Total Maximum Daily Load Development for Four Holes Swamp, SC

Hydrologic Unit Code: 03050206–010 through –030, -050

(Stations: E-022, E-076, E-059, E-050, E-051, and E-052)
Fecal Coliform Bacteria

South Carolina Department of Health and Environmental Control

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Abstract
Total Maximum Daily Load (TMDL) Development for Four Holes Swamp Watershed

1. 303(d) Listed Waterbody Information

State	South Carolina
County	Calhoun and Orangeburg
Major River Basin	Edisto
Watershed	Four Holes Swamp
Constituent(s) Causing Impairments	Fecal Coliform Bacteria
Designated Uses	Recreational

Impaired Stations (from South Carolina's 2004 Section 303(d) List):

Station	Station Location
E-022	GRAMLING CK ON SC 33 2 MI E OF ORANGEB
E-050	BRDG OVR COW CASTLE CK RD NO.92
E-051	PROVIDENCE SWAMP AT US 176 NW HOLLY HI
E-052	HORSE RANGE SWAMP AT US 176 NW HOLLY H
E-059	FOUR HOLE SWAMP AT S-38-50 SE CAMERON
E-076	TRIB TO GRAMLING CK AT SC-33 BL UTICA

Applicable fecal coliform bacteria water quality criteria for recreation (most stringent):
The concentration of the fecal coliform bacteria group shall not exceed 200 counts per 100 mL as a geometric mean based on five consecutive samples during any 30 day period (hereafter referred to as the geometric mean standard or criteria); nor shall more than 10 percent of the total samples during any 30 day period exceed 400 counts per 100 mL (hereafter referred to as the instantaneous standard or criteria).

2. TMDL Development

Analysis/Modeling:

EPA's Watershed Characterization System and Fecal Coliform Loading Estimation Spreadsheet were used to assess watershed characteristics and develop estimates of bacteria loading from various sources; EPA's Loading Simulation Program in C++ (LSPC) was used to develop the Four Holes Swamp fecal coliform bacteria TMDLs. An hourly time step was used to simulate hydrologic and water quality conditions with results expressed as daily averages.

The original modeling effort was completed in 2003 and included two additional impaired locations: E-030, BRDG OVER DEAN SWAMP ON US 176; E-100, FOUR HOLE SWAMP AT US 78 E OF DORCHEST. These stations were included on the 2002 303(d) list for fecal coliform bacteria but were removed from the list in 2004. Data showed water quality

improvement for that parameter at those locations. While the LSPC model provided for percentage reductions of fecal coliform bacteria at all eight of the original impaired locations, modeling was not revisited after the 2004 303(d) list was approved. Instead, the original TMDL document was revised to account for the changes. Percentage reductions were recommended only for the remaining six impaired locations.

Critical Conditions:

A simulation period of 6 years (January, 1995- December, 2000) was considered to determine a critical 30-day period for each impaired location. This time period was selected to reflect the most recent conditions in the watershed. For each subbasin, critical periods were identified for the geometric mean standard. Model results for the identified critical periods are consistent with observation data. A range of hydrologic and meteorological conditions was represented. Extreme low and high flow occurrences were eliminated from consideration in selecting the critical period.

Seasonal Variation:
Although a 6-year period was selected to identify critical conditions and to be consistent with the monitoring period upon which the Section 303(d) listing was based, a longer simulation period, twelve or ten years (depending on available data at each station), was used to verify water quality simulations for this TMDL. This period was selected to improve the accuracy of the water quality simulations and to represent a wide range of seasonal patterns associated with wet and dry years.

Impaired Water Quality Station	WLAs (counts/30 days)	LAs (counts/30 days)	MOS (counts/30 days)	TMDL (counts/30 days)	Percent Reduction
E-052	0.00E+00	4.86E+11	2.56E+10	5.11E+11	36
E-051	0.00E+00	2.32E+13	1.22E+12	2.45E+13	25
E-050	5.36E+10	5.51E+13	2.90E+12	5.81E+13	4
E-059	1.54E+10	2.67E+13	1.41E+12	2.81E+13	19
E-076	0.00E+00	3.40E+11	1.79E+10	3.58E+11	72
E-022	1.54E+10	6.78E+11	3.65E+10	7.30E+11	73

Notes:

a. A 5% explicit margin of safety (MOS) was applied.
b. The percent reduction of fecal coliform bacteria loads is based on the existing and TMDL conditions.

NPDES Discharges of Fecal Coliform Bacteria Upstream of Impaired Locations

NPDES No.	Facility Name	WLA[a] (counts/30 days)
SC0029645	CWS/ROOSEVELT GARDEN APTS	1.54E+10
SC0040037	TOWN OF BOWMAN	5.36E+10

Notes:

- An explicit margin of safety (MOS) equivalent to five percent was applied
- The percent reduction for fecal coliform bacteria loads is based on the existing and TMDL conditions

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1.0 INTRODUCTION

1.1 Background

Levels of fecal coliform bacteria can be elevated in waterbodies as the result of both point and nonpoint sources of pollution. Section 303(d) of the Clean Water Act and EPA's Water Quality Planning and Management Regulations (40 CFR Part 130) require states to develop total maximum daily loads (TMDLs) for waterbodies 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 waterbody 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 State of South Carolina has placed six locations in the Four Holes Swamp watershed (HUC 03050206) on South Carolina's 2004 Section 303(d) list due to fecal coliform bacteria impairments. The impaired locations are identified by water quality sampling station locations from which the samples that exceeded criteria were taken. The presence of fecal coliform bacteria in aquatic environments indicates that the water has been contaminated with the fecal material of humans or other animals. Fecal coliform bacteria contamination is an indicator that a potential health risk exists for individuals exposed to the water.

1.2 Watershed Description

The entire Four Holes Swamp watershed is located in Orangeburg, Calhoun, Berkeley, and Dorchester Counties, in South Carolina (Figure 1-1). Parts or all of the following towns fall within the watershed: Orangeburg, Cameron, Bowman, Santee, Eutawville, Holly Hill, and Harleyville. Portions of Orangeburg are drained by Middle Pen Swamp, which discharges to Four Holes Swamp, which flows through the watershed and is joined, along the way, by Goodbys Swamp, Cow Castle Creek, Providence Swamp, Target Swamp, Briner Branch, Home Branch, Dean Swamp, and Walnut Branch. The lower reach of Four Holes Swamp flows into the Edisto River 5 miles south of Ridgeville. Based on EPA's National Hydrography Dataset (NHD), there are a total of 660 miles of Level 2-7 streams in the Four Holes Swamp watershed.

The Four Holes Swamp watershed straddles the Southeastern Plain and Mid-Atlantic Coastal Plain ecoregions. The Southeastern Plain is characterized by gentle slopes, where elevations range from 100 to 450 feet above mean sea level. The headwaters of the Four Holes Swamp display these features but do not exceed 400 feet of elevation. The Mid-Atlantic Coastal Plain is a nearly level feature dissected by broad, shallow valleys with meandering stream channels at elevations of 25 to 125 feet above mean sea level (AMSL). Downstream portions of the Four Holes Swamp watershed lie within the Mid-Atlantic Coastal Plain, and the majority of the main stem is characterized by broad channels with small gradients. The lowest point in the watershed is 20 feet AMSL.

Based on USGS's Multi-Resolution Land Characterization (MRLC) data (1992), 56 percent of the watershed is forested. The remaining 44 percent is composed of pasture land (4%), cropland (35%), urban areas (2%), and a small mix of wetlands, barren, and transitional land uses. Figure 1-2 shows the land use distribution for the Four Holes Swamp watershed. Table 1-1 shows 14 digit HUCs included in Four Holes Swamp watershed.

Table 1-1. 14 digit HUCs in Four Holes Swamp watershed

14 digit-HUCs in Four Holes Swamp watershed	
3050206010010	3050206040040
3050206010020	3050206040050
3050206020010	3050206050010
3050206020020	3050206050020
3050206020030	3050206060010
3050206020040	3050206060020
3050206030010	3050206060030
3050206030020	3050206060040
3050206040010	3050206070010
3050206040020	3050206070020
3050206040030	

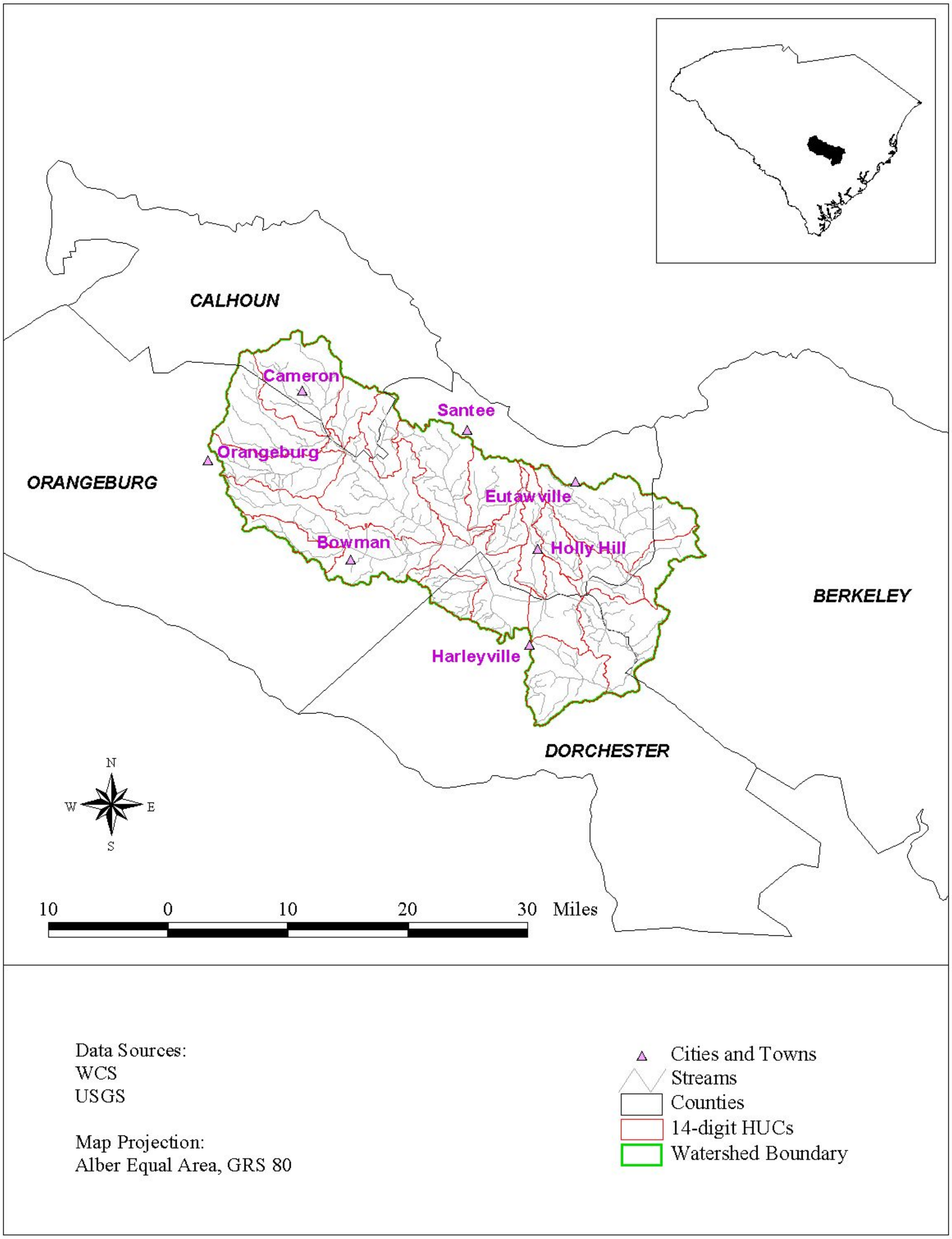

Figure 1-1. Location of Four Holes Swamp watershed showing 14-digit HUCs and nearby cities

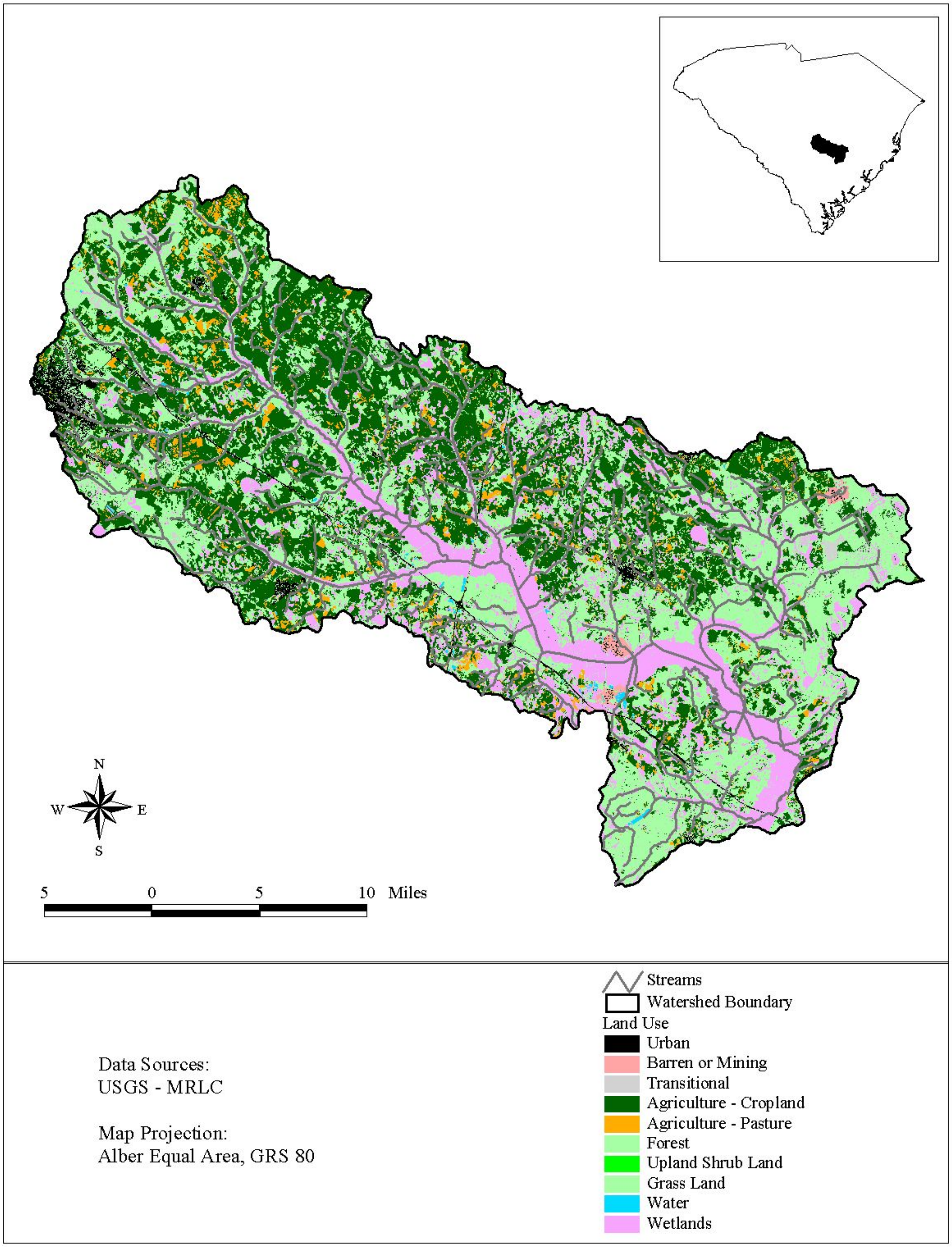

Figure 1-2. Land use distribution in the Four Holes Swamp watershed

1.3 Water Quality Standards

The impaired stations located in the Four Holes Swamp watershed are 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 conventional treatment in accordance with the requirements of the Department. Suitable for fishing and the survival and propagation of a balanced indigenous aquatic community of fauna and flora. Suitable also for industrial and agricultural uses." (R.61-68)

South Carolina's standard for fecal coliform bacteria in Freshwater is:

> "Not to exceed a geometric mean of 200/100ml, 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 400/100ml." (R.61-68).

2.0 WATER QUALITY ASSESSMENT

The *State of South Carolina Section 303(d) List for 2002* was used to identify impaired water quality stations in the Four Holes Swamp watershed. The Watershed Water Quality Management Strategy: Saluda-Edisto River Basin (SCDHEC 1995) initially identified stream stations in the Four Holes Swamp watershed (Figure 2-1) as impaired for fecal coliform bacteria. Eight stations were subsequently included on the 2002 South Carolina Section 303(d) list of impaired stations. The *State of South Carolina Section 303(d) List for 2002* was used in the 2003 TMDL analysis to identify impaired water quality stations of the Four Holes Swamp watershed. For fecal coliform bacteria, if 10 percent or less of the samples are greater than 400 counts per 100 mL, then recreational uses are said to be fully supported. A percentage of criteria exceedences greater than 10 percent indicates impairment of recreational uses and the waterbody is placed on the Section 303(d) list. Monitoring data for eight stations in the Four Holes Swamp watershed show violations of this standard, causing them to be placed on the Section 303 (d) List for 2002. In 2004, water quality data showed improvement for fecal coliform bacteria at two of these locations. Because of this change, E-030 and E-100 were not included on the 2004 303(d) list for fecal coliform or addressed as 'impaired' in the final 2005 TMDL document. Six stations remained impaired, however.

Available instream water quality monitoring data were evaluated with respect to seasonality, relation to flows, and magnitude of criteria exceedence. To develop a better understanding of the conditions under which bacteria loads are entering streams in the Four Holes Swamp watershed, several different analyses were performed including an analysis of flow weighted concentration data, monthly concentrations, and load duration curves. The goal of flow weighted concentration analysis is to compare in-stream observations with flow values to see whether violations generally occur during low flow periods or high flow periods. Data from all impaired stations in the Four Holes Swamp watershed were evaluated. Results from this analysis indicate that fecal coliform bacteria violations are occurring in the Four Holes Swamp watershed during both high and low flow periods. Load duration curves for the watershed support this assessment as well.

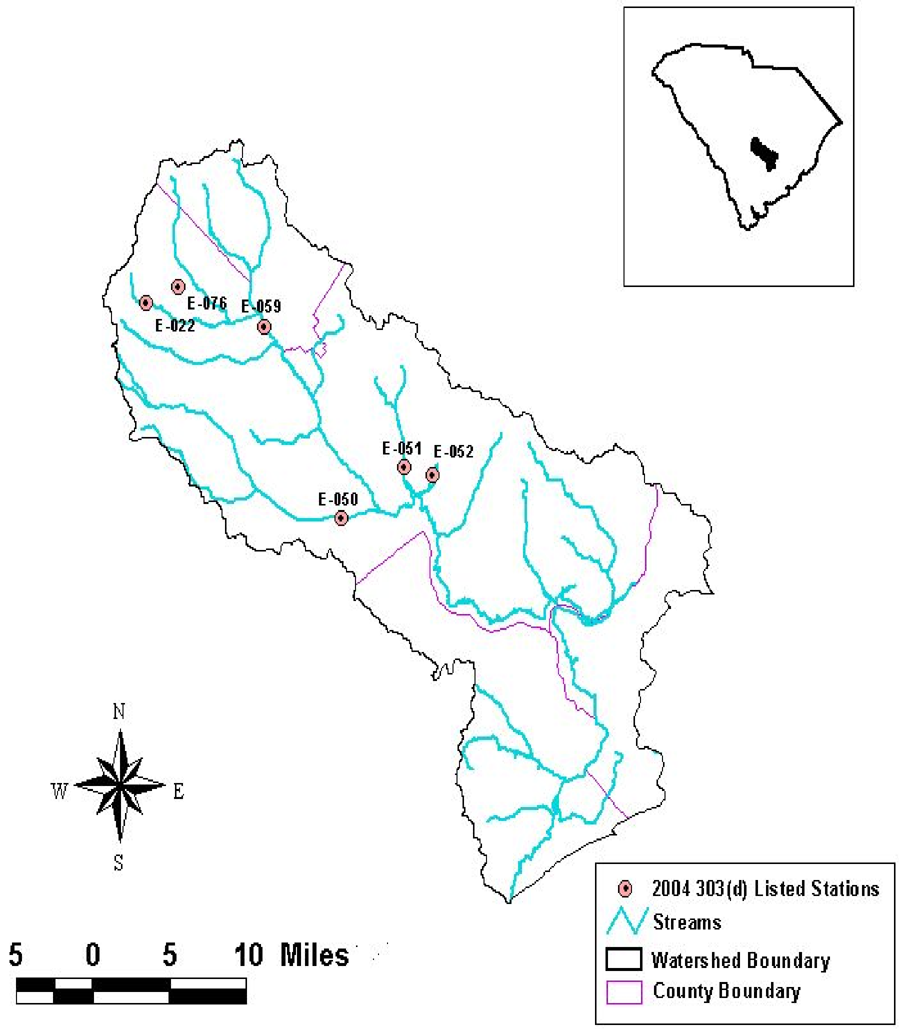

Figure 2-1. 2004 Section 303(d) listed waters of the Four Holes Swamp watershed

As an example, Figure 2-2 presents the load duration curve for Station E-059, located in the upper segment of Four Holes Swamp (see Figure 2-1). Load duration analysis involves using measured or estimated flow data, instream criteria, and fecal coliform observation data to assess flow conditions in which violations are occuring. For this analysis, the flow data was obtained from the modeled flow for the relevant subbasin (which is discussed later in this document). The flow was plotted based on exceedence probability, which indicates the percentage of time in days that the flow (or load) is exceeded. This is a useful technique in examining loading events because it shows the load magnitude and also reveals the corresponding hydrological event. The allowable load is the daily flow record multiplied by the instream fecal coliform criteria minus a five percent margin of safety; it represents the maximum load for the given flow that still satisfies water quality criteria. The line drawn through the allowable load data points is called the target line.

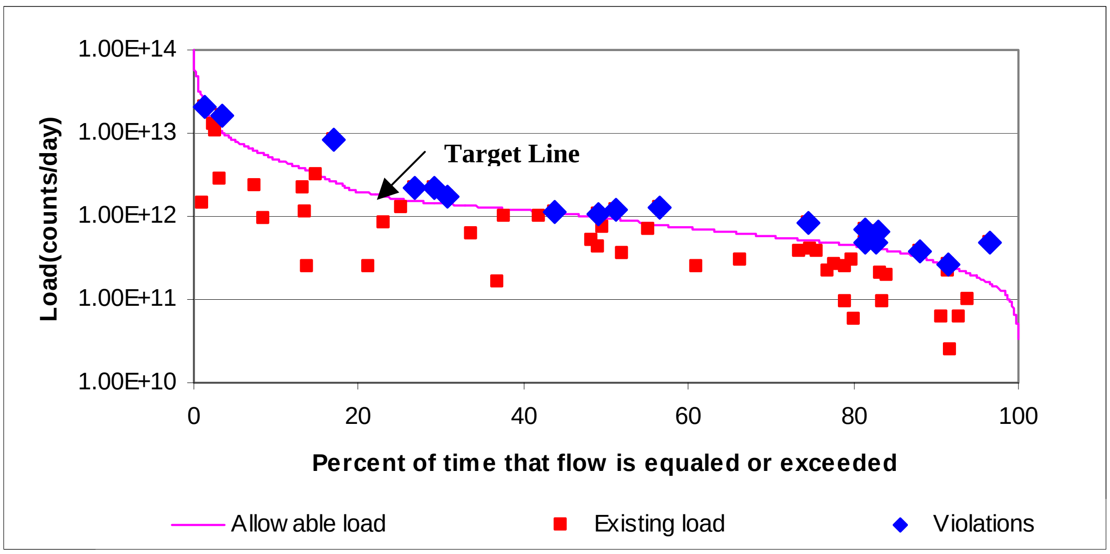

Figure 2-2. Example Fecal coliform bacteria load duration curve for Station E-059

The existing instream fecal coliform load (flow record multiplied by observed fecal coliform concentration) is compared to the allowable load for that flow. Any existing loads above the allowable load curves represent a violation of water quality criteria. For a low flow loading situation, one typically sees observations in excess of criteria at the low flow (right) side of the chart; for a high flow loading situation one would see observations in excess of criteria at the high flow (left) side of the chart. The load duration curve was developed for the time period for which the 2002 303(d) listing was based (1995-2000) and existing loads were plotted. Existing loads are shown as dots; violations as starred dots. The load duration curve for station E-059 indicates that there are occasional exceedences of the instantaneous standard under high, average, and low flow conditions. These exceedences are likely due to a combination of wet weather sources (surface runoff) and low flow direct sources.

