SUMMARY SHEET
TOTAL MAXIMUM DAILY LOAD (TMDL)
BUSH RIVER

1. 303(d) Listed Waterbody Information

State: South Carolina
County(s): Newberry, Laurens

Major River Basin: Saluda River Basin
8-Digit Hydrologic Unit Code: 03050109

Waterbody name: Bush River
Location: Headwaters to Junction with Lake Murray
Station: S-102 Latitude:34.63, Longitude:-82.97
Station: S-046 Latitude:34.64, Longitude:-83.58
Stream Length: 29.74 miles
Watershed Area: 115.94 square miles

Constituent of Concern: Fecal Coliform Bacteria

Classification: FW (Freshwater), Standard for recreational use only partially supported at sampling station S-046 and not supported at station S-102.

Applicable Standard: Fecal Coliform Bacteria: Not to exceed a geometric mean of 200/100ml, based on five consecutive samples during any 30 day period: nor shall more than 10% of the total samples during any 30 day period exceed 400/100ml.

2. TMDL Development

Analysis/Tools:
EPA's BASINS was used initially to set up this TMDL. The Watershed Characterization System was used as it became available. The NPSM/HSPF (Hydrologic Simulation Program Fortran) componant of BASINS was used to simulated hydrology and pollutant loading scenarios.

Critical Conditions/Seasonality:
A simulation period of 10 years was used to assess the water quality standards for this TMDL. This period represents a range of hydrologic and meteorological conditions.

3. TMDL Allocation

$TMDL = \sum WLA + \sum LA + MOS$

<u>Segment Above Station S-046</u>
Wasteload Allocation (WLA): 6.2496×10^{11}
Load Allocation (LA): 1.4885×10^{14}
Margin of Safety (MOS): Implicit in conservative assessment assumptions
Total Maximum Daily Load: 1.4948×10^{14}

<u>Above Station S-102</u>
Wasteload Allocation (WLA): 1.8259×10^{12}
Load Allocation (LA): 1.9961×10^{14}
Margin of Safety(MOS): Implicit in conservative modeling assumptions
Total Maximum Daily Load: 2.0144×10^{14}

South Carolina
Department of Health and Environmental Control

Total Maximum Daily Load Development for Bush River: Stations S-046, S-102 Fecal Coliform Bacteria

May 07, 2001
Bureau of Water

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PROMOTE PROTECT PROSPER

INDEX

State of South Carolina Administrative Record
TMDL Submittal for Bush River
Stations (S-046, S-102)

Abstract

Bush River (at Stations S-046 and S-102) has been placed on the South Carolina's 2000 303 (d) list of impaired water bodies because of violations of the fecal coliform bacteria water quality standard. Fecal coliform bacteria are an indicator of possible contamination by fecal matter and are thus a public health concern due to the potential for exposure to pathogens through contact recreation. Monitoring stations S-046 and S-102 failed to attain recreational use support by exceeding the state standard of 400 colonies per 100ml sample. During the assessment period of 1994 through 1998 standards were exceeded in 31% of samples taken at S-046 and 35% of samples taken at S-102. The geometric means of all samples taken during the period were 416 colonies/100ml and 674 colonies/100ml respectively. The averages of all exceedances from standard were 19,378 and 27,414. Maxima at the stations were 120,000 and 110,000. The Clean Water Act requires that a Total Maximum Daily Load be developed for all pollutants causing impairment of waters of The State. This TMDL was developed to determine the maximum amount of fecal coliform bacteria that Bush River can receive from both point and nonpoint sources and still meet water quality standards. EPA's BASINS model and Watershed Characterization System were used to estimate the continuous in-stream concentration of fecal coliform bacteria. Based on this estimation, the sum of the allowable loads of fecal coliform bacteria pollution from all contributing point and nonpoint sources was calculated. This TMDL takes into consideration seasonal variations. Conservative assumptions regarding pollutant sources in the watershed allow for a margin of safety to ensure that the water body can be used for recreational use purposes consistent with State and Federal water quality goals. Due to limits in source identification information, water quality data, land use, and other data limitations, this TMDL is only an initial estimate. This TMDL will begin the process of a phased implementation of measures that will ultimately result in achievement of fecal coliform bacteria standards in Bush River. As implementation progresses, and/or more data are obtained, this TMDL may be revised accordingly to facilitate the most efficient remediation of fecal coliform bacterial pollution to Bush River.

