Total Maximum Daily Load - Polk Swamp
(Hydrologic Unit Code 030502060203)
Stations E-016 & E-109
Fecal Coliform Bacteria

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Abstract
The Polk Swamp watershed is a tributary of the Edisto River located within Dorchester and Orangeburg counties in the Lower Coastal Plain region of South Carolina (HUC 030502060203). The two SC DHEC ambient water quality monitoring stations within the watershed, E-016 (Polk Swp at Unimp Rd S-18-180 2 Mi S of St George) and E-109 (Polk Swamp at S-18-19) are listed on the 2004 and draft 2006 303(d) list as impaired for recreational uses due to exceeding the fecal coliform standard. The primary land uses in the Polk Swamp watershed are row crops (33%), evergreen forest (21%), woody wetlands (19%), and mixed forest (8%). There is one permitted point source in the watershed, the Town of St. George WWTP (SC0025844). There are 15 permitted animal feeding operation within the watershed. Probable sources of fecal coliform bacteria in the swamp are wildlife, including waterfowl, livestock, application of manure to cropland, and possibly failing septic systems.

The TMDL and existing load for Polk Swamp watershed was developed using the load-duration curve methodology. The TMDL for stations E-016 and E-109 is $2.42*10^{11}$ cfu/day and $3.20*10^{11}$ respectively. To reach the TMDL, existing load must be reduced by 52% for E-016 and 43% for E-109. This can likely be achieved through nonpoint source education and agricultural BMPs.

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1.0 INTRODUCTION

1.1 Background

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 water quality standards. The TMDL process includes estimating pollutant loadings from all sources, linking pollutant sources to their impacts on water quality, allocation of pollutant loads to each source and establishment of control mechanisms to achieve water quality standards (US EPA, 1999). TMDLs are required to be developed for each waterbody and pollutant combination on the State 303(d) list by 40 CFR 130.31(a) (US EPA, 1999).

1.2 Watershed Description

The Polk Swamp watershed is located within Dorchester and Orangeburg counties in the Lower Coastal Plain region of South Carolina. The Polk Swamp watershed is a sub-watershed of the Edisto River Basin represented by the 12-digit hydrologic unit code (HUC) 030502060203 (Figure 1). The watershed encompasses the Town of Reevesville and a portion of the Town of St. George. Polk Swamp is the main waterbody within the HUC. Named tributaries to Polk Swamp within the watershed are Cowtail Creek and Bear Branch. Polk Swamp joins Indian Field Swamp at the outlet of the watershed.

There are two SC DHEC ambient water quality monitoring stations within the watershed, E-016 (Polk Swp at Unimp Rd S-18-180 2 Mi S of St George) and E-109 (Polk Swamp at S-18-19). Each of these stations is listed on the 2004 and draft 2006 303(d) list as impaired for recreational uses due to exceeding the fecal coliform standard (SC DHEC, 2004b).

Figure 1. Location of the Polk Swamp Watershed

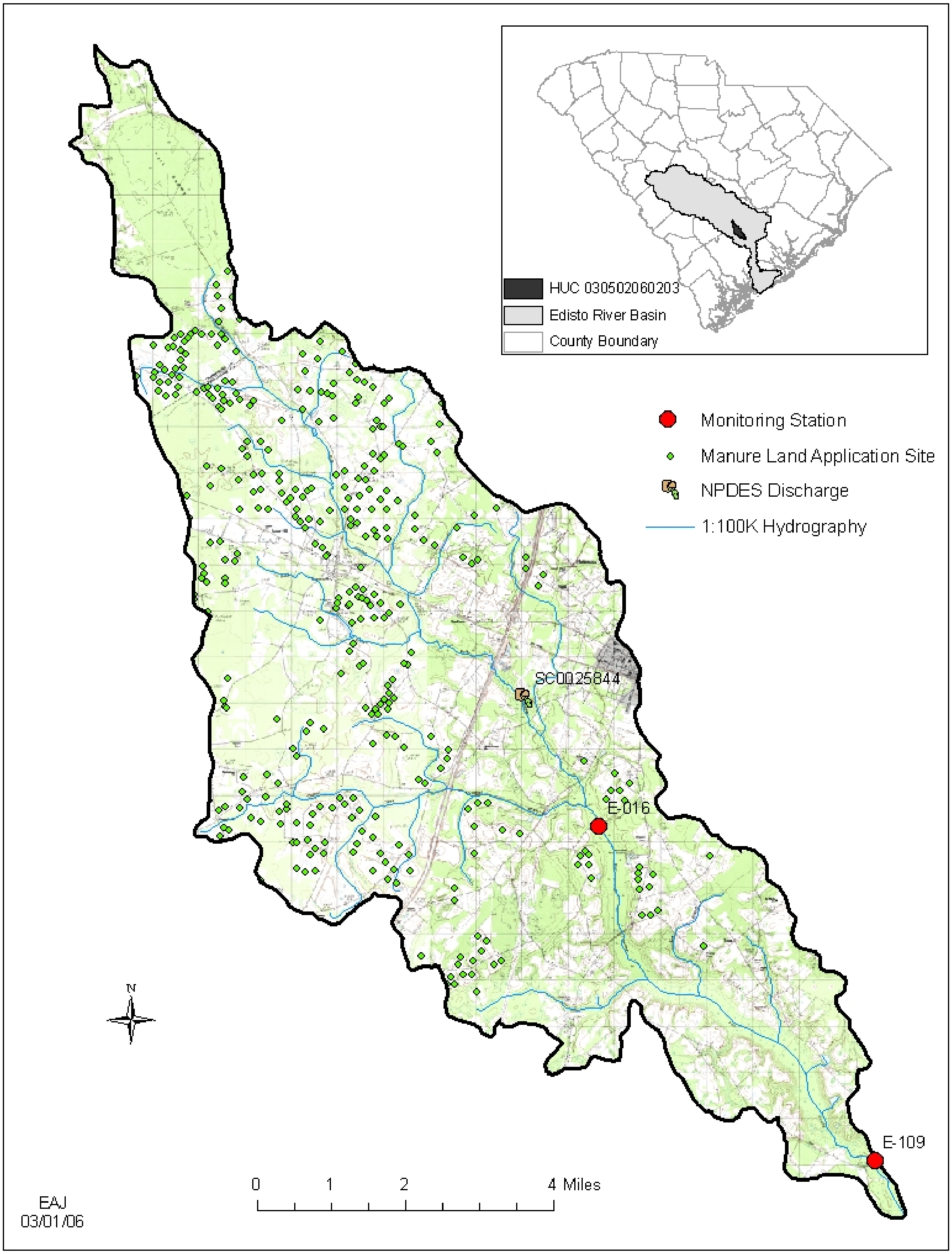
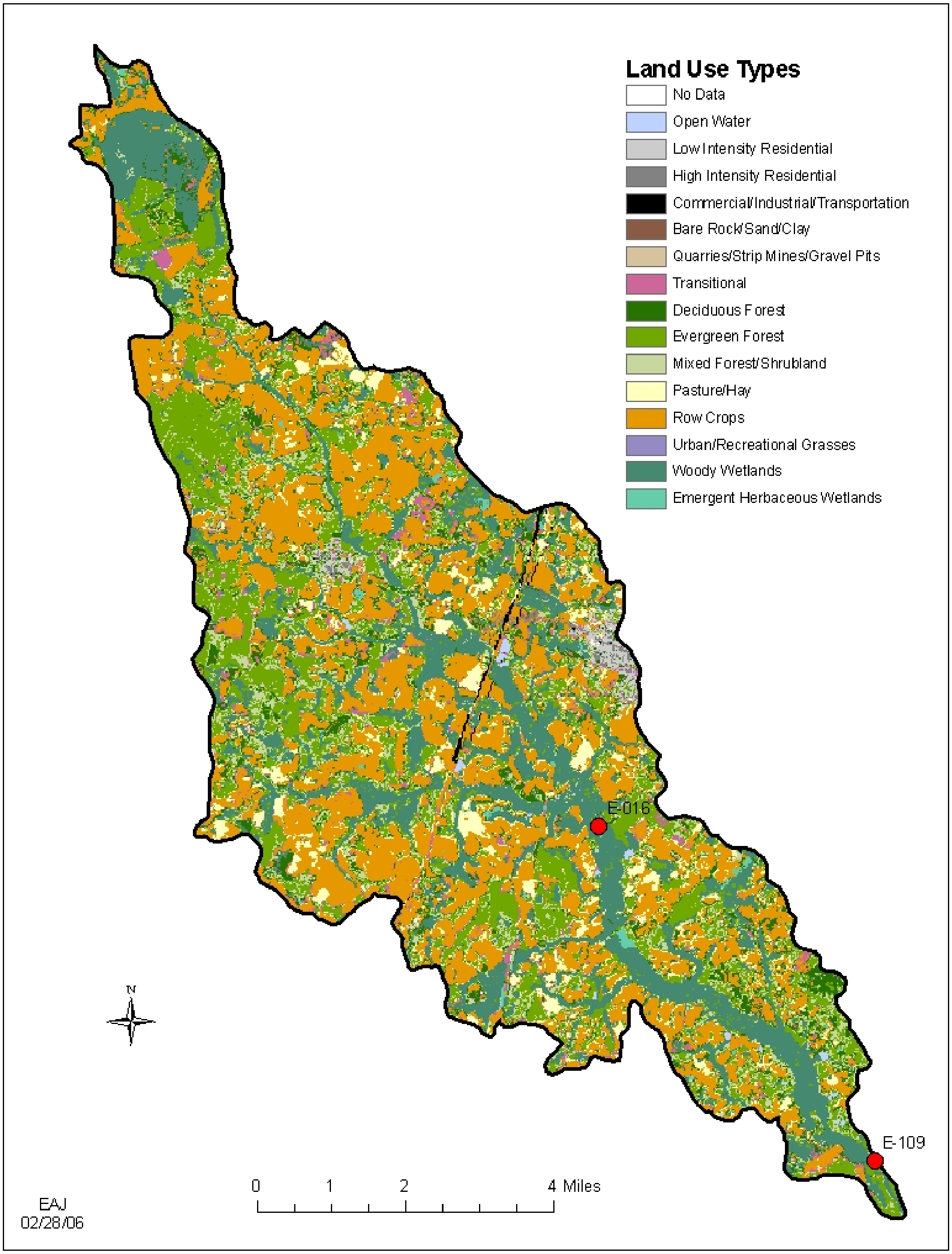