The load duration curves for each impaired station show similar loading characteristics (i.e., existing loads above the criteria curve under a range of flow conditions).
Half of the stations in the watershed have only recorded data from April through November. Three subbasins (E-059, E-051, and E-052) have collected water quality data year-round. For some subbasins, runoff during storm events is the more significant fecal coliform bacteria

source, for others, direct inputs to streams during low flow periods (e.g. in-stream cattle, failing septic systems, or wildlife) may be equally or even more important.

Examining the data in the context of existing land uses is also helpful in determining what types of sources are probably impacting a particular subbasin. Individual subbasins also clearly show the characteristics of both, although the sources of loading are most likely different. For example, E-022 has a higher percentage of urban lands relative to other subbasins in the watershed, yet exceedences occur during all flow regimes. While surrounding subwatersheds show similar loading patterns, loading to E-022 will be dominated by urban loading while others are probably dominated by loading related to agricultural activities or wildlife.

3.0 SOURCE AND LOAD ASSESSMENT

Fecal coliform bacteria enter surface waters from both point and nonpoint sources. Point sources are facilities that discharge at a specific location from pipes, outfalls, and conveyance channels from either municipal wastewater treatment plants or industrial waste treatment facilities. All point sources must have a National Pollutant Discharge Elimination System (NPDES) permit. Nonpoint sources are diffuse sources that have multiple routes of entry into surface waters. Some sources are related to land use activities that accumulate fecal coliform bacteria on the land surface (i.e., pasture land) that runs off during storm events. Other sources, such as in-stream cattle, are more or less continuous, at least seasonally. Point source contributions can typically be attributed to the following sources:

- Municipal wastewater facilities,
- Municipal Separate Storm Sewers (MS4s),
- Illicit discharges, and
- Leaking or overflowing sewers.

Municipal wastewater treatment facilities are permitted through the National Pollutant Discharge Elimination System (NPDES). Larger treatment facilities have disinfection systems that remove fecal coliform bacteria in the effluent before it is discharged. Treatment facilities treat human waste received from the collection system and then discharge their effluent into a nearby stream.

Municipal Separate Stormwater Systems (MS4s) are point sources also regulated by the NPDES program. Discharge from stormwater pipes or conveyances potentially include urban runoff high in bacteria and other pollutants.

Illicit discharges are made when facilities or persons discharge fecal coliform bacteria without a permit, or violate their defined permit discharge limit by exceeding the fecal coliform concentration.

In urban settings, sewer lines typically run parallel to the stream in the floodplain. If there is a leaking or overflowing sewer line, high concentrations of fecal coliform can flow into the stream or leach into the groundwater. Groundwater monitoring wells can signal if there are leaking sewer lines contributing to the problem.

3.1 Point Sources

3.1.1 Permitted Point Sources

Table 3-1 lists the 2 active facilities that are permitted to discharge fecal coliform bacteria into waterbodies of the Four Holes Swamp watershed, above impaired monitoring sites. Figure 3-1 shows the locations of these facilities. The permitted flows range from 0.0676 to 0.236 million gallons per day (MGD). In South Carolina, NPDES permittees that discharge sanitary wastewater must meet the state criterion for fecal coliform bacteria at the point of discharge (i.e. a daily maximum concentration of 400 counts/100ml, and a 30-day maximum geometric mean of 200 counts/100ml).

Table 3-1. Active facilities permitted to discharge fecal coliform bacteria into waterbodies of the Four Holes Swamp watershed and upstream of impaired sites.

NPDES No.	Facility Name	Flow Limit (MGD)
SC0040037	TOWN OF BOWMAN	0.236
SC0029645	CWS/ROOSEVELT GARDEN APTS	0.0676

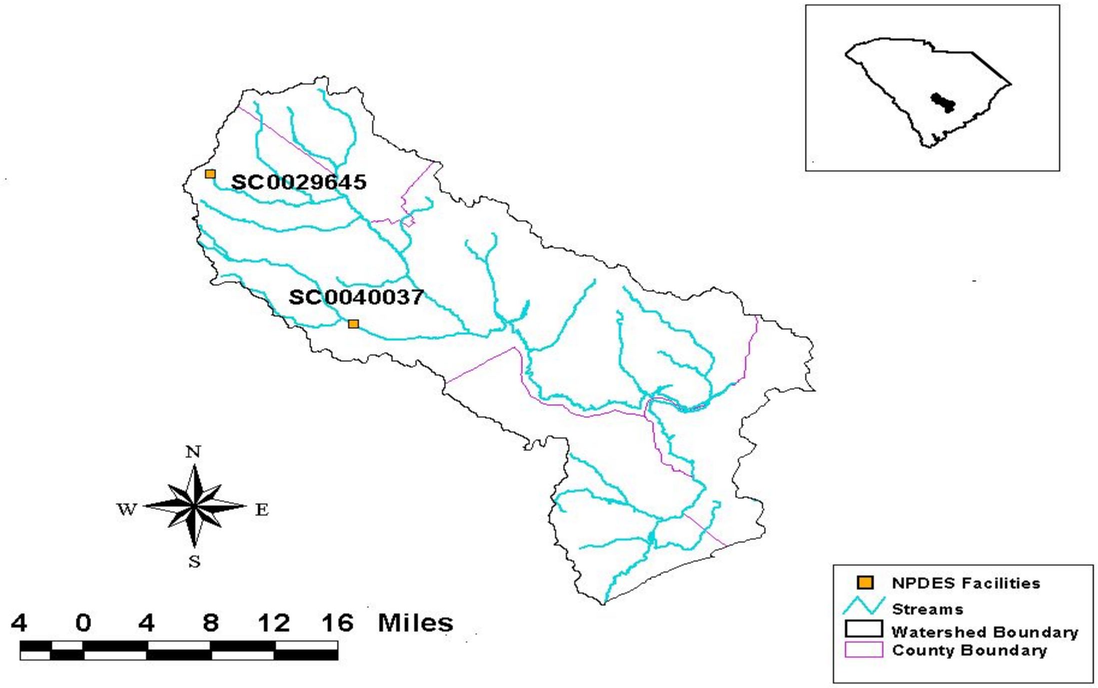

Figure 3-1. Location of NPDES facilities permitted to discharge fecal coliform bacteria into waters of the Four Holes Swamp watershed and upstream of impaired sites.

Table 3-2 presents the NPDES facilities located upstream of each of the impaired stations. Table 3-3 shows fecal coliform bacteria concentration statistics for both of these facilites. Estimates of existing fecal coliform bacteria loading for each NPDES facility are shown in Table 3-4. These results were obtained using Discharge Monitoring Report (DMR) data provided by DHEC. The original DMR data is shown in Appendix A. Note that DMR data is presented for all facilities included in the 2003 modeling effort.

Table 3-2. NPDES facilities located upstream of each impaired station

Impaired Station	NPDES Facilities
E-052	- None -
E-051	- None -
E-050	SC0040037
E-059	SC0029645
E-076	- None -
E-022	SC0029645

Table 3-3. Fecal coliform bacteria concentration statistics for NPDES facilities in the Four Holes Swamp watershed upstream of impaired sites

NPDES ID	Pipe	Count	Mean (counts/ 100ml)	Maximum (counts/ 100ml)	Geometric Mean (counts/ 100ml)	Exceedence based on 400counts/ 100ml	By-passes	Sanitary Sewer Overflow (SSO)
SC0029645	1	111	28	272	11	0	None	None
SC0040037	1	100	1252	22000	63	23	None	None

Table 3-4. Estimated existing fecal coliform loads from permitted NPDES facilities in the Four Holes Swamp watershed upstream of impaired sites

NPDES No.	Facility Name	Pipe	Geometric Mean of Observed Concentration (counts/100ml)	Geometric Mean of Observed Flow (MGD)	30-Day Load[1] (counts/30days)
SC0029645	CWS/ROOSEVELT GARDEN APTS	1	11	0.048	5.97E+08
SC0040037	TOWN OF BOWMAN	1	63	0.066	4.74E+09

[1] The geometric mean of observed fecal coliform concentrations and flows were used for this calculation.

3.1.2 Municipal Separate Storm System Permits

In 1990, EPA developed rules establishing Phase I of the National Pollutant Discharge Elimination System (NPDES) storm water program, designed to prevent harmful pollutants from being washed by storm water runoff into Municipal Separate Storm Sewer Systems (MS4s) (or from being dumped directly into the MS4) and then discharged from the MS4 into local waterbodies. Phase I of the program required operators of "medium" and "large" MS4s (those generally serving populations of 100,000 or greater) to implement a storm water management program as a means to control polluted discharges from MS4s. Approved storm water management programs for medium and large MS4s are required to address a variety of water quality related issues including roadway runoff management, municipal owned operations, hazardous waste treatment, etc. There are no large or medium MS4s in the Four Holes Swamp watershed.

Phase II of the rule extends coverage of the NPDES storm water program to certain "small" MS4s. Small MS4s are defined as any MS4 that is not a medium or large MS4 covered by Phase I of the NPDES Storm Water Program. Only a select subset of small MS4s, referred to as "regulated small MS4s", require an NPDES storm water permit. Regulated small MS4s are defined as all small MS4s located in "urbanized areas" as defined by the Bureau of the Census, and those small MS4s located outside of a UA that are designated by NPDES permitting authorities. Orangeburg, located in the western portions of the watershed, is considered a "potential regulated small MS4" and if designated as a regulated small MS4 by the SCDHEC, the town may be required to obtain an MS4 permit.

3.2 Nonpoint Sources

In addition to point sources, nonpoint sources also contribute fecal coliform bacteria loads into the waters of the Four Holes Swamp watershed. Nonpoint sources represent contributions from diffuse sources, rather than from a defined outlet. On the land surface, fecal coliform bacteria accumulate over time and wash off during rain events. As the runoff transports the sediment over the land surface, more fecal coliform bacteria are collected and carried to the stream. While the concentrations of bacteria are accumulating, they also die. The net loading into the stream is determined by the local watershed hydrology.

The land use distribution of the Four Holes Swamp watershed, illustrated previously in Figure 1-2, provides insight into determining nonpoint sources of fecal coliform bacteria. The predominant land uses in the Four Holes Swamp watershed were identified based on MRLC land use data (representative of1992). Figure 3-2 displays the land use distribution of the catchment area of each impaired water quality station. Key nonpoint sources identified in the watershed include livestock, manure application, failing septic systems, urban areas, and natural sources.

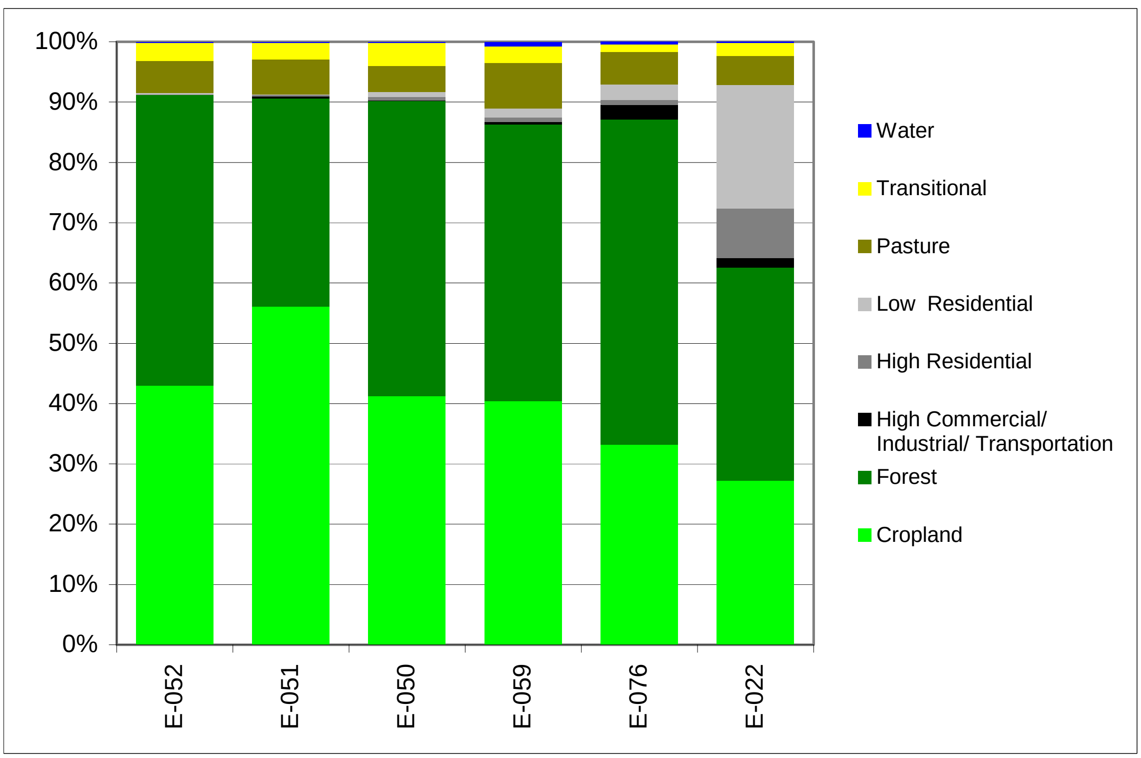

Figure 3-2. Landuse distribution in impaired stations' drainage areas (cumulative)

3.2.1 Urban Areas

Sources of fecal coliform bacteria in urban areas include wildlife and pets, particularly dogs. Much of the loading from urban areas is due simply to the increase in impervious surfaces relative to other land uses and the resulting increase in runoff. In estimating the potential loading of fecal coliform bacteria from urban areas, accumulation rates are often used to represent the aggregate of available sources. For this study, initial accumulation rates assumed for the built-up land were 1.0 x 10^7 counts/acre/day (Horner, 1992) for both the pervious and impervious fractions. The assumed perviousness percentages for built-up land were as follows:

- Low Intensity Residential—88 percent
- High Intensity Residential—35 percent
- High Intensity Commercial/Industrial/Transportation—15 percent
- Urban Grasses—100 percent

3.2.2 Failing Septic Systems

Failing septic systems represent a nonpoint source that can contribute fecal coliform bacteria to receiving waterbodies through surface or subsurface malfunctions. Loadings from failing septic systems were represented by constant flows and concentrations in the analysis. The estimate was derived by examining a combination of US Census data and technical references:

- Number of septic systems (derived from US Census 1990)
- Estimated population served by the septic systems (an average of 2.5 people per household, US Census 1990)
- An average daily discharge of 70 gallons/person/day (Horsley & Witten, 1996)
- Septic effluent concentration of 10^4 counts/100mL (Horsley & Witten, 1996)
- Septic failure rate of 20 percent (initial estimate)

Since the estimates of the number of septic systems were based on 1990 Census data, population estimates from 1990 were also used in estimating septic loadings. To provide a margin of safety accounting for the uncertainty of the number, location, and behavior (e.g., surface vs. subsurface breakouts; proximity to stream) of these sources, failing septic systems and illegal discharges or leaky sewer lines are represented in the model as direct sources of fecal coliform to the stream reaches. Although quantifying loading from precise contributions from these sources is not feasible, the MOS included in the septic failure rate is assumed to address the uncertainty regarding these sources.

Table 3-5 presents the estimated population on septic systems. Population estimates are cumulative for each station. The drainage area of each station includes all the area upstream of a particular impaired station.

Table 3-5. Estimated population on septic systems for each impaired station's drainage area (populations are cumulative for each station)

Impaired Station	Population
E-052	1,202
E-051	1,992
E-050	4,217
E-059	4,122
E-076	254
E-022	190

3.2.3 Agriculture

Agricultural land can be a source of fecal coliform bacteria. Runoff from pastures, animal operations, the improper land application of animal wastes, and animals with access to waterbodies are all sources of fecal coliform bacteria. Agricultural Best Management Practices or BMPs such as buffer strips, alternative watering sources, limiting livestock access to creeks, and the proper land application of animal wastes reduce fecal coliform loading to waterbodies.

EPA's Fecal Coliform Load Estimation Spreadsheet (FCLES) tool was used to develop initial estimates of the amount of fecal coliform bacteria introduced directly to streams, as well as initial estimates of accumulation rates of fecal coliform bacteria on the land surface (USEPA, 2000.) The FCLES tool quantifies the fecal coliform bacteria component of waste generated by warm-blooded animals and distributes these quantities to streams and to the land surface based on land use type and waste management practices. Estimates derived from the FCLES tool were used as inputs to the watershed loading model. These initial estimates were fine-tuned during the model testing (calibration) process to more closely match available monitoring data.

Grazing cattle are of more relevance in this watershed than confined animal operations. 1997 USDA census data is shown for Calhoun and OrangeburgCounties in Table 3-6. Table 3-7 describes fecal coliform production rates for various animals used to calculate loadings from each livestock category. Livestock, except for the dairy cattle, are not usually confined and are typically grazing in the pastures. Manure deposited by cattle onto pasture land is a source of nonpoint pollution. It was assumed that cattle manure is applied to cropland and pasture and hog manure is applied to pasture only. It is also assumed that no manure is imported into the watershed.

Table 3-6. 1997 Agricultural Census information for Orangeburg and Calhoun Counties

	Orangeburg	Calhoun
Cattle	17,603	2,962
Beef Cow	4,482	1,867
Milk Cow	4,347	15
Hogs	38,097	11,399
Sheep	131	-
Chickens-Broilers Sold	7,657,025	-

Table 3-7. Fecal coliform production rates for various animals

Livestock Animal	Fecal Coliform Bacteria Production Rate* (counts/animal/day)
Beef Cow	1.04E+11
Dairy Cow	1.01E+11
Hogs	1.08E+10
Sheep	1.20E+10
Chicken	1.36E+08

*Source: ASAE, 1998

Given the gradually sloping terrain and warm climate of the area (especially during spring and summer months) it is reasonable to expect cattle to spend some time directly in streams. Loading of fecal coliform bacteria from cattle defecating directly into streams was estimated based on the number of cattle and assumptions regarding the time cattle are expected to be standing or wading in the streams. This number was refined through model calibration, which considered bacteria monitoring data. The time that cattle spend in-streams was assumed to be 0.085 percent of its total grazing time.

3.2.4 Wildlife

Fecal coliform bacteria also originate in forested areas. Generally, sources include wild animals such as deer, raccoons, wild turkeys, and waterfowl. The Department of Natural Resources in South Carolina estimated a deer density of 45 deer per square mile of deer habitat (Data provided by Charles Ruth, Deer Project Supervisor, DNR, 5/1/01). Deer habitat was assumed to include forest, wetlands, cropland, and pasture. The fecal coliform bacteria production rate for deer was estimated based on best professional judgment using the rates for other animals, such as turkey and cattle, which are available in Metcalf and Eddy (1991). An interpolation was conducted based on animal weight. This method results in a rate of 5×10^8 counts/animal/day for deer. Using this rate and the assumption of an equally distributed population of deer across forest, wetlands, and agricultural land uses, the fecal coliform bacteria accumulation rates from wildlife were determined to be 3.52×10^7 counts/acre/day, which represents background fecal coliform bacteria loading. It is important to note that the accuracy of predicted loading depends upon the accuracy of the various assumptions described above.

4.0 MODELING

Watersheds with varied land uses and numerous potential sources of pollutants typically require a complex model to ascertain the effect of source loadings on in-stream water quality. This relationship must be understood in order to develop an effective TMDL. In this section, the modeling techniques that were applied to simulate fecal coliform bacteria fate and transport in the watershed are discussed as applied to the Four Holes Swamp watershed. Modeling was conducted in 2003.

4.1 Model Selection

Selection of the appropriate analytical technique for TMDL development was based on an evaluation of technical and regulatory criteria. Key technical factors that were important in the selection process include:

- Point and nonpoint sources must be considered.
- Fecal coliform bacteria impairments are temporally-variable and occur at low, average, and high flow conditions.
- Time-variable aspects of land practices have a large effect on in-stream bacteria concentrations.
- Bacteria transport mechanisms are highly variable and often weather dependent.

The primary regulatory factor that drove the selection process was South Carolina's water quality standards. Compliance with the standards requires attaining both instantaneous and geometric mean-based criteria. To ensure a valid comparison to these criteria, results from a time-variable analysis are required.

The US EPA has assembled a variety of tools to use in the development of TMDLs. Of these tools, the GIS-based Watershed Characterization System (WCS) and the Loading Simulation Program in C++ (LSPC) were applied to model the Four Holes Swamp watershed. WCS is similar to EPA's BASINS, however, it includes source loading calculation tools, updated agricultural data. The Watershed Characterization System (WCS), a geographic information system (GIS) tool, was used to display and analyze GIS information including land use, land type, point source discharges, soil types, population, and stream characteristics. FCLES is a spreadsheet tool used to quantify nonpoint source bacteria accumulation rates based on watershed-specific information.

LSPC is a system designed to support TMDL development for areas impacted by nonpoint and point sources. The most critical component of LSPC to TMDL development is the dynamic watershed model, because it provides the linkage between source contributions and in-stream response. LSPC is essentially a re-coded C++ version of selected Hydrological Simulation Program FORTRAN (HSPF) modules. LSPC is used to simulate watershed hydrology and pollutant transport as well as stream hydraulics and in-stream water quality. It is capable of simulating different flow regimes and bacteria loading variations. LSPC's algorithms are identical to those in HSPF. Table 4-1 presents the modules from HSPF used in LSPC for this study. Refer to the *Hydrologic Simulation Program FORTRAN User's Manual for Release 11* (USEPA, 1996) for a more detailed discussion of simulated processes and model parameters

Table 4-1. HSPF modules used in LSPC for the Four Holes Swamp TMDL analysis

RCHRES Modules	HYDR	Simulates hydraulic behavior
	GQUAL	Simulates behavior of a generalized quality constituent
PQUAL and IQUAL Modules	PWATER	Simulates water budget for a pervious land segment
	IQUAL	Uses simple relationships with solids and water yield
	PQUAL	Simple relationships with sediment and water yield

Source: USEPA, 1996

4.2 Model Set Up

LSPC was configured for the Four Holes Swamp watershed to simulate the watershed as a series of hydrologically connected subwatersheds. Configuration of the model involved subdivision of the Four Holes Swamp watershed into modeling units and continuous simulation of flow and water quality for these units using meteorological, land use, point source loading, and stream data.

In the modeling effort (2003), Four Holes Swamp was delineated into 37 subwatersheds in order to characterize the relative fecal coliform bacteria contributions from smaller units throughout the watershed (see Figure 4-1). Some of the small subwatersheds were created to ensure the stream network configuration within the basin. Watershed delineation was based on the NHD stream coverage digital elevation data, and USGS 1:24,000 scale topographic maps. This discretion allows for management and load reduction alternatives to be varied by subwatershed.

A continuous simulation period of six years (1988-1993) was used in the hydrologic simulation analysis. An important factor driving model simulations is precipitation data. The pattern and intensity of rainfall affects the build-up and wash-off of fecal coliform bacteria from the land into the streams, as well as the dilution potential of the stream. Meteorological data recorded at three weather stations were applied to the watersheds to simulate hydrologic events. These stations are located in St. Matthews, St. George, and at the Santee Cooper Spillway, as shown in Figure 4-1.