Bush River
03050109-150

1.0 INTRODUCTION:

1.1 Background

Levels of fecal coliform bacteria can be elevated in water bodies 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 water bodies that are not meeting designated uses after the full implementation of technology-based pollution controls. The TMDL process establishes the allowable loadings of pollutants or other quantifiable parameters for a water body based on the relationship between pollution sources and in stream water quality conditions so that states can establish water quality-based controls to reduce pollution and restore and maintain the quality of water resources (USEPA 1991). TMDLs are an important aspect of the Clean Water Act provisions for planning and formalizing the process of achieving the “fishable/swimable” goals of the law. While state regulatory authorities such as S.C. DHEC are committed to achieving TMDL reductions, TMDLs do not carry additional regulatory authority. It is expected that implementing the load reductions described below will involve coordinated efforts by various natural resource agencies working cooperatively with the citizens of the Bush River Watershed.

1.2 Watershed Description

The Bush River Watershed (hydrologic unit 03050109-150) is located in Newberry and Laurens Counties and contains all or parts of the towns of Newberry, Prosperity, Joanna and Clinton. Bush River flows generally northwest to southeast, draining a 74,199 acre (115.9mi^2) watershed that is a part of the Saluda River Basin (hydrologic unit 03050109). Bush River drains directly to Lake Murray, an eighty square mile regional reservoir used for drinking water, recreation, and power generation. While forestland is the predominant land use, extensive agricultural activities occur in the watershed. According to the South Carolina Agricultural Statistics Service, Newberry County ranks first in dairy production, second in egg production and fourth in cattle and calves statewide. The major uses of cropland are for raising hay, winter wheat, corn, and soybeans (S.C. Agricultural Statistics Service 1999).Table one presents the relative percentages of the major land uses within the Bush River Watershed.

Table 1. General Bush River Watershed Land Use

Land Use	mi2	Percentage
Forest	**64.7**	**55.8 %**
Pasture	**28.7**	**24.8 %**
Cropland	**13.6**	**11.7 %**
Urban	**8.9**	**7.7 %**
Total	**115.9**	**100 %**

For the purposes of this TMDL load assessment, the Bush River Watershed was divided into four sub-watersheds. These sub-watersheds correspond to the points on the mainstem of the river at which either long term flow or water quality data were available. The flow point of the *Lower Bush* sub-watershed is located at the SC DHEC water quality station S-102 on route S-36-41, *USGS* is at the USGS gauging station on County Road 244, *Mid Bush* is at SCDHEC water quality station S-046 on S.C route 34, and the *Upper Bush* is at the SCDHEC water quality station S-042 located on SC 560. See Figure 1.

Table 2 indicates detailed land use by sub-watershed as derived from EPA's Watershed Characterization System (WCS). The WCS is a software tool that provides a means to organize GIS and other existing data by user delineated watersheds. Land use information for this assessment was derived from the South Carolina's Multiple Resolution Land Coverage (MRLC). This coverage is based on Landsat Thematic Mapper digital images developed in 1992. See Figure 2.

Table 2. Detailed Landuse Distribution by Sub-watershed

	Watershed ID									
Landuse (acres/percent)	**Lower Bush S-102**	**%**	**USGS Flow Sta.**	**%**	**Mid Bush S-046**	**%**	**Upper Bush S-042**	**%**	**Watershed Totals**	**%**
Bare Rock/Sand/Clay	2	0.1	68	0.3	111	0.3	16	0.1	197	0.3
Deciduous Forest	567	24.9	3950	17.9	4248	11.9	2896	20.1	11661	15.6
Emergent Herbaceous Wetlands	0	0.0	2	0.0	9	0.0	2	0.0	12	0.0
Evergreen Forest	806	35.4	7274	32.9	8797	24.6	2550	17.7	19089	26.1
High Intensity Commercial/Industrial/Transportation	0	0.0	240	1.1	1124	3.1	378	2.6	1742	2.3
High Intensity Residential	0	0.0	59	0.3	425	1.2	126	0.9	610	0.8
Low Intensity Residential	1	0.0	390	1.8	1500	4.2	859	5.9	2749	3.7
Mixed Forest	417	18.3	3161	14.3	3759	10.5	1894	13.1	9230	12.4
Open Water	0	0.0	90	0.4	197	0.6	49	0.3	336	0.5
Other Grasses (Urban/recreational; e.g. parks law	0	0.0	83	0.4	363	1.0	253	1.8	699	0.9
Pasture/Hay	138	6.1	3888	17.6	10985	30.8	3109	21.5	18120	24.3
Quarries/Strip Mines/Gravel Pits	0	0.0	29	0.1	0	0.0	0	0.0	29	0.0
Row Crops	162	7.1	2475	11.2	3922	11.0	2240	15.5	8799	11.8
Transitional	173	7.6	326	1.5	185	0.5	0	0.0	684	0.9
Woody Wetlands	8	0.4	68	0.3	95	0.3	69	0.5	240	0.3
Total	**2275**	**99.9**	**22101**	**100.0**	**35721**	**100.0**	**14440**	**100.0**	**74199**	**100.0**

1.3 Water Quality Standard

The impaired stream segment, Bush River, is designated as Class Freshwater (FW). 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 (SCDHEC 1998).