Figure 2. Land Use Within the Polk Swamp Watershed



The primary land use in Polk Swamp watershed is row crops, with about one-third (33%) of the area designated as this land cover by the United States Geological Survey (USGS) 1992 National Land Cover Dataset (NLCD) (Vogelmann, 2001). Other major land uses in the watershed include evergreen forest (21%), woody wetlands (19%), and mixed forest (8%). There is very little urban development in the watershed with less than two percent of the total land area classified within the low intensity residential, high intensity residential and commercial/industrial/transportation categories. Land use percentages are very similar for the drainage area of each of the water quality monitoring stations (Table 1). Station E-109 percentages represent the entire watershed since the station is located at the outlet of the basin (Figure 2).

Table 1. Land Use Summary

Land Use	Station E-109		Station E-016	
	Area (mi^2)	Percent	Area (mi^2)	Percent
Row Crops	19.51	33.00	15.52	34.99
Pasture/Hay	3.30	5.59	2.34	5.28
Total Agricultural	*22.81*	*38.59*	*17.87*	*40.27*
Evergreen Forest	12.14	20.53	9.11	20.53
Mixed Forest	4.98	8.42	3.62	8.17
Deciduous Forest	4.57	7.73	3.36	7.58
Total Forested	*21.68*	*36.68*	*16.09*	*36.28*
Woody Wetlands	11.47	19.41	7.82	17.63
Emergent Herbaceous Wetlands	0.25	0.43	0.14	0.31
Total Wetlands	*0.25*	*0.43*	*0.14*	*0.31*
Low Intensity Residential	0.50	0.84	0.49	1.10
High Intensity Residential	0.22	0.38	0.22	0.50
Commercial/Industrial/Transportation	0.13	0.23	0.13	0.30
Total Developed	*0.85*	*1.45*	*0.84*	*1.90*
Open Water	0.15	0.25	0.08	0.19
Bare Rock/Sand/Clay	0.02	0.03	0.02	0.04
Urban/Recreational Grasses	0.01	0.01	0.01	0.01
Transitional	1.87	3.17	1.50	3.38
Total Other	*2.05*	*3.46*	*1.60*	*3.62*

1.3 Water Quality Standard

Water quality standards are based on the classification of the waterbody and are designed to protect the designated uses of that classification. Polk Swamp is designated as Freshwaters (FW) by R.61-69, Classified Waters (SC DHEC, 2004a). Freshwaters are defined as:

> "freshwaters suitable for primary and secondary contact recreation and as a source for drinking water supply after conventional treatment in accordance with the requirements for 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" (SC DHEC, 2004c pg. 25).

The fecal coliform standard for FW includes a geometric mean and a single sample standard. The geometric mean standard is 200cfu/100mL, based on five consecutive samples during any 30 day period. The single sample standard is no more than 10% of samples in any 30-day period exceeding 400cfu/100mL (SC DHEC, 2004c).

2.0 WATER QUALITY ASSESSMENT

The Polk Swamp monitoring stations have been on the 303(d) list for non-attainment of recreational use due to fecal coliform since 1998 (SC DHEC, 1998, 2000, 2002, 2004b). As of this drafting, these stations are also listed on the draft 2006 303(d) list (SC DHEC, 2006). Water quality at both stations does seem to be improving, as there has been a decreasing trend in the percentage of fecal coliform sample exceedances for each 303(d) list data set since the original 1998 listing (Table 2). Fecal coliform sample data is available in Appendix A. Fecal coliform was not found to be correlated with precipitation or turbidity (Appendix B).

Table 2. Percent Exceedances for 1998-2006 303(d) List

303(d) List Year	Time Period Included	% Samples Exceeding Standard (400 cfu/100mL)	
		E-016	E-109
1998	1992-1996	38%	38%
2000	1994-1998	46%	29%
2002	1996-2000	35%	29%
2004	1998-2002	27%	17%
2006	2000-2004	17%	19%

3.0 SOURCE ASSESSMENT AND LOAD ALLOCATION

3.1 Point Sources

There is one permitted discharger within the Polk Swamp watershed, the Town of St. George Wastewater Treatment Plant, SC0025844, which is upstream of both monitoring stations (Figure 1). The current NPDES permit for St. George allows a monthly average discharge of 0.8 MGD into Polk Swamp. Their fecal coliform limit is 200 cfu/100mL monthly average with a daily maximum of 400 cfu/100mL. The Town is required to take grab samples of the effluent twice per week for compliance and report this data to SC DHEC monthly on their discharge monitoring report. Since January 1989, there have been 6 violations of the fecal coliform standard. The last violation occurred in September 1999. Reported fecal coliform values have been very low since 2000, with most counts being less than 1 cfu/100mL. The greatest single sample maximum since 2000 has been 36 cfu/100mL (Appendix C). Since the Town has consistently met permit limits since late 1999, it is very unlikely that they are significantly contributing to the fecal coliform problem. As long as the Town continues to meet permit limit they are not considered to be a source of impairment to the watershed.

