for various animal sources including wildlife and unconfined livestock. The spreadsheet requires the user to define the number of animals present in the watershed, as well as area in acres for the forest, pastureland, cropland and built-up land components of the watershed. Estimated loading rates were used in a mass balance calculation (as described in section 4) to determine amounts of fecal coliform contributed to the stream by various sources.

The accuracy and precision of estimated loading rates are reduced by many sources of uncertainty and environmental variability. However, both local knowledge and a large body of previous studies and tools provide a basis for assessing the potential order-of-magnitude of various bacterial sources.

3.1 POINT SOURCES

There is one permitted discharge facility in the project watershed (Town of Pamplico WWTP – SC0021351) that discharges municipal effluent in to Big Swamp. This NPDES discharge facility is situated 7.5 miles upstream from the ambient water quality monitoring station PD-169 at the town of Pamplico. The current lagoon and chlorination system has a permitted discharge rate of 200,000 gallons/day (Pee Dee River Basinwide Plan 2000, Gary Stowe, S.C. Environmental Quality Control personal comm. 27-July-2005). The discharging facility has permit limits for 9 parameters, including a Fecal Coliform limit for a daily maximum of 400cfu/100ml and a thirty day geometric mean maximum of 200cfu/100ml. During the period January 2003 to April 2005 the Pamplico WWTP violated the NPDES fecal coliform permit limit during 15 of the 28 monthly evaluations and violated the flow permit limit during 23 of the 28 monthly evaluations. Reported DMR violations and operational/maintenance issues are handled through the SCDHEC compliance and enforcement mechanisms.

However, the Pamplico WWTP has been granted an NPDES permit for new construction that will transfer discharge from Big Swamp to the adjacent Pee Dee River (Figure 2-1) (Gary Stowe personal comm. 27-July-2005). According to the office of South Carolina United States Senator Lindsey Graham, Pamplico received rural development funds in the form of a $2,277,300 grant and a $495,800 loan for the construction of the new waste water treatment facility and system upgrades. The design phase is complete and construction bids are being solicited for project completion during the summer of 2006 (Lamar Johnson, Pamplico WWTP operator, personal comm.. 1-Aug-2005). Therefore, wasteload source and reduction calculations will include the current coliform loading from this facility, potential reductions from NPDES permit compliance for discharge into Big Swamp, and potential reductions from complete transfer of discharge to the Pee Dee River.

3.2 NON-POINT SOURCES

Non-point sources of fecal coliform bacteria loading that were explicitly considered included wildlife, cattle, and failing septic systems/straight pipe discharges. There are currently no Active Feeding Operation (AFOs) or associated sprayfields located in the watershed. Estimates of the number of fecal coliform counts per animal per day were based on literature-derived values of the BIT and are summarized in Table 3-2. Other sources are expected to be relatively minor by comparison, and are implicitly included by inclusion in other sources. Specifically, the small number of sheep in the project watershed can be conceptually lumped into the cattle source and the numbers of foxes are lumped into the raccoon source.

TABLE 3-2
Fecal Coliform Unit Loading Rates

Source	Fecal Coliform Loading Rate	Units	BIT Reference
Deer	5.0×10^{8}	counts/animal/day	Best Professional Judgment
Raccoon	1.2×10^{8}	counts/animal/day	Best Professional Judgment
Cattle	1.0×10^{11}	counts/animal/day	ASAE, 1998
Goats/Sheep	1.2×10^{10}	counts/animal/day	ASAE 1998
Septage	1.0×10^{4}	counts/100 mL	Horsley and Witten, 1996
Residential	1.6×10^{7}	counts/acre/day	Horner, 1992

3.2.1 WILDLIFE

A value of 27 deer per square mile was assumed for forest, pasture and cropland, based on estimates provided for Florence County by the South Carolina Department of Natural Resources (personal comm., Charles Ruth, Deer Project Supervisor, SCDNR, 25-July-2005). A value of 128 raccoons per square mile was assumed for forested land, based on the upper end of the raccoon density range given in the South Carolina coastal plain according to the SCDNR Wildlife Management Guide for Raccoon (1997). Although the actual raccoon density might be as much as 10 times lower, the upper end of the range was used to implicitly account for other wildlife such as snakes, birds, rodents, plus hunting dogs and foxes contained in two large fox pens within the project watershed (personal comm.. Lynette Savereno, District Conservationist for Florence County 2-August-2005).

Due to the presence of riparian wetlands near Big Swamp and the tributaries of Big Swamp within the project watershed, in-stream contributions from wildlife sources can occur. In-stream contributions from wildlife sources were estimated by assuming very limited attenuation of forest deposition within 100 yards of stream channels. The estimation was calculated by determine the fraction of forest within a 100

yard buffer of all streams and subsequently applying an attenuation factor only to the remaining fraction of forest not within 100 yards of a stream channel.

3.2.2 CATTLE

Cattle density on pastureland within the Big Swamp project watershed was estimated by multiplying by a factor of 2 the number of cattle observed during the MSD Associates August 2005 watershed inspections. The factor increase was applied to account for cattle concealed on isolated private lands. This resulted in an estimate of 50 cattle in the Big Swamp project watershed. There are no dairy or feedlot operations in the project watershed (personal communication, Lynette Savereno, District Conservationist for Florence County, July 20, 2005), and so cattle were assumed to be evenly distributed on pastureland. Cattle manure is not collected or applied as fertilizer to cropland in any parts of the watershed (personal communication, Savereno, District Conservationist for Florence County, August 2, 2005).

There are places where cattle can directly access Big Swamp or its tributaries; however, uncertainties exist about the percentage of time cattle spend in streams. As a result, direct deposit of fecal coliform from in-stream cattle was not explicitly differentiated from deposition on land. Instead, run-off resulting from manure deposits on pastures was used to estimate for load from all livestock sources (grazing and in-stream).

3.2.3 POULTRY LITTER APPLICATION

Despite a prevalence of poultry litter application to agricultural fields in other areas of South Carolina, there are no current applications of poultry litter in the Big Swamp Project Watershed (personal comm. Lynette Savereno, District Conservationist for Florence County, August 2, 2005).

3.2.4 FAILING SEPTIC SYSTEMS

The majority of the population residing within the Big Swamp project watershed are served by septic systems. Analysis of year 2000 census Tiger file data determined that 25% of the project watershed population lived with in the Town of Pamplico WWTP service area. The remaining 75% (2,455 persons) are distributed amongst 932 households served by septic systems... The total number of septic systems in the Big Swamp project watershed was estimated as 1 per household, with each serving 2.63 persons.

Septic system failures are assessed by citizen complaint basis only in Florence County, and there are currently no complaints on record with the Environmental Health Office (David Edy, supervisor, Environ Health Office, personal comm. 28-July-05). However, field inspections by MSD associates and Roy Todd, Santee-Wateree RC&D Coordinator, recorded localized failure/straight pipe rates as high as 50% in the northern extent of the watershed. Given the extent of failures observed from public roads, Roy Todd estimated a 35% overall septic failure rate in the Big Swamp watershed. This failure rate was used in conjunction with the default BIT values for wastewater generated per person per day (70 gallons), and wastewater fecal coliform count (10,000 cfu/100 mL) to calculate the fecal load to Big Swamp from septics (Horsley and Witten, 1996).

3.2.5 URBAN/SUBURBAN RUNOFF

While a portion of the Big Swamp watershed is classified as urban/suburban, the total population of the watershed is well below the need for a municipal separate storm sewer system. Consequently, runoff from developed land contributes diffuse fecal coliform loads mostly from domestic animals, and to a lesser extent, wildlife. The BIT uses literature-based rates of fecal coliform accumulation on different types of built-up land, instead of explicitly calculating the number of domestic animals (e.g. cats, dogs, etc.) in the watershed. For the Big Swamp project area, an average value of 1.13×107 counts/acre/day was used based on the work of Horner (1992).

LOAD DURATION CURVE METHOD

The load duration curve method was used to calculate the existing and the TMDL load for Big Swamp at DHEC water quality monitoring station PD-169. The load-duration method develops TMDLs based on a frequency analysis of the historic hydrologic record, resulting in a cumulative frequency of daily flows, and pollutant concentration data. A water quality standard load or "allowable load" is calculated by multiplying the numeric water quality criteria by the flows from the frequency analysis. Multiplication of the observed concentrations by the estimated streamflow results in an estimate of the actual pollutant loads. The critical flow and loads allocations are determined by a comparison of the pollutant loads with the allowable loads.

The load-duration method was selected for this project because it is a relatively simple method that provides adequate estimate of fecal coliform bacteria loading over a range of stream flow conditions. In addition, the load-duration method has a successful track record of DHEC and USEPA approval for similar fecal coliform bacteria TMDL applications. Primary disadvantages of the load-duration method are limited predictive capability and limited capability to link load reduction estimates, hydrologic conditions and contributing areas. In this project, the load duration curve analysis was supplemented by mass balance calculations to estimate the loads contributed by various non-point sources (discussed in Section 4.2). Estimates of the necessary load reduction were determined using a combination of results obtained from the mass balance approach and the calculated loads from the load-duration curve method. The load-duration curve method includes all flow conditions, ensuring that critical hydrologic conditions are addressed.

4.1 DEVELOPMENT OF THE LOAD-DURATION CURVE

Because the load-duration curve methodology is based on frequency analysis of stream flow, the first step in the analysis involved collecting or estimating historical record of flow in Big Swamp at DHEC water quality monitoring station PD-169. Big Swamp at water quality monitoring station PD-169 is not gauged. Therefore, streamflow at this station was estimated from streamflow records USGS station 02135300. This stream gauge is located in the Scape Ore Swamp drainage of adjacent Lee County and has similar watershed characteristics (single permitted NPDES discharge < 1MGD, land use, and topography) as Big Swamp above the impaired station.

The flow for Big Swamp at PD-169 was estimated by multiplying the daily flow rates (for flow period ranging from July 26, 1968 to September 30, 2003) from Scape Ore Swamp at the USGS station by the ratio of Big Swamp drainage area above PD-169 to that of Scape Ore Swamp above the USGS station (0.586). These streamflow data were then used to generate the flow-duration curve at water quality monitoring station at PD-169.

The flow-duration curve was used to evaluate the cumulative distribution of the streamflow, for the time period of July 26, 1968 to September 30, 2003. To accomplish this, daily streamflow were ranked from low to high and the values that exceeded certain selected percentiles determined. The fecal coliform bacteria loads at the water quality monitoring station were calculated by multiplying the fecal coliform bacteria concentration data by the calculated flow rate that corresponded to the date of coliform sampling.

Only fecal coliform bacterial concentration data collected since 1990 were used in the analysis. To generate the load-duration curves, the loads were plotted against the appropriate flow recurrence interval (Figure 4-1). The water quality standard load (400cfu/100ml) or "allowable load" was calculated by multiplying the appropriate fecal coliform bacteria standard concentration by the flows from the frequency analysis. A Margin Of Safety (MOS) of 5% was applied to the allowable load to calculate the MOS Target Load (380cfu/100ml) displayed as counts/day in Figure 4-1. At a given streamflow, fecal coliform bacteria loads above the target line are in violation of the standard, while loads below the line are in compliance.