The South Carolina standard for fecal coliform in Freshwater is:

> Not to exceed a geometric mean of 200/100 ml, based on five consecutive samples during any 30 day period; nor shall more than 10% of the total samples during any 30 day period exceed 400/100 ml. (SCDHEC 1998)

Table 3. Water Quality Criteria Applicable to the Bush River

Pollutant	**Criteria (counts/100ml)**	
	Instantaneous	**30-day Geometric Mean**
Fecal Coliform	**400**	**200**

Since samples are taken only one per month, Bush River was originally placed on the S.C. 2000 303(d) list based on the violations or the fecal coliform standard of 400#/100ml. However, the geometric mean standard (200#/100ml) is more appropriate for an assessment using continuous modeling. Therefore, in designing this TMDL, the geometric mean criterion has been used as the target. This geometric mean criterion is intended to be evaluated based on a 30-day assessment period.

2.0 WATER QUALITY ASSESSMENT

The Watershed Water Quality Assessment: Saluda Basin was used to identify this stream segment as impaired and for listing the water body on the 2000 South Carolina 303(d) list (SCDHEC 1998). Bush River was also included on the 1998 303(d) list. Waters in which no more than 10% of the samples collected over a five-year period are greater than 400 fecal coliforms/100 ml. are considered to comply with the South Carolina water quality standard for fecal coliform bacteria. Waters with more than 10 percent of samples greater than 400 fecal coliforms/100 ml are considered impaired and listed for fecal coliform bacteria on South Carolina's 303(d) List. There are three SCDHEC ambient monitoring stations on Bush River, S-102, S-046 and S-042. Aquatic life uses were supported at stations S-046 and S-102 during the assessment period (1994-1998). Recreational uses were not supported. During the assessment period, standards were exceeded in 31% of samples taken at S-046 and 35% of samples taken at S-102. The geometric means of all samples taken during the period were 416 and 674 respectively. Maxima at each station were 19,378 and 160,000. Both S-046 and S-102 are secondary stations and are only sampled during the warm months of May-October. Conversely, Station S-042 supports recreational standards and not aquatic life standards (dissolved oxygen) and will be assessed in a separate TMDL unless future water quality data indicate standards attainment. Fecal coliform data for S-046 and S-102 are located in Appendix A.

3.0 SOURCE ASSESSMENT AND LOAD ALLOCATION

Fecal coliform bacteria enter surface waters from both point and nonpoint sources. In the past, poorly treated municipal sewage has been a major source of fecal coliform impairment. However, with improved treatment practices, compliance monitoring, and enforcement capability, point sources are not usually the primary cause of recreational standards non-attainment. All point sources must have a NPDES (National Pollutant Discharge Elimination System) permit. In South Carolina NPDES permittees that discharge sanitary wastewater must meet the state standard for fecal coliform at their outfall to the stream.

Nonpoint sources are diffuse sources that have multiple routes of entry into surface waters. Some sources are related to land use activities that cause the accumulation of fecal coliform on the land surface. The transport of fecal coliform from these sources to the water body is a function of various meteorological, biological, and geological factors.
Potential nonpoint sources of fecal coliform bacteria in the Bush River Watershed are:

Wildlife
Land application of manure
Grazing animals
Failing septic systems
Urban storm runoff
Leaking or overflowing sewer collection systems

The Bush River/Camping Creek Agricultural Watershed Project

During October 1993 through August1998 a watershed project focused on an area that included Bush River was conducted. The project was funded using section 319 funds and was a cooperative effort between SCDHEC, South Carolina Department of Natural Resources, Clemson University, Newberry Soil and Water Conservation District, South Carolina Department of Agriculture and USDA Farm Service Agency. The project involved an assessment of the type and extent of agricultural derived pollution to ground and surface water. Certain agricultural BMPs were demonstrated and evaluated. Monitoring of nutrients, fecal coliform bacteria, aquatic macro invertebrates, and dissolved oxygen took place at a number of tributaries in the Bush River and adjacent Camping Creek Watersheds. During a three-year period, up to three fecal coliform bacteria samples were taken at eight sites in the Bush River watershed. A total of 15 bacteriological samples were taken. Of these, 9 samples did not meet the instantaneous standard of 400/100ml. Sample results ranged from 130 to 15,000 colonies per 100ml. The study noted that stations with sub-watersheds that contained dairy and swine operations seemed to have elevated fecal coliform levels. Field personnel also noted evidence of livestock access to one stream and obvious inputs of fecal matter. The limited data seem to indicate that the watershed draining to Big Beaverdam Creek was a possibly significant source of fecal coliform bacteria to Bush River (SCNDR 1998).