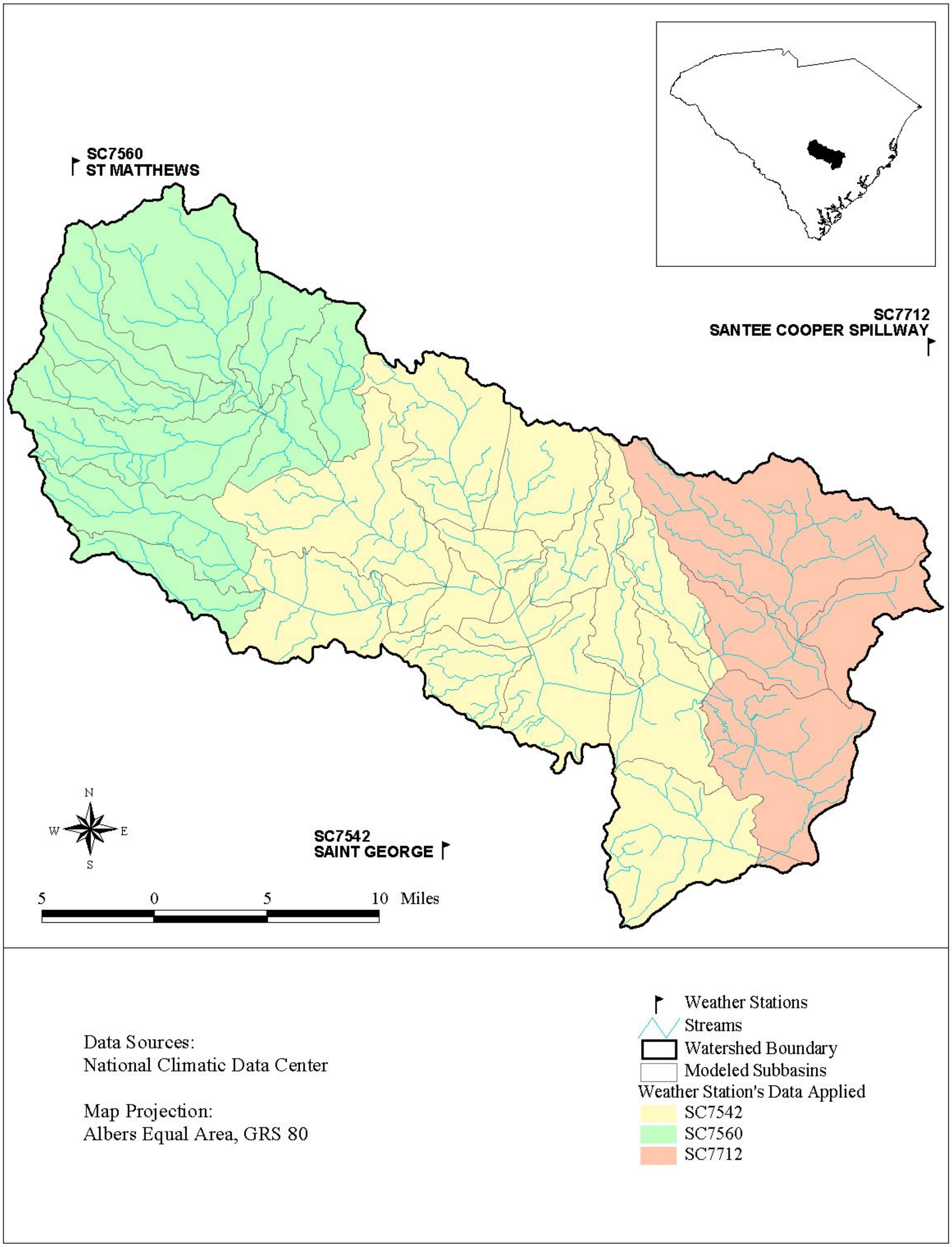

Figure 4-1. Delineated subwatersheds in the Four Holes Swamp watershed and meteorological stations used in the simulation

Modeled land uses contributing to bacteria loads include pasture, cropland, urban pervious lands, urban impervious lands, and forest (including barren and wetlands). Other sources, such as septic systems and livestock in streams were modeled as direct sources in the model. These initial estimates are presented in Table 4-2, and they were further refined during the model testing (calibration) process (described in Section 4.3). Initial loading rates estimated for Orangeburg county are applied to every modeled subwatersheds since majority of Four Holes swamp basin fall into the county.

Table 4-3 presents the final bacteria accumulation rates for land use sources. Loading rates used in the model to represent cattle and septic system contributions are presented in Table 4-4. The septic system contribution represents a failure rate of 12 percent.

Table 4-2. Initial monthly accumulation rates (counts/acre/day) derived from FCLES

Orangeburg County, SC	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Cropland	6.95E+08	1.87E+09	3.29E+09	6.36E+09	4.32E+09	5.49E+09	4.32E+09	5.31E+09	5.35E+09	4.28E+09	7.17E+08	5.19E+10
Forest	3.52E+07	3.52E+07	3.52E+07	3.52E+07	3.52E+07	3.52E+07	3.52E+07	3.52E+07	3.52E+07	3.52E+07	3.52E+07	3.52E+07
Pasture	5.19E+10	5.21E+10	5.30E+10	5.44E+10	5.39E+10	5.40E+10	5.39E+10	5.39E+10	5.44E+10	5.30E+10	5.19E+10	5.19E+10
UrbanPervious and impervious	9.42E+06	9.42E+06	9.42E+06	9.42E+06	9.42E+06	9.42E+06	9.42E+06	9.42E+06	9.42E+06	9.42E+06	9.42E+06	9.42E+06

Table 4-3. Final (calibrated) monthly accumulation rates (counts/acre/day) used in the model

Orangeburg County, SC	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Cropland	6.95E+08	1.87E+09	3.29E+09	6.36E+09	4.32E+09	5.49E+09	4.32E+09	5.31E+09	5.35E+09	4.28E+09	7.17E+08	5.19E+10
Forest	3.52E+07	3.52E+07	3.52E+07	3.52E+07	3.52E+07	3.52E+07	3.52E+07	3.52E+07	3.52E+07	3.52E+07	3.52E+07	3.52E+07
Pasture	5.19E+10	5.21E+10	5.30E+10	5.44E+10	5.39E+10	5.40E+10	5.39E+10	5.39E+10	5.44E+10	5.30E+10	5.19E+10	5.19E+10
UrbanPervious and impervious	1.96E+09	1.96E+09	1.96E+09	1.96E+09	1.96E+09	1.96E+09	1.96E+09	1.96E+09	1.96E+09	1.96E+09	1.96E+09	1.96E+09

Table 4-4. Final loading rates for cattle and septic systems (counts/day)

	Sub 1	Sub 2	Sub 3	Sub 4	Sub 5	Sub 6	Sub 7	Sub 8	Sub 9	Sub 10	Sub 11	Sub 12	Sub 14
Cattle loadings (counts/day)	1.32E+09	2.45E+09	5.90E+09	3.10E+09	1.29E+10	2.16E+09	2.42E+09	2.39E+09	5.29E+09	4.95E+09	8.65E+09	1.51E+10	4.30E+08
Septic loadings (counts/day)	6.92E+09	1.26E+10	2.96E+10	1.34E+10	4.88E+10	1.09E+10	1.22E+10	1.18E+10	1.09E+10	4.12E+09	1.81E+10	2.48E+10	2.18E+09
	Sub 15	**Sub 16**	**Sub 17**	**Sub 18**	**Sub 19**	**Sub 20**	**Sub 25**	**Sub 26**	**Sub 27**	**Sub 28**	**Sub 29**	**Sub 30**	**Sub 31**
Cattle loadings (counts/day)	3.06E+09	6.12E+09	3.66E+08	3.99E+09	4.75E+09	1.51E+10	6.69E+07	1.83E+09	7.81E+09	5.48E+08	2.09E+09	1.53E+09	7.10E+08
Septic loadings (counts/day)	1.55E+10	2.76E+10	1.45E+09	1.07E+10	2.40E+10	1.66E+10	3.51E+08	9.27E+09	3.95E+10	9.13E+08	5.18E+09	7.68E+09	3.02E+09
	Sub 32	**Sub 33**	**Sub 34**	**Sub 35**	**Sub 36**	**Sub 37**	**Sub 38**	**Sub 39**	**Sub 40**	**Sub 41**	**Sub 42**		
Cattle loadings (counts/day)	1.95E+09	8.09E+08	6.05E+08	6.26E+09	8.41E+08	6.35E+09	1.47E+09	3.83E+09	1.34E+08	1.53E+08	9.02E+09		
Septic loadings (counts/day)	9.86E+09	4.07E+09	3.05E+09	2.55E+10	4.24E+09	3.19E+10	7.43E+09	1.93E+10	7.03E+08	7.88E+08	1.80E+10		

4.3 Model Calibration

Initial model set-up included watershed area above eight stations impaired for fecal coliform bacteria. In 2004, two stations E-030 and E-100 showed water quality improvement for that parameter and were removed from the 303(d) list of impaired waters. The model had been calibrated to the original eight station set-up and was not altered as the final TMDL recommendations were developed in 2005.

Hydrology and water quality calibration were performed in sequence, since water quality modeling is dependent on an accurate hydrology simulation. Flow data from Water Quality Stations E-051 and E-100 (Figure 4-2) were obtained for comparison to model results for the time period of 1988-1993. Flow data does not exist for E-100, the most downstream station, after 1993. These stations were used instead of USGS Gage 02174250 due to the more relevant locations of those flow samples. Station E-051 monitors an impaired headwater, and E-100 monitors an impaired location at the pour point of the swamp system (see Figure 2-1). USGS Gage 02174250 was not functional during the period of 1988 to 1993, and monitors an unimpaired headwater. Calibration of the hydrologic model was accomplished by adjusting model parameters until the simulated and observed flow observations matched. The model hydrology was calibrated to observed data recorded from January 1st, 1991 to December 31st, 1991. The hydrology was validated for the longer period of January 1st, 1988 to December 31st, 1993. Results of the hydrology calibration and validation are included in Appendix B.

Following hydrology calibration, the water quality was calibrated by comparing modeled versus observed in-stream fecal coliform bacteria concentrations. The water quality calibration consisted of executing the watershed model, comparing water quality time series output to available water quality observation data, and adjusting water quality parameters within a reasonable range. The water quality parameters that were adjusted to obtain a calibrated model were the build-up and washoff of fecal coliform bacteria from the land uses and the direct load estimates such as cattle in the streams and the failing septic systems as described in Section 3.2.

The approach taken to calibrate water quality focused on matching trends identified during the water quality analysis. Daily average in-stream fecal coliform concentrations from the model were compared directly to observed data. Observed fecal coliform data were obtained from EPA's STORET for 1988 through 2000; not all stations had data for the entire period. The objective was to best simulate low flow, mean flow, and storm peaks at representative water quality monitoring stations. The available water quality data for the water quality calibration locations are presented in Appendix C.

The time period of the model water quality calibration was from January 1st, 1995 to December 31st, 1997, and validation was from January 1st, 1988 to December 31st, 2000 or December 31st, 1998, to the extent data existed for a particular calibration station. These time periods were selected based on the availability and relevance of the observed data to the current conditions in the watershed. The period also includes various wet and dry conditions. The water quality calibration results are shown in Appendix D.

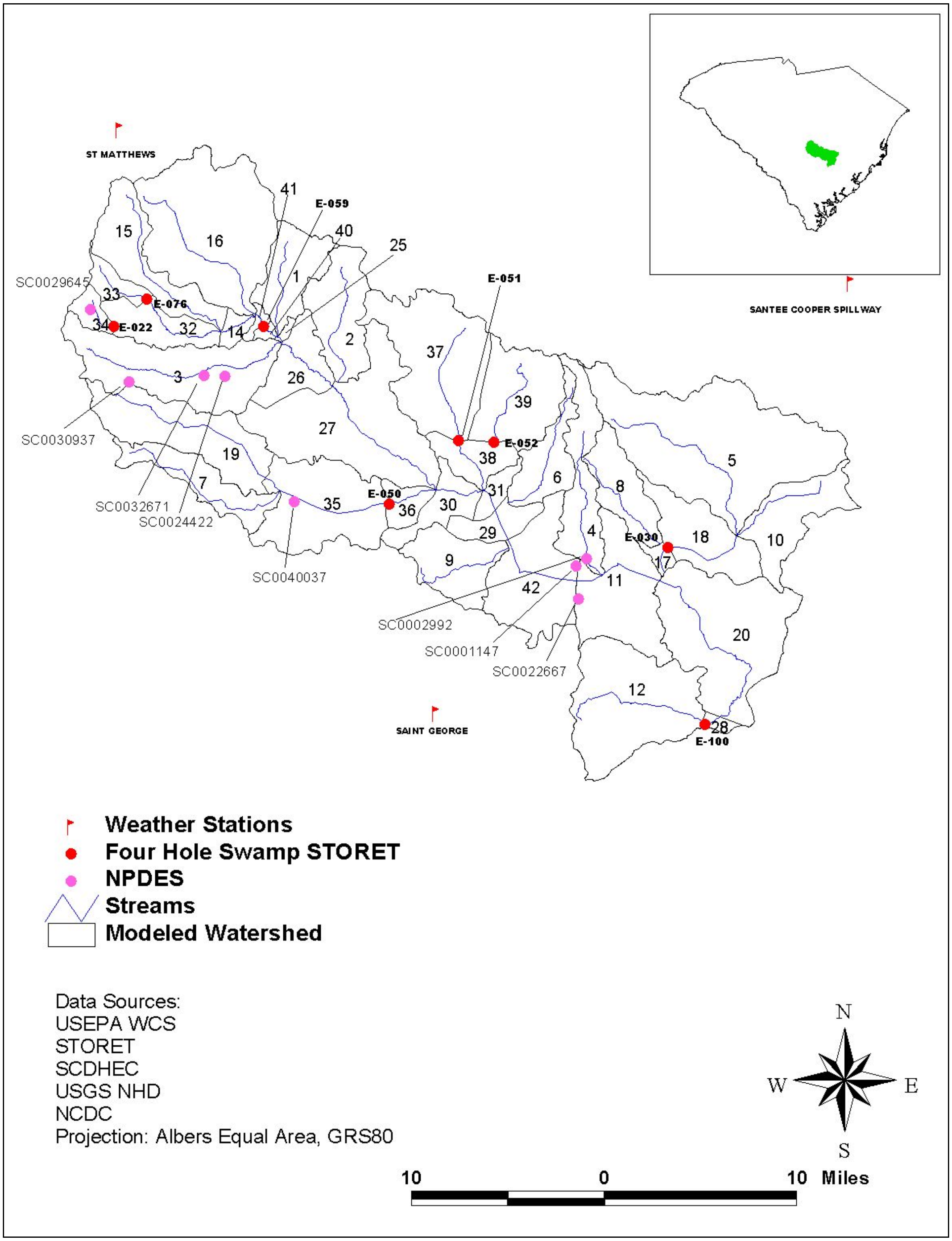

Figure 4-2. Modeled subbasins, water quality stations, and NPDES permits in the Four Holes Swamp watershed

5.0 MODELING RESULTS

5.1 Existing Conditions

An examination of the Four Holes Swamp model results indicates that the majority of the violations of the geometric mean standard occur in streams during low-flow conditions followed by storm events. Storm events create high loading inputs from various land use categories due to the accumulation of fecal coliform bacteria on the land surface. These high flow conditions, especially the high flows created by a storm after a long dry period, cause not only violations of the geometric mean standard, but also violations of the not to exceed criterion.

Existing conditions of each source are determined based on available information or simulated model results. Loadings from permitted facilities are calculated using their flow and fecal coliform bacteria concentration limits. Existing loading (Table 5-1 and Figure 5-1) from land, cattle in the streams, failing septics, and permitted facilities are simulated using the LSPC model during the critical condition determined based on the procedure described in Section 5.1. The loadings presented in Table 5-1 represent cumulative loadings from the contributions of upper watersheds at each impaired water quality station.

Table 5-1. 30-day cumulative existing loadings at impaired water quality stations by source

Impaired Water Quality Station	FC Loading from the Land (counts/30 days)	FC Loading from In-stream Cattle (counts/30 days)	FC Loading from Point Sources (counts/30 days)	FC Loading from Septic Systems (counts/30 days)
E-100**	4.19E+14	1.48E+13	1.17E+11	4.39E+12
E-030**	7.82E+12	1.90E+12	0.00E+00	6.55E+11
E-052	5.87E+10	5.80E+11	0.00E+00	1.15E+11
E-051	2.97E+13	9.57E+11	0.00E+00	1.90E+11
E-050	5.54E+13	1.85E+12	4.74E+09	4.04E+11
E-059	3.08E+13	1.89E+12	5.97E+08	3.94E+11
E-076	1.06E+12	1.22E+11	0.00E+00	2.43E+10
E-022	2.46E+12	9.16E+10	5.97E+08	1.82E+10

- The 30-day period presented here is based on the critical period identified for the instantaneous standard (described in the TMDL section).
- **Modeled in 2003 but not included in the final 2005 TMDL recommendations

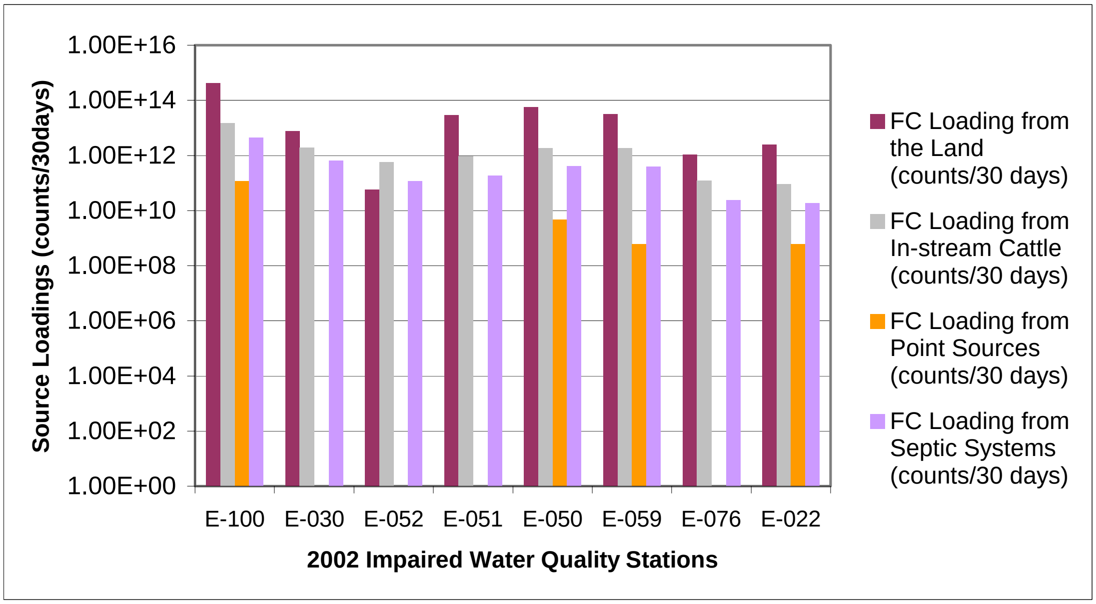

Figure 5-1. Cumulative existing loading percentages at impaired water quality stations from different sources (loadings are based on counts/30days).

6.0 TMDL

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

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

The TMDL is the total amount of pollutant that can be assimilated by the receiving waterbody while still achieving water quality standards. In TMDL development, allowable loadings from all pollutant sources that cumulatively amount to no more than the TMDL must be established and thereby provide the basis to establish water quality-based controls. For some pollutants, TMDLs are expressed on a mass loading basis (e.g., kilograms per day). For bacteria, however, TMDLs can be expressed in terms of organism counts (or resulting concentration), in accordance with 40 CFR 130.2(l).

6.1 Critical Conditions

EPA regulations at 40 CFR 130.7(c)(1) require TMDLs to take into account critical conditions for stream flow, loading, and water quality parameters. The critical condition for the Four Holes Swamp watershed was selected based on the 5-year simulation of fecal coliform bacteria concentrations from 1995 to 2000. A summary of how critical conditions were determined at each impaired water quality station is described below:

1. The running geometric mean of simulated concentrations was calculated over the entire simulation period and compared to South Carolina's geometric mean criterion of 200 fecal coliform bacteria counts per 100ml.
2. Each violation of the criterion was compared to the corresponding 30-day geometric mean simulated flow value.
3. If the violation occurred during a flow event that was above the 10th percentile (low flows) or below the 90th percentile (high flow) the violation was ignored because these flows were considered to be extreme conditions (USEPA Region 4, personal communication 2002).
4. Of the remaining violations, the largest was then identified and used to develop the TMDL. This resulted in meeting the criteria at all times. The date on which this violation occurred was determined to be the critical date. The critical period was established so that it represented the 30-day period leading up to the critical date. For example, if the critical date for a subbasin was identified as January 30, the critical period for that subbasin would be January 1 through January 30.

A critical period was determined for each impaired station. For allocations, if unimpaired subbasins were located upstream of an impaired station, they were assigned the same critical date and any reductions were calculated for the same period. The critical dates identified for each impaired station are presented in Table 6-1.

Table 6-1. Critical dates for impaired subbasins in the Four Holes Swamp watershed

Water Quality Station	Critical Date*
E-100**	4/14/2000
E-030**	7/15/2000
E-052	7/4/1998
E-051	10/9/1998
E-050	7/15/2000
E-059	8/4/2000
E-076	8/28/1996
E-022	8/28/1996

* The critical date represents the last day of the 30-day critical period.
**Modeled in 2003 but not included in the final 2005 TMDL recommendations

6.2 TMDL methodology and Endpoints

TMDLs and source allocations were developed at impaired water quality monitoring stations in the Four Holes Swamp watershed based on the 30-day geometric mean fecal coliform bacteria criteria. A top-down methodology was used to develop these TMDLs and allocate loads to sources. Impaired headwaters were analyzed first, because their impact frequently had a profound effect on down-stream water quality. Loading contributions were reduced from applicable sources for these waterbodies and TMDLs were developed. After meeting water quality criteria for the upper subwatersheds, the results were then routed to downstream stations. In many situations, it was necessary to revisit allocations made at upstream stations (and make additional reductions), in order to meet water quality criteria at downstream stations. Reductions were determined through a comparison to the geometric mean criteria during the geometric mean critical period. The instantaneous portion of the WQS was also evaluated because the standards require that both the geometric mean and instantaneous criteria are met. Reductions required to meet the instantaneous portion were similar to those required to meet the geometric mean standard; therefore the TMDL and reductions are presented in terms of the geometric mean criteria. Appendix E shows both the existing conditions and allocation scenarios that achieve the water quality criteria at the impaired water quality stations under the geometric mean critical conditions.

6.3 Wasteload Allocations

Table 6-2 shows each of the permitted facilities with their allocated loadings. Since these facilities were assumed to be discharging at their permitted limits, it was assumed that they are not contributing to the fecal coliform impairment at the each stations, and therefore, were not considered to be major contributing sources. This assumption was derived from DMR data provided from South Carolina (Refer to table 3-2 and Appendix A).

Table 6-2. Waste load allocations (WLAs) for each NPDES permitted facility included in the 2003 modeling effort.

NPDES Permit	Facility Name	Pipe	Permitted Concentration (counts/100ml)	Permitted Flow (MGD)	Permitted Load (counts/30days)
SC0030937**	MIDDLE PEN SWAMP DITCH , NORTHWOOD ESTATES/MID-CAROLINA	1	200	0.063*	1.43E+10**
SC0032671**	BROOKLAND PLANTATION BOYS HOME	1	200	0.009	2.06E+09**
SC0024422**	MIDDLE PEN SWAMP DITCH, DAYS INN/ORANGEBURG	1	200	0.007*	1.64E+09**
SC0002992**	HOLNAM INCORPORATED SAFETY KLEEN SYSTEMS INCORPORATED	1	200	4.836*	1.10E+12**
SC0002992**	HOLNAM INCORPORATED SAFETY KLEEN SYSTEMS INCORPORATED	1A	200	0.002*	6.46E+08**
SC0022667**	GIANT CEMENT COMPANY	1	200	0.006*	1.42E+09**
SC0022667**	GIANT CEMENT COMPANY	11	200	0.008*	1.82E+09**
SC0029645	CWS/ROOSEVELT GARDEN APTS	1	200	0.067	1.54E+10
SC0040037	TOWN OF BOWMAN	1	200	0.235	5.36E+10
SC0001147**	GEORGIA PACIFIC FIBER BOARD PLANT	1	200	0.433*	9.86E+10**
SC0001147**	GEORGIA PACIFIC FIBER BOARD PLANT	2	200	0.633*	1.44E+11**
SC0001147**	GEORGIA PACIFIC FIBER BOARD PLANT	3	200	0.005*	1.14E+09**

*Permit is "Measure and Report". The number provided is a representative flow based on DMR data.
**Modeled in 2003 but not included as a WLA in the final 2005 TMDL recommendations

6.4 Load Allocations

Load allocations were made for the dominant source categories as follows:

- Washoff from urban land uses
- Washoff from agricultural land uses (cropland and pasture land)
- Cattle in the stream reaches
- Failing septic systems and illegal discharges

Nonpoint sources were arranged into three categories for the model: land loading, septic loading, and in-stream livestock loading. The land loading category represents bacteria that accumulate on the land surface (including pasture land, cropland, urban land, forested land, barren land, and wetlands) and are then washed into streams. Septic loading represents bacteria contributed to streams by failing septic systems (including illegal discharges). The in-stream livestock category represents bacteria from animals, primarily cattle in this watershed, which are deposited directly into a waterbody.

Major inputs of fecal coliform bacteria can be periodic in nature, such as from rainfall driven accumulation and wash-off events, or more constant, such as from the regular inputs that would come from in-stream cattle or failing septic systems. Depending on flow conditions, the fecal coliform bacteria in the stream at a given time may originate mostly from in-stream livestock or wildlife, and/or septics (usually during low flow conditions), from build-up/wash-off actions (usually during high flow conditions), or from some combination of both. In order to determine allocation ratios between different sources, the simulated 30-day geometric mean and daily concentrations were considered. Depending on the land uses present in a particular subbasin, as well as its relative location upstream or downstream within the watershed, appropriate reduction scenarios were developed. For example, in a subbasin in which there were substantial agricultural lands but no urban areas, simulated inputs from cattle and septic systems, as well as loading from pasture and croplands were reduced until water quality standards were met. In subbasins where there are more urban areas, reduction scenarios focused more on urban lands.