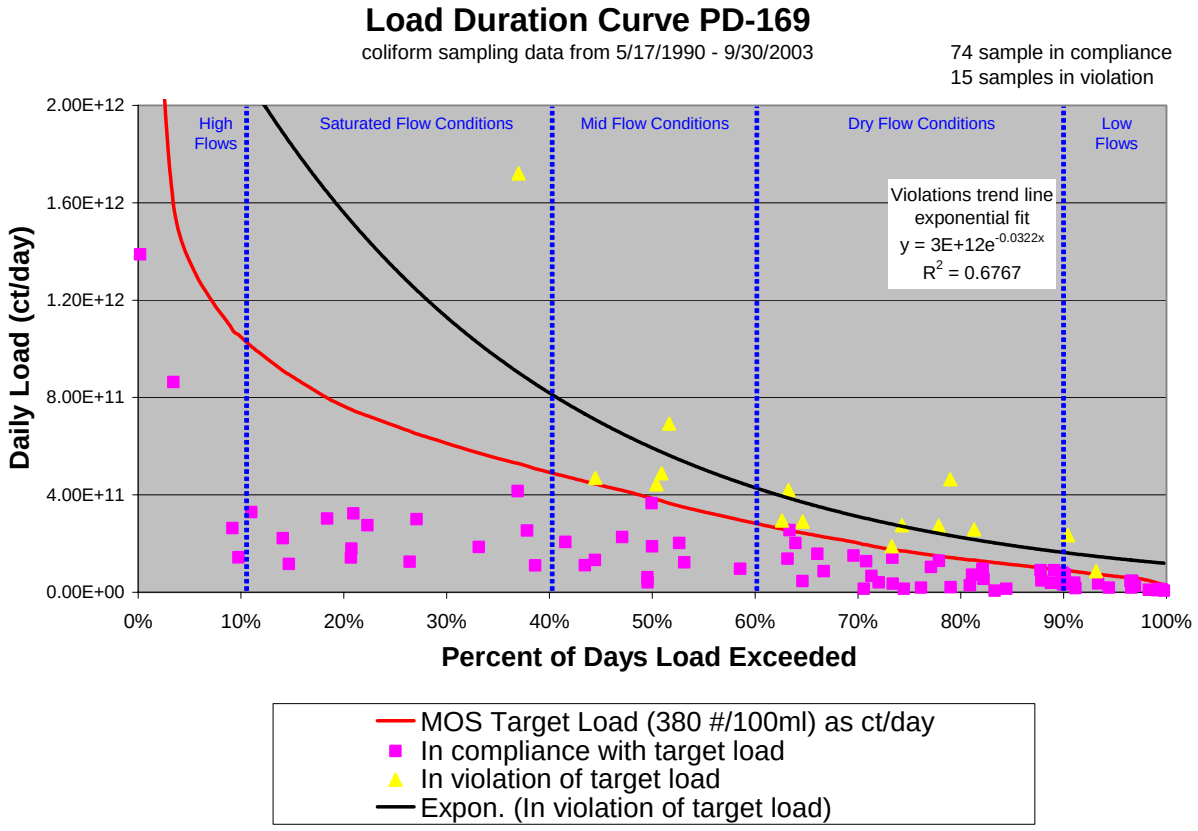


Figure 4-1
Load Duration curve for Big Swamp at Monitoring Station PD-169

The total existing load of fecal coliform bacteria at the water quality monitoring station in the Big Swamp project area was determined from the samples that violated the water quality standard. That is, a best fit trend line was determined for fecal coliform load data in violation of the standard, and the equation of the trend line used to estimate loads for the range of the flow recurrence intervals that had a majority of the loads in violation of the standard. The existing loads were then calculated by taking the average of the loads estimated within those flow duration intervals.

The best fit trend line at water quality monitoring station PD-169 was an exponential curve with a regression coefficient value of R2 = 0.67. The majority of the violating loads were between 50% and 90% streamflow duration intervals. Therefore, the average loads were determined within these flow

duration intervals at 2% intervals. Similarly, the allowable load at the monitoring station PD-169 on Big Swamp was calculated by determining trend line for the target load at the water quality monitoring station and calculating the average load estimated within the appropriate flow duration intervals (i.e., 50% - 90%). Calculations for both existing and allowable loads are provided in Appendix B.

4.2 MASS BALANCE CALCULATIONS

A mass balance approach was used to estimate amounts of loads contributed by various non-point sources including livestock, wildlife (from land deposits and directly deposited to streams); urban runoff, and failing septic systems. In quantifying the fecal coliform bacteria load contributed by the various sources, the BIT described in section 3.0 was used to estimate coliform loads to the land surface and stream (USEPA, 2000a).

The BIT spreadsheet was used to estimate loads to the land surface from wildlife, urban sources, livestock, and failing septic systems. To determine the loads actually reaching the stream from the BIT estimated sources, land surface accumulated loads resulting from livestock, urban run-off, and wildlife sources were multiplied by an attenuation factor. An attenuation factor is a fraction amount by which the total land surface accumulated load is reduced before it is directly deposited into the stream. Forested wildlife loads within 100 yards of a stream channel were assumed to encounter very limited attenuation and were consequently excluded from attenuation calculations. The attenuated land loads and the direct wildlife loads were then combined with the documented direct loads from the Pamplico WWTP plant NPDES evaluations to determine the percent contribution of each individual load and identify dominant fecal coliform sources.

The attenuation factor was determined by calculating the reduction in the livestock, urban run-off, and wildlife sources necessary to reach to total existing load observed at water quality monitoring station PD-169. Attenuation factor evaluated at the water quality monitoring station PD-169 was 0.24%. It is important to note that the evaluated run-off fecal coliform bacteria load resulting from livestock is used to account for loads from all livestock sources.

LOAD ASSESSMENT RESULTS

This section summarizes results of the total existing and recommended loads estimated by the load-duration curve analysis, and the breakdown by source of those determined from the mass balance calculations.

5.1 EXISTING CONDITIONS

The total load under observed conditions at water quality monitoring station PD-169 was calculated from the trend line of the observed values that violated the water quality standard. The majority of observed values exceeded the water quality standards within flow recurrence intervals of 50% to 90% at PD-169. Based on the load duration curve analysis, the total existing load at PD-169 is 3.39 × 1011 counts/day. This is the mean load for flow recurrence interval ranging from 90% - 50%, which corresponds to a flow range of 9.96 ft3/sec – 42.19 ft3/sec.

Results of the mass balance estimates of fecal coliform bacteria loads contributed by different sources to Big Swamp at water quality monitoring station PD-169 are listed in Table 5-1. At the impaired water quality monitoring station, livestock and wildlife are estimated to be the largest contributing sources on an annual animal basis. Failing and straight-pipe septic systems the Pamplico WWTP discharge constitute the remainder of the fecal loading. The relatively high proportion of the total load contributed by wildlife is due to the higher proportion of forest cover and extensive riparian wetlands of Big Swamp, which provide a large area for direct deposition by wildlife.

Urban runoff and failing septic systems were also estimated to be the contributing sources. The unusually high septic failure rate and chronic standard violations at the Pamplico WWTP are atypical of watersheds in this surrounding area. It is important to note that percentages of the total load contributed by each source are estimates, but these estimated percentages indicate the relative importance of each source.

TABLE 5-1
Fecal Coliform Bacteria Load to Big Swamp at Water quality Monitoring Station PD-169

Source	Coliform Load to Land Surface (ct/day)	Realized Coliform Load to Big Swamp (ct/day)	Percent of Total Load
Wildlife (including attenuated deposit to pastureland, cropland, and non-wetland forest and direct deposit in wetland riparian areas within 100yd creek buffers)	3.97E+12	1.43E+11	42.28%
Livestock (grazing)	6.32E+13	1.54E+11	45.37%
Urban Runoff	6.74E+09	1.64E+07	< 0.01%
Failing Septic systems	2.28E+10	2.28E+10	6.71%
Pamplico WWTP	1.92E+10	1.92E+10	5.64%
Total	**6.72E+13**	**3.39E+11**	100.00%

Note: Pamplico WWTP NPDES permit violations during the summer of 2003 were as much as 12 times WLA and represented as much as 25% of the Target Load for PD-169

5.2 TOTAL MAXIMUM DAILY LOAD

The Total Maximum Daily Load (TMDL) is the maximum amount of a pollutant loading a water body can receive and still maintain water quality standards. In this case, the pollutant of concern is fecal coliform bacteria, and the load is expresses as counts/day (number of coliform bacteria counts/day). Conceptually, the TMDL load is calculated using the following equation:

TMDL = Sum of LA + Sum of WLA + MOS

Where:

LA (Load allocation) is the pollutant load allocated to non-point sources and natural occurrences.

WLA (Waste load allocation) is the pollutant load allocated to existing and future point sources.

MOS (margin of safety) is used to account for uncertainty in determining pollutant loads allowing for the unknown.

Table 5-2 details the two TMDL component scenarios for Big Swamp at water quality monitoring stations PD-169.

The South Carolina DHEC has previously used a margin of safety at 5% of the fecal coliform bacteria standard or a fecal concentration of 20cfu/100 ml. For Big Swamp at water quality monitoring station PD-169, this equates to MOS fecal load of 9.67 × 109 counts/day.

The LA was determined from the target line of the load-duration curve within the range of flow recurrence intervals for which the water quality standard was violated (50% to 90% or stream flow ranging from 9.96 ft3/sec – 42.19 ft3/sec), which was developed by setting the fecal coliform bacteria concentration of 380 counts/day that is equivalent to the standard concentration less the MOS. The LA for Big Swamp at PD-169 is 1.93 × 1011 counts/day.

The NPDES permit limits for the Pamplico WWTP discharge facility are a fecal coliform daily maximum of 400counts/100ml, a fecal coliform monthly geometric mean of 200counts/100ml, and a discharge flow limit of 0.2 Million Gallons Daily (average 1.547 ft3/sec) (EPA envirofacts, SCDHEC NPDES permit SC0021351). Accordingly, the current Waste Load Allocation (WLA) for the Pamplico WWTP discharge is 3.03 × 109 counts/day.

However, the Pamplico WWTP has the permits and a compliance schedule to upgrade facilities and transfer all discharge to the Pee Dee River outside the Big Swamp Watershed. Therefore, Big Swamp TMDL components have been established for two scenarios:

a. Interim NPDES compliance discharge by Pamplico WWTP to Big Swamp and
b. Complete removal of Pamplico WWTP discharge from Big Swamp.

It is important to note that removal of the Pamplico WWTP from the TMDL also reduces the total flow of Big Swamp; therefore, the LA for NPS does not change. This change in the TMDL illustrates the relationship between flow and total maximum daily load.

TABLE 5-2
TMDL Components for Big Swamp at Monitoring Stations PD-169

Scenario	Impaired Station	Sum of WLA (counts/day)	Sum of LA (counts/day)	MOS (counts/day)	TMDL (counts/day)
a) Interim permit limit discharge from Pamplico WWTP	PD-169	3.03×10^{9}	1.93×10^{11}	9.67×10^{9}	2.06×10^{11}
b) Removal of Pamplico WWTP discharge	PD-169	N/A	1.93×10^{11}	9.67×10^{9}	2.03×10^{11}

5.3 CRITICAL CONDITIONS

Both monitoring and load-duration curve results demonstrate that the fecal coliform bacteria standard at monitoring station PD-169 on Big Swamp can be exceeded under low and moderate flow conditions (at flow exceedence intervals ranging from 50 – 90 % as evaluated by the load-duration curve method). Load-duration curves show that most of the standard violations occurred during flows of 40 cfs or less. Monitoring results also indicate that the critical seasonal conditions for Big Swamp at PD-169 are during the summer warm weather and low flow period. Because the load duration method makes use of data from the full range of flow and seasonal conditions, the resulting TMDL inherently addresses the critical hydrologic and seasonal conditions

SECTION 6.0

POTENTIAL ALLOCATIONS

The waste load allocation (WLA) of the Pamplico WWTP (3.03 × 109 counts/day) is a minor component (1.5%) of the TMDL at water quality monitoring station PD-169. The average contribution of the WWTP to the existing load was also found to be minor (5.6%); despite the fact that during the 28 monthly evaluations for the period January 2003 to April 2005 the Pamplico WWTP exceeded the NPDES fecal coliform permit limit during 15 evaluations and exceeded the flow permit limit during 23 evaluations. However, it should be noted that the majority of the WWTP exceedances have occurred during the warm summer months; during the summer of 2003 the loading from the Pamplico WWTP was as much as 12 times the WLA and represented as much as 25% of the Target Load for PD-169. Consequently, load reductions at the WWTP may have a significant effect on attainment during the problematic summer months.