3.2 Nonpoint Sources

3.2.1 Wildlife

Wildlife can be a significant source of fecal matter, and therefore fecal coliform. As this is a rural watershed, it is very likely that a large wildlife population exists. A field survey was conducted on March 9, 2006. As seen during the survey, there are large wooded areas surrounding the main channels of the waterbody. There is also ample suitable habitat for water birds. Waterfowl are a "direct" nonpoint source as they defecate directly into the waterbody (US EPA, 2001). In the upper reaches of the stream there is evidence of beaver activity. A large beaver population was also confirmed by staff at the St. George WWTP. Beaver can be a significant source of the protozoan *Giardia* (US EPA, 2001). The only wildlife seen during the survey was a large group of vultures at station E-016 and a dead mammal, possibly a deer, beside the bridge at E-109. The survey was conducted mainly roadside, so it is likely there was much more wildlife activity than observed. The Department of Natural Resources deer density map estimates 30-45 deer/mi^2 in this area (SC DNR, 2000). It is very likely that there is a large deer population due to the characteristics of the area. Deer feces can be a large contributor of the parasite *Cryptosporidium* (US EPA, 2001). Although wildlife is possibly a source in the watershed, any control of the source would be difficult to implement and not likely to have the desired results.

3.2.2 Agriculture/Livestock

Agriculture is a major component of the Polk Swamp watershed, as can be seen by land use (Table 1, Figure 2). Animal feeding operations are also prevalent in the watershed. While there are currently no confined animal feeding operations (CAFOs) in South Carolina, there are fifteen permitted animal feeding operations (AFOs) within the watershed, which apply manure to over 350 fields, or manure utilization units, within the watershed (Figure 1). Fourteen of these permits are for poultry with a total design capacity of over 127, 000 birds. The manure from these operations is applied by dry spreader to approximately 3,735 acres of cropland. The remaining permit is for a medium size (1280 hog design capacity) swine feeding operation. The manure from this facility is applied by spray irrigation to approximately 49 acres of land. Pasture cattle facilities are not permitted by SC DHEC, but according to the 2002 Census of Agriculture, there are a total of 21,045 cattle and calves in Dorchester and Orangeburg counties as a whole (NASS, 2002). Assuming that cattle are evenly distributed across the pasture land in each county, an estimate of the number of cattle in the watershed can be obtained by comparing the area of pasture/hay land use of each county to the portion of that county within the HUC. This method gives a total of 1,269 cattle within the watershed.

A large number of farmed fields were seen during the field survey. Many of these fields are in close proximity to creeks or roadside ditches that feed into the swamp. Several pasture fields with horses or cattle were also observed. Due to the expansive nature of the swamp, with many tributaries, it is very possible that cattle may have direct access to Polk Swamp or its tributaries. Defecation directly into a waterbody by cattle can be a very significant source of fecal coliform bacteria as a single beef or dairy cow can produce $1.0*10^{11}$ organisms/day (ASAE, 1998). In an assessment of a similar watershed, Linville Creek in Virginia, cattle directly defecating in streams were found to contribute nearly 45% of the mean daily bacterial concentration in the stream (Benham, 2005).

3.2.3 Failing Septic Systems

Failed septic tanks can contribute to bacterial contamination of downstream waterbodies (US EPA, 2001). A rough estimate of the population and number of households with septic systems was derived by comparing the GIS coverage of sewage lines with the 2000 census block coverage. Census blocks within the watershed that were intersected by sewer lines were considered to be on public sewer. All other blocks were considered to have private septic systems. Using this method, about 34% of the total population within the watershed is served by public sewer. The remaining 66% of the population, approximately 1, 190 households have private septic tanks. Most of the homes seen during the watershed survey were older indicating that septic tank failure could be a possible source of fecal coliform bacteria.

3.2.4 Urban Runoff

Urban and suburban stormwater runoff from streets, parking lots and lawns can contribute large bacterial load to receiving waters (Gaffield, 2003). However, there is very little urban development within the watershed. The Town of Reevesville and a portion of St. George are the only urbanized areas within the watershed. The municipalities are not currently under MS4 coverage. Total developed land within the watershed is less than 2% of the total area (Vogelmann, 2001). Due to the small size of the urban area, loading from this source is most likely insignificant.

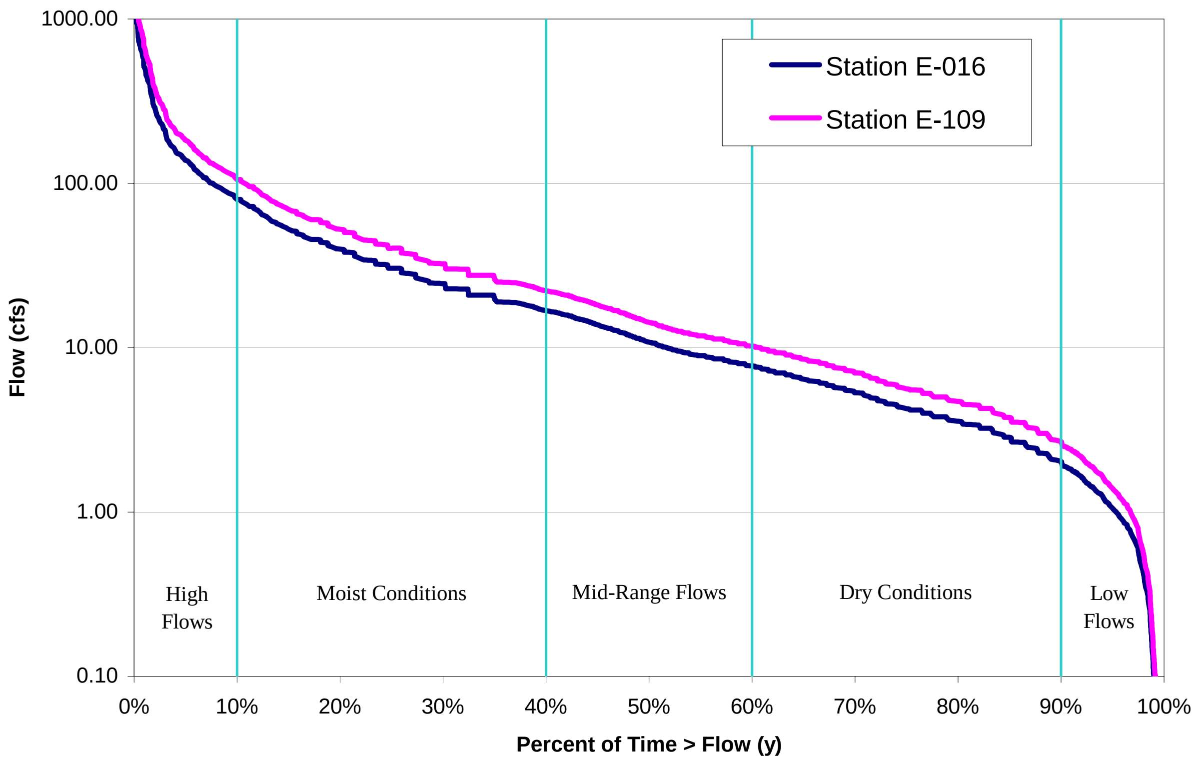
4.0 METHODS

The TMDL for Polk Swamp watershed was developed using the load-duration curve methodology. This method combines a flow-duration curve with pollutant loadings to determine the maximum loading allowed by standards and the percent reduction in existing load required to meet those standards. This method has been successfully used by SC DHEC to develop numerous US EPA approved fecal coliform TMDLs for various watersheds (SC DHEC, n.d.). This methodology has also successfully been used by other states such as Kansas, Nevada and Mississippi (Cleland, 2003; NDEP, 2003; MDEQ, 2002).