3.1 Point Sources in the Bush River Watershed

There are three point sources in the Bush River watershed. Table 4 provides a summary of Bush River point sources.

Table 4. Bush River Point Sources

Discharger Name	NPDES Permit #	Permit Flow (MGD)	Permit FC Conc. (#/100ml)	DMR* Flow (Avg)	DMR* Conc. (Avg)
City of Newberry/Bush River Plant	SC0024490	3.22	200/400	2.022	29
Newberry County Water and Sewer Plt #1	SC0040860	0.50	200/400	0.193	45
Laurens County/Clinton	SC0037974	2.75	200/400	2.007	40

*Discharge Monitoring Reports as per NPDES permits

3.2 Nonpoint Sources in Bush River Watershed

3.2.1 Wildlife

Wildlife (mammals and birds) contributes a low level of fecal coliform to surface waters. Wildlife wastes are carried into nearby streams by runoff during rainfall. Deer are used as a surrogate for all wildlife in this TMDL. The SC Department of Natural Resources has estimated a density of 10 to 12 deer/mi^2 of deer habitat in the Bush River Watershed (personal communication Charles Ruth, Deer Project Supervisor, Sept 2000). DNR deer habitat includes forest, cropland, and pasture land. Deer are assumed to be distributed evenly throughout their habitat and the population uniform during the simulation period. For this assessment, the upper estimate of 12 deer/mi^2 was used to estimate the potential contribution of fecal bacteria from all wildlife. A deposition rate of 5.0×10^8 #/animal/day was assumed. Using this rate and the assumption of a deer population equally distributed within the three land use areas suitable for habitat, the build up of wildlife related fecal coliform was estimated for the Bush River Watershed and incorporated into the runoff simulation. This rate was consdered to be the background rate.

3.2.2 Concentrated Animals

Manure from concentrated animal operations is usually collected and then distributed on crop and pasture land. A number of confined animal operations are located in the Bush River Watershed. SCDHEC currently permits 13 dairy facilities, 4 turkey facilities, 1 poultry laying facility, 2 poultry fryer facilities, and 5 swine operations. EPA Region IV's WCS was used to determine animal numbers and the amount of waste produced and then applied to the land. It was assumed that 75% of collected confined livestock manure was applied to cropland and 25% was applied to pastureland. Livestock population estimates are based on the 1997 USDA Census of Agriculture and the S.C. State Agricultural Statistics services inventory of 1999. Land Application practices and rates were based on NRCS guidelines as contained in WCS related spreadsheets (See example appendix B).

3.2.3 Grazing Animals

Livestock such as cattle, sheep, and horses spend most of their time grazing on pastureland. Runoff from rainfall washes some of the manure deposited on the pastures into nearby streams. The population of animals and the percentage of time they graze are used to estimate the bacteria loading from grazing animals. It was assumed that 100% of the manure derived from grazing livestock was distributed evenly to pastureland. Tables 5 and 6 provide details on the estimated Bush River Watershed livestock numbers and the fecal coliform production rates used for this assessment.

Table 5. Bush River Livestock Estimates

Cattle	Grazing	6265
Dairy Cattle	Confined/Grazing	819
Hogs	Confined	1515
Chickens	Confined	159448
Turkeys	Confined	518267
Horses	Grazing	31

*Adapted from 1997 USDA Agricultural Census using WCS

Table 6. Livestock Fecal Coliform Bacteria Production

From ASAE, 1998* Animal	Manure prod per animal (lb/day)	Fecal Coliform Content in Manure (#/lb)	Fecal Coliform (#/day)
Dairy cow	120	8.37E+08	1.01E+11
Beef cow	46	2.24E+09	1.04E+11
Hog	11	9.52E+08	1.08E+10
Sheep	2	5.00E+09	1.20E+10
Horse	51	8.24E+06	4.20E+08
Chicken (Layer)	<1	5.31E+08	1.36E+08
Turkey	1	1.32E+08	1.32E+08

*Adapted from "ASAE Standards:1998" 45^{tth} Edition"

Frequently cattle and other animals are allowed access to streams and ponds. Fecal matter deposited directly into streams and ponds can be a significant source of fecal coliform (USDA 2000). Potential loading from this source is estimated from the number of Bush River Watershed cattle and the percentage of time they might be expected to spend in streams. WCS was used to derive a direct bacteria loading to each of the four stream segments (See appendix C).
It is assumed that wildlife also contribute waste directly to streams. Insufficient data exists to estimate loading from this source. For this assessment, direct animal loading includes both livestock and natural sources.