The required total load reduction is the difference between the existing load and the target load expressed as a percentage. The target load to the stream is the TMDL minus MOS. The target loading for Big Swamp at PD-169 under both WWTP scenarios is detailed in Table 6-1. Recommended allocations at monitoring station PD-169 includes a 68.5% reduction in loads from livestock and a 100% reduction in loads from failing septic systems. The existing Pamplico WWTP has reasonable expectations to decrease the number and magnitude of loading exceedances via infrastructure improvements that are to accompany construction of the new Pamplico Pee Dee River discharge plant. Full compliance with the NPDES permit and Waste Load Allocation for interim discharge to Big Swamp, would require an 84.2% load reduction from current conditions. The total required reduction from all sources needed to achieve the target load in scenario ‘b’ is 43% (Table 6-1).

The recommended load allocations are based on good engineering and agricultural practices. For example, although failing septic systems represent just 6.7% of the fecal load at PD-169, but their elimination is an important priority for public health reasons. Similarly, the reduction in loads from the Pamplico WWTP will help reduce exceedances of the criteria magnitude during summer storm events and/or at times of abnormally low stream flow.

TABLE 6-1
Recommended Load Reduction for Big Swamp at Monitoring Station PD-169

Scenario a) Interim permit limit discharge from Pamplico WWTP	**Existing Coliform Load to Big Swamp**	**Target Coliform Load to Big Swamp**	**Reduction**	**Reduction**
Source	**(ct/day)**	**(ct/day)**	**(ct/day)**	**(%)**
Wildlife (Sum of Attenuated Deposit and Direct Deposit)	1.43E+11	1.43E+11	0.00E+00	0.00%
Livestock (grazing)	1.54E+11	5.00E+10	1.04E+11	67.56%
Urban Runoff	1.64E+07	1.64E+07	0.00E+00	0.00%
Failing Septic systems	2.28E+10	0.00E+00	2.28E+10	100.00%
Pamplico WWTP	1.92E+10	3.03E+09	1.61E+10	84.19%
Total	**3.39E+11**	**1.97E+11**	**1.43E+11**	**42.11%**
Scenario b) Removal of Pamplico WWTP discharge	**Existing Coliform Load to Big Swamp**	**Target Coliform Load to Big Swamp**	**Reduction**	**Reduction**
Source	**(ct/day)**	**(ct/day)**	**(ct/day)**	**(%)**
Wildlife (Sum of Attenuated Deposit and Direct Deposit)	1.43E+11	1.43E+11	0.00E+00	0.00%
Livestock (grazing)	1.54E+11	4.99E+10	1.04E+11	67.57%
Urban Runoff	1.64E+07	1.64E+07	0.00E+00	0.00%
Failing Septic systems	2.28E+10	0.00E+00	2.28E+10	100.00%
Pamplico WWTP	1.92E+10	0.00E+00	1.92E+10	100.00%
Total	**3.39E+11**	**1.93E+11**	**1.46E+11**	**43.00%**

SECTION 7.0

AGRICULTURAL LAND USE CHARACTERIZATION

A Geographic Information System (GIS) database will be used during TMDL implementation planning to identify viable pasture, poultry litter application and other types of farm field sites for agricultural BMP and conservation practice implementation. In addition, any straight pipe or failing septic system sightings were also noted in the GIS database.

7.1 GIS DATALAYER DEVELOPMENT OF AGRICULTURAL LAND USES

Numerous South Carolina agricultural agencies are charged with the responsibility of satisfying the provisions described in the fecal coliform bacteria Load Reduction Management Plan, and any future requirements resulting from state TMDL development endeavors. GIS datalayers have been developed to assist these agencies meet the following future tasks associated with the implementation of agricultural BMP and conservation practices in the Big Swamp project watershed area:

- Assess potential sources of fecal coliform bacteria loading from specific pasture land use areas;
- Effectively and efficiently consolidate and monitor corrective actions (i.e., Best Management Practices (BMPs) and conservation practices) associated with meeting the goals of the Load Reduction Management Plan;
- Facilitate consensus building among the various agencies and landowners during implementation decision making.

The datalayer development effort included the following steps:

1. The County-wide Common Land Use (CLU) datalayer of farm practices developed by the Farm Service Agency (FSA) possess farm field delineations as defined by the individual land owners. The datalayers were created by the FSA by referencing the hard hand-marked FSA hardcopy aerial photographs located in the respective County Agriculture Service Centers. These farm field boundaries were then digitized over 1999 color Digital Ortho Quarter Quadrangle (DOQQ) electronic aerial photographs. Those digitized farm fields within the Big Swamp project watershed area (approximately 1,400 farm fields) were extracted from the Florence County CLU databases. The FSA tract and farm field numbers were retained for project referencing purposes. Additional farm fields were also digitized using the FSA procedures when they were noted during drive-byes, but lacked an FSA designated boundary because the grower has not enrolled in an FSA program.

2. Once this farm field datalayer was completed, it was combined with other datalayers including roads to form a GIS project database. A Geographic Positioning System (GPS) was linked to the GIS project database. The GPS was connected to a laptop computer and interfaced with the GIS ArcView 3.2 software. The GPS provides a real time display of the GPS location on the GIS project database. The exact location, movements, and direction of movement were displayed on the laptop screen in conjunction with the GIS program displaying the DOQQ base map and spatial data, roads, streams, field boundaries, and other features.

3. The GIS/GPS system was taken into the field where drive-byes were conducted from August 15 through August 19, 2005 to acquire bacteria-related loading information from agricultural sources in

the impaired watershed. The GPS unit showed the movement of the survey vehicle on the roads datalayer. In addition, a record of those roads that had been traveled during the drive-bye survey was maintained. To note farm fields with pertinent bacteria information, the GIS database of farm fields was referenced to determine and record the administrative number of respective farm fields in question, and any bacteria loading information specific to the individual farm fields.

4. This drive-bye information was compiled in the GIS database by incorporating the following farm field GIS attributes or tabular data: agricultural land uses (i.e., various field sightings, including the location of straight pipes, farm animal sightings, and estimated animal stocking rates).

5. Additional information regarding bacteria loading from farm fields was acquired from USDA Natural Resource Conservation Service (NRCS) District Conservationists via interviews conducted on August 16, 2005 and was subsequently incorporated in the GIS database.

6. Other fecal coliform bacteria information was added to the farm field datalayer through a review of aerial photographs.

7.2 AGRICULTURAL LAND USE CHARACTERIZATION RESULTS

The Big Swamp project watershed area is located in the Lower Coastal Plain region of South Carolina. For review purposes, the project watershed area was divided into six distinct subwatershed areas:

- Big Swamp Branch (10.3 square miles);
- Buck Branch (6.4 square miles);
- Cypress Branch (10.6 square miles);
- Upper Mainstem (10.4 square miles);
- Lower Mainstem (9.9 square miles), and
- Little Swamp (8.7 square miles).

Figure 7-1 shows the location of each subwatershed and those farm fields located within the respective subwatersheds areas. Although the PD-169 ambient water quality monitoring station located at the endpoint of the project watershed area is showing a fecal coliform bacteria impairment, the PD-168 ambient water quality monitoring station located on the Route 360 Bridge 1.1 miles west of the Town of Pamplico is not showing exceedances to the fecal coliform bacteria standard. The Pamplico WWTP is located downstream of the PD-168 station.

Figure 7-1
Big Swamp Subwatershed Areas

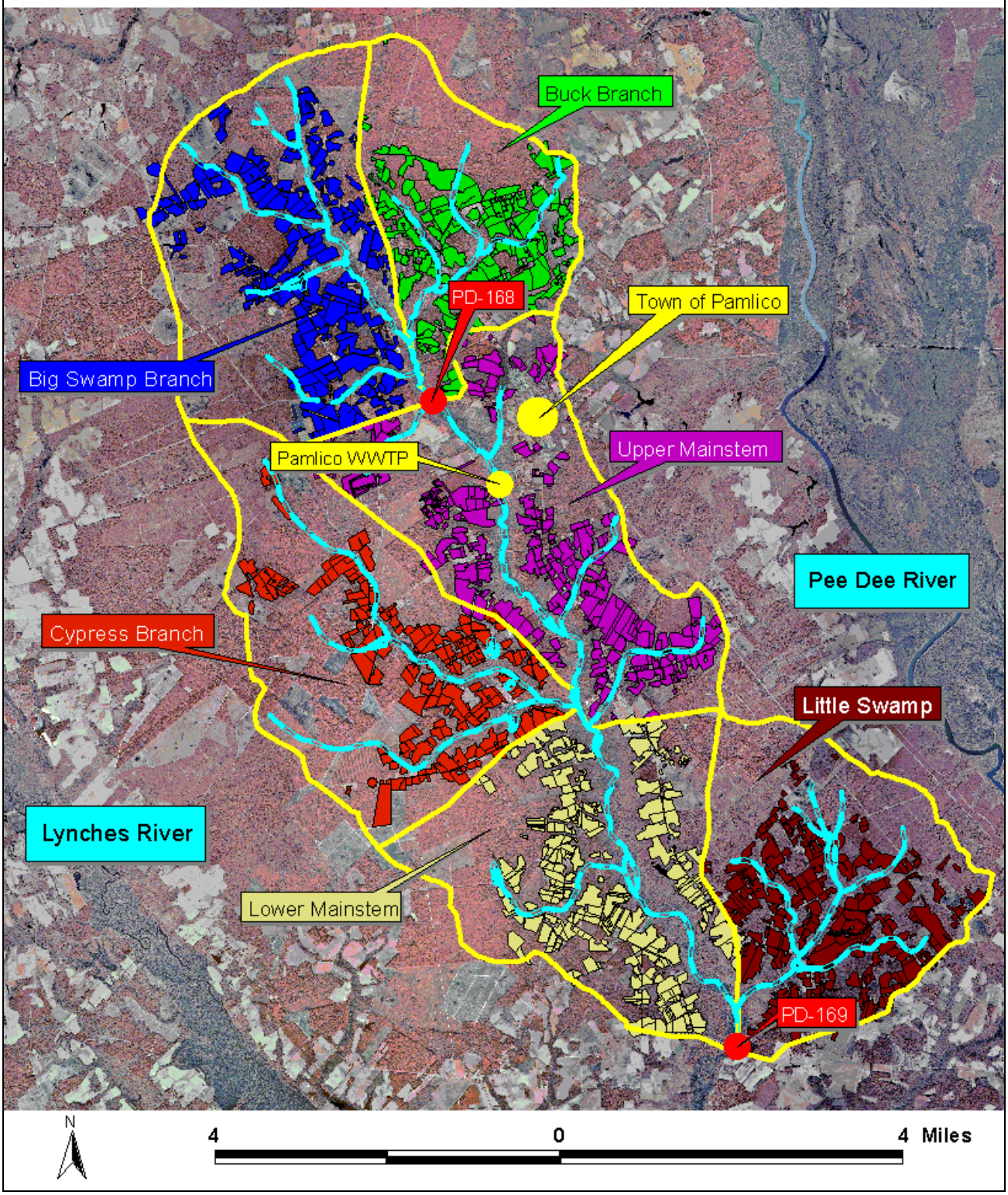


Table 7-1 depicts an assortment of farm field information categorized by subwatershed that is pertinent to fecal coliform bacteria loading. The information was acquired during the agricultural land use characterization phase of the project.