6.5 Margin of Safety

There are two basic methods for incorporating the margin of safety or MOS (USEPA 1991):

1. Implicitly incorporate the MOS using conservative model assumptions to develop allocations, or
2. Explicitly specify a portion of the total TMDL as the MOS and use the remainder for allocations.

For the Four Holes Swamp TMDLs, both methods were applied to incorporate a MOS. An implicit MOS was incorporated the following ways:

- The use of a five-year simulation period enabled the consideration of multiple hydrologic conditions; the TMDL was ultimately based on the most stringent.

- Conservative assumptions were employed in developing the TMDL. Permitted facilities were represented in the model using maximum permitted quantities. All cattle were assumed to have access to streams.

As for the explicit MOS, five percent of the geometric mean water quality criterion was reserved. Specifically, the water quality target was set at 190 counts per 100ml for a 30-day period and 380 counts per 100ml for the instantaneous criterion, which is five percent lower than the water quality criteria of 200 and 400 counts per 100ml, respectively.

6.6 Seasonal Variability

Fecal coliform data (Appendix C) in the Four Holes Swamp watershed shows that increased fecal coliform concentrations occur during both wet and dry weather periods with increased concentrations during high flows as well as low summer flows. To adequately address the wet and dry weather related problems, a long-term simulation covering a variety of hydrologic and rainfall conditions must be evaluated. By using continuous flow simulation (estimating flow over a period of several years), seasonal hydrologic and source loading was inherently considered.

6.7 TMDL Results

Based on an interpretation of the model results and water quality standards, the TMDL and its components (WLA, LA, and MOS) were derived. The TMDLs are presented in Table 6-3 for the geometric mean criteria. They are presented for each impaired water quality monitoring station, starting with the downstream stations and working upstream. The loadings presented for the downstream stations are cumulative and represent contributions from the upstream drainage area.

Table 6-3. TMDL based on geometric mean criteria

Impaired Water Quality Station	Existing Point Source Loads (counts/30 days)	WLAs (counts/30 days)	Existing Nonpoint Source Loads (counts/30 days)	LAs (counts/30 days)	MOS (counts/30 days)	TMDL (counts/30 days)	Percent Reduction
E-052	0.00E+00	0.00E+00	7.54E+11	4.86E+11	2.56E+10	5.11E+11	36
E-051	0.00E+00	0.00E+00	3.08E+13	2.32E+13	1.22E+12	2.45E+13	25
E-050	4.74E+09	5.36E+10	5.76E+13	5.51E+13	2.90E+12	5.81E+13	4
E-059	5.97E+08	1.54E+10	3.31E+13	2.67E+13	1.41E+12	2.81E+13	19
E-076	0.00E+00	0.00E+00	1.21E+12	3.40E+11	1.79E+10	3.58E+11	72
E-022	5.97E+08	1.54E+10	2.57E+12	6.78E+11	3.65E+10	7.30E+11	73

7.0 References

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Appendix A
DMR Data

DMR data for bacteria concentrations and flow are presented for the permitted facilities located in the 2003 Four Holes Swamp watershed modeling effort. Concentrations in excess of permit limits are shown in **BOLD**.

Table A-1. DMR data for NPDES permitted facilities in Four Holes Swamp model.

NPDES	PIPE	DATE	counts/ 100ml	AVG. FLOW	NPDES	PIPE	DATE	counts/ 100ml	AVG. FLOW
SC0001147	1	8/31/1992	2	0.006	SC0024422	1	10/31/1999	7	0.0158
SC0001147	1	7/31/1992	2	0.005	SC0024422	1	11/30/1999	59	0.011
SC0001147	1	4/30/1997	50	0.0024	SC0024422	1	12/31/1999	20	0.0172
SC0001147	1	5/31/1997	50	0.0024	SC0024422	1	1/31/2000	2	0.015
SC0001147	1	6/30/1997	50	0.001	SC0024422	1	2/29/2000	9	0.0133
SC0001147	1	7/31/1997	50	0.001	SC0024422	1	3/31/2000	2	0.0158
SC0001147	1	8/31/1997	50	0.001	SC0024422	1	4/30/2000	208	0.01
SC0001147	1	9/30/1997	50	0.00046	SC0024422	1	5/31/2000	2	0.0008
SC0001147	1	10/31/1997	50	0.0004	SC0024422	1	6/30/2000	16	0.004
SC0001147	1	11/30/1997	50	0.0007	SC0024422	1	7/31/2000	84	0.005
SC0001147	1	12/31/1997	50	0.00046	SC0024422	1	8/31/2000	15	0.003
SC0001147	1	1/31/1998	50	0.0007	SC0024422	1	9/30/2000	4	0.004
SC0001147	1	2/28/1998	50	0.0004	SC0024422	1	10/31/2000	46	0.003
SC0001147	1	3/31/1998	50	0.0004	SC0024422	1	11/30/2000	75	0.004
SC0001147	1	4/30/1998	50	0.0004	SC0024422	1	12/31/2000	1	0.004
SC0001147	2	7/31/1992	**600**	1.2	SC0029645	1	6/30/1994	10	0
SC0001147	2	8/31/1999	10	0.0024	SC0029645	1	8/31/1994	41	0
SC0001147	2	9/30/1999	10	0.0019	SC0029645	1	7/31/1994	10	0
SC0001147	2	7/31/1999	10	0.0036	SC0029645	1	9/30/1994	24	0
SC0001147	2	10/31/1999	10	0.0036	SC0029645	1	10/31/1994	37	0
SC0001147	2	11/30/1999	10	0.0014	SC0029645	1	11/30/1994	79	0
SC0001147	2	12/31/1999	10	0.0024	SC0029645	1	12/31/1994	24	0
SC0001147	2	1/31/2000	10	0.0036	SC0029645	1	1/31/1995	10	0
SC0001147	2	2/29/2000	2	0.0024	SC0029645	1	2/28/1995	10	0
SC0001147	2	3/31/2000	2	0.0024	SC0029645	1	3/31/1995	68	0
SC0001147	2	4/30/2000	2	0.0014	SC0029645	1	4/30/1995	43	0
SC0001147	2	5/31/2000	2	0.0019	SC0029645	1	5/31/1995	56	0
SC0001147	2	6/30/2000	2	0.0036	SC0029645	1	6/30/1995	90	0
SC0001147	2	7/31/2000	2	0.0019	SC0029645	1	7/31/1995	272	0
SC0001147	2	8/31/2000	2	0.0014	SC0029645	1	8/31/1995	87	0
SC0001147	2	9/30/2000	2	0.0019	SC0029645	1	9/30/1995	27	0
SC0001147	2	10/31/2000	2	0.0019	SC0029645	1	10/31/1995	69	0
SC0001147	2	11/30/2000	2	0.0019	SC0029645	1	11/30/1995	37	0
SC0001147	2	12/31/2000	2	0.0014	SC0029645	1	12/31/1995	17	0
SC0001147	3	7/31/1992	2	0.01	SC0029645	1	1/31/1996	55	0
SC0001147	3	4/30/1997	50	0.0054	SC0029645	1	2/29/1996	49	0
SC0001147	3	5/31/1997	50	0.0024	SC0029645	1	3/31/1996	39	0
SC0001147	3	6/30/1997	50	0.0054	SC0029645	1	4/30/1996	48	0
SC0001147	3	7/31/1997	50	0.0092	SC0029645	1	5/31/1996	68	0
SC0001147	3	8/31/1997	50	0.0092	SC0029645	1	6/30/1996	32	0
SC0001147	3	9/30/1997	50	0.0054	SC0029645	1	7/31/1996	26	0
SC0001147	3	10/31/1997	50	0.0073	SC0029645	1	8/31/1996	109	0
SC0001147	3	11/30/1997	50	0.0054	SC0029645	1	9/30/1996	100	0

NPDES	PIPE	DATE	counts/ 100ml	AVG. FLOW
SC0001147	3	12/31/1997	50	0.0036
SC0001147	3	1/31/1998	50	0.0054
SC0001147	3	2/28/1998	50	0.0054
SC0001147	3	3/31/1998	50	0.0054
SC0001147	3	4/30/1998	50	0.0073
SC0001147	3	5/31/1998	10	0.0036
SC0001147	3	6/30/1998	10	0.0073
SC0001147	3	7/31/1998	10	0.0054
SC0001147	3	8/31/1998	10	0.0054
SC0001147	3	9/30/1998	10	0.0054
SC0001147	3	10/31/1998	10	0.0036
SC0001147	3	11/30/1998	10	0.0036
SC0001147	3	12/31/1998	10	0.0036
SC0001147	3	1/31/1999	10	0.0024
SC0001147	3	2/28/1999	20	0.0036
SC0001147	3	3/31/1999	150	0.0024
SC0001147	3	4/30/1999	**1600**	0.0036
SC0001147	3	5/31/1999	10	0.0024
SC0001147	3	6/30/1999	10	0.0024
SC0002992	1	1/31/1991	13.2	2.48
SC0002992	1	2/28/1991	10	1.61
SC0002992	1	3/31/1991	10	3.68
SC0002992	1	4/30/1991	10	4.07
SC0002992	1	5/31/1991	42	3.73
SC0002992	1	7/31/1991	26.9	2.08
SC0002992	1	6/30/1991	14	1.87
SC0002992	1	8/31/1991	42	7.28
SC0002992	1	9/30/1991	30.7	5.99
SC0002992	1	12/31/1991	5.6	3.29
SC0002992	1	12/31/1992	32.4	2.35
SC0002992	1	10/31/1992	68.4	1.88
SC0002992	1	11/30/1992	10	2.41
SC0002992	1	9/30/1992	20	1.5
SC0002992	1	8/31/1992	52.5	2.68
SC0002992	1	7/31/1992	28.1	1.6
SC0002992	1	3/31/1994	8.3	8.6
SC0002992	1	4/30/1994	39.3	5.7
SC0002992	1	5/31/1994	28.7	5.2
SC0002992	1	6/30/1994	221.3	5.3
SC0002992	1	7/31/1994	17.8	5.8
SC0002992	1	8/31/1994	131.2	5.98
SC0002992	1	10/31/1994	10	8.9
SC0002992	1	9/30/1994	68.9	5.65
SC0002992	1	11/30/1994	120.5	6.7
SC0002992	1	12/31/1994	51.8	12.7
SC0002992	1	1/31/1995	6.3	8.7

NPDES	PIPE	DATE	counts/ 100ml	AVG. FLOW
SC0029645	1	11/30/1996	11	0
SC0029645	1	12/31/1996	0	0
SC0029645	1	10/31/1996	10	0
SC0029645	1	1/31/1997	3	0
SC0029645	1	2/28/1997	2	0
SC0029645	1	3/31/1997	15	0
SC0029645	1	4/30/1997	0	0
SC0029645	1	5/31/1997	13	0
SC0029645	1	6/30/1997	10	0
SC0029645	1	7/31/1997	4	0
SC0029645	1	8/31/1997	46	0
SC0029645	1	9/30/1997	3	0
SC0029645	1	10/31/1997	7	0
SC0029645	1	11/30/1997	10	0
SC0029645	1	12/31/1997	10	0
SC0029645	1	1/31/1998	2	0
SC0029645	1	2/28/1998	6	0
SC0029645	1	3/31/1998	2	0
SC0029645	1	4/30/1998	2	0
SC0029645	1	5/31/1998	17	0
SC0029645	1	6/30/1998	25	0
SC0029645	1	7/31/1998	3	0
SC0029645	1	8/31/1998	2	0
SC0029645	1	9/30/1998	3	0
SC0029645	1	10/31/1998	2	0
SC0029645	1	11/30/1998	2	0
SC0029645	1	12/31/1998	4	0
SC0029645	1	1/31/1999	8	0
SC0029645	1	2/28/1999	9	0
SC0029645	1	3/31/1999	3	0
SC0029645	1	4/30/1999	2	0
SC0029645	1	5/31/1999	2	1
SC0029645	1	6/30/1999	2	0
SC0029645	1	7/31/1999	2	0
SC0029645	1	8/31/1999	2	0
SC0029645	1	9/30/1999	2	0
SC0029645	1	10/31/1999	2	0
SC0029645	1	11/30/1999	2	0
SC0029645	1	12/31/1999	2	0
SC0029645	1	1/31/2000	2	0
SC0029645	1	2/29/2000	2	0
SC0029645	1	3/31/2000	2	0
SC0029645	1	4/30/2000	2	0
SC0029645	1	5/31/2000	2	0
SC0029645	1	6/30/2000	10	0
SC0029645	1	7/31/2000	2	0

NPDES	PIPE	DATE	counts/ 100ml	AVG. FLOW
SC0022667	1	1/31/1994	5	0.0048
SC0022667	1	2/28/1994	3	0.005
SC0022667	1	3/31/1994	2	0.006
SC0022667	1	4/30/1994	3	0.0049
SC0022667	1	5/31/1994	3	0.0037
SC0022667	1	6/30/1994	2	0.005
SC0022667	1	7/31/1994	5	0.0062
SC0022667	1	9/30/1994	2	0.004
SC0022667	1	10/31/1994	2	0.006
SC0022667	1	8/31/1994	2	0.00355
SC0022667	1	11/30/1994	2	0.002
SC0022667	1	12/31/1994	3	0.003
SC0022667	1	1/31/1995	2	0.005
SC0022667	1	2/28/1995	5	0.005
SC0022667	1	4/30/1995	50	0.0036
SC0022667	1	5/31/1995	50	0.005
SC0022667	1	3/31/1995	50	0.0052
SC0022667	1	6/30/1995	50	0.008
SC0022667	1	7/31/1995	71	0.008
SC0022667	1	8/31/1995	50	0.009
SC0022667	1	9/30/1995	50	0.012
SC0022667	1	10/31/1995	50	0.012
SC0022667	1	11/30/1995	50	0.009
SC0022667	1	12/31/1995	50	0.007
SC0022667	1	2/29/1996	50	0.009
SC0022667	1	1/31/1996	50	0.013
SC0022667	1	3/31/1996	50	0.005
SC0022667	1	4/30/1996	50	0.006
SC0022667	1	6/30/1996	50	0.006
SC0022667	1	5/31/1996	50	0.006
SC0022667	1	7/31/1996	50	0.011
SC0022667	1	8/31/1996	50	0.006
SC0022667	1	9/30/1996	50	0.007
SC0022667	1	10/31/1996	50	0.009
SC0022667	1	11/30/1996	50	0.007
SC0022667	1	12/31/1996	50	0.007
SC0022667	1	1/31/1997	50	0.007
SC0022667	1	2/28/1997	50	0.007
SC0022667	1	3/31/1997	50	0.008
SC0022667	1	4/30/1997	50	0.006
SC0022667	1	5/31/1997	50	0.007
SC0022667	1	6/30/1997	50	0.006
SC0022667	1	7/31/1997	50	0.006
SC0022667	1	8/31/1997	50	0.008
SC0022667	1	9/30/1997	50	0.006
SC0022667	1	10/31/1997	50	0.007

NPDES	PIPE	DATE	counts/ 100ml	AVG. FLOW
SC0032671	1	2/29/1996	55	0.001
SC0032671	1	3/31/1996	10	0.0033
SC0032671	1	4/30/1996	10	0.0039
SC0032671	1	5/31/1996	10	0.0028
SC0032671	1	6/30/1996	10	0.0049
SC0032671	1	7/31/1996	120	0.0007
SC0032671	1	2/28/1997	2	0.001
SC0032671	1	3/31/1997	2	0.0029
SC0032671	1	4/30/1997	2	0.0023
SC0032671	1	5/31/1997	2	0.0005
SC0032671	1	6/30/1997	2	0.0008
SC0032671	1	8/31/1997	2	0.005
SC0032671	1	7/31/1997	10	0.002
SC0032671	1	9/30/1997	6	0.003
SC0032671	1	10/31/1997	120	0.003
SC0032671	1	12/31/1997	6	0.004
SC0032671	1	1/31/1998	0	0.0024
SC0032671	1	2/28/1998	2	0.0044
SC0032671	1	3/31/1998	2	0.0033
SC0032671	1	4/30/1998	2	0.0016
SC0032671	1	5/31/1998	6	0.0013
SC0032671	1	6/30/1998	40	0.0016
SC0032671	1	7/31/1998	120	0.003
SC0032671	1	8/31/1998	2	0.003
SC0032671	1	9/30/1998	2	0.0001
SC0032671	1	1/31/1999	2	0.0013
SC0032671	1	2/28/1999	2	0.0014
SC0032671	1	3/31/1999	2	0.0018
SC0032671	1	4/30/1999	72	0.004
SC0032671	1	5/31/1999	2	0.0037
SC0032671	1	6/30/1999	88	0.001
SC0032671	1	7/31/1999	118	0.001
SC0032671	1	9/30/1999	20	0.001
SC0032671	1	10/31/1999	20	0.0028
SC0032671	1	11/30/1999	2	0.0013
SC0032671	1	12/31/1999	140	0.0013
SC0032671	1	1/31/2000	10	0.002
SC0032671	1	2/29/2000	10	0.0057
SC0032671	1	3/31/2000	10	0.002
SC0032671	1	4/30/2000	70	0.001
SC0032671	1	5/31/2000	10	0.0001
SC0032671	1	6/30/2000	10	0.003
SC0032671	1	7/31/2000	12	0.002
SC0032671	1	8/31/2000	93	0.002
SC0032671	1	9/30/2000	44	0.003
SC0032671	1	10/31/2000	2	0.001

NPDES	PIPE	DATE	counts/ 100ml	AVG. FLOW	NPDES	PIPE	DATE	counts/ 100ml	AVG. FLOW
SC0022667	1	11/30/1997	50	0.007	SC0032671	1	11/30/2000	28	0.001
SC0022667	1	12/31/1997	50	0.008	SC0032671	1	12/31/2000	1	0.002
SC0022667	1	1/31/1998	50	0.009	SC0040037	1	1/31/1990	10	0
SC0022667	1	2/28/1998	50	0.005	SC0040037	1	2/28/1990	183	0
SC0022667	1	3/31/1998	50	0.007	SC0040037	1	3/31/1990	12	0
SC0022667	1	4/30/1998	28	0.04	SC0040037	1	4/30/1990	47	0
SC0022667	1	5/31/1998	10	0.011	SC0040037	1	5/31/1990	**1897**	0
SC0022667	1	7/31/1998	10	0.004	SC0040037	1	6/30/1990	**775**	0
SC0022667	1	6/30/1998	10	0.003	SC0040037	1	4/30/1991	10	0
SC0022667	1	8/31/1998	10	0.005	SC0040037	1	5/31/1991	10	0
SC0022667	1	9/30/1998	10	0.003	SC0040037	1	6/30/1991	**930**	0
SC0022667	1	10/31/1998	10	0.002	SC0040037	1	7/31/1991	15	0
SC0022667	1	11/30/1998	10	0.004	SC0040037	1	8/31/1991	10	0
SC0022667	1	12/31/1998	10	0.002	SC0040037	1	9/30/1991	300	0
SC0022667	1	1/31/1999	10	0.005	SC0040037	1	10/31/1991	10	0
SC0022667	1	2/28/1999	10	0.005	SC0040037	1	1/31/1992	10	0
SC0022667	1	3/31/1999	10	0.005	SC0040037	1	3/31/1992	5	0
SC0022667	1	4/30/1999	10	0.005	SC0040037	1	9/30/1992	45	0
SC0022667	1	5/31/1999	10	0.003	SC0040037	1	8/31/1992	10	0
SC0022667	1	6/30/1999	10	0.003	SC0040037	1	7/31/1992	10	0
SC0022667	1	7/31/1999	19	0.005	SC0040037	1	6/30/1992	7	0
SC0022667	1	8/31/1999	10	0.004	SC0040037	1	5/31/1992	10	0
SC0022667	1	9/30/1999	10	0.005	SC0040037	1	4/30/1992	15	0
SC0022667	1	10/31/1999	10	0.004	SC0040037	1	4/30/1993	**622**	0
SC0022667	1	12/31/1999	10	0.0024	SC0040037	1	5/31/1993	257	0
SC0022667	1	11/30/1999	10	0.0017	SC0040037	1	6/30/1993	330	0
SC0022667	1	1/31/2000	10	0.003	SC0040037	1	7/31/1993	**450**	0
SC0022667	1	2/29/2000	2	0.002	SC0040037	1	8/31/1993	7	0
SC0022667	1	3/31/2000	2	0.003	SC0040037	1	9/30/1993	10	0
SC0022667	1	4/30/2000	2	0.002	SC0040037	1	10/31/1993	320	0
SC0022667	1	5/31/2000	2	0.0017	SC0040037	1	11/30/1993	94	0
SC0022667	1	6/30/2000	2	0.0024	SC0040037	1	12/31/1993	**3200**	0
SC0022667	1	7/31/2000	2	0.0023	SC0040037	1	1/31/1994	15	0
SC0022667	1	8/31/2000	2	0.0025	SC0040037	1	2/28/1994	20	0
SC0022667	1	9/30/2000	2	0.0034	SC0040037	1	4/30/1994	25	0
SC0022667	1	10/31/2000	2	0.002	SC0040037	1	5/31/1994	20	0
SC0022667	1	11/30/2000	2	0.003	SC0040037	1	6/30/1994	172	0
SC0022667	1	12/31/2000	2	0.0025	SC0040037	1	9/30/1994	50	0
SC0022667	11	11/30/1992	2	0	SC0040037	1	10/31/1994	220	0
SC0024422	1	8/31/1994	4	0.13	SC0040037	1	11/30/1994	**20000**	0
SC0024422	1	9/30/1994	156	0.0005	SC0040037	1	12/31/1994	200	0
SC0024422	1	11/30/1994	160	0.0014	SC0040037	1	1/31/1995	**500**	0
SC0024422	1	10/31/1994	2	0.0013	SC0040037	1	2/28/1995	386	0
SC0024422	1	12/31/1994	2	0.002	SC0040037	1	3/31/1995	**1822**	0
SC0024422	1	4/30/1995	2	0.005	SC0040037	1	4/30/1995	18	0
SC0024422	1	3/31/1995	2	0.005	SC0040037	1	6/30/1995	**1149**	0

NPDES	PIPE	DATE	counts/ 100ml	AVG. FLOW
SC0024422	1	2/28/1995	10	0.0014
SC0024422	1	7/31/1995	10	0.00014
SC0024422	1	8/31/1995	10	0.0029
SC0024422	1	11/30/1995	2	0.0029
SC0024422	1	12/31/1995	30	0.004
SC0024422	1	2/29/1996	2	0.0014
SC0024422	1	1/31/1996	88	0.0031
SC0024422	1	4/30/1996	10	0.002
SC0024422	1	5/31/1996	10	0.002
SC0024422	1	7/31/1996	**590**	0.0028
SC0024422	1	8/31/1996	35	0.0021
SC0024422	1	9/30/1996	4	0.0024
SC0024422	1	11/30/1996	240	0.0016
SC0024422	1	12/31/1996	2	0.02
SC0024422	1	10/31/1996	10	0.002
SC0024422	1	1/31/1997	12	0.0022
SC0024422	1	2/28/1997	2	0.0028
SC0024422	1	4/30/1997	2	0.0023
SC0024422	1	5/31/1997	2	0.0024
SC0024422	1	6/30/1997	2	0.0026
SC0024422	1	7/31/1997	2	0.0042
SC0024422	1	8/31/1997	2	0.0023
SC0024422	1	9/30/1997	2	0.0028
SC0024422	1	12/31/1997	34	0.002
SC0024422	1	1/31/1998	12	0.0018
SC0024422	1	2/28/1998	4	0.0024
SC0024422	1	4/30/1998	64	0.003
SC0024422	1	5/31/1998	2	0.0027
SC0024422	1	6/30/1998	2	0.0036
SC0024422	1	7/31/1998	110	0.018
SC0024422	1	8/31/1998	2	0.019
SC0024422	1	9/30/1998	2	0.015
SC0024422	1	10/31/1998	108	0.0049
SC0024422	1	11/30/1998	6	0.015
SC0024422	1	12/31/1998	106	0.0031
SC0024422	1	1/31/1999	94	0.0065
SC0024422	1	2/28/1999	2	0.008
SC0024422	1	3/31/1999	96	0.0028
SC0024422	1	3/31/1999	96	0.0028
SC0024422	1	3/31/1999	96	0.0028
SC0024422	1	3/31/1999	96	0.0028
SC0024422	1	4/30/1999	32	0.0043
SC0024422	1	5/31/1999	2	0.0057
SC0024422	1	6/30/1999	25	0.0033
SC0024422	1	7/31/1999	6	0.0043
SC0024422	1	8/31/1999	60	0.0036