3.2.4 Failing Septic Systems

Using GIS, the most recent census theme was overlaid onto the existing sewer system cover. The number of persons not likely to receive municipal sewer treatment was estimated by summing the population of the census tracts that did not intersect with the distribution systems. Because of a lack of data, several assumptions were made: an average waste flow of 70 gal/capita/day; an average of 2.5 persons per household; a failure rate of 10%; all the inadequately treated wastewater reached the stream; and the concentration of fecal coliform was 10^4 counts/100ml (Horsley and Witten 1996, Center for Watershed Protection 1999). The estimated number of failing septic systems in the Bush River Watershed is listed in Table 7.

Table7. Bush River Septic Systems

Sub-watershed	Number of People Served	Estimated Systems Failing
Upper Bush	486	19
Mid Bush	2152	84
USGS Bush	1264	50
Lower Bush	150	6

3.2.5 Urban Stormwater Runoff

Urbanized or developed land typically generates an increased loading of pollutants relative to undeveloped land. Sources of fecal coliform in urban areas include pet waste, concentrated urban wildlife, and illicit connections to the storm drainage network. Inputs from these sources build up on the urban land surface or within the storm drainage network and are flushed through the network into streams during and after rainfall. These sources were quantified in this assessment as the number of fecal coliform accumulated over time per unit of urbanized area.

3.2.6 Other Unknown Sources

In the Bush River watershed, another possible source of fecal coliform contamination is leakage and spillage from sanitary sewers. These are expected to have a more or less continuous flow and are considered as a separate point source. As a measure of leakage from sewer collection systems, 1% of the combined flow from the point sources was assumed to leak directly into Bush River. It was assumed this effluent was similar to that from combined sanitary sewer system overflows. A rate of 2×10^5 #/100ml was assumed for the fecal coliform concentration (Center for Watershed Protection, 1999).

4.0 MODELING

4.1 Model Selection

In order to quantify the Total Maximum Daily Load, it was necessary to establish the relationship between pollution sources and in stream water quality. A watershed model for Bush River was developed in order to provide a means to estimate the relative impacts of both point and nonpoint sources of fecal coliform bacteria to Bush River and to simulate the effects that various pollution control scenarios might have on water quality.

The objectives of the modeling effort were: 1) to simulate the accumulation of fecal coliform on the land surface and the wash off and transport of these pollutants into the impaired streams; 2) to simulate the response of the stream to the given inputs continuously so as to determine the critical conditions; 3) evaluate seasonal effects on water quality; 4) analyze the stream response to various loading scenarios.

This TMDL was developed using a system of tools provided by EPA Region IV called the Watershed Characterization System (WCS). WCS utilizes the ArcView Geographic Information System to automate land use analysis, watershed delineation, stream reach characterization, and data organization. Additionally, the WCS automates the process of building various project files necessary for the Nonpoint Source Pollution Model (NPSM) which is based on the Hydrological Simulation Program-Fortran (HSPF) program. HSPF is a modeling program that provides a means of simulating both hydrology, and pollutant fate and transport on a watershed scale. Precipitation data is used in conjunction with estimates of pollutant build up on the land surface to estimate the in stream impacts of nonpoint source pollution. The WCS also makes use of a suite of special spreadsheet tools that help with pollutant build up estimation, calibration, and TMDL calculation (See Appendix D)

4.2 Model Set Up

For this simulation effort, Bush River was divided into four segments corresponding to the locations along the river where long-term data were available. Using GIS techniques, watershed boundaries were determined and land use information was incorporated into an NPSM project. A continuous simulation period from October 1, 1988 to October 1, 1998, was used in the analysis. The period from October 1, 1988 to December 31, 1989, was used to allow the model output to stabilize. The period from January 1, 1990 to October 1, 1998 was used to identify the critical condition period from which to develop the TMDL. Model calibration was based on the period January 1, 1992 to December 31, 1994.

Precipitation data drives the HSPF program. 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. Daily weather data from the Newberry meteorological station were used in the simulation. Constant flows/loads were also included in the model to represent the WWTP's, direct discharge by animals, leaking septic systems, and sanitary sewer system overflows. These were set up in the model as point sources.

4.3 Model Calibration

Calibration of a watershed model involves both hydrology and water quality components. The hydrology calibration is performed first and involves comparing simulated stream flows to historic stream flow data from a U.S. Geological Survey (USGS) stream gauging station for the same period of time. Calibration of the hydrologic model involves adjusting various model parameters (e.g,. evapo-transpiration, infiltration, interflow, etc) that are used to represent watershed hydrologic processes. Initial values for key parameters were estimated using methods outlined in BASINS Technical Note 6 (USEPA 2000). Parameters were adjusted step-wise through multiple runs until simulated output corresponded reasonably well with observed data. Observed data were available from the US Geological Surveys gauging station (02167582) located 26.8 miles downstream on the main stem of Bush River. Results of the hydrology calibration are included in Figures 3a and 3b.