Table 7-1
Subwatershed Agricultural Information

Subwatershed	Total Farm Fields	Pastures	Animal Sightings	Approx. Stocking Rate	Idle or Converted to Forestry (CRP)
Big Swamp Branch	234	2	Horses	2	5
Buck Branch	178	2	Cattle, Horses, Goats, Ponies	15-20	1
Cypress Branch	188	6	Horses, Goats	7	1
Upper Mainstem	272	9	Horses, Donkeys	31	17
Lower Mainstem	268	13	Horses, Goats	51	9
Little Swamp	282	13	Cattle, Horses, Ponies	37	15
Total	*1,422*	*45*	*N/A*	*143-148*	*48*

As compared to other watersheds, very few farm fields have gone idle or were converted to forestry over the last several years. The Scape Ore Swamp watershed in Lee and Kershaw Counties and the Fork Creek watershed in Chesterfield County, for example, are located partially or totally in the Sandhills region of South Carolina where the soils are less conducive to farming. As a consequence, forestry land uses were found to be increasing far more dramatically than in the Big Swamp watershed. In addition, as a consequence of the productivity of the soils in the Lower Coastal Plain, the vast majority of farm fields were cropland that were not receiving poultry litter or manure supplements.

Table 7-1 also shows that a greater number of pastures and animal sightings occurred in the lower section of the project watershed area (Upper Mainstem, Lower Mainstem, and Little Swamp subwatersheds) below the PD-168 ambient water quality monitoring station. This coincides with the water quality findings and modeling results: The direct deposition of farm animal waste into the streams and the runoff of manure from pastures are occurring predominately in areas just above the impaired PD-169 ambient water quality monitoring station.

Although not presented in Table 7-1, extreme ditching was noted throughout the Big Swamp project watershed area. Numerous straight pipes discharging directly into these ditches were identified, and potentially failing septic systems is likely occurring throughout the project watershed area.

It is, therefore, expected that:

- An overall reduction in fecal coliform bacteria will not occur from land use conversions to forestry because farming practices remain more economically viable in the project watershed area;

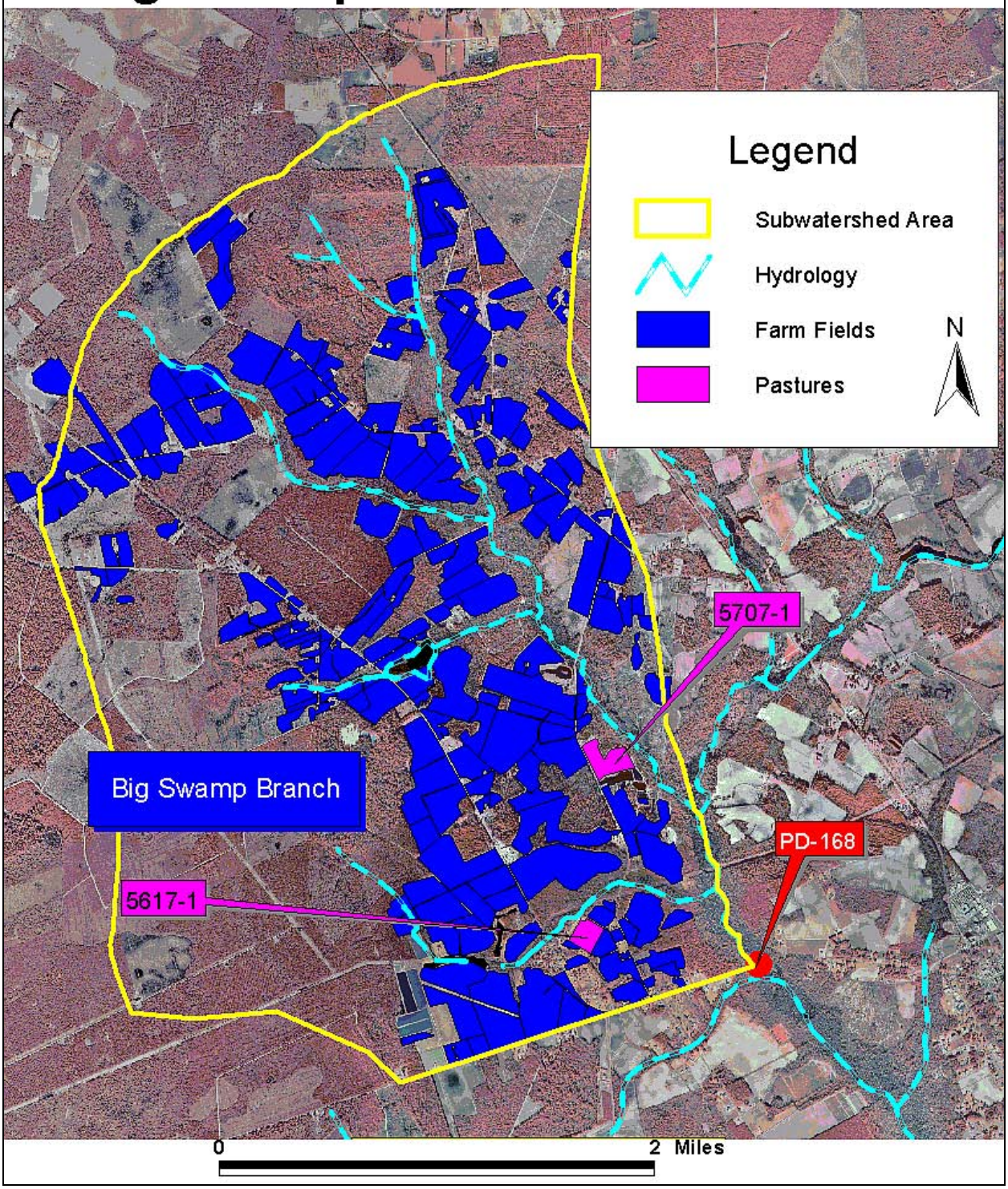
- Agricultural agency field personnel will be able to conduct a more refined search of those farm fields that are potentially the greatest sources of fecal coliform bacteria loading; particularly pastures areas in the Upper Mainstem, Lower Mainstem, and Little Swamp subwatersheds. These three subwatersheds are prioritized because they posses the largest quantity of farm animals and are located in a close proximity to the impaired PD-169 ambient water quality monitoring station. In addition, a more refined accounting of septic failures throughout the project watershed areas has been identified as a needed endeavor.

This land use information will be consolidated with the water quality modeling results and stakeholder recruitment efforts to initiate the development of an effective TMDL implementation effort. The following Big Swamp subwatershed descriptions and figures provide a detailed accounting of agricultural practices in the Big Swamp project watershed area.

7.2.1 Big Swamp Branch Subwatershed

The Big Swamp Branch Subwatershed represents the extreme western headwaters of the Big Swamp project watershed area. Big Swamp Branch and Buck Branch converge to form the Big Swamp mainstem above the PD-168 ambient water quality monitoring station. As shown in Figure 7-2, the farm fields in this Subwatershed area are concentrated in the vicinity of streams. The areas above the perennial streams are mainly forested. A total of just two pastures are found in this Subwatershed area. The pasture to the north possessed two horses. Both pastures are found in the vicinity of streams and potential access is a concern. In addition, straight pipe discharges and a septic system problem were also noted in this Subwatershed area. A photographic record of the pasture with horses and two straight pipe discharges are shown in Figures 7-3 through 7-5. For reference purposes, farm field 'Tract-CLU' have been provided as farm field unique identifiers.

Figure 7-2
Big Swamp Branch Subwatershed



AGRICULTURAL LAND USE CHARACTERIZATION

Figure 7-3

Pasture '5707-1'
Big Swamp Branch

Figure 7-4

Straight Pipe Discharge
Big Swamp Branch

Figure 7-5

Straight Pipe Discharge
Big Swamp Branch

7.2.2 Buck Branch Subwatershed

The Buck Branch Subwatershed is located in the eastern headwater section of the Big Swamp project watershed area. It merges with the Big Swamp Branch to create the Big Swamp mainstem. A large forested area is located along the northern extent of the Subwatershed area. The farm fields are concentrated around the perennial streams. Three pastures were identified in the Subwatershed area and are shown on Figure 7-6. The two denoted 'A-1' and 'C-1' possessed farm animals. Two of the pastures are also located in the vicinity of streams and should be investigated. Adjacent to pasture 'C-1,' a home with a straight pipe was identified. In addition, a large dog pen was noted against a stream channel and is sited on Figure 7-6. A photographic record of many of the sightings pertinent to fecal coliform bacteria loading are shown in Figures 7-7 through 7-10. For reference purposes, farm field 'Tract-CLU' have been provided as farm field unique identifiers. The animal operations on pastures 'A-1' and 'C-1' are both not recognized or receiving any assistance from the United States Department of Agriculture (USDA) FSA or NRCS.

7.2.3 Cypress Branch Subwatershed

The Cypress Branch Subwatershed, depicted in Figure 7-11, drains into the Big Swamp mainstem from the west below the Town of Pamplico between the PD-168 and PD-169 ambient water quality monitoring stations. The farm fields are concentrated around the bottomland areas as the headwaters are predominately forested. Six pastures are found in this Subwatershed area; with farm animal sightings occurring on four of the pastures. Two animal operations, pastures 'D-1' and a second lacking an administrative number are both not recognized or receiving any assistance from the United States Department of Agriculture (USDA) FSA or NRCS. Although the pasture lacking an administrative number is located directly adjacent to a perennial stream, it was noted to support just one goat. Figures 7-12 and 7-13 provide a photographic record of two of the identified pastures potentially providing fecal coliform bacteria loading to the Big Swamp project watershed area.