4.1 Flow-Duration Curve

The first step in the load-duration methodology is the development of a flow-duration curve. Flow-duration curves are used for a variety of management purposes including water-use planning and characterization of erosion and sedimentation problems (Fan and Li, 2004). Flow-duration curves provide a graphic representation of the cumulative frequency of historic flow data over a time period (Cleland, 2003). Flow-duration curves are typically generated from long-term continuous-record flow-gauging USGS stations. There is not a USGS gauge within the Polk Swamp watershed. The closest gauge is USGS 02174250, Cow Castle Creek near Bowman. This station was used as the basis for development of the flow-duration curves for Polk Swamp because it is near the watershed, located within the same ecoregion (lower coastal plain) and has similar land cover characteristics. This station is not ideal because it is located in a creek instead of a swamp, but it is the best data available. Curves were developed for each of the monitoring stations. Daily mean streamflow data for the period of record was retrieved from http://sc.water.usgs.gov/. This provisional data for 10/01/2003 through 12/31/2004, which was not available on the website, was requested and received from Mr. Whitney Stringfield with the Columbia USGS office. The period of 01/01/1995 through 12/31/2004 was used in this analysis, due to a gap in the data prior to 1995. This period should provide an adequate and relevant record of flows. Daily flow data was adjusted for each site to account for the difference in drainage area. Daily flow was multiplied by the ratio of the gauge to the site drainage area. The flow-duration curve points are found by ranking the daily flow from highest to lowest and calculating the percent of days these flows were exceeded (NDEP, 2003). These calculations were performed in Excel ® using the Rank and Percentile functions. These points are plotted on a semi-log plot with flow on the y-axis and percent on the x-axis to form the curve. Low values of x correspond to the highest flows or flood conditions (flows rarely exceed these values) and high values correspond to the lowest flows, which are nearly always exceeded (drought conditions) (Cleland, 2002). Due to using the same gauge for each station, the resulting curves are of the same shape but station E-109 has slightly higher flows due to a larger drainage area (Figure 3).

Figure 3. Flow-Duration Curve



4.2 Load-Duration Curve

After development of the flow-duration curves, load-duration curves are created by combining flow duration data with water quality data (Cleland, 2002). Points for this plot are calculated by multiplying daily stream flows by the water quality standard concentration and a conversion factor to get daily load (NDEP, 2003). These values were calculated at 5% flow intervals from 5%-95% and plotted on semi-log scale with y being the daily load of fecal coliform and x being the percent of time the flow is exceeded and hence the percent of time the load is exceeded. Curves were calculated for each monitoring station using the instantaneous water quality standard with a 5% margin of safety, which equals 380 cfu/100mL (Figures 4&5).

Figure 4. Station E-016 Load-Duration Curve

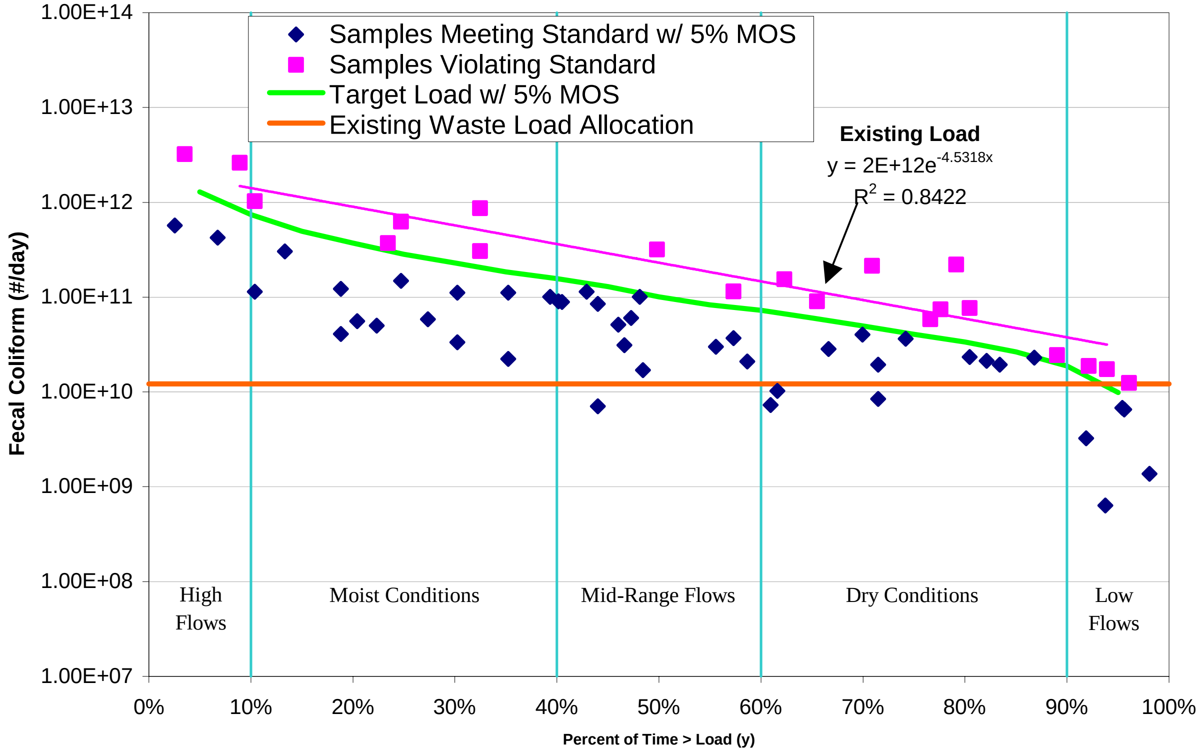
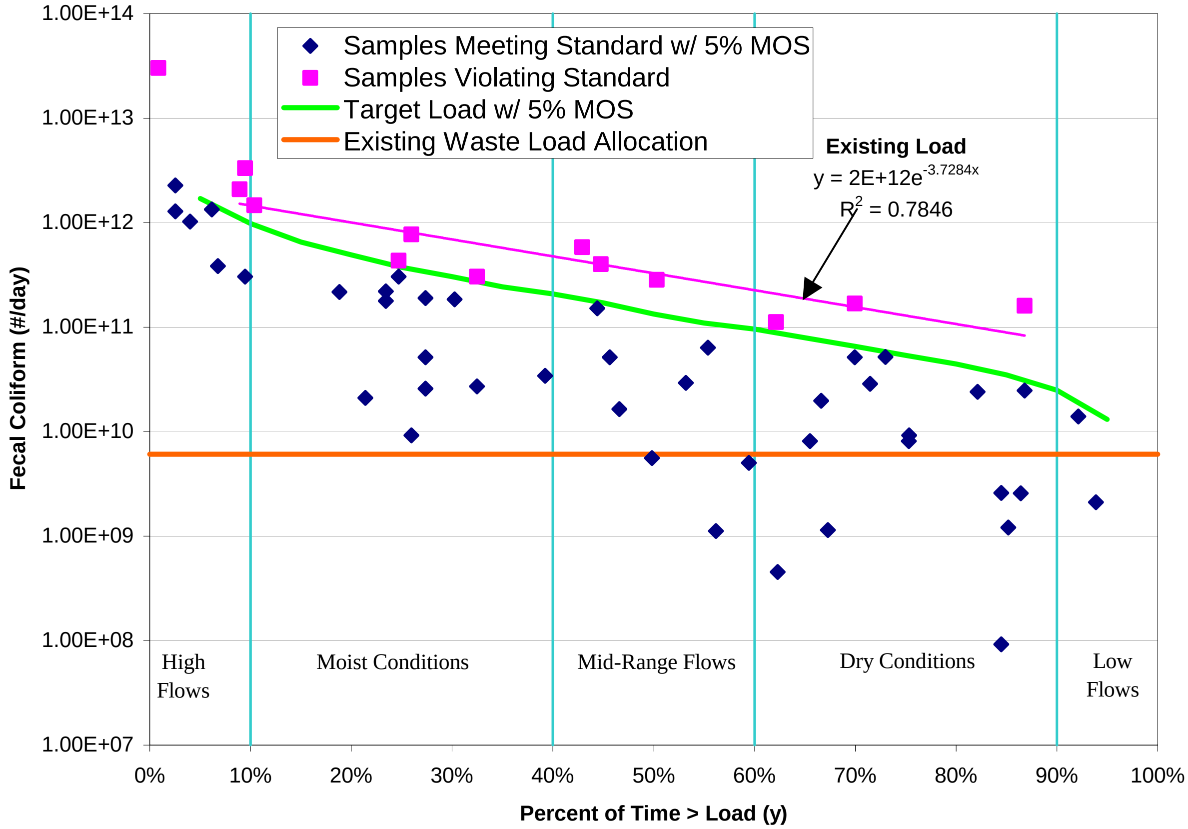