Figure 3a Calibration year

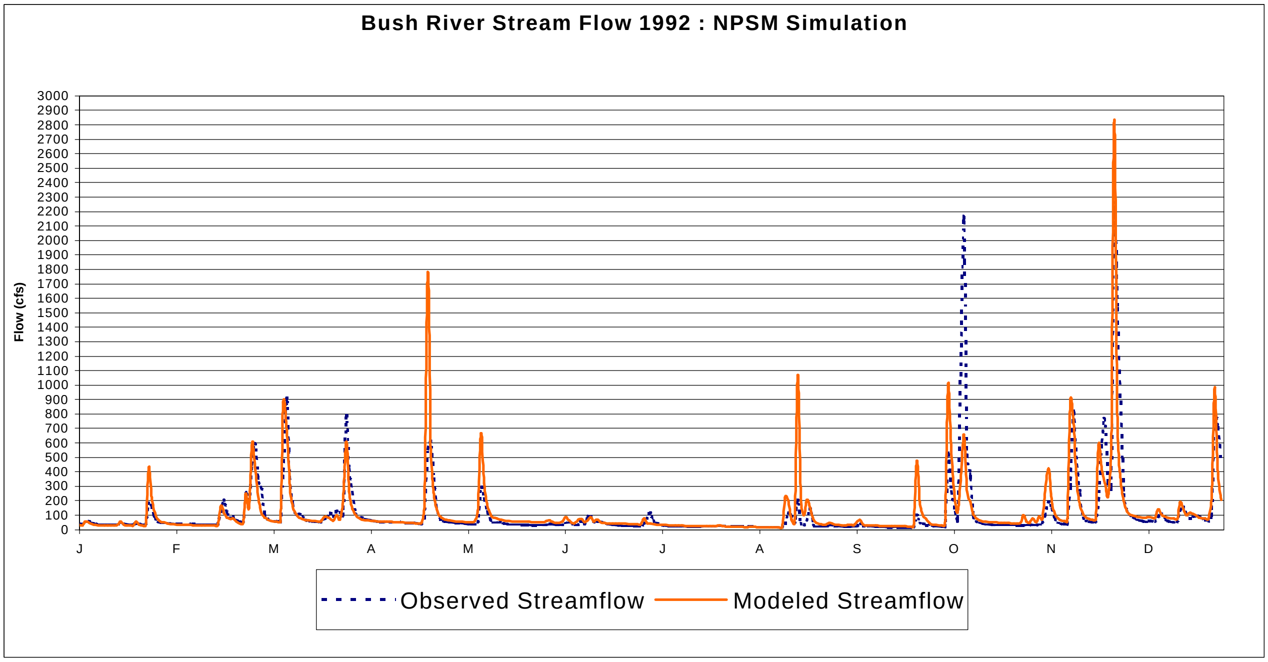
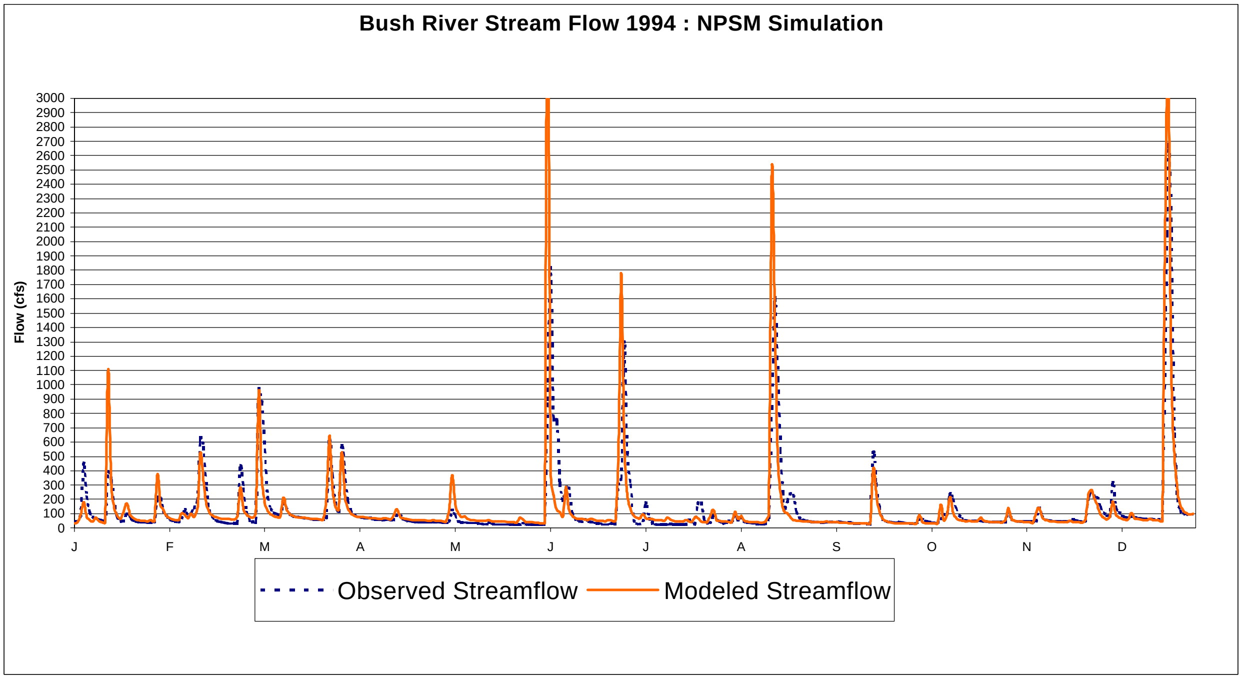