Figure 7-6
Buck Branch Subwatershed

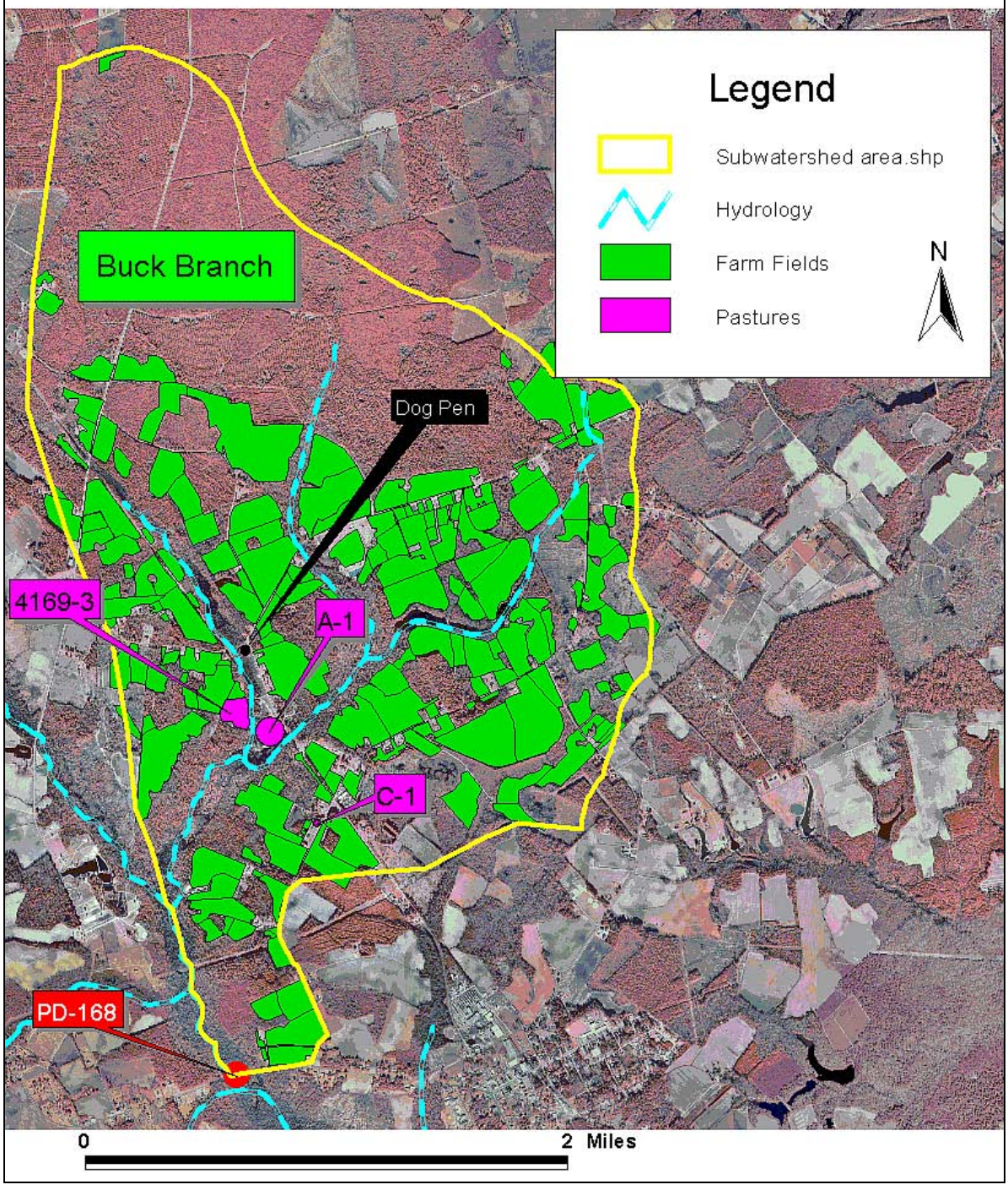


Figure 7-7

Pasture 'A-1'
Buck Branch

Figure 7-8

Pasture 'A-1'
Buck Branch

Figure 7-9

Pasture 'C-1'
Buck Branch

Figure 7-10

Straight Pipe Discharge
Buck Branch

Figure 7-11
Cypress Branch Subwatershed

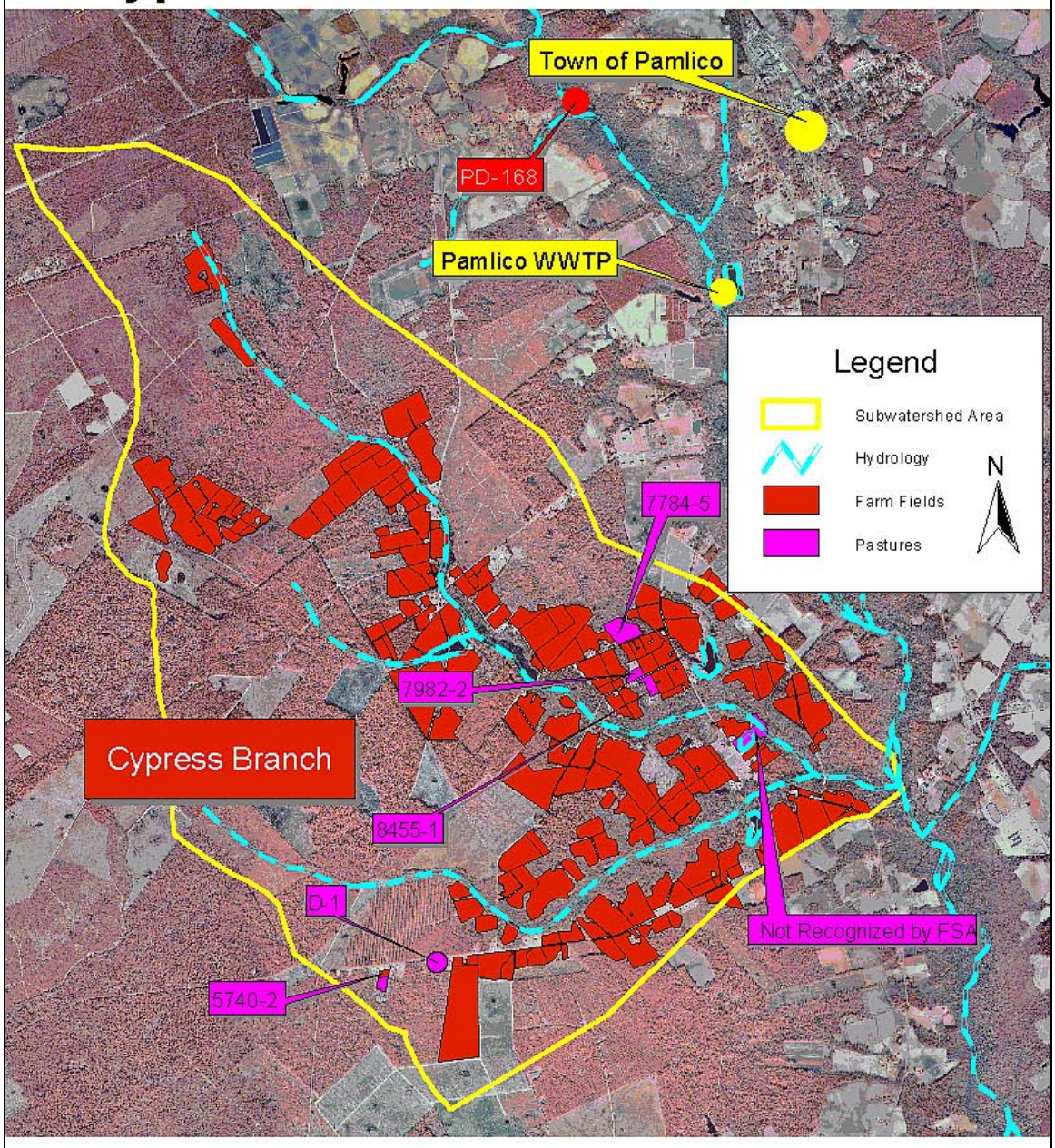


Figure 7-12

Pasture '8455-1'
Cypress Branch

Figure 7-13

Pasture '7784-5'
Cypress Branch

7.2.4 Upper Mainstem Subwatershed

The Upper Mainstem Subwatershed area, depicted in Figure 7-14 includes drainage from small tributary systems and flow directly into the Big Swamp mainstem. The Subwatershed is located just south of the PD-168 ambient water quality monitoring station and includes urban stormwater flow from the Town of Pamplico. Cypress Swamp flows enter the Upper Mainstem Subwatershed area along its southwestern margin. Unlike many of the Subwatershed areas, the Upper Mainstem Subwatershed possesses a concentration of farm fields throughout its extent. Although cropland accounts for the majority of farm fields to the north and on the eastern side of the Big Swamp mainstem, a concentration of pastures are located to the west of the mainstem (seven of the nine pastures in the Subwatershed); many sited along the border of the Big Swamp bottomlands. Nearly all of the animal sightings were horses with pastures containing as many as nine animals. A photographic record of all but two of the pastures is provided Figures 7-15 through 7-21.

7.2.5 Lower Mainstem Subwatershed

The Lower Mainstem Subwatershed area is shown in Figure 7-22. It receives flow from the Upper Mainstem Subwatershed to the north and from Little Swamp in the southeastern corner of this Subwatershed area. The fecal coliform bacteria impaired PD-169 ambient water quality monitoring station is located at the endpoint of the Lower Mainstem Subwatershed. Concentrated farm fields are located along the margin of the Big Swamp mainstem bottomlands and adjacent to a small tributary system to the west. Forested land uses are found in the extreme western headwater areas of the Subwatershed. Cropland land uses are found exclusively along the eastern margin of the Big Swamp mainstem. The western side of Big Swamp includes thirteen pastures mixed in with cropland. One of these pastures was noted to have definitive access to a stream. Two pastures harbored as many as twelve horses. Neither animal operation on pastures ‘E-1’ and the pasture noted further to the north are recognized by the United States Department of Agriculture (USDA) FSA or NRCS. A photographic record of many of these pastures is provided in Figures 7-23 through 7-28.

7.2.6 Little Swamp Subwatershed

The Little Swamp Subwatershed, depicted in Figure 7-29, flows into the Big Swamp mainstem approximately 0.5 miles from the PD-169 ambient water quality monitoring station. The outer rim of the Subwatershed area is comprised exclusively of forestry practices. Farm fields are again concentrated around the stream systems. Thirteen pastures were noted towards the lower end of the Subwatershed area during the drive-bye field survey. These pastures harbor a number of animals including 22 head of cattle over three pastures. A photograph of one of the thirteen pastures is provided in Figures 7-30.