Figure 5. Station E-109 Load-Duration Curve



4.3 Existing Load Calculation

To calculate the average existing load for development of the TMDL, the water quality sample values are plotted on the load-duration curves. Water quality monitoring data from 1996-2004 is used for calculation of this fecal coliform TMDL. This time period results in roughly the same number of samples for each site (Table 3) and is a good representation of recent water quality. Data used in TMDL development is listed in Appendix A.

Table 3. Water Quality Sample Summary

Station	# Samples	Exceeds Standard	Average (cfu/100mL)	Maximum (cfu/100mL)	Minimum (cfu/100mL)
E-016	59	22 %	303	2000	0
E-109	66	32 %	596	14000	0

Daily loads for each water quality sample were calculated by multiplying the sample concentration by the flow on that date and the conversion factor. The flows used for this calculation are those calculated for the flow-duration curve. Flows were not recorded during sample collection. Again, this is not ideal, but it is the best data available. Daily loads are then plotted on the load-duration curve with y being the sample load and x being the percentile corresponding to that day's flow. A line is then fit through the sample loads that exceed the margin of safety standard, in this case an exponential function was used (Figures 4&5).

5.0 DEVELOPMENT OF TMDL

5.1 Critical Conditions

Critical conditions are the "worst-case" environmental conditions for exceedance of water quality standards and which occur at an acceptable frequency (US EPA, 1999). Load-duration curves allow for visualization of critical conditions. If high samples values are mainly confined to a specific flow range, the critical conditions for establishing the TMDL can be targeted to that flow range. This information can also be used to target potential sources. For example exceedances that occur at low flows could indicate point source contributions, while exceedances at higher flows would be more indicative of non-point sources (Cleland, 2003). In this case, high fecal coliform concentrations are seen across most of the range of flows. There are no exceedances in the low flow category for station E-109, but this may be due to lack of sufficient sampling data at low flows. Critical conditions for this TMDL are taken to be the flow range between the 5th and 95th percentile, incorporating all but the most extreme flows. This is considered appropriate because the standards are based on not more than 10% exceedance and loading occurring at extreme flows is unlikely to be controllable. Seasonal variation is taken into account since all but the most extreme flows are represented in the calculations.

5.2 Wasteload Allocation

The wasteload allocation (WLA) is the portion of the TMDL allocated to point sources (US EPA, 1999). A portion of the loading capacity of Polk Swamp is allocated to the wasteload for the Town of St. George. The current NPDES permit for the Town (issued 11/29/04) allows for a discharge of 0.8 MGD with 200 cfu/100mL monthly average and 400 cfu/100mL daily maximum fecal coliform concentrations. Since the Town has historically discharged a much lower concentration of fecal coliform than allowed by permit, the ambient water quality samples do not fully represent the loading which could occur if St. George were to operate near or at their permit limits. In order to be conservative and fully account for this source, the daily maximum load (0.8 MGD at 400 cfu/100mL or $1.21*10^{10}$ cfu/day) was considered as the WLA for station E-016. Half of that load, $6.06*10^{9}$ cfu/day, was considered the WLA for station E-109.

5.3 Existing Load

The line fit to the exceedance data is used to calculate existing load. The equation of the fitted line is applied to the 5% intervals of the 5th to 95th percentile flows and the resultant loads averaged to determine an average load at critical conditions (Appendix D). For station E-016, this load is $4.54*10^{11}$ cfu/day. The average load for station E-109 is $5.27*10^{11}$ cfu/day (Table 4).

5.4 Margin of Safety

A margin of safety (MOS) allows for an accounting of the uncertainty in the relationship between pollutant loads and receiving water quality (US EPA, 1999). Incorporation of a MOS can be done either explicitly within the TMDL calculation or implicitly by using conservative assumptions (US EPA, 1999). The margin of safety component of the TMDL for Polk Swamp is calculated explicitly. Five percent or 20 cfu/100mL of the water quality standard (400 cfu/100mL) is reserved in the TMDL calculation as a margin of safety. Again loads were calculated for the 5th to 95th percentile and averaged (Appendix D). For station E-016 this concentration results in an average load of $1.21*10^{10}$ cfu/day. For station E-109 the margin of safety load is $1.60*10^{10}$ cfu/day (Table 4). Conservative assumptions in the modeling process also contribute to the margin of safety.

5.5 Calculation of the TMDL

A TMDL represents the loading capacity (LC) of a waterbody, which is the maximum loading a waterbody can receive without exceeding water quality standards (US EPA, 1999). The TMDL is the sum of the wasteload allocations (WLA) for point sources, the load allocation (LA) for non-point sources and natural background, and a margin of safety (MOS). The TMDL can be represented by the equation:

$$\text{TMDL} = \text{LC} = \text{WLA} + \text{LA} + \text{MOS}$$ (US EPA, 2001).

The LC for each station was calculated as the water quality standard concentration, converted to load and averaged over the 5th to 95th percentile flows (Appendix D). This gives a loading capacity of $2.42*10^{11}$ cfu/day for station E-016 and $3.20*10^{11}$ cfu/day for E-109. Since the existing load for each of the stations is greater than the calculated loading capacity or TMDL, a reduction in existing loading is required to meet water quality standards. Percent reduction is calculated as:

$$\frac{\text{Existing Load - Allowable Load Allocation}}{\text{Existing Load}} * 100 .$$

This calculation results in a 52% load reduction for station E-016 and a 43% load reduction for station E-109 to consistently meet the instantaneous water quality criteria for fecal coliform. By meeting the instantaneous standard it is assumed the geometric mean criteria will also be consistently met.