Figure 3b Verification Year



Fecal coliform bacteria data for Bush River were available for the period 7/27/90 through 10/29/98 for station S-046 and 10/3/88 through 10/13/97 for station S-102. Both stations were secondary stations so data were collected only during the warm months of the year; May through October. These data were used to calibrate the water quality model. Calibration results for the period beginning April 2, 1992 and October 1993 are shown in figures 4a and 4b for both sampling stations.

Figure 4a Bush River Water Quality Calibration Plot at Station S-046

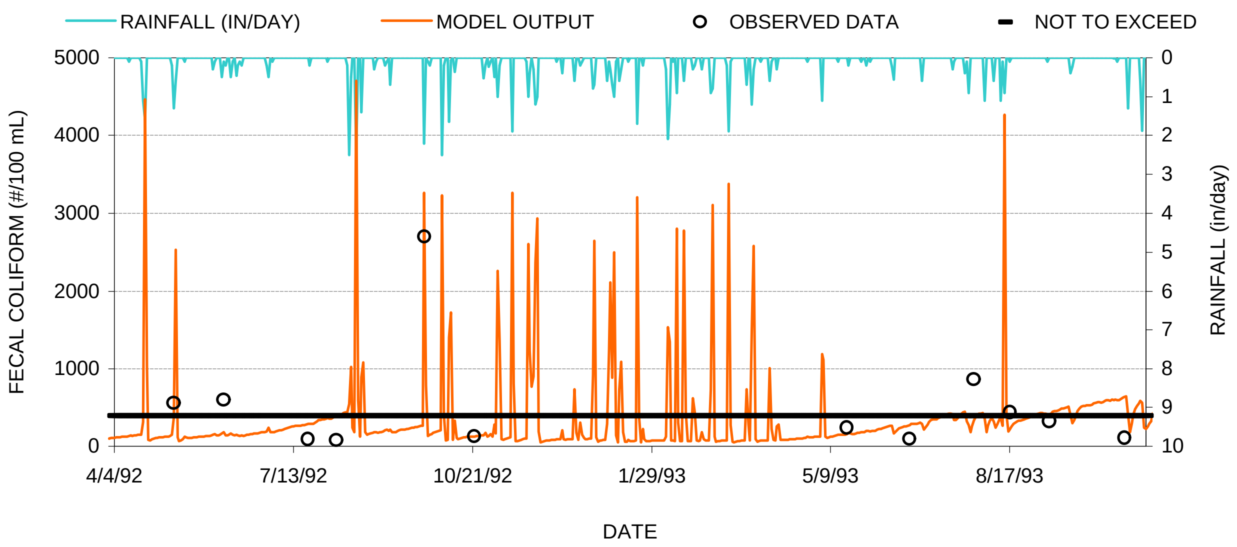
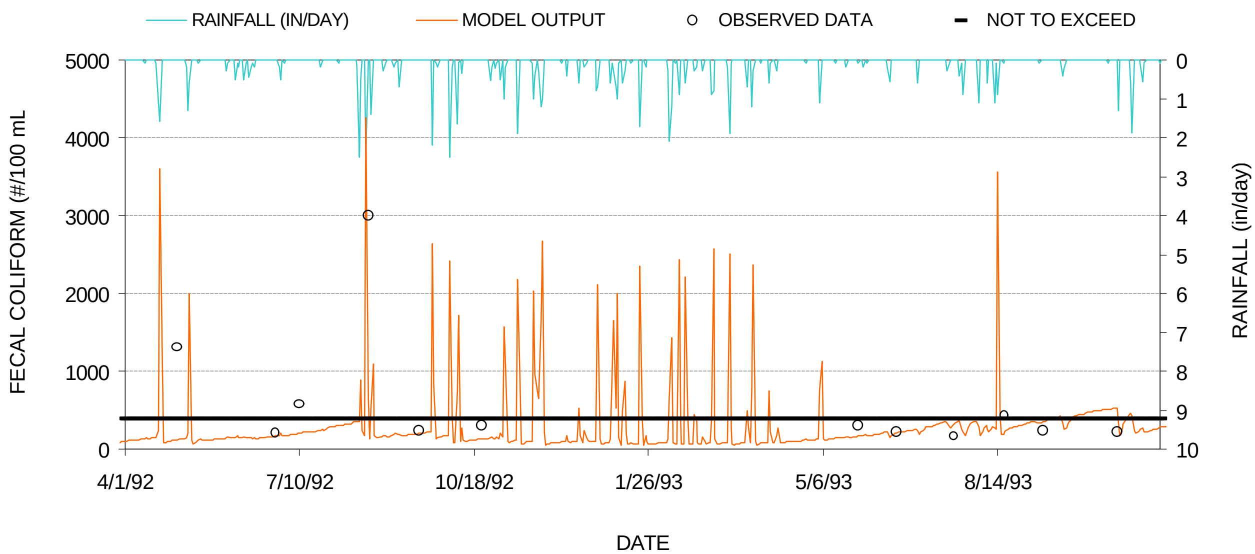