NPDES	PIPE	DATE	counts/ 100ml	AVG. FLOW
SC0032671	1	11/30/2000	28	0.001
SC0032671	1	12/31/2000	1	0.002
SC0040037	1	1/31/1990	10	0
SC0040037	1	2/28/1990	183	0
SC0040037	1	3/31/1990	12	0
SC0040037	1	4/30/1990	47	0
SC0040037	1	5/31/1990	**1897**	0
SC0040037	1	6/30/1990	**775**	0
SC0040037	1	4/30/1991	10	0
SC0040037	1	5/31/1991	10	0
SC0040037	1	6/30/1991	**930**	0
SC0040037	1	7/31/1991	15	0
SC0040037	1	8/31/1991	10	0
SC0040037	1	9/30/1991	300	0
SC0040037	1	10/31/1991	10	0
SC0040037	1	1/31/1992	10	0
SC0040037	1	3/31/1992	5	0
SC0040037	1	9/30/1992	45	0
SC0040037	1	8/31/1992	10	0
SC0040037	1	7/31/1992	10	0
SC0040037	1	6/30/1992	7	0
SC0040037	1	5/31/1992	10	0
SC0040037	1	4/30/1992	15	0
SC0040037	1	4/30/1993	**622**	0
SC0040037	1	5/31/1993	257	0
SC0040037	1	6/30/1993	330	0
SC0040037	1	7/31/1993	**450**	0
SC0040037	1	8/31/1993	7	0
SC0040037	1	9/30/1993	10	0
SC0040037	1	10/31/1993	320	0
SC0040037	1	11/30/1993	94	0
SC0040037	1	12/31/1993	**3200**	0
SC0040037	1	1/31/1994	15	0
SC0040037	1	2/28/1994	20	0
SC0040037	1	4/30/1994	25	0
SC0040037	1	5/31/1994	20	0
SC0040037	1	6/30/1994	172	0
SC0040037	1	9/30/1994	50	0
SC0040037	1	10/31/1994	220	0
SC0040037	1	11/30/1994	**20000**	0
SC0040037	1	12/31/1994	200	0
SC0040037	1	1/31/1995	**500**	0
SC0040037	1	2/28/1995	386	0
SC0040037	1	3/31/1995	**1822**	0
SC0040037	1	4/30/1995	18	0
SC0040037	1	6/30/1995	**1149**	0

NPDES	PIPE	DATE	counts/ 100ml	AVG. FLOW
SC0024422	1	2/28/1995	10	0.0014
SC0024422	1	7/31/1995	10	0.00014
SC0024422	1	8/31/1995	10	0.0029
SC0024422	1	11/30/1995	2	0.0029
SC0024422	1	12/31/1995	30	0.004
SC0024422	1	2/29/1996	2	0.0014
SC0024422	1	1/31/1996	88	0.0031
SC0024422	1	4/30/1996	10	0.002
SC0024422	1	5/31/1996	10	0.002
SC0024422	1	7/31/1996	**590**	0.0028
SC0024422	1	8/31/1996	35	0.0021
SC0024422	1	9/30/1996	4	0.0024
SC0024422	1	11/30/1996	240	0.0016
SC0024422	1	12/31/1996	2	0.02
SC0024422	1	10/31/1996	10	0.002
SC0024422	1	1/31/1997	12	0.0022
SC0024422	1	2/28/1997	2	0.0028
SC0024422	1	4/30/1997	2	0.0023
SC0024422	1	5/31/1997	2	0.0024
SC0024422	1	6/30/1997	2	0.0026
SC0024422	1	7/31/1997	2	0.0042
SC0024422	1	8/31/1997	2	0.0023
SC0024422	1	9/30/1997	2	0.0028
SC0024422	1	12/31/1997	34	0.002
SC0024422	1	1/31/1998	12	0.0018
SC0024422	1	2/28/1998	4	0.0024
SC0024422	1	4/30/1998	64	0.003
SC0024422	1	5/31/1998	2	0.0027
SC0024422	1	6/30/1998	2	0.0036
SC0024422	1	7/31/1998	110	0.018
SC0024422	1	8/31/1998	2	0.019
SC0024422	1	9/30/1998	2	0.015
SC0024422	1	10/31/1998	108	0.0049
SC0024422	1	11/30/1998	6	0.015
SC0024422	1	12/31/1998	106	0.0031
SC0024422	1	1/31/1999	94	0.0065
SC0024422	1	2/28/1999	2	0.008
SC0024422	1	3/31/1999	96	0.0028
SC0024422	1	3/31/1999	96	0.0028
SC0024422	1	3/31/1999	96	0.0028
SC0024422	1	3/31/1999	96	0.0028
SC0024422	1	4/30/1999	32	0.0043
SC0024422	1	5/31/1999	2	0.0057
SC0024422	1	6/30/1999	25	0.0033
SC0024422	1	7/31/1999	6	0.0043
SC0024422	1	8/31/1999	60	0.0036

NPDES	PIPE	DATE	counts/ 100ml	AVG. FLOW
SC0040037	1	5/31/1995	200	0
SC0040037	1	7/31/1995	**13397**	0
SC0040037	1	8/31/1995	**824**	0
SC0040037	1	9/30/1995	**673**	0
SC0040037	1	10/31/1995	45	0
SC0040037	1	11/30/1995	9	0
SC0040037	1	12/31/1995	2	0
SC0040037	1	1/31/1996	2	0
SC0040037	1	2/29/1996	2	0
SC0040037	1	3/31/1996	33	0
SC0040037	1	5/31/1996	**529**	0
SC0040037	1	6/30/1996	77	0
SC0040037	1	7/31/1996	**3840**	0
SC0040037	1	8/31/1996	**20000**	0
SC0040037	1	9/30/1996	49	0
SC0040037	1	6/30/1997	**12570**	0
SC0040037	1	4/30/1998	140	0
SC0040037	1	5/31/1998	236	0
SC0040037	1	7/31/1998	83	0
SC0040037	1	6/30/1998	41	0
SC0040037	1	8/31/1998	1	0
SC0040037	1	9/30/1998	16	0
SC0040037	1	10/31/1998	2	0
SC0040037	1	11/30/1998	4	0
SC0040037	1	12/31/1998	**1081**	0
SC0040037	1	1/31/1999	14	0
SC0040037	1	2/28/1999	9	0
SC0040037	1	3/31/1999	48	0
SC0040037	1	4/30/1999	**6000**	0
SC0040037	1	5/31/1999	**540**	0
SC0040037	1	6/30/1999	4	0
SC0040037	1	7/31/1999	4	0
SC0040037	1	8/31/1999	154	0
SC0040037	1	9/30/1999	384	0
SC0040037	1	10/31/1999	340	0
SC0040037	1	11/30/1999	**728**	0
SC0040037	1	12/31/1999	6	0
SC0040037	1	1/31/2000	5	0
SC0040037	1	2/29/2000	4	0
SC0040037	1	3/31/2000	**6000**	0
SC0040037	1	4/30/2000	15	0
SC0040037	1	5/31/2000	4	0
SC0040037	1	6/30/2000	154	0
SC0040037	1	7/31/2000	10	0
SC0040037	1	8/31/2000	3	0
SC0040037	1	9/30/2000	4	0

NPDES	PIPE	DATE	counts/ 100ml	AVG. FLOW
SC0024422	1	9/30/1999	25	0.016

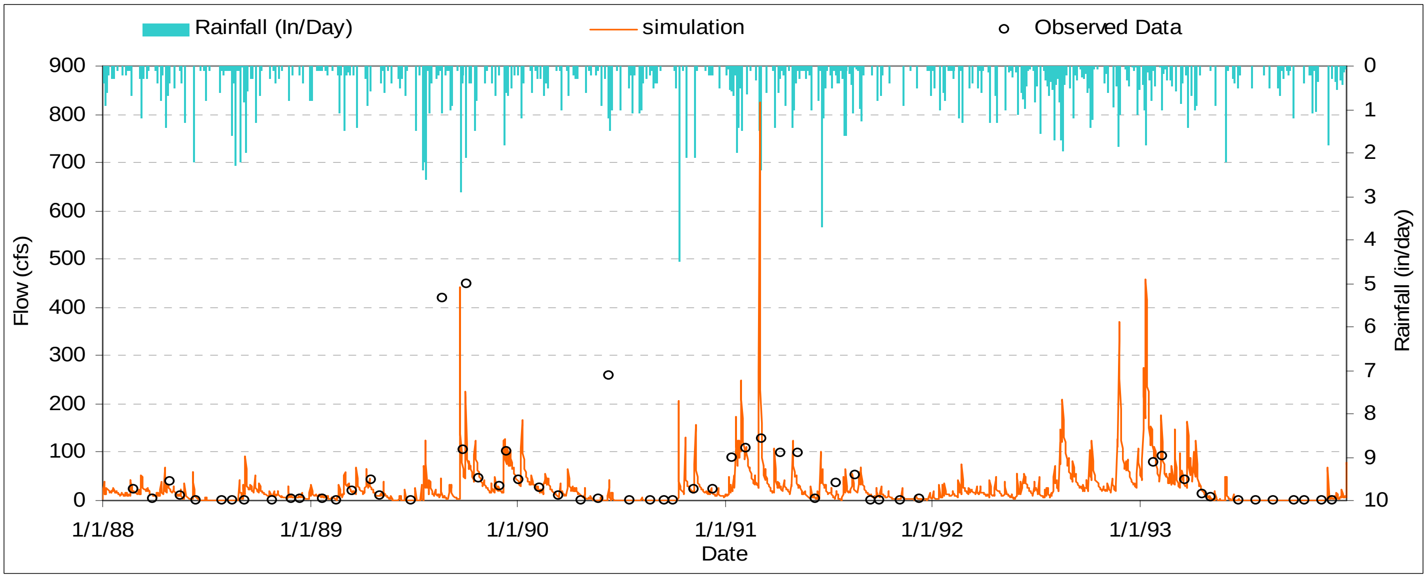
NPDES	PIPE	DATE	counts/ 100ml	AVG. FLOW
SC0040037	1	10/31/2000	4	0
SC0040037	1	11/30/2000	21	0
SC0040037	1	12/31/2000	4	0

Appendix B
Hydrology Calibration and Validation

The following pages present graphs depicting model runs versus observed flow data for the calibration period (January 1, 1991 to December 31, 1991) and validation period (January 1, 1988 to December 31, 1993). Insufficient data were available to perform a detailed statistical comparison between model results and observations.

Two USGS flow gages have recorded flow data in the Four Holes Swamp watershed. However, the Cow Castle Creek gage (USGS 2174250) is located on an unimpaired headwater basin that is physically uncharacteristic of the majority of the cataloging unit. The second gage, though optimally located, only collected data during water years 1915 and 1916. Though USGS gages are traditionally used to compare the accuracy of the model, other sources were used to assess the hydrology calibration.

Although the intervals between observations are longer, the range of observed values and the multi-year, multi-season period of record provide a good dataset for comparing model results.



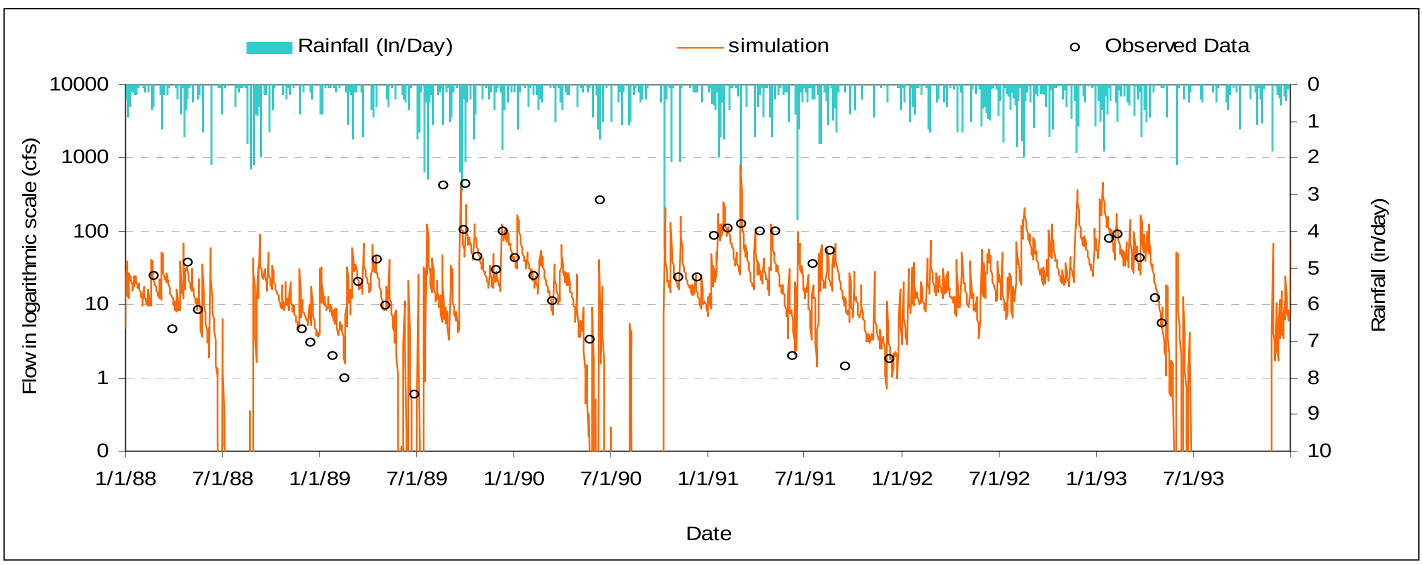
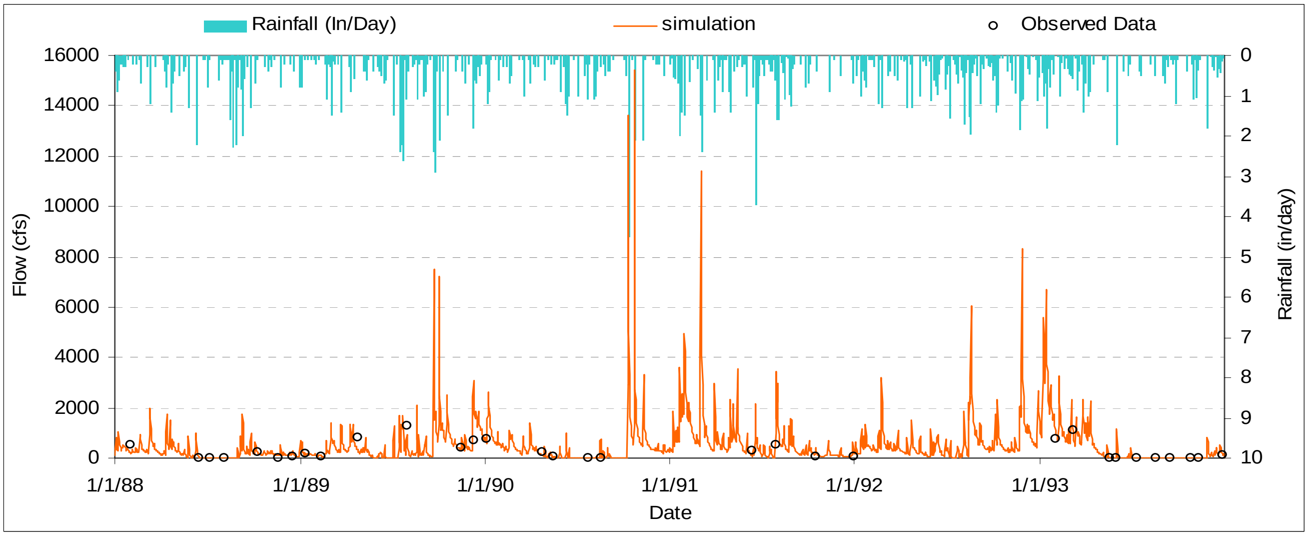


Figure B-1. Hydrology Calibration (1991) and Validation (1988-1993) at Water Quality Station E-051



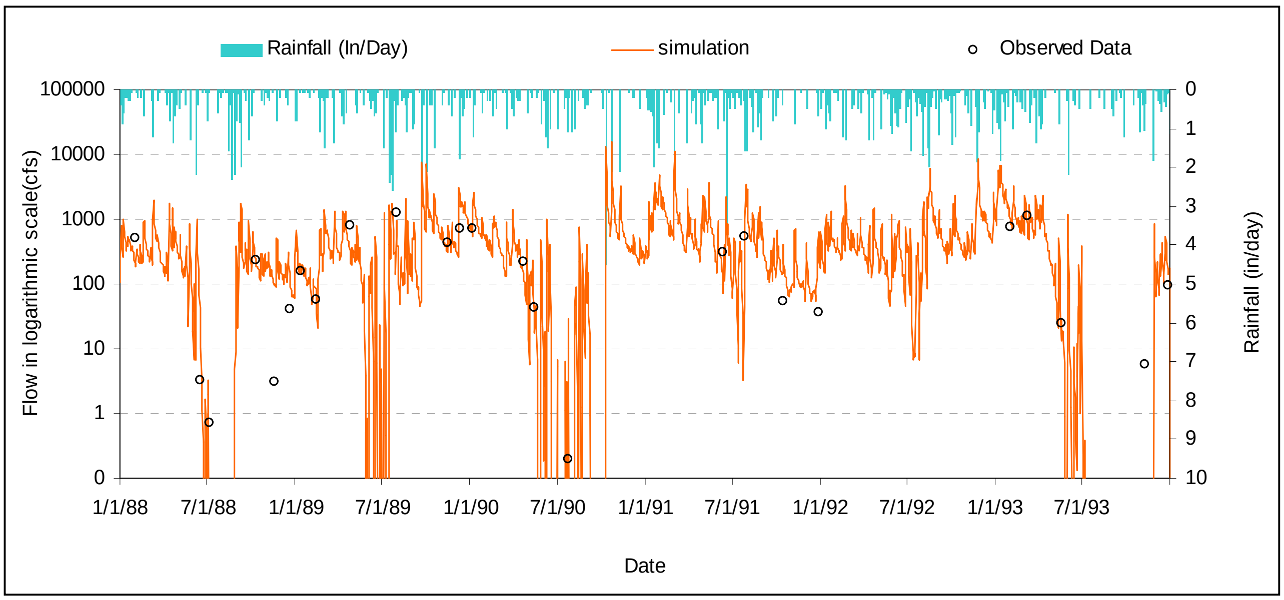


Figure B-2. Hydrology Calibration (1991) and Validation (1988-1993) at Water Quality Station E-100

Appendix C
Water Quality Data

Table C-1. Water Quality Data for the Four Holes Swamp watershed model

Station ID	Station Name	Date	Characteristic Name	Value
E-022	GRAMLING CK ON SC 33 2 MI E OF ORANGEB	5/19/88	Total Fecal Coliform (#/100mL)	150
E-022	GRAMLING CK ON SC 33 2 MI E OF ORANGEB	6/16/88	Total Fecal Coliform (#/100mL)	45
E-022	GRAMLING CK ON SC 33 2 MI E OF ORANGEB	7/28/88	Total Fecal Coliform (#/100mL)	300
E-022	GRAMLING CK ON SC 33 2 MI E OF ORANGEB	8/23/88	Total Fecal Coliform (#/100mL)	3000
E-022	GRAMLING CK ON SC 33 2 MI E OF ORANGEB	9/14/88	Total Fecal Coliform (#/100mL)	30
E-022	GRAMLING CK ON SC 33 2 MI E OF ORANGEB	10/13/88	Total Fecal Coliform (#/100mL)	40
E-022	GRAMLING CK ON SC 33 2 MI E OF ORANGEB	6/8/89	Total Fecal Coliform (#/100mL)	600
E-022	GRAMLING CK ON SC 33 2 MI E OF ORANGEB	7/13/89	Total Fecal Coliform (#/100mL)	1100
E-022	GRAMLING CK ON SC 33 2 MI E OF ORANGEB	8/10/89	Total Fecal Coliform (#/100mL)	120
E-022	GRAMLING CK ON SC 33 2 MI E OF ORANGEB	9/14/89	Total Fecal Coliform (#/100mL)	65
E-022	GRAMLING CK ON SC 33 2 MI E OF ORANGEB	10/12/89	Total Fecal Coliform (#/100mL)	108
E-022	GRAMLING CK ON SC 33 2 MI E OF ORANGEB	5/17/90	Total Fecal Coliform (#/100mL)	18
E-022	GRAMLING CK ON SC 33 2 MI E OF ORANGEB	6/12/90	Total Fecal Coliform (#/100mL)	54
E-022	GRAMLING CK ON SC 33 2 MI E OF ORANGEB	7/5/90	Total Fecal Coliform (#/100mL)	260
E-022	GRAMLING CK ON SC 33 2 MI E OF ORANGEB	8/9/90	Total Fecal Coliform (#/100mL)	600
E-022	GRAMLING CK ON SC 33 2 MI E OF ORANGEB	9/13/90	Total Fecal Coliform (#/100mL)	190
E-022	GRAMLING CK ON SC 33 2 MI E OF ORANGEB	5/2/91	Total Fecal Coliform (#/100mL)	130
E-022	GRAMLING CK ON SC 33 2 MI E OF ORANGEB	6/12/91	Total Fecal Coliform (#/100mL)	150
E-022	GRAMLING CK ON SC 33 2 MI E OF ORANGEB	7/1/91	Total Fecal Coliform (#/100mL)	37
E-022	GRAMLING CK ON SC 33 2 MI E OF ORANGEB	8/8/91	Total Fecal Coliform (#/100mL)	150
E-022	GRAMLING CK ON SC 33 2 MI E OF ORANGEB	9/19/91	Total Fecal Coliform (#/100mL)	300
E-022	GRAMLING CK ON SC 33 2 MI E OF ORANGEB	10/2/91	Total Fecal Coliform (#/100mL)	400
E-022	GRAMLING CK ON SC 33 2 MI E OF ORANGEB	5/21/92	Total Fecal Coliform (#/100mL)	300
E-022	GRAMLING CK ON SC 33 2 MI E OF ORANGEB	6/10/92	Total Fecal Coliform (#/100mL)	600
E-022	GRAMLING CK ON SC 33 2 MI E OF ORANGEB	7/14/92	Total Fecal Coliform (#/100mL)	440
E-022	GRAMLING CK ON SC 33 2 MI E OF ORANGEB	8/19/92	Total Fecal Coliform (#/100mL)	360
E-022	GRAMLING CK ON SC 33 2 MI E OF ORANGEB	9/3/92	Total Fecal Coliform (#/100mL)	330
E-022	GRAMLING CK ON SC 33 2 MI E OF ORANGEB	10/1/92	Total Fecal Coliform (#/100mL)	170
E-022	GRAMLING CK ON SC 33 2 MI E OF ORANGEB	5/20/93	Total Fecal Coliform (#/100mL)	980
E-022	GRAMLING CK ON SC 33 2 MI E OF ORANGEB	6/10/93	Total Fecal Coliform (#/100mL)	92
E-022	GRAMLING CK ON SC 33 2 MI E OF ORANGEB	7/26/93	Total Fecal Coliform (#/100mL)	200
E-022	GRAMLING CK ON SC 33 2 MI E OF ORANGEB	8/24/93	Total Fecal Coliform (#/100mL)	55
E-022	GRAMLING CK ON SC 33 2 MI E OF ORANGEB	9/28/93	Total Fecal Coliform (#/100mL)	34
E-022	GRAMLING CK ON SC 33 2 MI E OF ORANGEB	10/20/93	Total Fecal Coliform (#/100mL)	4
E-030	BRDG OVER DEAN SWAMP ON US 176	5/14/92	Total Fecal Coliform (#/100mL)	110
E-030	BRDG OVER DEAN SWAMP ON US 176	6/18/92	Total Fecal Coliform (#/100mL)	300
E-030	BRDG OVER DEAN SWAMP ON US 176	7/15/92	Total Fecal Coliform (#/100mL)	520
E-030	BRDG OVER DEAN SWAMP ON US 176	8/18/92	Total Fecal Coliform (#/100mL)	540
E-030	BRDG OVER DEAN SWAMP ON US 176	9/15/92	Total Fecal Coliform (#/100mL)	180
E-030	BRDG OVER DEAN SWAMP ON US 176	10/6/92	Total Fecal Coliform (#/100mL)	250
E-030	BRDG OVER DEAN SWAMP ON US 176	1/10/01	Total Fecal Coliform (#/100mL)	100
E-030	BRDG OVER DEAN SWAMP ON US 176	2/6/01	Total Fecal Coliform (#/100mL)	260