Figure 7-14
Upper Mainstem Subwatershed

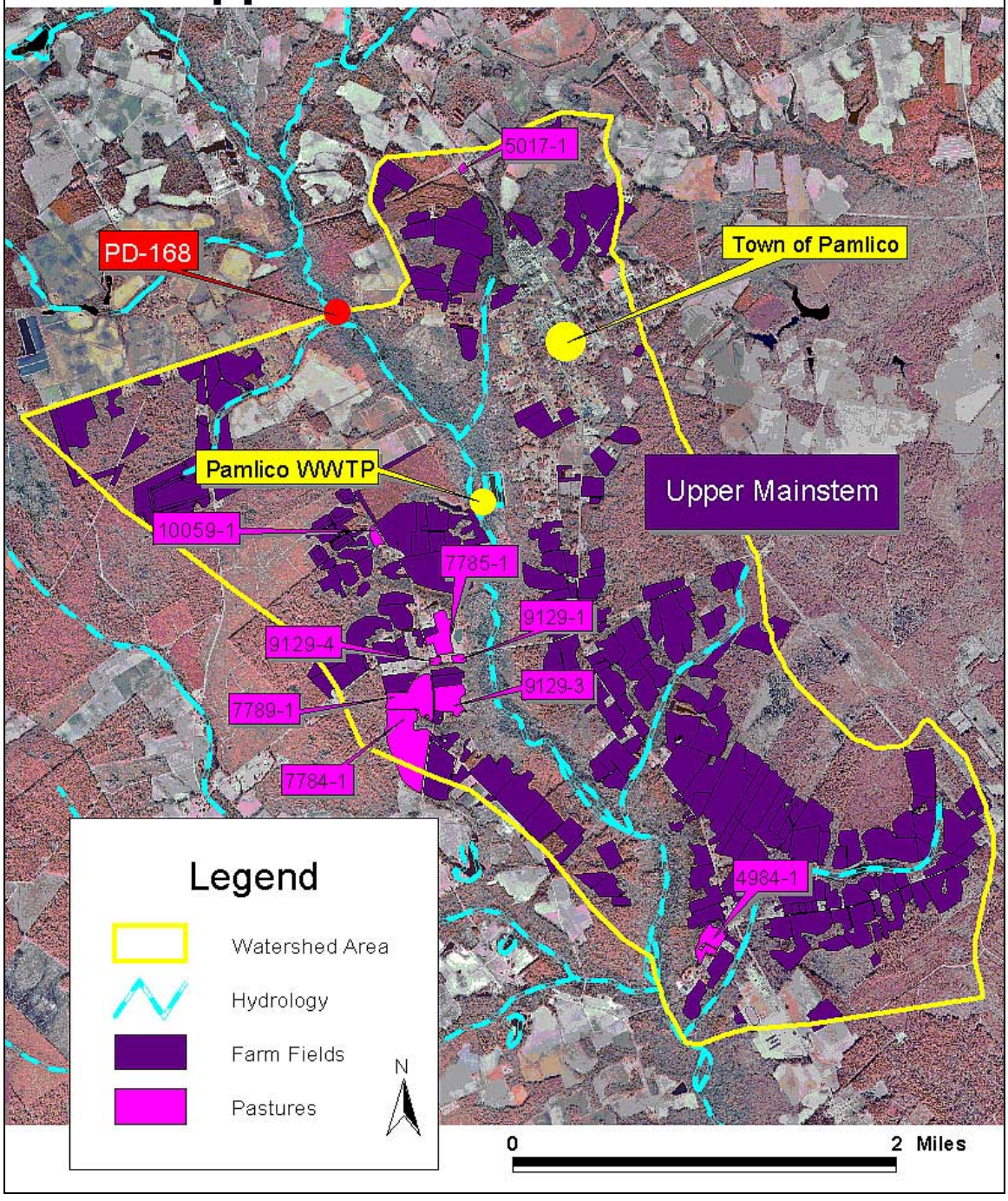


Figure 7-15

Pasture '5017-1'
Upper Mainstem

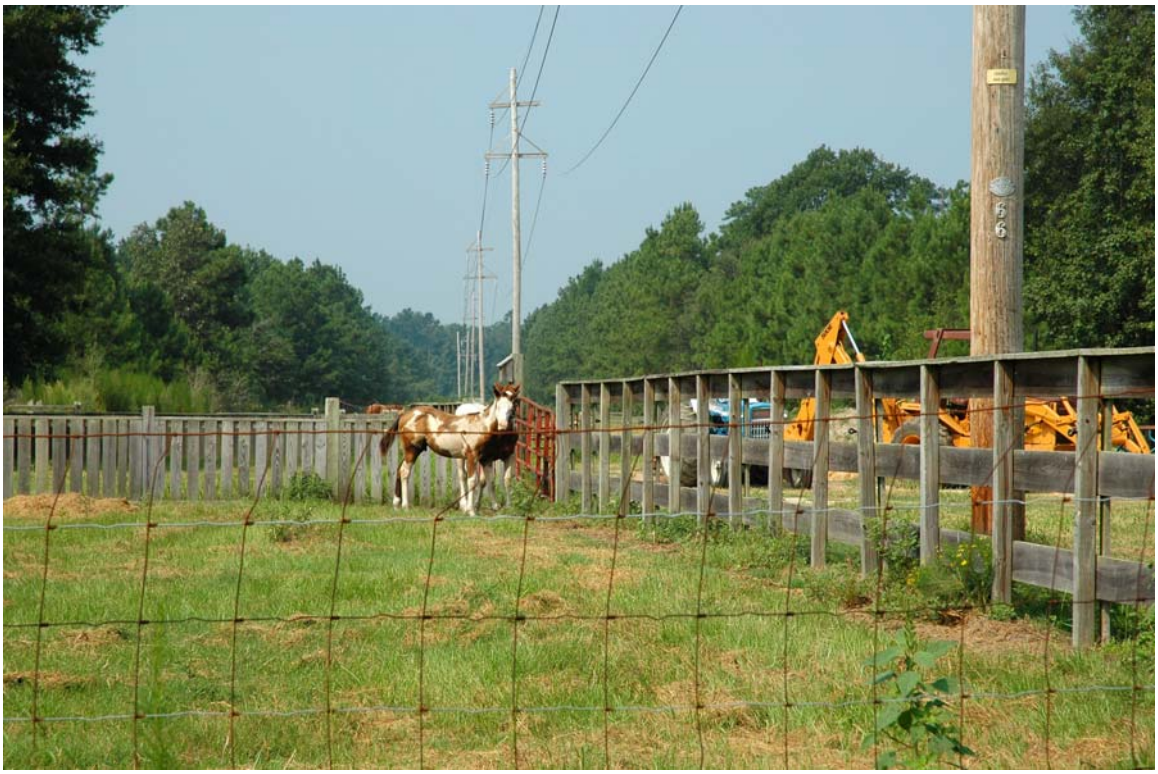


Figure 7-16

Pasture '10059-1'
Upper Mainstem

Figure 7-17

Pasture '7784-1'
Upper Mainstem

Figure 7-18

Pasture '7789-1'
Upper Mainstem

Figure 7-19

Pasture '9129-4'
Upper Mainstem

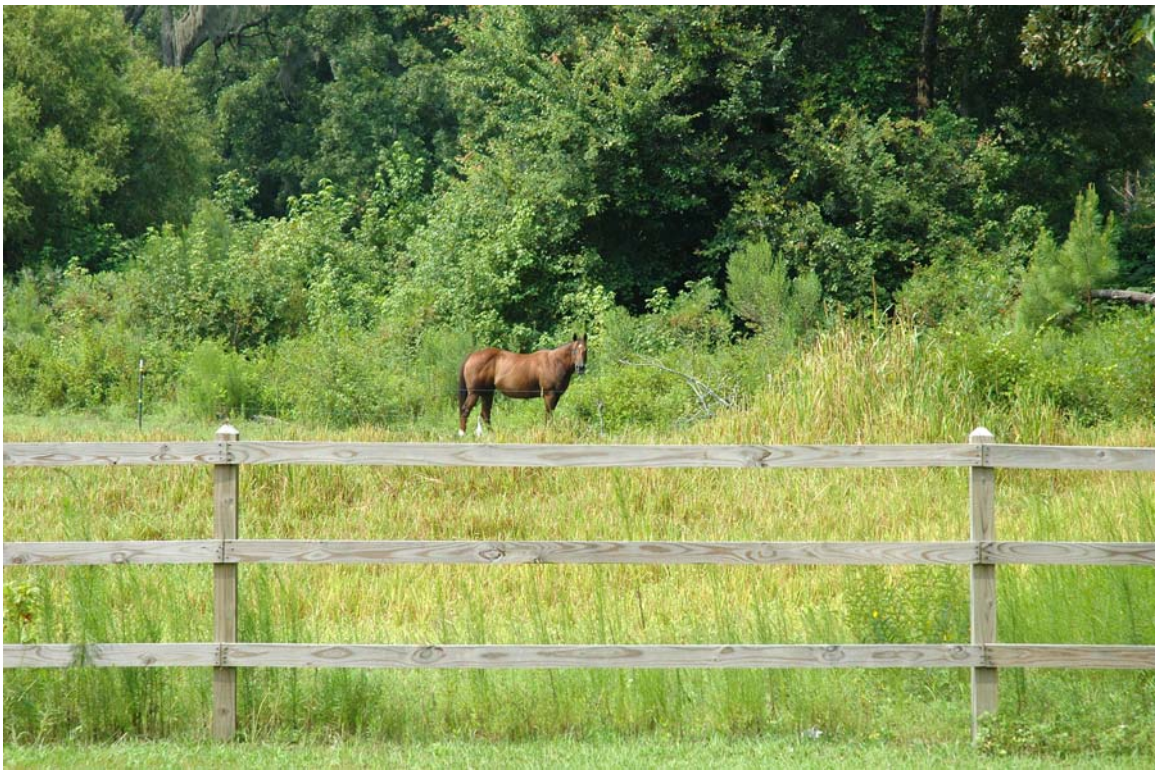


Figure 7-20

Pasture '9129-1'
Upper Mainstem

Figure 7-21

Pasture '9129-3'
Upper Mainstem

Figure 7-22
Lower Mainstem Subwatershed

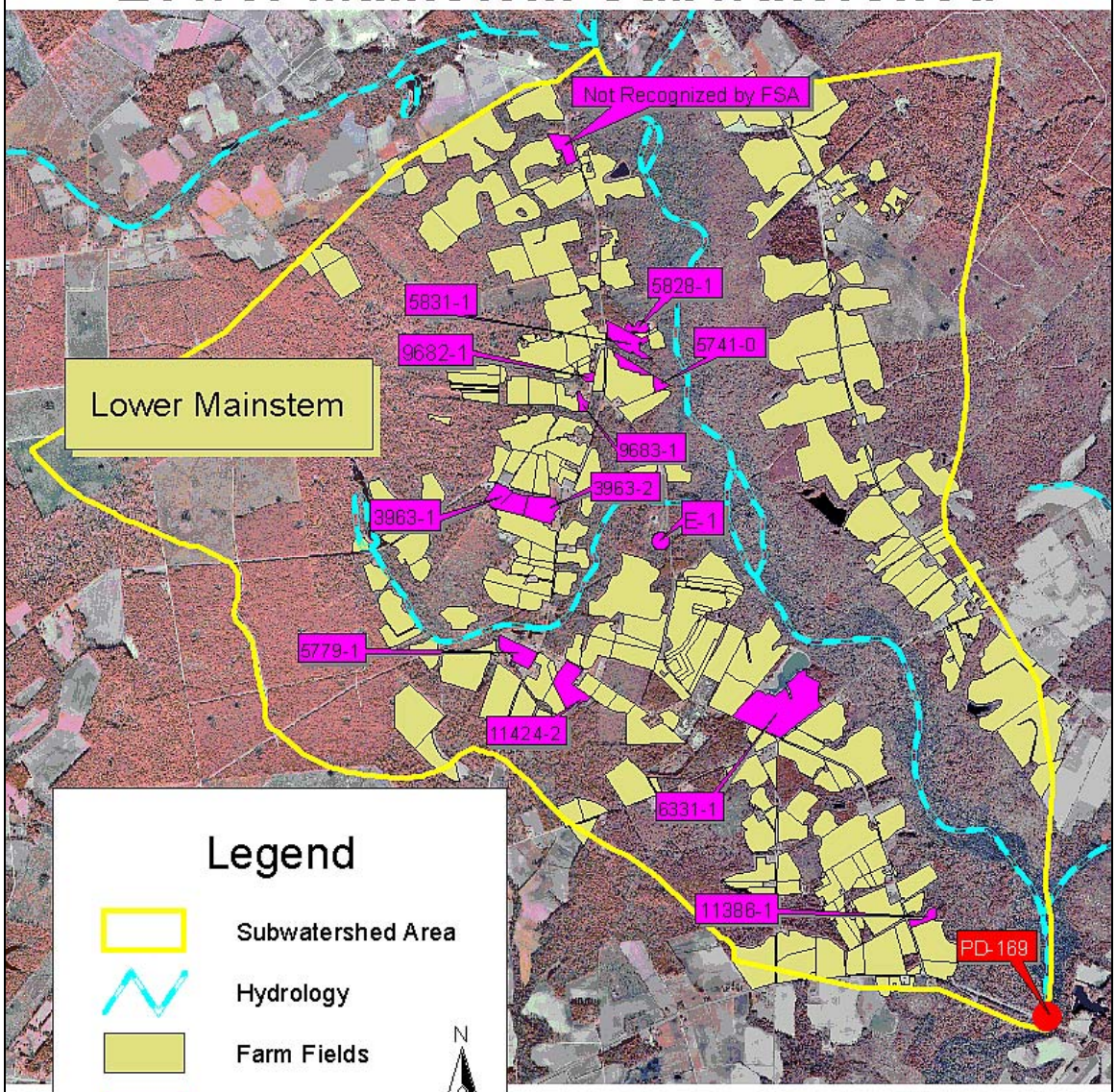


Figure 7-23

Pasture '3963-1'
Lower Mainstem

Figure 7-24

Pasture '3963-2'
Lower Mainstem

Figure 7-25

Pasture '5779-1'
Lower Mainstem

Figure 7-26

Pasture '6331-1'
Lower Mainstem

Figure 7-27

Pasture '6331-1'
Lower Mainstem

Figure 7-28

Pasture 'E-1'
Lower Mainstem

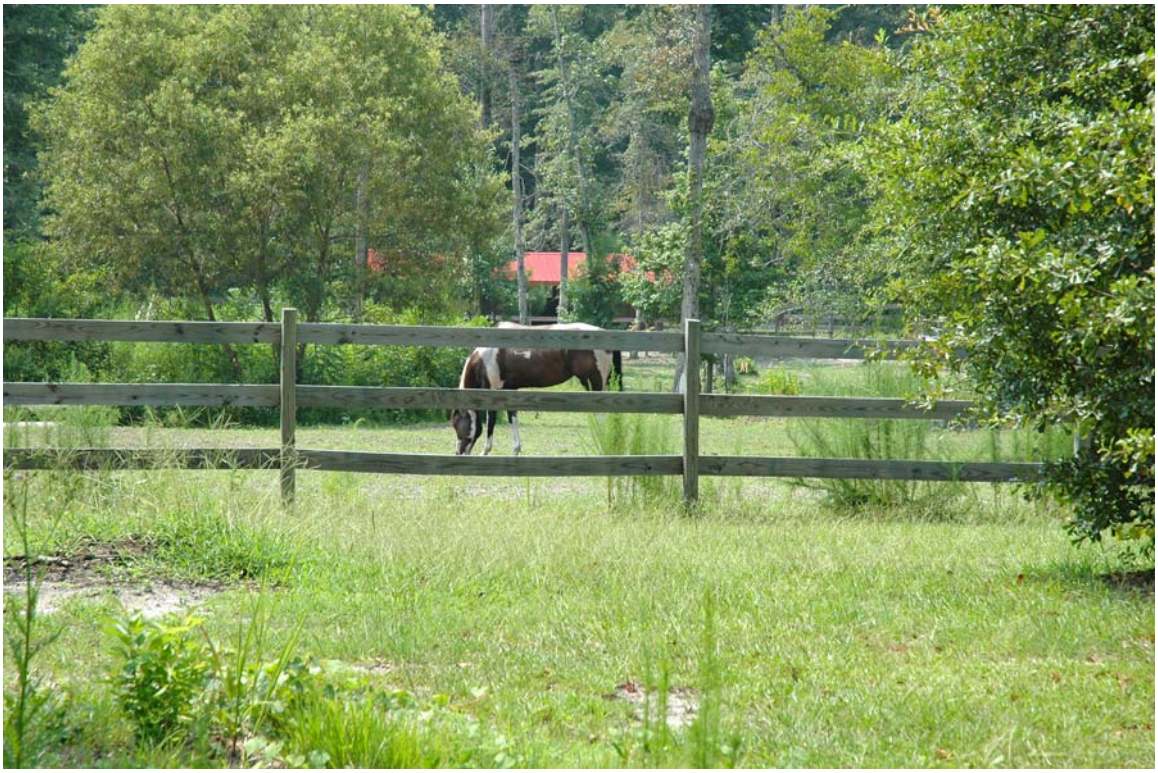


Figure 7-29
Little Swamp Subwatershed

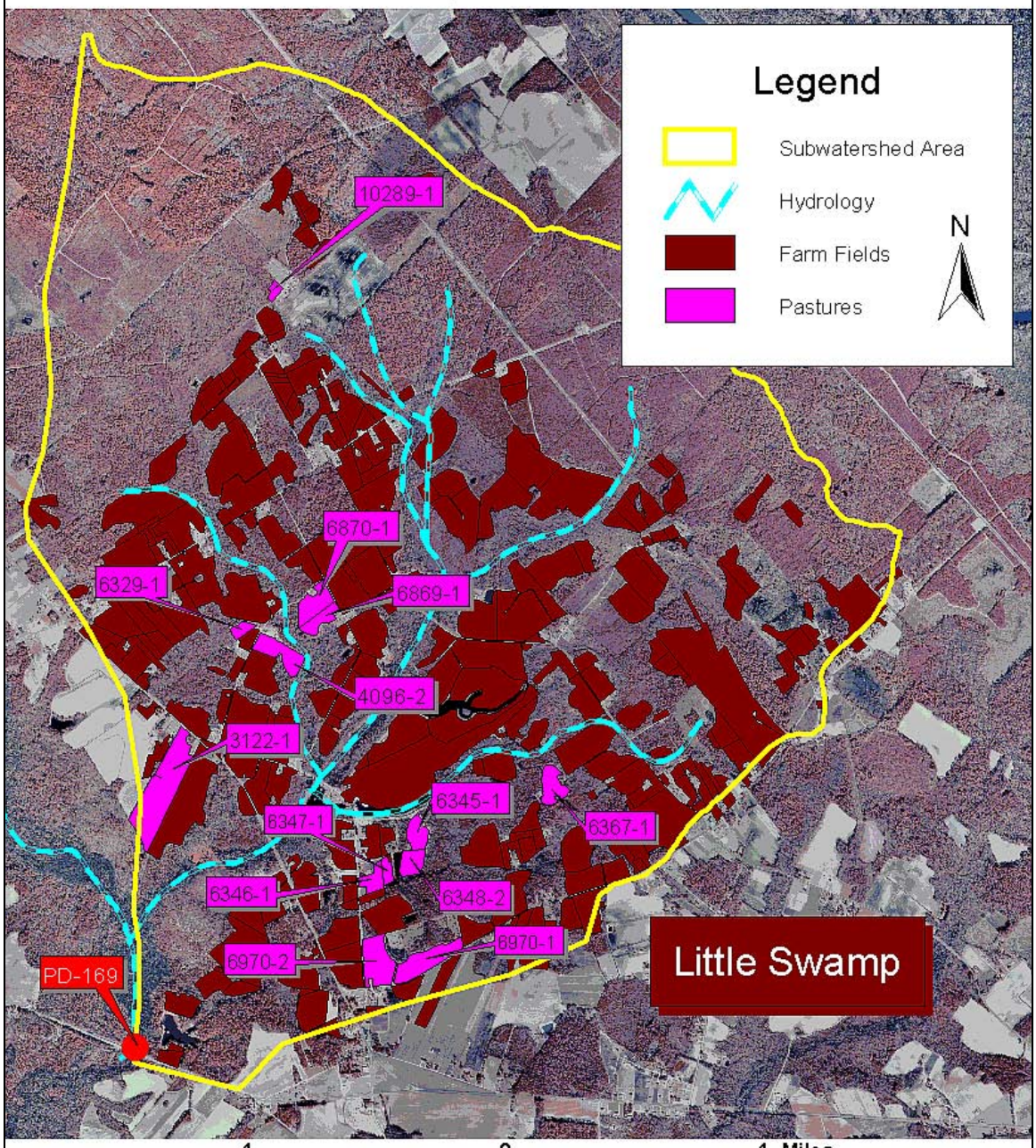


Figure 7-30

Pasture '4096-2'
Little Swamp

IMPLEMENTATION PLANNING RECOMMENDATIONS

8.0 IMPLEMENTATION PLANNING RECOMMENDATIONS

The Load Reduction Plan was developed using the best data available to identify a **load reduction allocation scenario** that, when implemented, will meet the state water quality goals for fecal coliform bacteria in the Big Swamp project watershed area. Additional watershed planning efforts included in this Load Reduction Plan consist of a **detailed characterization and accounting of agricultural land uses** and the formation of a **stakeholder group and an informed citizenry**. These three Load Reduction Plan components will facilitate and provide a structure for the development and application of an effective TMDL implementation plan. Four implementation planning strategies are recommended:

- Watershed Management and Planning Administration;
- Selection and Implementation of Corrective Actions;
- Citizen Awareness and Education, and;
- Continued Water Quality Sampling.

8.1 Watershed Management and Planning

To reduce the quantities of fecal coliform bacteria from the potential loading sources within the Big Swamp project watershed area, a decision-making framework and management process is required. This framework will be developed to:

- Foster cooperation between federal, state and local agencies and partners; and
- Advance a coordinated approach to acquiring landowner support for the implementation of corrective actions that meet the goals of the load reduction allocation scenario.

The recommended framework will contain provisions that address the monitoring of implementation tasks (and their measured success) in the Big Swamp project watershed area, the application of a citizen awareness and education program, and the administration of multiple and concurrent grant and other cost-share programs.

8.2 Selection and Implementation of Corrective Actions

The administration of the load reduction allocation scenario suggests the need for a multi-phased approach to TMDL implementation to meet the applicable water quality standards and support the recreation use classification. The load reduction allocation scenario identifies a primary need for corrective actions that address fecal coliform bacteria loading reductions from direct livestock deposition into the stream, runoff from pasture manure, and failing septic systems. A DHEC sampling program has shown that the concentrations of fecal coliform bacteria are frequently in violation of the state standard at the PD-169 ambient water quality monitoring stations in the Big Swamp project watershed area. The agricultural land use characterization has identified forty-five pastures and noted nearly 150 farm animals in the Big Swamp project watershed area that are potential sources of fecal coliform bacteria loading.