Table 4. TMDL Components for Polk Swamp

Station	TMDL (cfu/day)	-	Margin of Safety (cfu/day)	-	Wasteload Allocation (cfu/day)	=	Available Load Allocation (cfu/day)	Existing Load (cfu/day)	Percent Reduction to Meet Load Allocation
E-016	$2.42*10^{11}$	-	$1.21*10^{10}$	-	$1.21*10^{10}$	=	$2.18*10^{11}$	$4.54*10^{11}$	52 %
E-109	$3.20*10^{11}$	-	$1.60*10^{10}$	-	$6.06*10^{9}$	=	$2.98*10^{11}$	$5.27*10^{11}$	43 %

6.0 IMPLEMENTATION

As discussed in the Implementation Plan for Achieving Total Maximum Daily Load Reductions From Nonpoint Sources for the State of South Carolina (SC DHEC, 1998), South Carolina has several tools available for implementing this nonpoint source TMDL. Specifically, SC DHEC's animal agriculture permitting program addresses animal operations and land application of animal wastes. There are also a number of voluntary measures available to interested parties. SC DHEC will work with the existing agencies in the area to provide nonpoint source education in the Cattle Creek Watershed. Local sources of nonpoint source education and assistance include Clemson Extension Service, the Natural Resource Conservation Service (NRCS), the Orangeburg and Dorchester County Soil and Water Conservation Services, and the South Carolina Department of Natural Resources. 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 agricultural nonpoint source problems. NRCS can provide cost share money to land owners installing BMPs.

SC DHEC is empowered under the State Pollution Control Act to perform investigations of and pursue enforcement for activities and conditions which threaten the quality of waters of the state. In addition, other interested parties (universities, local watershed groups, etc.) may apply for section 319 grants to install BMPs that will reduce fecal coliform loading to Polk Swamp. TMDL implementation projects are given highest priority for 319 funding.

In addition to the resources cited above for the implementation of this TMDL in the Polk Swamp watershed, Clemson Extension has developed a Home-A-Syst handbook that can help urban or rural homeowners reduce sources of NPS pollution on their property. This document guides homeowners through a self-assessment, including information on proper maintenance practices for septic tanks. SC DHEC also employs a nonpoint source educator who can assist with distribution of these tools as well as provide additional BMP information.

Using existing authorities and voluntary mechanisms, these measures will be implemented in the Polk Swamp watershed in order to bring about an approximate 50% reduction in fecal coliform bacteria loading to Polk Swamp. SC DHEC will continue to monitor, according to the basin monitoring schedule, the effectiveness of implementation measures and evaluate stream water quality as the implementation strategy progresses.

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APPENDIX A – WATER QUALITY DATA, 1996-2004

Station E-016		Station E-109	
Sample Date	Fecal Coliform (cfu/100mL)	Sample Date	Fecal Coliform (cfu/100mL)
01/11/96	120	11/14/96	230
05/02/96	210	12/04/96	980
06/20/96	1700	01/16/97	450
07/23/96	580	03/06/97	220
08/14/96	1200	04/03/97	40
09/24/96	140	05/01/97	210
10/31/96	80	06/19/97	1200
11/14/96	270	07/22/97	40
12/04/96	310	08/19/97	310
01/16/97	600	09/02/97	270
02/06/97	350	10/07/97	100
03/06/97	90	11/03/97	310
04/03/97	100	12/01/97	720
05/01/97	470	01/12/98	110
06/19/97	310	02/03/98	300
07/22/97	590	03/19/98	1600
08/19/97	380	04/02/98	160
09/02/97	480	01/30/01	40
10/07/97	190	02/22/01	200
11/03/97	840	03/13/01	1200
12/01/97	1200	06/07/01	300
01/12/98	160	07/23/01	120
02/03/98	100	08/15/01	16
03/19/98	14000*	09/13/01	0
04/02/98	40	10/16/01	68
05/04/98	540	11/01/01	20
06/25/98	2500	12/10/01	2
07/20/98	800	01/31/02	1
08/06/98	20	03/20/02	6
09/29/98	920	04/01/02	30
10/06/98	260	05/01/02	28
11/04/98	480	06/26/02	0
12/01/98	340	09/17/02	2000
01/21/99	220	10/21/02	60
02/25/99	240	11/18/02	580
03/17/99	240	12/03/02	0
07/08/99	180	01/29/03	61
08/04/99	280	03/27/03	110
09/02/99	560	04/24/03	18

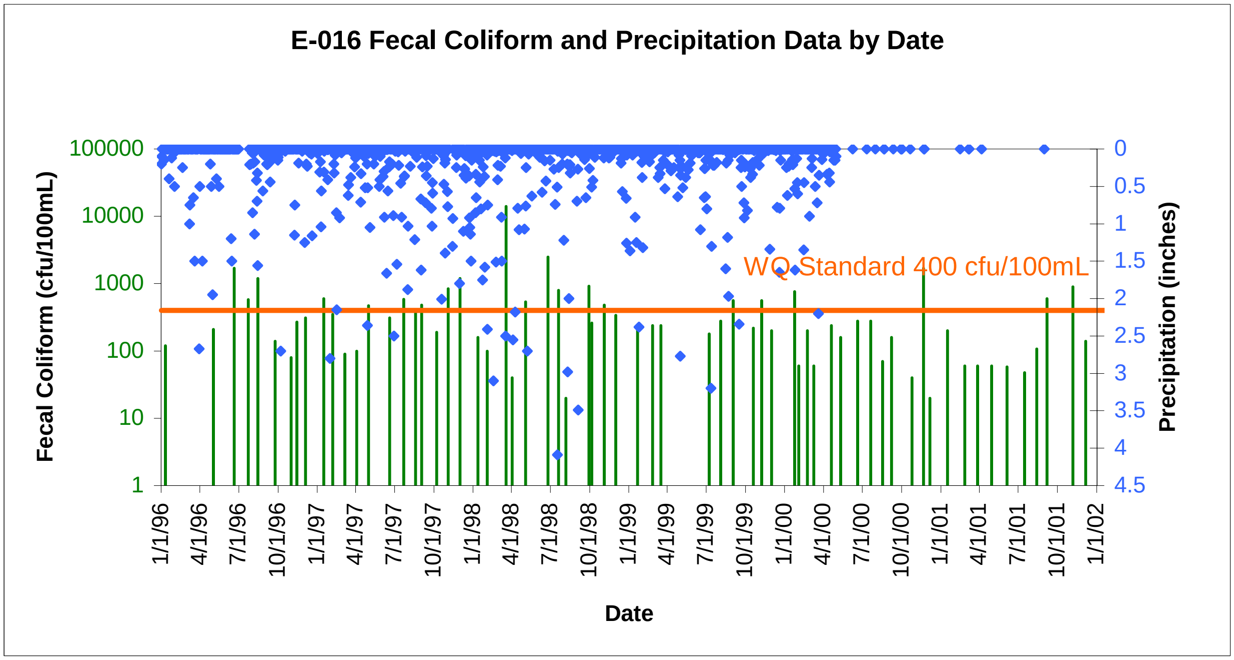
Continued Station E-016	
Sample Date	**Fecal Coliform (cfu/100mL)**
10/19/99	220
11/08/99	560
12/01/99	200
01/24/00	760
02/03/00	60
02/23/00	200
03/09/00	60
04/19/00	240
05/11/00	160
06/20/00	280
07/20/00	280
08/17/00	70
09/07/00	160
10/25/00	40
11/21/00	1700
12/06/00	20
01/16/01	200
02/26/01	60
03/28/01	60
04/30/01	60
06/05/01	58
07/16/01	48
08/13/01	107
09/06/01	600
10/03/01	0
11/06/01	900
12/06/01	140