Station ID	Station Name	Date	Characteristic Name	Value
E-030	BRDG OVER DEAN SWAMP ON US 176	3/6/01	Total Fecal Coliform (#/100mL)	360
E-030	BRDG OVER DEAN SWAMP ON US 176	4/4/01	Total Fecal Coliform (#/100mL)	50
E-030	BRDG OVER DEAN SWAMP ON US 176	6/26/01	Total Fecal Coliform (#/100mL)	32
E-030	BRDG OVER DEAN SWAMP ON US 176	7/18/01	Total Fecal Coliform (#/100mL)	20
E-030	BRDG OVER DEAN SWAMP ON US 176	8/7/01	Total Fecal Coliform (#/100mL)	50
E-030	BRDG OVER DEAN SWAMP ON US 176	9/4/01	Total Fecal Coliform (#/100mL)	48
E-030	BRDG OVER DEAN SWAMP ON US 176	10/1/01	Total Fecal Coliform (#/100mL)	120
E-050	BRDG OVR COW CASTLE CK RD NO.92	5/14/92	Total Fecal Coliform (#/100mL)	300
E-050	BRDG OVR COW CASTLE CK RD NO.92	6/18/92	Total Fecal Coliform (#/100mL)	300
E-050	BRDG OVR COW CASTLE CK RD NO.92	7/15/92	Total Fecal Coliform (#/100mL)	140
E-050	BRDG OVR COW CASTLE CK RD NO.92	8/18/92	Total Fecal Coliform (#/100mL)	600
E-050	BRDG OVR COW CASTLE CK RD NO.92	9/15/92	Total Fecal Coliform (#/100mL)	620
E-050	BRDG OVR COW CASTLE CK RD NO.92	10/6/92	Total Fecal Coliform (#/100mL)	1200
E-050	BRDG OVR COW CASTLE CK RD NO.92	1/10/01	Total Fecal Coliform (#/100mL)	110
E-050	BRDG OVR COW CASTLE CK RD NO.92	2/6/01	Total Fecal Coliform (#/100mL)	120
E-050	BRDG OVR COW CASTLE CK RD NO.92	3/6/01	Total Fecal Coliform (#/100mL)	0
E-050	BRDG OVR COW CASTLE CK RD NO.92	4/4/01	Total Fecal Coliform (#/100mL)	80
E-050	BRDG OVR COW CASTLE CK RD NO.92	6/26/01	Total Fecal Coliform (#/100mL)	0
E-050	BRDG OVR COW CASTLE CK RD NO.92	7/18/01	Total Fecal Coliform (#/100mL)	490
E-050	BRDG OVR COW CASTLE CK RD NO.92	10/1/01	Total Fecal Coliform (#/100mL)	0
E-050	BRDG OVR COW CASTLE CK RD NO.92	11/20/01	Total Fecal Coliform (#/100mL)	200
E-050	BRDG OVR COW CASTLE CK RD NO.92	12/5/01	Total Fecal Coliform (#/100mL)	480
E-051	PROVIDENCE SWAMP AT US 176 NW HOLLY HI	1/21/88	Total Fecal Coliform (#/100mL)	80
E-051	PROVIDENCE SWAMP AT US 176 NW HOLLY HI	2/25/88	Total Fecal Coliform (#/100mL)	110
E-051	PROVIDENCE SWAMP AT US 176 NW HOLLY HI	3/31/88	Total Fecal Coliform (#/100mL)	67
E-051	PROVIDENCE SWAMP AT US 176 NW HOLLY HI	4/28/88	Total Fecal Coliform (#/100mL)	125
E-051	PROVIDENCE SWAMP AT US 176 NW HOLLY HI	5/18/88	Total Fecal Coliform (#/100mL)	600
E-051	PROVIDENCE SWAMP AT US 176 NW HOLLY HI	6/14/88	Total Fecal Coliform (#/100mL)	20
E-051	PROVIDENCE SWAMP AT US 176 NW HOLLY HI	10/25/88	Total Fecal Coliform (#/100mL)	130
E-051	PROVIDENCE SWAMP AT US 176 NW HOLLY HI	11/29/88	Total Fecal Coliform (#/100mL)	170
E-051	PROVIDENCE SWAMP AT US 176 NW HOLLY HI	12/15/88	Total Fecal Coliform (#/100mL)	100
E-051	PROVIDENCE SWAMP AT US 176 NW HOLLY HI	1/24/89	Total Fecal Coliform (#/100mL)	90
E-051	PROVIDENCE SWAMP AT US 176 NW HOLLY HI	2/16/89	Total Fecal Coliform (#/100mL)	57
E-051	PROVIDENCE SWAMP AT US 176 NW HOLLY HI	3/15/89	Total Fecal Coliform (#/100mL)	78
E-051	PROVIDENCE SWAMP AT US 176 NW HOLLY HI	4/20/89	Total Fecal Coliform (#/100mL)	300
E-051	PROVIDENCE SWAMP AT US 176 NW HOLLY HI	5/4/89	Total Fecal Coliform (#/100mL)	200
E-051	PROVIDENCE SWAMP AT US 176 NW HOLLY HI	6/29/89	Total Fecal Coliform (#/100mL)	660
E-051	PROVIDENCE SWAMP AT US 176 NW HOLLY HI	7/26/89	Total Fecal Coliform (#/100mL)	640
E-051	PROVIDENCE SWAMP AT US 176 NW HOLLY HI	8/22/89	Total Fecal Coliform (#/100mL)	1200
E-051	PROVIDENCE SWAMP AT US 176 NW HOLLY HI	9/28/89	Total Fecal Coliform (#/100mL)	510
E-051	PROVIDENCE SWAMP AT US 176 NW HOLLY HI	10/3/89	Total Fecal Coliform (#/100mL)	1200
E-051	PROVIDENCE SWAMP AT US 176 NW HOLLY HI	10/25/89	Total Fecal Coliform (#/100mL)	90
E-051	PROVIDENCE SWAMP AT US 176 NW HOLLY HI	11/30/89	Total Fecal Coliform (#/100mL)	260
E-051	PROVIDENCE SWAMP AT US 176 NW HOLLY HI	12/13/89	Total Fecal Coliform (#/100mL)	200
E-051	PROVIDENCE SWAMP AT US 176 NW HOLLY HI	1/4/90	Total Fecal Coliform (#/100mL)	130

Station ID	Station Name	Date	Characteristic Name	Value
E-051	PROVIDENCE SWAMP AT US 176 NW HOLLY HI	2/8/90	Total Fecal Coliform (#/100mL)	160
E-051	PROVIDENCE SWAMP AT US 176 NW HOLLY HI	3/15/90	Total Fecal Coliform (#/100mL)	160
E-051	PROVIDENCE SWAMP AT US 176 NW HOLLY HI	4/24/90	Total Fecal Coliform (#/100mL)	290
E-051	PROVIDENCE SWAMP AT US 176 NW HOLLY HI	5/23/90	Total Fecal Coliform (#/100mL)	420
E-051	PROVIDENCE SWAMP AT US 176 NW HOLLY HI	6/12/90	Total Fecal Coliform (#/100mL)	860
E-051	PROVIDENCE SWAMP AT US 176 NW HOLLY HI	7/19/90	Total Fecal Coliform (#/100mL)	50
E-051	PROVIDENCE SWAMP AT US 176 NW HOLLY HI	12/13/90	Total Fecal Coliform (#/100mL)	88
E-051	PROVIDENCE SWAMP AT US 176 NW HOLLY HI	1/14/91	Total Fecal Coliform (#/100mL)	200
E-051	PROVIDENCE SWAMP AT US 176 NW HOLLY HI	2/7/91	Total Fecal Coliform (#/100mL)	500
E-051	PROVIDENCE SWAMP AT US 176 NW HOLLY HI	3/7/91	Total Fecal Coliform (#/100mL)	120
E-051	PROVIDENCE SWAMP AT US 176 NW HOLLY HI	4/10/91	Total Fecal Coliform (#/100mL)	110
E-051	PROVIDENCE SWAMP AT US 176 NW HOLLY HI	5/9/91	Total Fecal Coliform (#/100mL)	30
E-051	PROVIDENCE SWAMP AT US 176 NW HOLLY HI	6/11/91	Total Fecal Coliform (#/100mL)	240
E-051	PROVIDENCE SWAMP AT US 176 NW HOLLY HI	7/18/91	Total Fecal Coliform (#/100mL)	320
E-051	PROVIDENCE SWAMP AT US 176 NW HOLLY HI	8/20/91	Total Fecal Coliform (#/100mL)	280
E-051	PROVIDENCE SWAMP AT US 176 NW HOLLY HI	9/17/91	Total Fecal Coliform (#/100mL)	170
E-051	PROVIDENCE SWAMP AT US 176 NW HOLLY HI	10/1/91	Total Fecal Coliform (#/100mL)	300
E-051	PROVIDENCE SWAMP AT US 176 NW HOLLY HI	11/7/91	Total Fecal Coliform (#/100mL)	95
E-051	PROVIDENCE SWAMP AT US 176 NW HOLLY HI	12/10/91	Total Fecal Coliform (#/100mL)	280
E-051	PROVIDENCE SWAMP AT US 176 NW HOLLY HI	1/23/92	Total Fecal Coliform (#/100mL)	600
E-051	PROVIDENCE SWAMP AT US 176 NW HOLLY HI	2/10/92	Total Fecal Coliform (#/100mL)	170
E-051	PROVIDENCE SWAMP AT US 176 NW HOLLY HI	4/5/92	Total Fecal Coliform (#/100mL)	100
E-051	PROVIDENCE SWAMP AT US 176 NW HOLLY HI	4/16/92	Total Fecal Coliform (#/100mL)	160
E-051	PROVIDENCE SWAMP AT US 176 NW HOLLY HI	5/6/92	Total Fecal Coliform (#/100mL)	150
E-051	PROVIDENCE SWAMP AT US 176 NW HOLLY HI	6/18/92	Total Fecal Coliform (#/100mL)	300
E-051	PROVIDENCE SWAMP AT US 176 NW HOLLY HI	7/15/92	Total Fecal Coliform (#/100mL)	320
E-051	PROVIDENCE SWAMP AT US 176 NW HOLLY HI	8/18/92	Total Fecal Coliform (#/100mL)	350
E-051	PROVIDENCE SWAMP AT US 176 NW HOLLY HI	9/15/92	Total Fecal Coliform (#/100mL)	140
E-051	PROVIDENCE SWAMP AT US 176 NW HOLLY HI	10/6/92	Total Fecal Coliform (#/100mL)	600
E-051	PROVIDENCE SWAMP AT US 176 NW HOLLY HI	11/19/92	Total Fecal Coliform (#/100mL)	160
E-051	PROVIDENCE SWAMP AT US 176 NW HOLLY HI	12/3/92	Total Fecal Coliform (#/100mL)	200
E-051	PROVIDENCE SWAMP AT US 176 NW HOLLY HI	1/27/93	Total Fecal Coliform (#/100mL)	150
E-051	PROVIDENCE SWAMP AT US 176 NW HOLLY HI	2/11/93	Total Fecal Coliform (#/100mL)	120
E-051	PROVIDENCE SWAMP AT US 176 NW HOLLY HI	3/23/93	Total Fecal Coliform (#/100mL)	120
E-051	PROVIDENCE SWAMP AT US 176 NW HOLLY HI	4/22/93	Total Fecal Coliform (#/100mL)	290
E-051	PROVIDENCE SWAMP AT US 176 NW HOLLY HI	5/6/93	Total Fecal Coliform (#/100mL)	600
E-051	PROVIDENCE SWAMP AT US 176 NW HOLLY HI	6/24/93	Total Fecal Coliform (#/100mL)	60
E-051	PROVIDENCE SWAMP AT US 176 NW HOLLY HI	7/26/93	Total Fecal Coliform (#/100mL)	160
E-051	PROVIDENCE SWAMP AT US 176 NW HOLLY HI	8/26/93	Total Fecal Coliform (#/100mL)	5
E-051	PROVIDENCE SWAMP AT US 176 NW HOLLY HI	9/29/93	Total Fecal Coliform (#/100mL)	32
E-051	PROVIDENCE SWAMP AT US 176 NW HOLLY HI	11/17/93	Total Fecal Coliform (#/100mL)	14
E-051	PROVIDENCE SWAMP AT US 176 NW HOLLY HI	12/8/93	Total Fecal Coliform (#/100mL)	65
E-052	HORSE RANGE SWAMP AT US 176 NW HOLLY H	5/14/92	Total Fecal Coliform (#/100mL)	300
E-052	HORSE RANGE SWAMP AT US 176 NW HOLLY H	6/18/92	Total Fecal Coliform (#/100mL)	300
E-052	HORSE RANGE SWAMP AT US 176 NW HOLLY H	7/15/92	Total Fecal Coliform (#/100mL)	250

Station ID	Station Name	Date	Characteristic Name	Value
E-052	HORSE RANGE SWAMP AT US 176 NW HOLLY H	8/18/92	Total Fecal Coliform (#/100mL)	370
E-052	HORSE RANGE SWAMP AT US 176 NW HOLLY H	9/15/92	Total Fecal Coliform (#/100mL)	600
E-052	HORSE RANGE SWAMP AT US 176 NW HOLLY H	10/6/92	Total Fecal Coliform (#/100mL)	2600
E-059	FOUR HOLE SWAMP AT S-38-50 SE CAMERON	1/28/88	Total Fecal Coliform (#/100mL)	140
E-059	FOUR HOLE SWAMP AT S-38-50 SE CAMERON	2/25/88	Total Fecal Coliform (#/100mL)	300
E-059	FOUR HOLE SWAMP AT S-38-50 SE CAMERON	3/31/88	Total Fecal Coliform (#/100mL)	125
E-059	FOUR HOLE SWAMP AT S-38-50 SE CAMERON	4/28/88	Total Fecal Coliform (#/100mL)	150
E-059	FOUR HOLE SWAMP AT S-38-50 SE CAMERON	5/18/88	Total Fecal Coliform (#/100mL)	410
E-059	FOUR HOLE SWAMP AT S-38-50 SE CAMERON	6/14/88	Total Fecal Coliform (#/100mL)	580
E-059	FOUR HOLE SWAMP AT S-38-50 SE CAMERON	7/29/88	Total Fecal Coliform (#/100mL)	370
E-059	FOUR HOLE SWAMP AT S-38-50 SE CAMERON	8/18/88	Total Fecal Coliform (#/100mL)	200
E-059	FOUR HOLE SWAMP AT S-38-50 SE CAMERON	9/14/88	Total Fecal Coliform (#/100mL)	980
E-059	FOUR HOLE SWAMP AT S-38-50 SE CAMERON	10/6/88	Total Fecal Coliform (#/100mL)	80
E-059	FOUR HOLE SWAMP AT S-38-50 SE CAMERON	11/30/88	Total Fecal Coliform (#/100mL)	100
E-059	FOUR HOLE SWAMP AT S-38-50 SE CAMERON	12/15/88	Total Fecal Coliform (#/100mL)	185
E-059	FOUR HOLE SWAMP AT S-38-50 SE CAMERON	1/24/89	Total Fecal Coliform (#/100mL)	100
E-059	FOUR HOLE SWAMP AT S-38-50 SE CAMERON	2/16/89	Total Fecal Coliform (#/100mL)	155
E-059	FOUR HOLE SWAMP AT S-38-50 SE CAMERON	3/15/89	Total Fecal Coliform (#/100mL)	79
E-059	FOUR HOLE SWAMP AT S-38-50 SE CAMERON	4/20/89	Total Fecal Coliform (#/100mL)	200
E-059	FOUR HOLE SWAMP AT S-38-50 SE CAMERON	5/18/89	Total Fecal Coliform (#/100mL)	220
E-059	FOUR HOLE SWAMP AT S-38-50 SE CAMERON	6/29/89	Total Fecal Coliform (#/100mL)	188
E-059	FOUR HOLE SWAMP AT S-38-50 SE CAMERON	7/27/89	Total Fecal Coliform (#/100mL)	600
E-059	FOUR HOLE SWAMP AT S-38-50 SE CAMERON	8/23/89	Total Fecal Coliform (#/100mL)	220
E-059	FOUR HOLE SWAMP AT S-38-50 SE CAMERON	9/28/89	Total Fecal Coliform (#/100mL)	110
E-059	FOUR HOLE SWAMP AT S-38-50 SE CAMERON	10/3/89	Total Fecal Coliform (#/100mL)	300
E-059	FOUR HOLE SWAMP AT S-38-50 SE CAMERON	10/25/89	Total Fecal Coliform (#/100mL)	80
E-059	FOUR HOLE SWAMP AT S-38-50 SE CAMERON	11/21/89	Total Fecal Coliform (#/100mL)	180
E-059	FOUR HOLE SWAMP AT S-38-50 SE CAMERON	12/11/89	Total Fecal Coliform (#/100mL)	200
E-059	FOUR HOLE SWAMP AT S-38-50 SE CAMERON	1/4/90	Total Fecal Coliform (#/100mL)	200
E-059	FOUR HOLE SWAMP AT S-38-50 SE CAMERON	2/8/90	Total Fecal Coliform (#/100mL)	240
E-059	FOUR HOLE SWAMP AT S-38-50 SE CAMERON	3/13/90	Total Fecal Coliform (#/100mL)	160
E-059	FOUR HOLE SWAMP AT S-38-50 SE CAMERON	4/18/90	Total Fecal Coliform (#/100mL)	240
E-059	FOUR HOLE SWAMP AT S-38-50 SE CAMERON	5/16/90	Total Fecal Coliform (#/100mL)	240
E-059	FOUR HOLE SWAMP AT S-38-50 SE CAMERON	6/12/90	Total Fecal Coliform (#/100mL)	600
E-059	FOUR HOLE SWAMP AT S-38-50 SE CAMERON	7/19/90	Total Fecal Coliform (#/100mL)	40
E-059	FOUR HOLE SWAMP AT S-38-50 SE CAMERON	8/16/90	Total Fecal Coliform (#/100mL)	200
E-059	FOUR HOLE SWAMP AT S-38-50 SE CAMERON	9/6/90	Total Fecal Coliform (#/100mL)	130
E-059	FOUR HOLE SWAMP AT S-38-50 SE CAMERON	10/1/90	Total Fecal Coliform (#/100mL)	120
E-059	FOUR HOLE SWAMP AT S-38-50 SE CAMERON	12/13/90	Total Fecal Coliform (#/100mL)	130
E-059	FOUR HOLE SWAMP AT S-38-50 SE CAMERON	1/14/91	Total Fecal Coliform (#/100mL)	300
E-059	FOUR HOLE SWAMP AT S-38-50 SE CAMERON	2/7/91	Total Fecal Coliform (#/100mL)	320
E-059	FOUR HOLE SWAMP AT S-38-50 SE CAMERON	3/7/91	Total Fecal Coliform (#/100mL)	180
E-059	FOUR HOLE SWAMP AT S-38-50 SE CAMERON	4/10/91	Total Fecal Coliform (#/100mL)	500
E-059	FOUR HOLE SWAMP AT S-38-50 SE CAMERON	5/9/91	Total Fecal Coliform (#/100mL)	690
E-059	FOUR HOLE SWAMP AT S-38-50 SE CAMERON	6/11/91	Total Fecal Coliform (#/100mL)	300

Station ID	Station Name	Date	Characteristic Name	Value
E-059	FOUR HOLE SWAMP AT S-38-50 SE CAMERON	7/18/91	Total Fecal Coliform (#/100mL)	300
E-059	FOUR HOLE SWAMP AT S-38-50 SE CAMERON	8/20/91	Total Fecal Coliform (#/100mL)	230
E-059	FOUR HOLE SWAMP AT S-38-50 SE CAMERON	1/23/92	Total Fecal Coliform (#/100mL)	300
E-059	FOUR HOLE SWAMP AT S-38-50 SE CAMERON	2/10/92	Total Fecal Coliform (#/100mL)	240
E-059	FOUR HOLE SWAMP AT S-38-50 SE CAMERON	3/5/92	Total Fecal Coliform (#/100mL)	490
E-059	FOUR HOLE SWAMP AT S-38-50 SE CAMERON	4/16/92	Total Fecal Coliform (#/100mL)	290
E-059	FOUR HOLE SWAMP AT S-38-50 SE CAMERON	5/6/92	Total Fecal Coliform (#/100mL)	520
E-059	FOUR HOLE SWAMP AT S-38-50 SE CAMERON	6/10/92	Total Fecal Coliform (#/100mL)	1200
E-059	FOUR HOLE SWAMP AT S-38-50 SE CAMERON	7/14/92	Total Fecal Coliform (#/100mL)	560
E-059	FOUR HOLE SWAMP AT S-38-50 SE CAMERON	8/19/92	Total Fecal Coliform (#/100mL)	380
E-059	FOUR HOLE SWAMP AT S-38-50 SE CAMERON	9/3/92	Total Fecal Coliform (#/100mL)	100
E-059	FOUR HOLE SWAMP AT S-38-50 SE CAMERON	10/1/92	Total Fecal Coliform (#/100mL)	190
E-059	FOUR HOLE SWAMP AT S-38-50 SE CAMERON	11/19/92	Total Fecal Coliform (#/100mL)	90
E-059	FOUR HOLE SWAMP AT S-38-50 SE CAMERON	12/3/92	Total Fecal Coliform (#/100mL)	130
E-059	FOUR HOLE SWAMP AT S-38-50 SE CAMERON	1/28/93	Total Fecal Coliform (#/100mL)	170
E-059	FOUR HOLE SWAMP AT S-38-50 SE CAMERON	2/23/93	Total Fecal Coliform (#/100mL)	170
E-059	FOUR HOLE SWAMP AT S-38-50 SE CAMERON	3/17/93	Total Fecal Coliform (#/100mL)	240
E-059	FOUR HOLE SWAMP AT S-38-50 SE CAMERON	4/1/93	Total Fecal Coliform (#/100mL)	280
E-059	FOUR HOLE SWAMP AT S-38-50 SE CAMERON	5/19/93	Total Fecal Coliform (#/100mL)	240
E-059	FOUR HOLE SWAMP AT S-38-50 SE CAMERON	6/23/93	Total Fecal Coliform (#/100mL)	360
E-059	FOUR HOLE SWAMP AT S-38-50 SE CAMERON	7/26/93	Total Fecal Coliform (#/100mL)	400
E-059	FOUR HOLE SWAMP AT S-38-50 SE CAMERON	8/24/93	Total Fecal Coliform (#/100mL)	320
E-059	FOUR HOLE SWAMP AT S-38-50 SE CAMERON	9/28/93	Total Fecal Coliform (#/100mL)	120
E-059	FOUR HOLE SWAMP AT S-38-50 SE CAMERON	10/20/93	Total Fecal Coliform (#/100mL)	100
E-059	FOUR HOLE SWAMP AT S-38-50 SE CAMERON	11/23/93	Total Fecal Coliform (#/100mL)	98
E-059	FOUR HOLE SWAMP AT S-38-50 SE CAMERON	12/8/93	Total Fecal Coliform (#/100mL)	110
E-076	TRIB TO GRAMLING CK AT SC-33 BL UTICA	5/19/88	Total Fecal Coliform (#/100mL)	70
E-076	TRIB TO GRAMLING CK AT SC-33 BL UTICA	6/16/88	Total Fecal Coliform (#/100mL)	175
E-076	TRIB TO GRAMLING CK AT SC-33 BL UTICA	7/28/88	Total Fecal Coliform (#/100mL)	800
E-076	TRIB TO GRAMLING CK AT SC-33 BL UTICA	8/23/88	Total Fecal Coliform (#/100mL)	3900
E-076	TRIB TO GRAMLING CK AT SC-33 BL UTICA	9/14/88	Total Fecal Coliform (#/100mL)	400
E-076	TRIB TO GRAMLING CK AT SC-33 BL UTICA	10/13/88	Total Fecal Coliform (#/100mL)	95
E-076	TRIB TO GRAMLING CK AT SC-33 BL UTICA	10/25/88	Total Fecal Coliform (#/100mL)	350
E-076	TRIB TO GRAMLING CK AT SC-33 BL UTICA	6/8/89	Total Fecal Coliform (#/100mL)	70
E-076	TRIB TO GRAMLING CK AT SC-33 BL UTICA	7/13/89	Total Fecal Coliform (#/100mL)	190
E-076	TRIB TO GRAMLING CK AT SC-33 BL UTICA	8/10/89	Total Fecal Coliform (#/100mL)	300
E-076	TRIB TO GRAMLING CK AT SC-33 BL UTICA	9/14/89	Total Fecal Coliform (#/100mL)	155
E-076	TRIB TO GRAMLING CK AT SC-33 BL UTICA	10/12/89	Total Fecal Coliform (#/100mL)	87
E-076	TRIB TO GRAMLING CK AT SC-33 BL UTICA	5/17/90	Total Fecal Coliform (#/100mL)	200
E-076	TRIB TO GRAMLING CK AT SC-33 BL UTICA	6/12/90	Total Fecal Coliform (#/100mL)	570
E-076	TRIB TO GRAMLING CK AT SC-33 BL UTICA	7/5/90	Total Fecal Coliform (#/100mL)	1200
E-076	TRIB TO GRAMLING CK AT SC-33 BL UTICA	8/9/90	Total Fecal Coliform (#/100mL)	1120
E-076	TRIB TO GRAMLING CK AT SC-33 BL UTICA	9/13/90	Total Fecal Coliform (#/100mL)	120
E-076	TRIB TO GRAMLING CK AT SC-33 BL UTICA	5/2/91	Total Fecal Coliform (#/100mL)	160
E-076	TRIB TO GRAMLING CK AT SC-33 BL UTICA	6/12/91	Total Fecal Coliform (#/100mL)	140