Prioritization of Land Use Activity. As a result of these quantities and widespread locations of potential fecal coliform bacteria loading sources, the targeting and ranking of farm fields for implementation measures is a necessary component to implementation planning. It not only ensures the optimal utilization of implementation revenues, but also facilitates a multi-phased implementation approach where stakeholders can identify and prioritize sets of farm fields for corrective action based on their probability of success and the availability of implementation funds.

Due to the larger quantity of pastures in the lower sections of the Big Swamp project watershed area, and their proximity to the fecal coliform bacteria impaired PD-169 ambient water quality monitoring station, it is recommended that agricultural BMP and conservation practices be applied to fecal coliform bacteria loading sites on pastures in the following Subwatershed areas: Upper Mainstem, Lower Mainstem, and Little Swamp. These Subwatershed areas are located below the PD-168 ambient water quality monitoring station where the fecal coliform bacteria concentrations are not exceeding the state standard. As a consequence, these pastures should be prioritized for immediate implementation. In addition, all straight pipes and failing septic systems found throughout the Big Swamp project watershed area should be addressed immediately.

Second stage BMP and conservation practices implementation is recommended to occur in the upper section of the Big Swamp project watershed area including the Cypress Branch, Big Swamp Branch, and Buck Branch Subwatershed areas because the opportunities to address fecal coliform bacteria from pastures are fewer, the location of these Subwatershed areas is a considerable distance from the impaired PD-169 ambient waters quality station, and the Big Swamp Branch and Buck Branch Subwatershed areas are located above the fecal coliform bacteria compliant PD-168 ambient water quality monitoring station.

Corrective Action Implementation. Once farm fields have been prioritized based on their potential for causing unacceptable loads of fecal coliform bacteria, fundable and site-specific corrective actions will be selected. The South Carolina Department of Natural Resources and the NRCS have jointly developed a handbook of conservation practices applicable to South Carolina farming concerns entitled ***Farming for Clean Water in South Carolina*** (July, 1997). The Handbook provides descriptions of several corrective actions that address various sources of fecal coliform bacteria loading, and the relative costs for the implementation of these respective corrective actions. Corrective actions that are applicable to the direct deposition of farm animal waste into streams include:

- 'Stream protection' that promotes the fencing off buffer zones and managing livestock access to streams;
- 'Stream crossings' which allows livestock to drink and cross streams at designated points; and
- 'Water tanks' and 'Farm Ponds' that provide livestock with alternative sites for drinking water.

To limit fecal coliform bacteria loading from pasture runoff, 'pasture management' and 'runoff management' are recommended by the Handbook where rotational grazing, proper pasture stocking rates, paddock planning based on cutting intervals for forage, methods of keeping feedlots and loafing areas dry, and other grazing techniques that improve water quality are promoted.

Site-specific corrective actions for the sources of fecal coliform bacteria outlined in the load reduction allocation scenario will be made by technical experts following on-site farm field investigations.