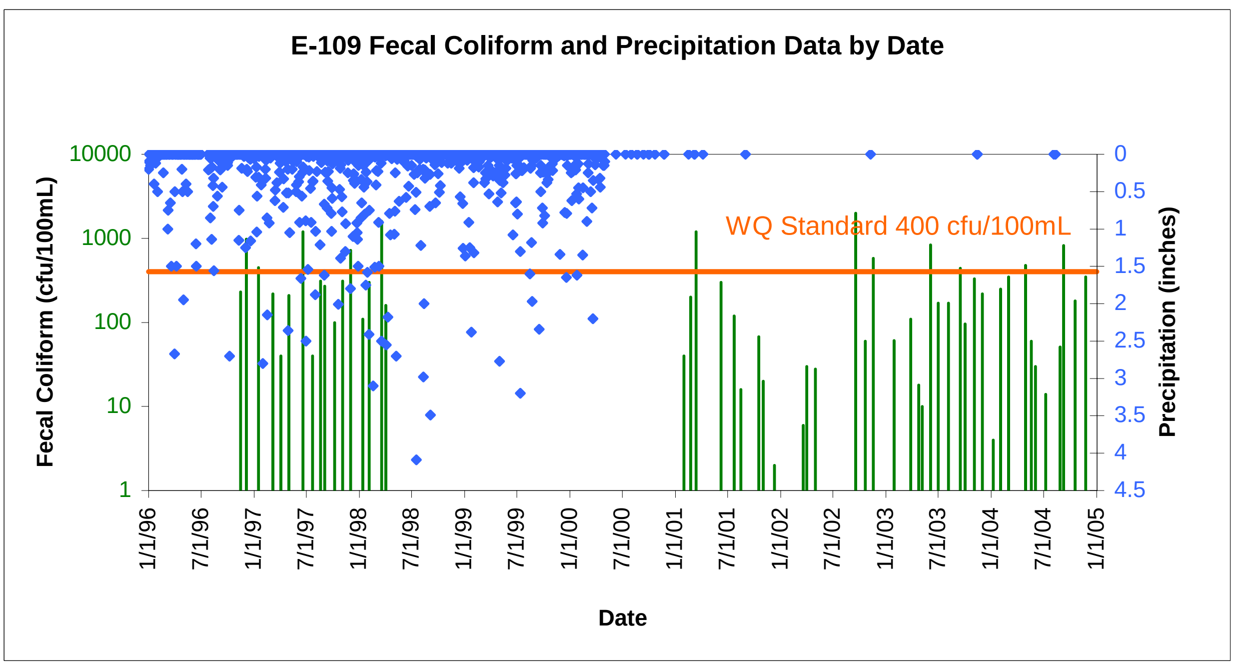
Continued Station E-109	
Sample Date	**Fecal Coliform (cfu/100mL)**
05/06/03	10
06/04/03	840
07/01/03	170
08/05/03	170
09/15/03	440
10/02/03	96
11/03/03	330
12/01/03	220
01/08/04	4
02/02/04	250
03/01/04	350
04/28/04	480
05/18/04	60
06/02/04	30
07/07/04	14
08/26/04	51
09/07/04	820
10/18/04	180
11/23/04	350
12/28/04	890

* The 3/19/98 sample for station E-016 was not included in calculations due to being an outlier and possibly in error.

APPENDIX B – FECAL COLIFORM VERSUS PRECIPITATION AND TURBIDITY

Pearson Correlation Coefficients of Fecal Coliform versus Rain and Turbidity			
		E-016 Fecal Coliform	E-109 Fecal Coliform
Rain (inches)	R	-0.02	-0.04
	p-value	0.89	0.89
Turbidity (ntu)	R	0.13	-0.11
	p-value	0.30	0.41





APPENDIX C – DMR DATA, TOWN OF ST. GEORGE

Report Date	Average Fecal Coliform Concentration (cfu/100mL)	Maximum Fecal Coliform Concentration (cfu/100mL)	Average Flow (MGD)	Maximum Flow (MGD)
01/31/96	< 50	< 50	0.77	1.15
02/29/96	< 50	< 50	0.78	1.21
03/31/96	< 50	< 50	0.29	0.57
04/30/96	< 50	< 50	0.51	1.01
05/31/96	< 50	< 50	0.41	0.66
06/30/96	< 50	< 50	0.35	0.41
07/31/96	< 50	< 50	0.35	0.57
08/31/96	< 50	< 50	0.4	0.57
09/30/96	< 50	< 50	0.33	0.51
10/31/96	< 42	< 50	0.32	0.55
11/30/96	< 262	2500	0.26	0.33
12/31/96	< 50	< 50	0.41	0.54
01/31/97	< 50	< 50	0.55	0.97
02/28/97	< 50	< 50	0.87	0.97
03/31/97	< 50	< 50	0.68	0.86
04/30/97	< 125	500	0.69	5.15
05/31/97	< 50	< 50	0.57	0.85
06/30/97	< 50	< 50	0.58	0.89
07/31/97	< 50	50	0.61	1
08/31/97	< 50	650	0.45	0.56
09/30/97	< 50	< 50	0.39	0.63
10/31/97	< 50	< 50	0.53	0.85
11/30/97	< 50	< 50	0.77	1.08
12/31/97	< 50	< 50	0.94	1.14
01/31/98	< 50	< 50	0.98	1.2
02/28/98	< 50	< 50	1.01	1.11
03/31/98	50	50	0.99	1.1
04/30/98	56	1370	0.99	1.13
05/31/98	160	410	0.79	1.1
06/30/98	10	10	0.5	0.816
07/31/98	14.6	70	0.4	0.6
08/31/98	17.3	90	0.4	0.5
09/30/98	15	70	0.4	0.809
11/30/98	< 10	< 10	0.3	0.329
12/31/98	< 10	< 10	0.3	0.547
01/31/99	11.6	20	0.5	0.922

02/28/99	10	10	0.716	1.035
03/31/99	10	10	0.531	0.584
04/30/99	< 10	< 10	0.453	0.55
05/31/99	14.2	40	0.648	1.005
06/30/99	17	150	0.426	0.725
07/31/99	37	160	0.602	0.926
08/31/99	10	10	0.509	0.988
09/30/99	40	1030	0.512	0.878
10/31/99	< 10	< 10	0.8	0.992
11/30/99	< 10	< 10	0.579	0.719
12/31/99	< 10	< 10	0.619	0.868
01/31/00	< 10	< 10	0.739	1.116
02/29/00	< 2	< 2	0.85	1.127
03/31/00	< 2	< 2	0.74	1.081
04/30/00	< 2	< 2	0.633	0.798
05/31/00	< 2	< 2	0.414	0.69
06/30/00	2	2	0.346	0.568
07/31/00	2	2	0.5194	1.09
08/31/00	3.16	20	0.554	0.717
09/30/00	< 2	< 2	0.632	0.789
10/31/00	< 2	< 2	0.493	0.597
11/30/00	< 2	< 2	0.43	0.694
12/31/00	< 2	< 2	0.558	0.795
01/31/01	< 2	< 2	0.7	0.8
02/28/01	< 2	< 2	0.68	1.15
03/31/01	< 2	< 2	0.93	1.13
04/30/01	2	2	0.68	1.13
05/31/01	< 2	< 2	0.43	0.6
06/30/01	< 1	< 2	0.388	0.6
07/31/01	2	8	0.42	0.66
08/31/01	1	1	0.36	0.47
09/30/01	2	2	0.36	0.59
10/31/01	1	< 2	0.34	0.37
11/30/01	< 1	< 1	0.28	0.31
12/31/01	< 1	< 1	0.276	0.27
01/31/02	< 1	< 1	0.3	0.31
02/28/02	< 1	< 1	0.372	0.414
03/31/02	< 1	< 1	0.47	0.51
04/30/02	< 1	< 1	0.485	0.573
05/31/02	1	1	0.421	0.53
06/30/02	< 1	< 1	0.334	0.366
07/31/02	< 1	< 1	0.335	0.366