Station ID	Station Name	Date	Characteristic Name	Value
E-076	TRIB TO GRAMLING CK AT SC-33 BL UTICA	7/1/91	Total Fecal Coliform (#/100mL)	220
E-076	TRIB TO GRAMLING CK AT SC-33 BL UTICA	8/8/91	Total Fecal Coliform (#/100mL)	300
E-076	TRIB TO GRAMLING CK AT SC-33 BL UTICA	9/19/91	Total Fecal Coliform (#/100mL)	85
E-076	TRIB TO GRAMLING CK AT SC-33 BL UTICA	10/2/91	Total Fecal Coliform (#/100mL)	110
E-076	TRIB TO GRAMLING CK AT SC-33 BL UTICA	5/21/92	Total Fecal Coliform (#/100mL)	140
E-076	TRIB TO GRAMLING CK AT SC-33 BL UTICA	6/10/92	Total Fecal Coliform (#/100mL)	300
E-076	TRIB TO GRAMLING CK AT SC-33 BL UTICA	7/14/92	Total Fecal Coliform (#/100mL)	600
E-076	TRIB TO GRAMLING CK AT SC-33 BL UTICA	8/19/92	Total Fecal Coliform (#/100mL)	500
E-076	TRIB TO GRAMLING CK AT SC-33 BL UTICA	9/3/92	Total Fecal Coliform (#/100mL)	150
E-076	TRIB TO GRAMLING CK AT SC-33 BL UTICA	10/1/92	Total Fecal Coliform (#/100mL)	80
E-076	TRIB TO GRAMLING CK AT SC-33 BL UTICA	5/20/93	Total Fecal Coliform (#/100mL)	190
E-076	TRIB TO GRAMLING CK AT SC-33 BL UTICA	6/10/93	Total Fecal Coliform (#/100mL)	600
E-076	TRIB TO GRAMLING CK AT SC-33 BL UTICA	7/26/93	Total Fecal Coliform (#/100mL)	1200
E-076	TRIB TO GRAMLING CK AT SC-33 BL UTICA	8/24/93	Total Fecal Coliform (#/100mL)	140
E-076	TRIB TO GRAMLING CK AT SC-33 BL UTICA	9/28/93	Total Fecal Coliform (#/100mL)	300
E-076	TRIB TO GRAMLING CK AT SC-33 BL UTICA	10/20/93	Total Fecal Coliform (#/100mL)	290
E-100	FOUR HOLE SWAMP AT US 78 E OF DORCHEST	1/13/88	Total Fecal Coliform (#/100mL)	575
E-100	FOUR HOLE SWAMP AT US 78 E OF DORCHEST	2/2/88	Total Fecal Coliform (#/100mL)	270
E-100	FOUR HOLE SWAMP AT US 78 E OF DORCHEST	3/3/88	Total Fecal Coliform (#/100mL)	200
E-100	FOUR HOLE SWAMP AT US 78 E OF DORCHEST	4/20/88	Total Fecal Coliform (#/100mL)	480
E-100	FOUR HOLE SWAMP AT US 78 E OF DORCHEST	5/2/88	Total Fecal Coliform (#/100mL)	60
E-100	FOUR HOLE SWAMP AT US 78 E OF DORCHEST	6/15/88	Total Fecal Coliform (#/100mL)	12
E-100	FOUR HOLE SWAMP AT US 78 E OF DORCHEST	7/7/88	Total Fecal Coliform (#/100mL)	2
E-100	FOUR HOLE SWAMP AT US 78 E OF DORCHEST	8/5/88	Total Fecal Coliform (#/100mL)	94
E-100	FOUR HOLE SWAMP AT US 78 E OF DORCHEST	9/30/88	Total Fecal Coliform (#/100mL)	160
E-100	FOUR HOLE SWAMP AT US 78 E OF DORCHEST	10/10/88	Total Fecal Coliform (#/100mL)	144
E-100	FOUR HOLE SWAMP AT US 78 E OF DORCHEST	11/18/88	Total Fecal Coliform (#/100mL)	96
E-100	FOUR HOLE SWAMP AT US 78 E OF DORCHEST	12/19/88	Total Fecal Coliform (#/100mL)	106
E-100	FOUR HOLE SWAMP AT US 78 E OF DORCHEST	1/13/89	Total Fecal Coliform (#/100mL)	292
E-100	FOUR HOLE SWAMP AT US 78 E OF DORCHEST	2/13/89	Total Fecal Coliform (#/100mL)	68
E-100	FOUR HOLE SWAMP AT US 78 E OF DORCHEST	3/1/89	Total Fecal Coliform (#/100mL)	148
E-100	FOUR HOLE SWAMP AT US 78 E OF DORCHEST	4/26/89	Total Fecal Coliform (#/100mL)	72
E-100	FOUR HOLE SWAMP AT US 78 E OF DORCHEST	5/19/89	Total Fecal Coliform (#/100mL)	360
E-100	FOUR HOLE SWAMP AT US 78 E OF DORCHEST	7/13/89	Total Fecal Coliform (#/100mL)	250
E-100	FOUR HOLE SWAMP AT US 78 E OF DORCHEST	7/31/89	Total Fecal Coliform (#/100mL)	122
E-100	FOUR HOLE SWAMP AT US 78 E OF DORCHEST	8/25/89	Total Fecal Coliform (#/100mL)	220
E-100	FOUR HOLE SWAMP AT US 78 E OF DORCHEST	9/14/89	Total Fecal Coliform (#/100mL)	16
E-100	FOUR HOLE SWAMP AT US 78 E OF DORCHEST	10/13/89	Total Fecal Coliform (#/100mL)	10
E-100	FOUR HOLE SWAMP AT US 78 E OF DORCHEST	10/20/89	Total Fecal Coliform (#/100mL)	26
E-100	FOUR HOLE SWAMP AT US 78 E OF DORCHEST	10/30/89	Total Fecal Coliform (#/100mL)	18
E-100	FOUR HOLE SWAMP AT US 78 E OF DORCHEST	11/16/89	Total Fecal Coliform (#/100mL)	74
E-100	FOUR HOLE SWAMP AT US 78 E OF DORCHEST	12/11/89	Total Fecal Coliform (#/100mL)	124
E-100	FOUR HOLE SWAMP AT US 78 E OF DORCHEST	1/5/90	Total Fecal Coliform (#/100mL)	28
E-100	FOUR HOLE SWAMP AT US 78 E OF DORCHEST	2/26/90	Total Fecal Coliform (#/100mL)	68
E-100	FOUR HOLE SWAMP AT US 78 E OF DORCHEST	3/5/90	Total Fecal Coliform (#/100mL)	42

Station ID	Station Name	Date	Characteristic Name	Value
E-100	FOUR HOLE SWAMP AT US 78 E OF DORCHEST	4/23/90	Total Fecal Coliform (#/100mL)	22
E-100	FOUR HOLE SWAMP AT US 78 E OF DORCHEST	5/15/90	Total Fecal Coliform (#/100mL)	38
E-100	FOUR HOLE SWAMP AT US 78 E OF DORCHEST	6/11/90	Total Fecal Coliform (#/100mL)	80
E-100	FOUR HOLE SWAMP AT US 78 E OF DORCHEST	7/25/90	Total Fecal Coliform (#/100mL)	26
E-100	FOUR HOLE SWAMP AT US 78 E OF DORCHEST	8/17/90	Total Fecal Coliform (#/100mL)	220
E-100	FOUR HOLE SWAMP AT US 78 E OF DORCHEST	12/6/90	Total Fecal Coliform (#/100mL)	84
E-100	FOUR HOLE SWAMP AT US 78 E OF DORCHEST	1/9/91	Total Fecal Coliform (#/100mL)	120
E-100	FOUR HOLE SWAMP AT US 78 E OF DORCHEST	2/6/91	Total Fecal Coliform (#/100mL)	170
E-100	FOUR HOLE SWAMP AT US 78 E OF DORCHEST	3/4/91	Total Fecal Coliform (#/100mL)	2300
E-100	FOUR HOLE SWAMP AT US 78 E OF DORCHEST	4/1/91	Total Fecal Coliform (#/100mL)	42
E-100	FOUR HOLE SWAMP AT US 78 E OF DORCHEST	5/2/91	Total Fecal Coliform (#/100mL)	124
E-100	FOUR HOLE SWAMP AT US 78 E OF DORCHEST	6/12/91	Total Fecal Coliform (#/100mL)	32
E-100	FOUR HOLE SWAMP AT US 78 E OF DORCHEST	7/29/91	Total Fecal Coliform (#/100mL)	102
E-100	FOUR HOLE SWAMP AT US 78 E OF DORCHEST	10/17/91	Total Fecal Coliform (#/100mL)	198
E-100	FOUR HOLE SWAMP AT US 78 E OF DORCHEST	11/26/91	Total Fecal Coliform (#/100mL)	52
E-100	FOUR HOLE SWAMP AT US 78 E OF DORCHEST	12/31/91	Total Fecal Coliform (#/100mL)	404
E-100	FOUR HOLE SWAMP AT US 78 E OF DORCHEST	1/15/92	Total Fecal Coliform (#/100mL)	360
E-100	FOUR HOLE SWAMP AT US 78 E OF DORCHEST	2/21/92	Total Fecal Coliform (#/100mL)	220
E-100	FOUR HOLE SWAMP AT US 78 E OF DORCHEST	3/4/92	Total Fecal Coliform (#/100mL)	122
E-100	FOUR HOLE SWAMP AT US 78 E OF DORCHEST	4/21/92	Total Fecal Coliform (#/100mL)	134
E-100	FOUR HOLE SWAMP AT US 78 E OF DORCHEST	5/13/92	Total Fecal Coliform (#/100mL)	72
E-100	FOUR HOLE SWAMP AT US 78 E OF DORCHEST	6/19/92	Total Fecal Coliform (#/100mL)	78
E-100	FOUR HOLE SWAMP AT US 78 E OF DORCHEST	7/30/92	Total Fecal Coliform (#/100mL)	24
E-100	FOUR HOLE SWAMP AT US 78 E OF DORCHEST	8/17/92	Total Fecal Coliform (#/100mL)	620
E-100	FOUR HOLE SWAMP AT US 78 E OF DORCHEST	9/11/92	Total Fecal Coliform (#/100mL)	190
E-100	FOUR HOLE SWAMP AT US 78 E OF DORCHEST	10/22/92	Total Fecal Coliform (#/100mL)	188
E-100	FOUR HOLE SWAMP AT US 78 E OF DORCHEST	11/2/92	Total Fecal Coliform (#/100mL)	140
E-100	FOUR HOLE SWAMP AT US 78 E OF DORCHEST	12/10/92	Total Fecal Coliform (#/100mL)	200
E-100	FOUR HOLE SWAMP AT US 78 E OF DORCHEST	1/14/93	Total Fecal Coliform (#/100mL)	184
E-100	FOUR HOLE SWAMP AT US 78 E OF DORCHEST	2/2/93	Total Fecal Coliform (#/100mL)	200
E-100	FOUR HOLE SWAMP AT US 78 E OF DORCHEST	3/9/93	Total Fecal Coliform (#/100mL)	76
E-100	FOUR HOLE SWAMP AT US 78 E OF DORCHEST	4/7/93	Total Fecal Coliform (#/100mL)	144
E-100	FOUR HOLE SWAMP AT US 78 E OF DORCHEST	5/20/93	Total Fecal Coliform (#/100mL)	60
E-100	FOUR HOLE SWAMP AT US 78 E OF DORCHEST	6/1/93	Total Fecal Coliform (#/100mL)	116
E-100	FOUR HOLE SWAMP AT US 78 E OF DORCHEST	7/12/93	Total Fecal Coliform (#/100mL)	52
E-100	FOUR HOLE SWAMP AT US 78 E OF DORCHEST	8/18/93	Total Fecal Coliform (#/100mL)	8
E-100	FOUR HOLE SWAMP AT US 78 E OF DORCHEST	9/16/93	Total Fecal Coliform (#/100mL)	39
E-100	FOUR HOLE SWAMP AT US 78 E OF DORCHEST	10/25/93	Total Fecal Coliform (#/100mL)	30
E-100	FOUR HOLE SWAMP AT US 78 E OF DORCHEST	11/10/93	Total Fecal Coliform (#/100mL)	80
E-100	FOUR HOLE SWAMP AT US 78 E OF DORCHEST	12/28/93	Total Fecal Coliform (#/100mL)	172

Appendix D

Water Quality Calibration

The following pages present water quality simulation graphs depicting model runs versus observed water quality data for impaired stations in the Four Holes Swamp Watershed. The water quality calibration was performed for the period 1995 to 1997. The validation period was from 1988 to 1998 or 2000 depending on available data. Although low flows were accurately represented by the model as discussed in the hydrology calibration section, frequently observed zero flows in swampy areas during 1993 and 1994 resulted in unreasonably high calculated bacteria concentrations. However, these periods do not occur within the critical condition periods, and did not affect TMDL results.

In some cases the model failed to simulate observed concentrations during low flow conditions, likely due to the limitations associated with simulating time variable loadings (i.e., animals in stream or failing septic systems) as constant loadings.