8.3 Citizen Awareness and Education

The success of this multi-phased approach to implementation also requires support and acceptance from the landowners, growers, and operators farming in the Big Swamp project watershed area. A citizen awareness and education program is, therefore, suggested to make the local citizenry aware of:

- The human health risks of fecal coliform bacteria impaired water bodies;
- The different sources of fecal coliform bacteria;
- How these sources are contributing to the specific water quality impairment in the project watershed area; and
- The available, voluntary, and often cost-shared corrective actions utilized to minimize fecal coliform bacteria loading into Big Swamp project watershed area.

Outreach plan components may include field days where successful and demonstration corrective actions are endorsed; workshops presenting water quality issues and the benefits of corrective actions; use of agricultural operators willing to share management solutions; partner building with commodity groups to promote conservation; the use of local school districts to take part in water quality sampling or corrective action implementation and construction; and the development of brochures specific to fecal coliform bacteria impairment in the Big Swamp project watershed area. The brochures could be used to facilitate the advancement of project goals at large forums or at one-on-one meetings with landowners, growers, and operators.

A foundation of support for implementation endeavors has been established during the development of this Load Reduction Plan. Local, state, and federal agricultural and environmental agencies have dedicated an interest in the project; and landowners, growers, operators and farming organizations located in the Big Swamp project area will be introduced to the project when the findings are presented at a meeting tentatively scheduled for January/February 2006.

8.4 Continued Water Quality Sampling

It is recommended that DHEC continue their sampling at the PD-169 ambient water quality monitoring site in the Big Swamp project watershed area throughout the implementation stage of the project to:

- Measure progress towards meeting the goals of the load reduction allocation scenario;
- Determine the effectiveness of the load reduction allocation scenario; and
- Allow for implementation flexibility by providing justification for making mid-course changes to the load reduction allocation scenario.

Potential action item tasks associated with the recommended implementation planning strategies are depicted in Table 8-1. Suggested lead organizations and funding sources for each action item task are also listed.

TABLE 8-1 RECOMMENDED IMPLEMENTATION ACTION ITEMS

Action Item	Lead Organization	Potential Funding Source
WATERSHED MANAGEMENT PLANNING AND ADMINISTRATION		
Development of Decision Making Stakeholder Group for Implementation Planning.	Santee-Wateree RC&D Council	EPA Section 319 Program.
Project Management and Coordination of Tasks and Agencies/Organizations in South Carolina.	Santee-Wateree RC&D Council	EPA Section 319 Program.
Identification of Funding Sources, Proposal Development, and Grant Administration.	Santee-Wateree RC&D Council	EPA Section 319 Program.
Continuous Measurement of Project Success and Administration of Mid-Course Changes to Meet Project Goals.	Santee-Wateree RC&D Council	EPA Section 319 Program.
SELECTION AND IMPLEMENTATION OF CORRECTIVE ACTIONS		
Targeting and Prioritizing Farm Fields for Implementation Using GIS Database of Farm Field Information (Criteria for Selection may Include Vicinity to Stream, Soil Types, Slopes, Land Use Practices, etc.).	Florence SWCD with Support from NRCS District Conservationists.	EPA Section 319 Program.
Selection and Implementation of Farm Field Specific Corrective Actions.	Florence SWCD with Support from NRCS District Conservationists and SC Department of Natural Resources (DNR).	EPA Section 319 Program, USDA Conservation Reserve Program (CRP), USDA Environmental Quality Incentives Program (EQIP), USDA Wildlife Habitat Incentives Program (WHIP), USDA Wetland Reserve Program (WRP).
CITIZEN AWARENESS AND EDUCATION		
Public Awareness Effort Targeting Residential Landowners; Including Coordination with the local health department and Clemson Extension Personnel, Advocacy of Constructed Wetlands for Failing Septic Systems, News Articles and Brochures Promoting Septic Pump-out and Other Methods of Homeowner Cooperation.	Santee-Wateree RC&D Council/ SC Department of Natural Resources / SC DHEC	EPA Environmental Education and/or Environmental Justice Grant Programs.
Promotion of Various Voluntary BMP / Conservation Practices to Landowners of Prioritized Farm Fields at One-on-One Meetings.	Florence SWCD with Support from NRCS District Conservationists and SC DNR.	EPA Section 319 Program, USDA Conservation Reserve Program (CRP), USDA Environmental Quality Incentives Program (EQIP), USDA Wildlife Habitat Incentives Program (WHIP), USDA Wetland Reserve Program (WRP).
CONTINUED WATER QUALITY SAMPLING		
Continued Review of Water Quality Information from DHEC Ambient Water Quality Monitoring Stations (PD-168 and PD-169) to Measure Progress.	Santee-Wateree RC&D Council	EPA Section 319 Program.

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APPENDIX A, B & C

APPENDIX A

FECAL COLIFORM CONCENTRATION DATA FROM SCDHEC MONITORING STATION PD-169

Date	Fecal Coliform Concentration (counts/100mL
5/17/1990	680
6/7/1990	150
7/26/1990	330
8/23/1990	130
9/6/1990	80
10/26/1990	120
5/17/1991	110
6/6/1991	50
7/18/1991	700
8/8/1991	90
9/10/1991	27
10/28/1991	200
5/14/1992	390
6/11/1992	170
7/24/1992	330
8/26/1992	120
9/21/1992	320
10/8/1992	200
5/5/1993	200
6/10/1993	170
7/7/1993	290
8/18/1993	270
9/9/1993	20
10/14/1993	280
11/4/1993	90
12/2/1993	70
1/5/1994	140
2/22/1994	90
3/10/1994	140
4/28/1994	45
5/19/1994	45

Date	Fecal Coliform Concentration (counts/100mL
6/29/1994	430
7/7/1994	80
8/10/1994	160
9/7/1994	140
10/17/1994	120
5/15/1995	1200
6/14/1995	290
8/2/1995	610
9/20/1995	250
10/9/1995	160
5/23/1996	75
6/4/1996	160
7/1/1996	120
8/27/1996	180
9/23/1996	70
10/24/1996	70
5/22/1997	53
6/10/1997	250
7/9/1997	300
8/5/1997	400
9/18/1997	300
10/16/1997	440
4/2/1998	48
5/19/1998	130
6/23/1998	200
7/14/1998	430
8/13/1998	600
9/10/1998	120
10/1/1998	300
8/23/1999	80
9/23/1999	210
10/19/1999	350
5/25/2000	130
6/27/2000	74
7/26/2000	300
9/20/2000	350
10/25/2000	100
1/2/2001	80
3/1/2001	130

Date	Fecal Coliform Concentration (counts/100mL
4/18/2001	74
5/22/2001	140
8/2/2001	180
9/10/2001	80
3/4/2002	180
4/4/2002	58
5/20/2002	270
7/8/2002	170
10/30/2002	720
12/16/2002	38
1/7/2003	32
2/4/2003	420
3/26/2003	88
4/2/2003	180
5/13/2003	240
6/19/2003	480
7/2/2003	1200
8/5/2003	370
9/22/2003	960

APPENDIX B

CALCULATIONS OF EXISTING AND ALLOWABLE LOADS AT PD-169

Calculation of Existing Load from Trend Line

Equation of Trend line: $y = 3E+12\ e^{-0.0322x}$

% exceeded from load duration curve	Existing Load (ct/day)
50	6.00E+11
52	5.62E+11
54	5.27E+11
56	4.94E+11
58	4.63E+11
60	4.35E+11
62	4.07E+11
64	3.82E+11
66	3.58E+11
68	3.36E+11
70	3.15E+11
72	2.95E+11
74	2.77E+11
76	2.60E+11
78	2.43E+11
80	2.28E+11
82	2.14E+11
84	2.01E+11
86	1.88E+11
88	1.76E+11
90	1.65E+11
Mean	**3.39E+11**

Existing Load = 3.39×10^{11} counts/day

Calculation of Allowable Load from Trend Line

Equation of Trend Line: $y = 2E+13\ e^{-0.0346x}$

% exceeded from load duration curve	Target MOS load (ct/day) which = LA
50	3.55E+11
52	3.31E+11
54	3.09E+11
56	2.88E+11
58	2.69E+11
60	2.51E+11
62	2.34E+11
64	2.18E+11
66	2.04E+11
68	1.90E+11
70	1.77E+11
72	1.66E+11
74	1.55E+11
76	1.44E+11
78	1.35E+11
80	1.26E+11
82	1.17E+11
84	1.09E+11
86	1.02E+11
88	9.52E+10
90	8.88E+10
Mean	**1.93E+11**

Allowable Load = 1.93×10^{11} counts/day

APPENDIX C

Pamplico Waste Water Treatment Plant NPDES Information
Source: USEPA Envirofacts Database
NPDES Permit SC0021351
(click link for online access)

Pamplico WWTP NPDES Permit SC0021351 Limits for Selected Parameters

Parameter	Max Limit	Maximum Limit Statistical Basis	Average Limit	Average Limit Statistical Basis	Minimum Limit	Units	permit type	date adopted
BOD, 5-DAY (20 DEG. C)	15	Weekly Average	10	Monthly Average	--	mg/L	final	1-Mar-05
BOD, 5-DAY PERCENT REMOVAL	--	--	--	--	65	percent	final	1-Mar-05
Fecal Coliform	400	Daily Max	200	30 Day Geometric Mean	--	count #/100mL	final	1-Mar-05
Flow	0.2	Monthly Mean	0.2	Weekly Mean	--	MGD	final	1-Mar-05
DO	--	--	--	--	6	mg/L	final	1-Mar-05

Monthly Fecal Coliform Record
Pamplico WWTP NPDES Permit SC0021351
17 Total Violations

Monitoring Period End Date	Concentration Maximum (cfu/100ml)	Concentration Mean (cfu/100ml)	Permit Limit Status
30-Jun-05	2200	840	Violation of Permit Limit
31-May-05	2800	< 237	Violation of Permit Limit
30-Apr-05	100	<45	
31-Mar-05	2100	502	Violation of Permit Limit
28-Feb-05	580	373	Violation of Permit Limit
31-Jan-05	440	188	Violation of Permit Limit
31-Dec-04	380	87	
30-Nov-04	< 20	< 20	
31-Oct-04	360	< 85	
30-Sep-04	200	< 64	
31-Aug-04	4600	< 303	Violation of Permit Limit
31-Jul-04	800	473	Violation of Permit Limit
30-Jun-04	2400	< 155	Violation of Permit Limit
31-May-04	2500	2240	Violation of Permit Limit
30-Apr-04	220	< 47	
31-Mar-04	200	118	
29-Feb-04	> 3000	> 1340	Violation of Permit Limit
31-Jan-04	500	< 50	Violation of Permit Limit
31-Dec-03	200	< 64	
30-Nov-03	< 10	< 10	
31-Oct-03	< 20	< 15	
30-Sep-03	2750	< 235	Violation of Permit Limit
31-Aug-03	> 3000	> 3000	Violation of Permit

Monitoring Period End Date	Concentration Maximum (cfu/100ml)	Concentration Mean (cfu/100ml)	Permit Limit Status
			Limit
31-Jul-03	> 3000	> 2598	Violation of Permit Limit
30-Jun-03	> 3000	> 245	Violation of Permit Limit
31-May-03	20	< 20	
30-Apr-03	370	< 43	
31-Mar-03	240	219	Violation of Permit Limit
28-Feb-03	> 3000	> 173	Violation of Permit Limit
31-Jan-03	< 20	< 14	
Max	**4600**	**> 3000**	
Mean*	**1301**	**455**	
Min	**< 10**	**< 10**	

** Mean includes values where '<' or '>' are reported*