08/31/02	< 1	< 1	0.411	0.611
09/30/02	< 1	< 1	0.8	0.87
10/31/02	< 1	< 1	0.89	1.01
11/30/02	< 1	< 1	0.87	0.98
12/31/02	< 1	< 1	0.8	0.95
01/31/03	< 1	< 1	0.7	0.84
02/28/03	< 1	< 1	0.68	0.78
03/31/03	3	5	0.95	0.97
04/30/03	4.6	36	0.93	0.99
05/31/03	4.95	30	0.7616	0.899
06/30/03	< 1	< 1	0.85	0.92
07/31/03	< 1	< 1	0.84	0.8
08/31/03	< 1	< 1	0.92	0.96
09/30/03	1	1	0.81	0.99
10/31/03	< 1	< 1	0.55	0.59
11/30/03	< 1	< 1	0.61	0.75
12/31/03	< 1	< 1	0.65	0.73
01/31/04	< 1	< 1	0.6	0.67
02/29/04	< 1	< 1	0.93	1.01
03/31/04	< 1	< 1	0.776	0.97
04/30/04	< 1	< 1	0.54	0.58
05/31/04	< 1	< 1	0.468	0.513
06/30/04	2	2	0.41	0.43
07/31/04	< 1	< 1	0.42	0.5
08/31/04	3.8	11	0.496	0.574
09/30/04	< 1	< 1	0.581	0.72
10/31/04	< 1	< 1	0.65	0.75
11/30/04	< 1	< 1	0.48	0.51
12/31/04	< 1	< 1	0.518	0.573

APPENDIX D – LOADING CALCULATIONS

Station E-016

Loading Capacity	
Target: 400 cfu/100ml	
% Exceeded	Load
5%	1.36E+12
10%	7.81E+11
15%	5.21E+11
20%	3.90E+11
25%	2.98E+11
30%	2.42E+11
35%	1.94E+11
40%	1.65E+11
45%	1.36E+11
50%	1.06E+11
55%	8.74E+10
60%	7.62E+10
65%	6.32E+10
70%	5.21E+10
75%	4.28E+10
80%	3.53E+10
85%	2.79E+10
90%	1.98E+10
95%	1.04E+10
Average	**2.42E+11**

Margin of Safety	
Target: 20 cfu/100ml	
% Exceeded	Load
5%	6.79E+10
10%	3.90E+10
15%	2.60E+10
20%	1.95E+10
25%	1.49E+10
30%	1.21E+10
35%	9.68E+09
40%	8.27E+09
45%	6.79E+09
50%	5.30E+09
55%	4.37E+09
60%	3.81E+09
65%	3.16E+09
70%	2.60E+09
75%	2.14E+09
80%	1.77E+09
85%	1.39E+09
90%	9.91E+08
95%	5.21E+08
Average	**1.21E+10**

Existing Load	
$Y=2*10^{12}e^{-4.5318x}$	
% Exceeded	Load
5%	1.77E+12
10%	1.41E+12
15%	1.13E+12
20%	8.98E+11
25%	7.16E+11
30%	5.71E+11
35%	4.55E+11
40%	3.63E+11
45%	2.89E+11
50%	2.31E+11
55%	1.84E+11
60%	1.47E+11
65%	1.17E+11
70%	9.32E+10
75%	7.43E+10
80%	5.92E+10
85%	4.72E+10
90%	3.76E+10
95%	3.00E+10
Average	**4.54E+11**

Station E-109

Loading Capacity	
Target: 400 cfu/100ml	
% Exceeded	Load
5%	1.79E+12
10%	1.03E+12
15%	6.88E+11
20%	5.16E+11
25%	3.93E+11
30%	3.19E+11
35%	2.56E+11
40%	2.19E+11
45%	1.79E+11
50%	1.40E+11
55%	1.15E+11
60%	1.01E+11
65%	8.35E+10
70%	6.88E+10
75%	5.65E+10
80%	4.67E+10
85%	3.68E+10
90%	2.62E+10
95%	1.38E+10
Average	**3.20E+11**

Margin of Safety	
Target: 20 cfu/100ml	
% Exceeded	Load
5%	8.97E+10
10%	5.16E+10
15%	3.44E+10
20%	2.58E+10
25%	1.97E+10
30%	1.60E+10
35%	1.28E+10
40%	1.09E+10
45%	8.97E+09
50%	7.00E+09
55%	5.77E+09
60%	5.04E+09
65%	4.18E+09
70%	3.44E+09
75%	2.82E+09
80%	2.33E+09
85%	1.84E+09
90%	1.31E+09
95%	6.88E+08
Average	**1.60E+10**

Existing Load	
$Y=2*10^{12}e^{-3.7284}$	
% Exceeded	Load
5%	1.75E+12
10%	1.45E+12
15%	1.21E+12
20%	1.00E+12
25%	8.32E+11
30%	6.90E+11
35%	5.73E+11
40%	4.75E+11
45%	3.95E+11
50%	3.27E+11
55%	2.72E+11
60%	2.26E+11
65%	1.87E+11
70%	1.55E+11
75%	1.29E+11
80%	1.07E+11
85%	8.88E+10
90%	7.37E+10
95%	6.12E+10
Average	**5.27E+11**

Appendix E – Polk SWAMP FECAL COLIFORM TMDL Responsiveness Summary

Commenter: McNair Law Firm, P.A., representing Dorchester County Public Works Department

Comment 1:

McNair Law Firm (McNair) stated: "Dorchester County does not object to this TMDL."

Response 1:

The Department acknowledges Dorchester County's acceptance of the Polk Swamp Fecal Coliform TMDL.

Comment 2:

McNair noted that neither Dorchester County nor the MS4 permit for Dorchester County are explicitly addressed in the implementation portion of the TMDL.

Response 2:

Terms and conditions of existing NPDES permits demonstrate implementation of the wasteload allocation (WLA) component of this TMDL. There is currently only one NPDES-permitted wastewater discharge of fecal coliform bacteria in the Polk Swamp watershed. A WLA has been included in the TMDL to address the NPDES point source. Implementation of the load allocation (LA) component of the TMDL is demonstrated through a combination of permit terms/conditions, as well as voluntary measures, as noted in Section 6 of the TMDL document. At the time of TMDL development, the watershed was not inside an urbanized area. Neither Dorchester County nor the MS4 general permit for Dorchester County were discussed in the TMDL document because Dorchester County does not currently have coverage under an MS4 permit and a WLA for that NPDES point source is not required.

Comment 3:

McNair also noted that areas in the TMDL watershed could potentially become subject to MS4 coverage, under the existing MS4 general permit for urbanized areas of Dorchester County. The area affected by the TMDL is subject to expansion of sewer service, additional potable water infrastructure, and future economic growth. McNair outlined Dorchester County's position that, should the portions of the Polk Swamp drainage become urbanized and subject to MS4 coverage, compliance with the MS4 general permit fulfills any obligations, present and future, with respect to implementation of the final TMDL.

Response 3:

At such time as portions of the Polk Swamp watershed become urbanized and subject to MS4 general permit coverage, Dorchester County will be required to comply with implementation of the WLA portion of the TMDL if the water quality standard for the pollutant(s) of concern has not been attained. The terms/conditions of the MS4 general permit would constitute the County's NPDES regulatory obligations for implementing the TMDL. The Department reserves the right to revise the existing TMDL if additional information becomes available in the future.