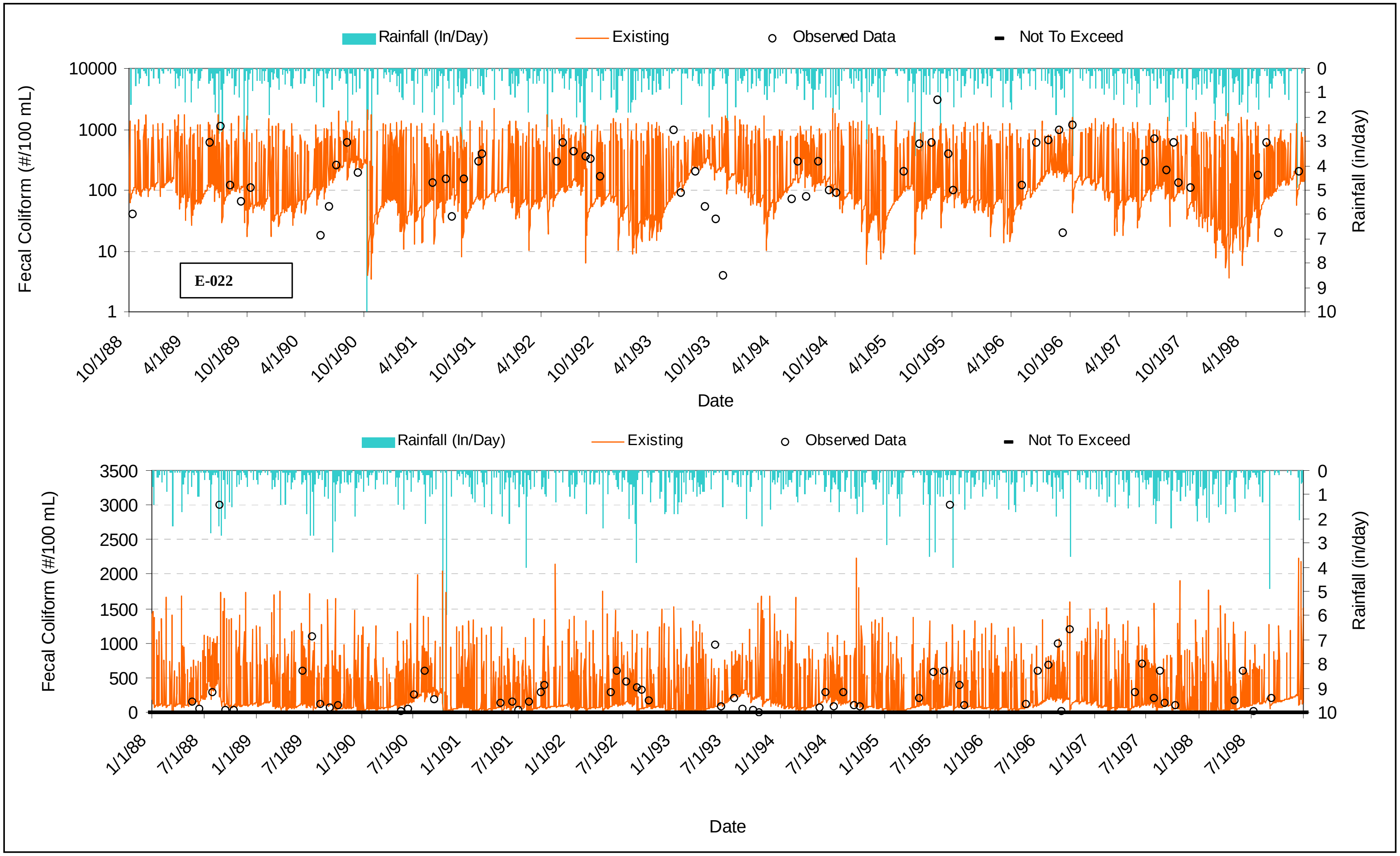


Figure D-1. Fecal coliform calibration at water quality station E-022

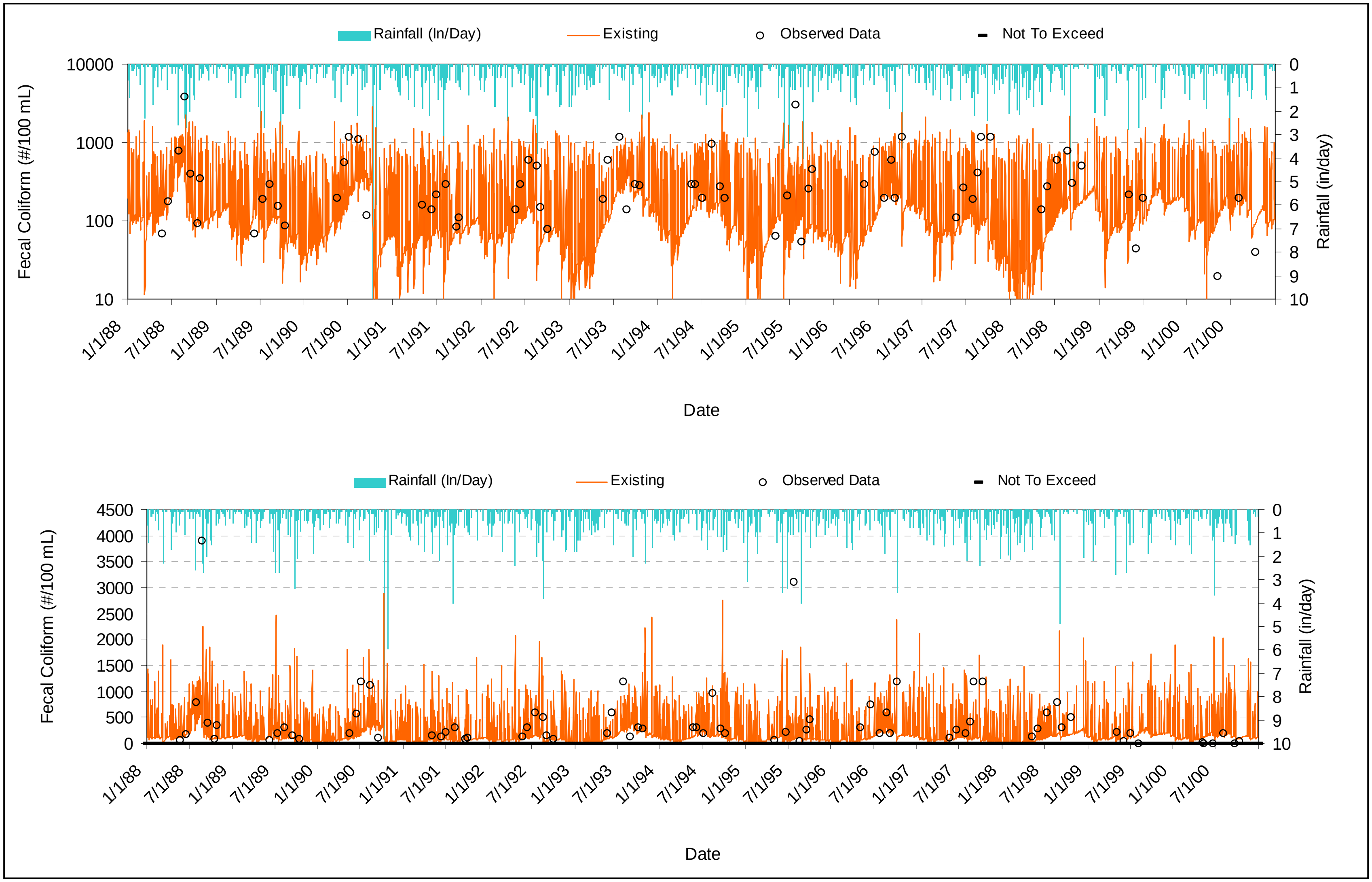


Figure D-2 Fecal coliform calibration at water quality station E-076

Figure D-3. Fecal coliform calibration at water quality station E-059

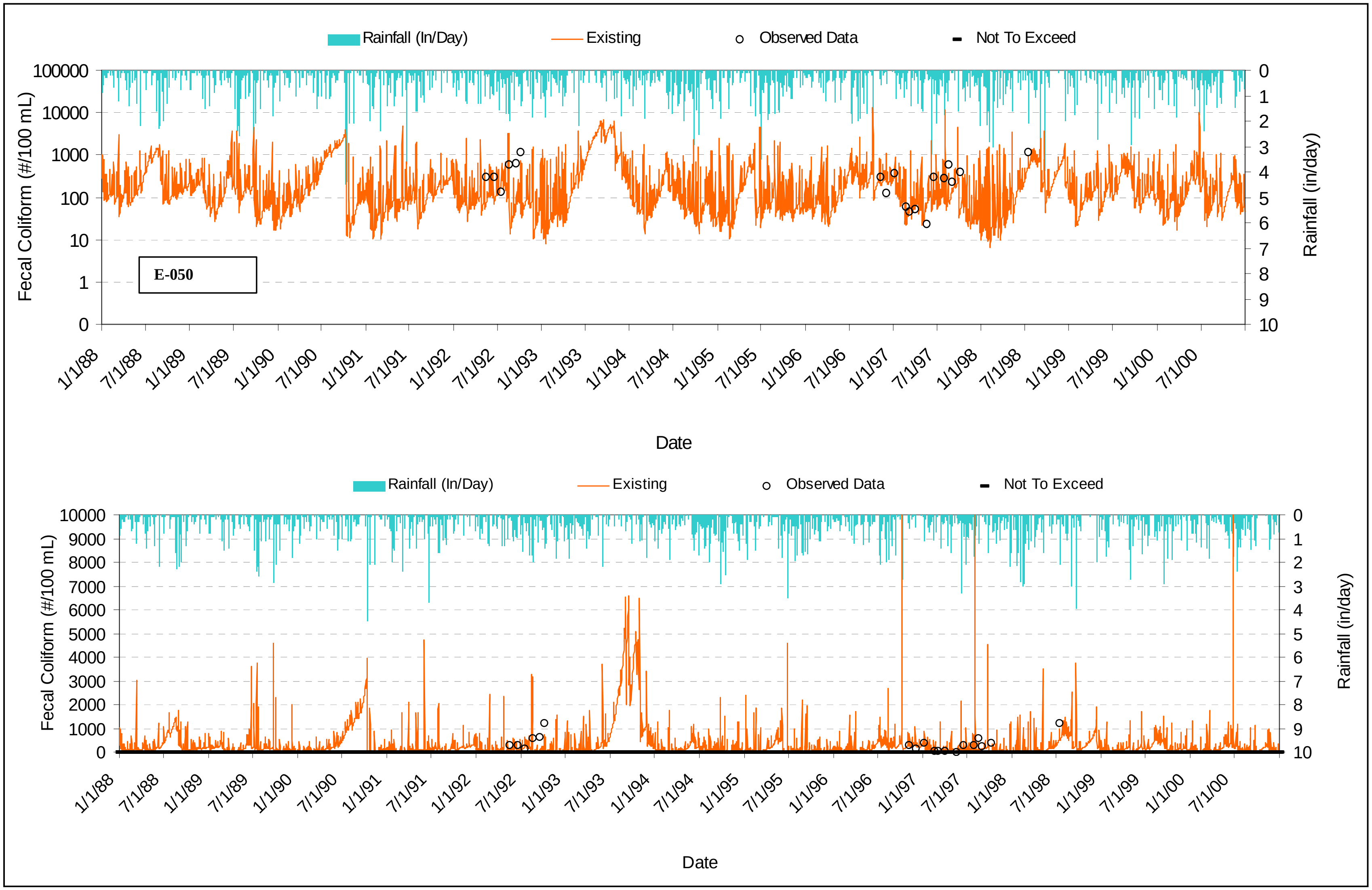


Figure D-4. Fecal coliform calibration at water quality station E-050

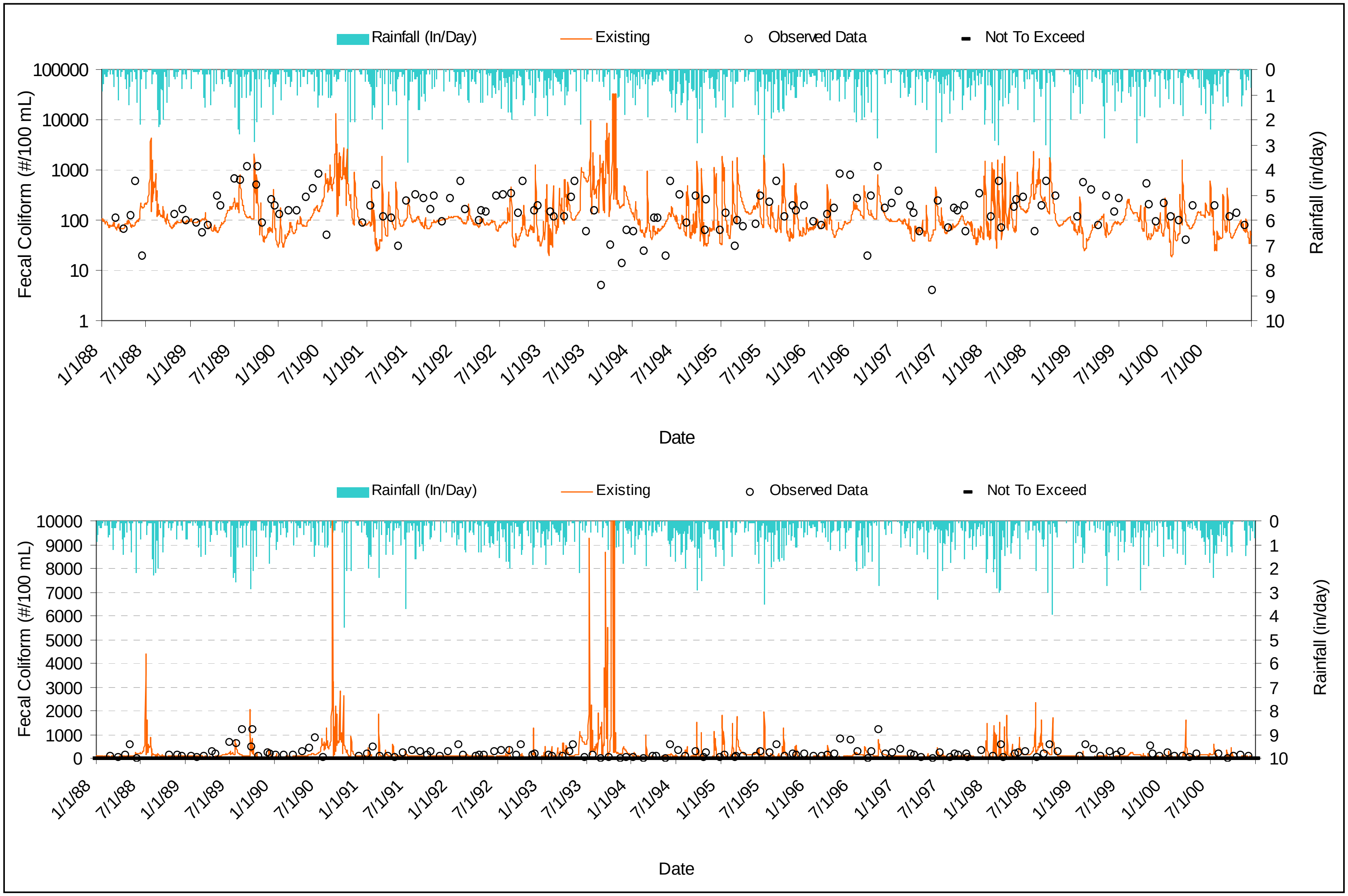


Figure D-5. Fecal coliform calibration at water quality station E-051

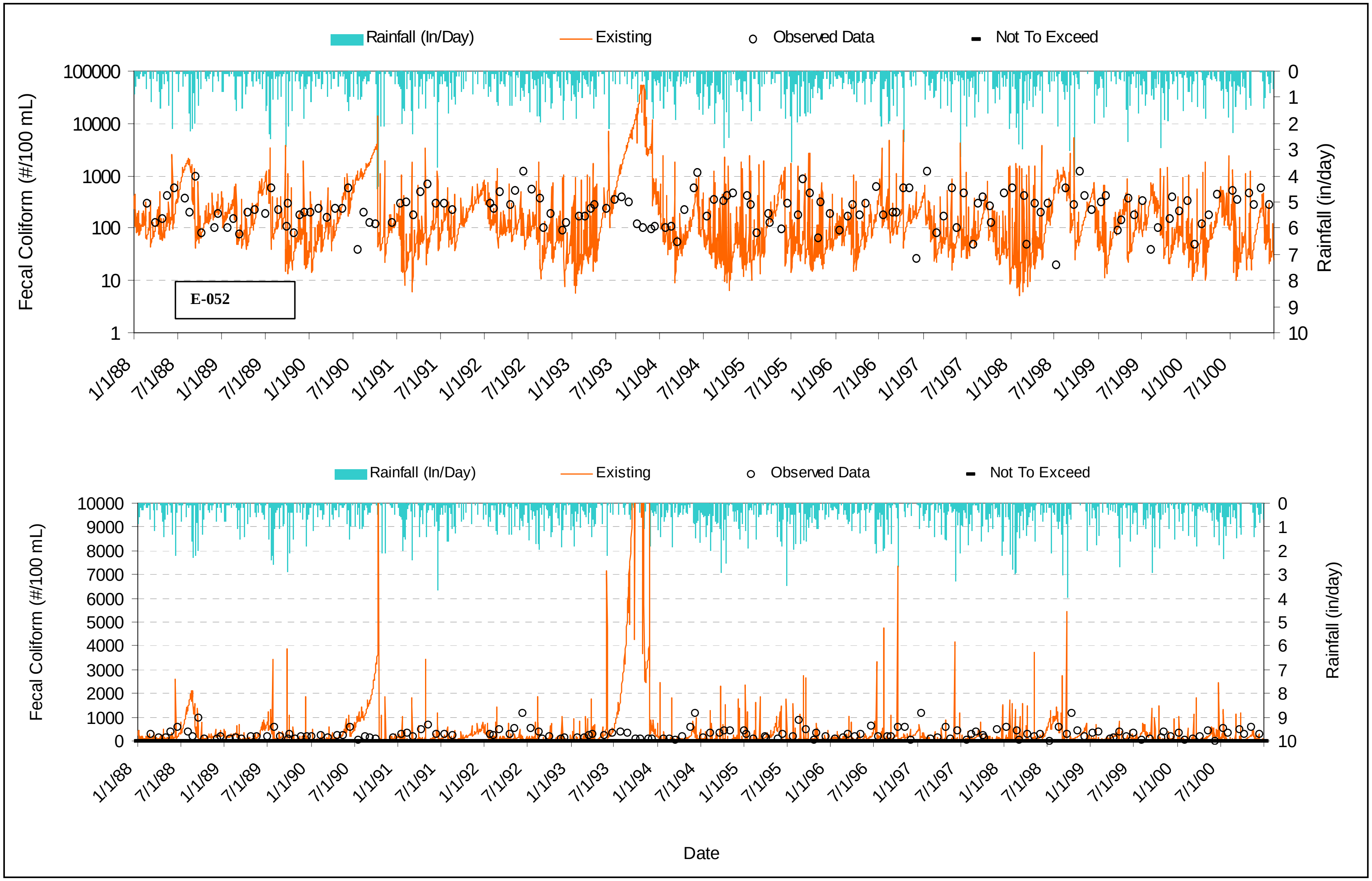


Figure D-6. Fecal coliform calibration at water quality station E-052

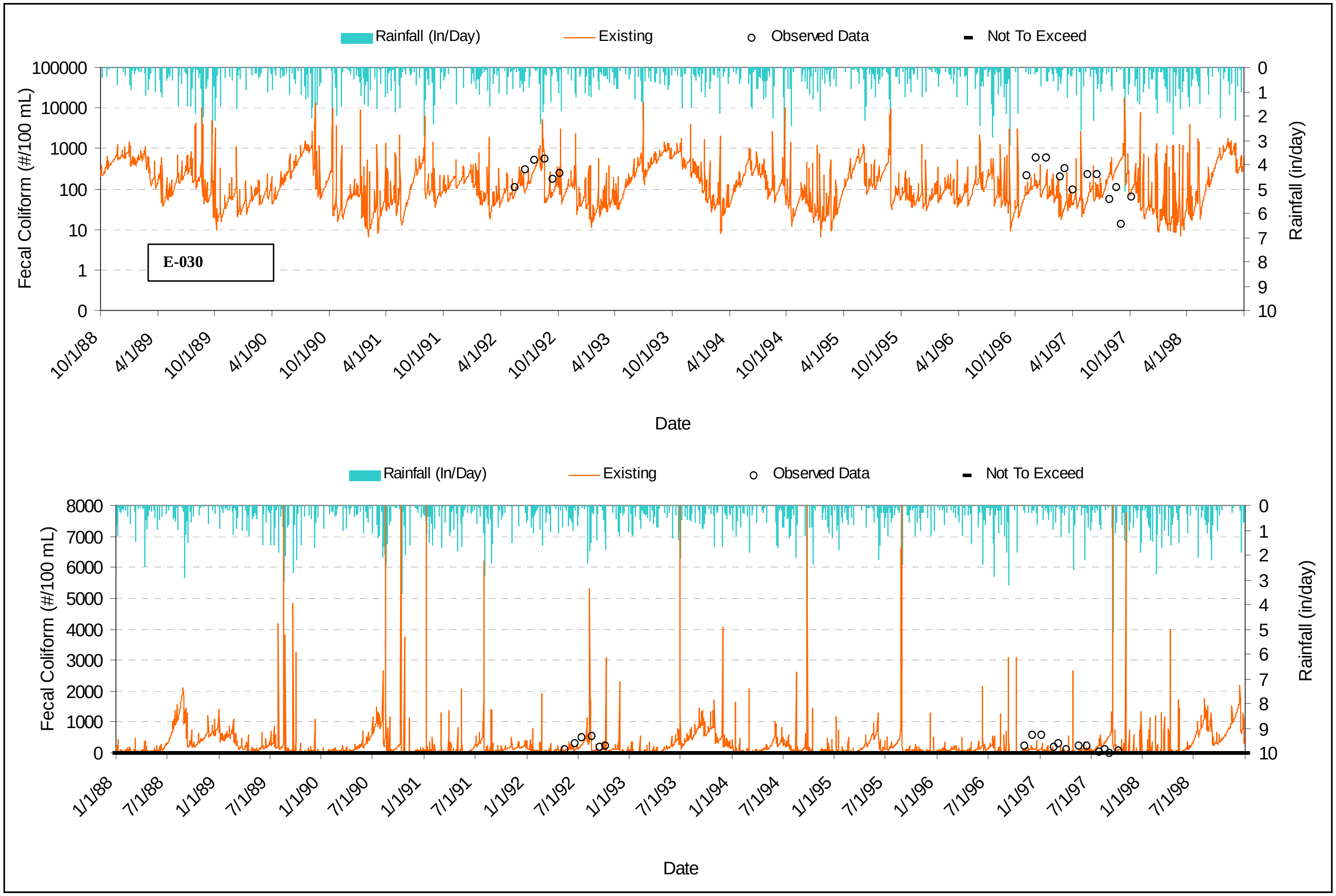


Figure D-7. Fecal coliform calibration at water quality station E-030

Figure D-8. Fecal coliform calibration at water quality station E-100

Appendix E

TMDL Allocation Plots at Impaired Water Quality Stations

The figures in Appendix E present the allocation analysis for the geometric mean criteria at each impaired water quality station in the Four Holes Swamp watershed. Each of these plots shows 30-day geometric mean model results for existing and allocation conditions. A text box on each of these plots denotes the last day of the 30-day critical period. These plots display the entire time period used to identify the geometric mean critical period. The concentration that occurred during the identified critical date is not necessarily the highest exceedence for the given subbasin. This is due to the exclusion of exceedences that may have occurred during the highest and lowest ten percent of flows. Plots are presented only for those sites included on the 2004 303(d) list. E-030 and E-0100 were not impaired in 2004.

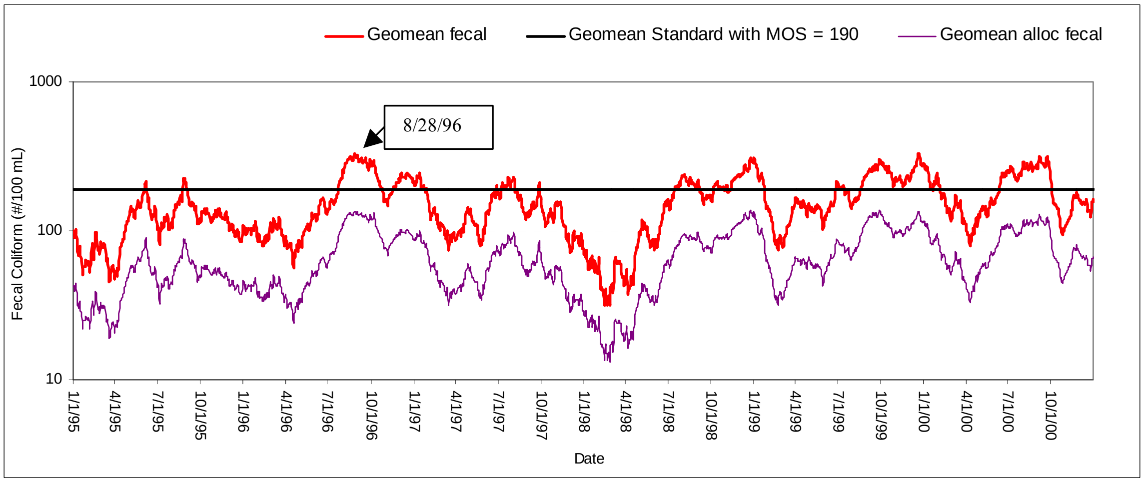


Figure E-1. Existing and allocated 30-day geometric mean fecal coliform bacteria concentrations at water quality station E-022.

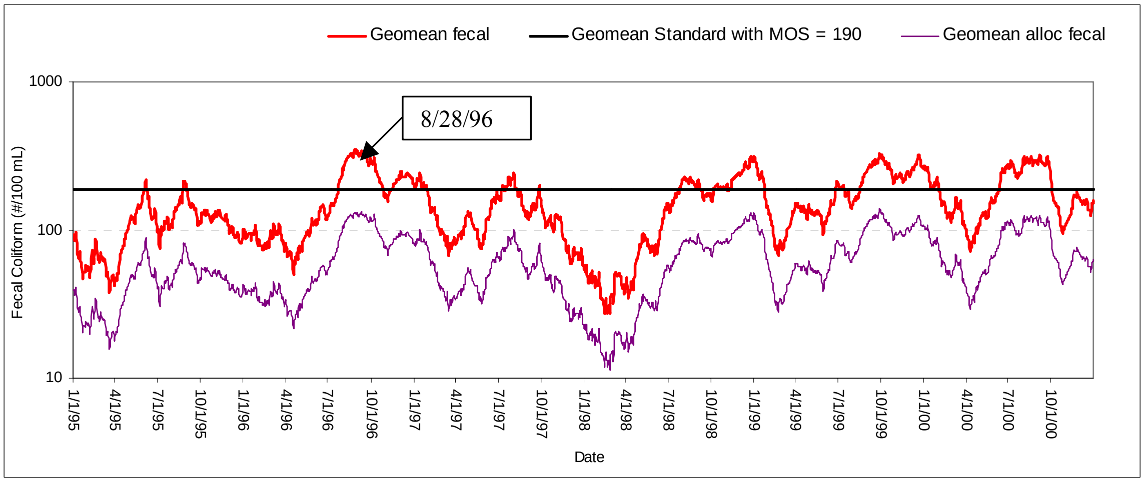


Figure E-2 Existing and allocated 30-day geometric mean fecal coliform bacteria concentrations at water quality station E-076.

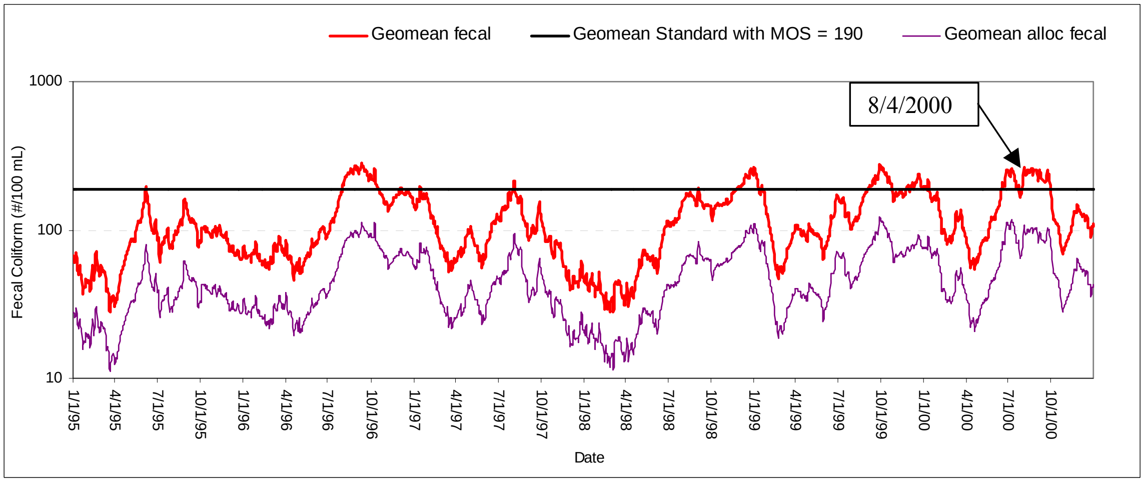


Figure E-3. Existing and allocated 30-day geometric mean fecal coliform bacteria concentrations at water quality station E-059

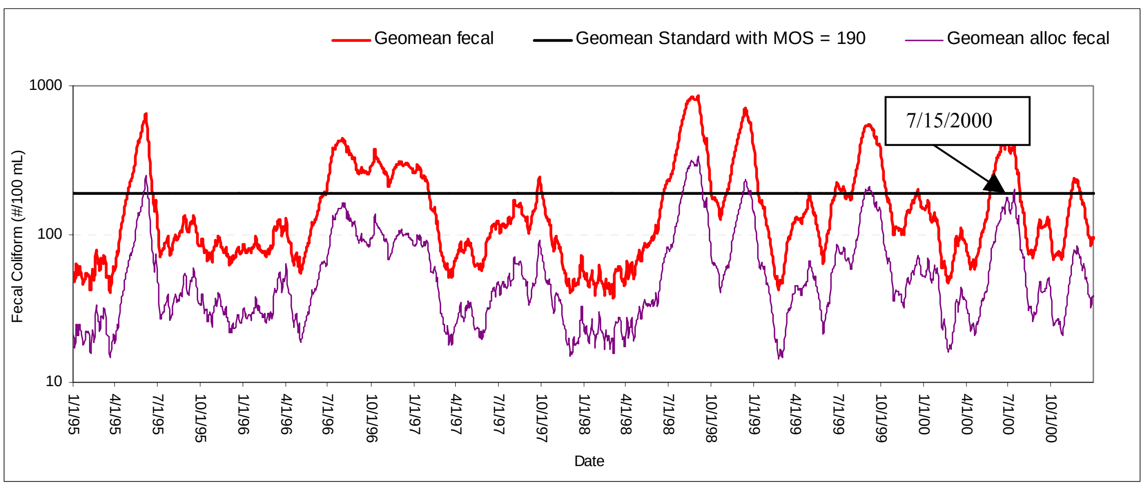


Figure E-4. Existing and allocated 30-day geometric mean fecal coliform bacteria concentrations at water quality station E-050

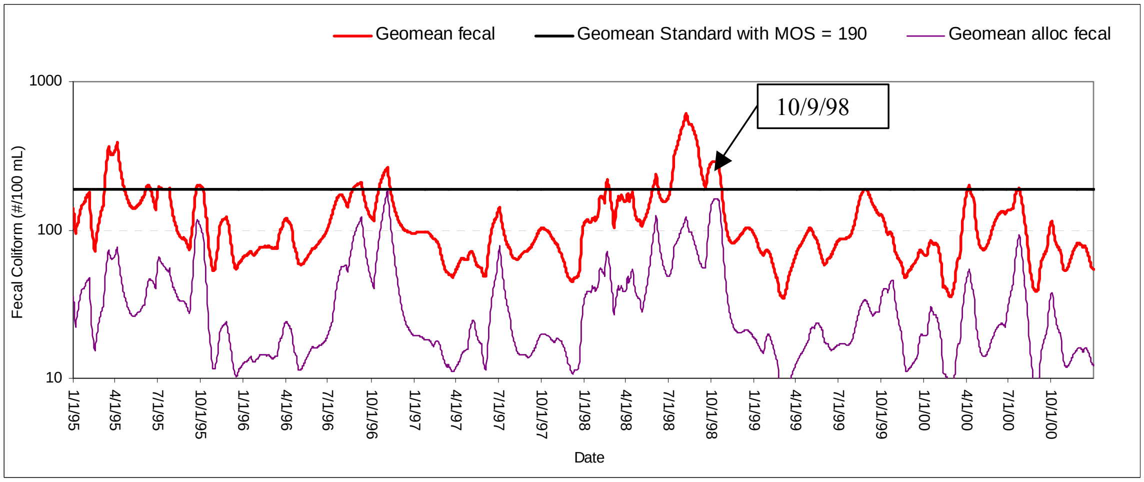


Figure E-5. Existing and allocated 30-day geometric mean fecal coliform bacteria concentrations at water quality station E-051

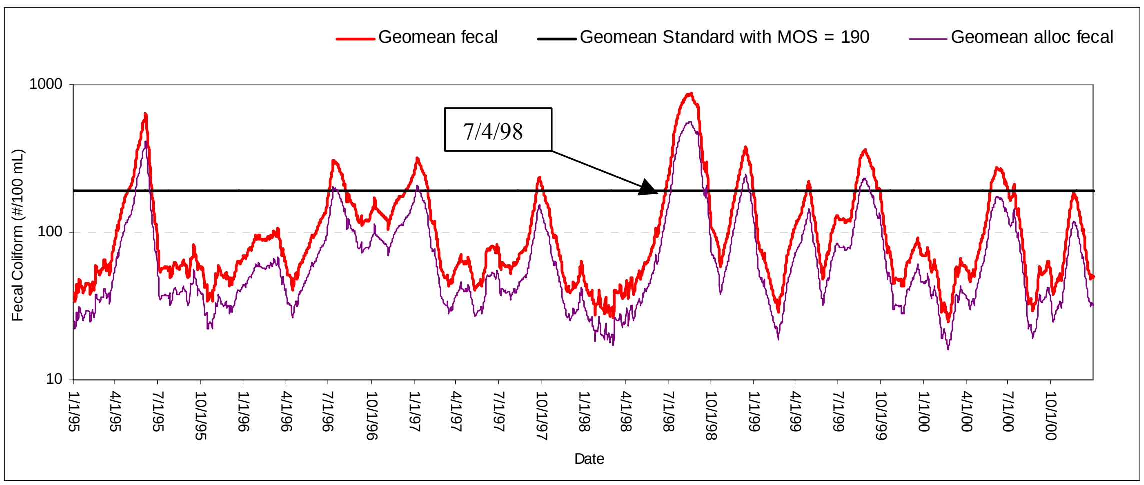


Figure E-6. Existing and allocated 30-day geometric mean fecal coliform bacteria concentrations at water quality station E-052