Figure 4b. Bush River Water Quality Calibration Plot at Station S-102



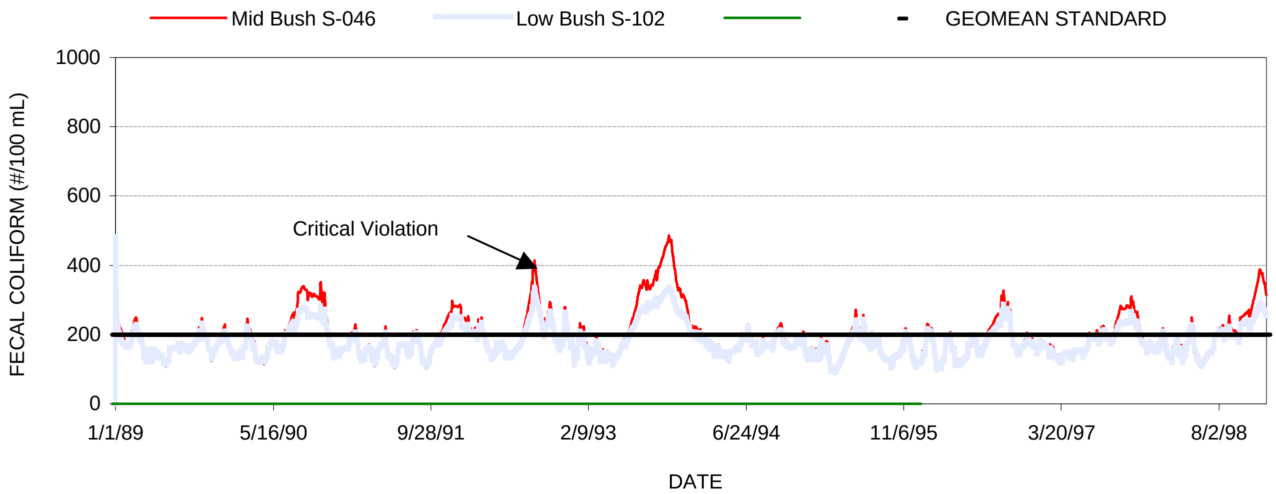
Although there were only a few wet weather water quality samples collected, these graphs demonstrate that the model can simulate spikes in fecal coliform bacteria in response to rainfall events. Additionally, the dry weather baseline is adequately simulated. However, considerable error is expected in this water quality simulation due to relatively few data points and the inherent variability in rainfall intensity at the watershed scale.

5.0 MODEL RESULTS

5.1 Existing Conditions

After calibration, estimates of bacteria build up and loading were used in NPSM to derive existing nonpoint source loads. Loading rates used were those estimated from WCS and refined in the calibration process. The 30-day critical period in the model is the 30 day time period including and immediately preceding the largest simulated violation of the geometric mean standard (USEPA 1991). Achieving the water quality standard during this period ensures that the fecal coliform water quality standard can be achieved throughout the conditions represented in the ten-year simulation. The critical condition for Bush River was determined from the plot of the 10 year simulation of fecal coliform geometric mean at station S-046 and station S-102 (Figure 5). In evaluating critical conditions, periods of extreme drought and flooding are not considered. For the listed segments, the highest violation of the 30-day geometric mean occurred on August 21, 1992. This occurred during a summer wet weather period that followed about six weeks of no significant rainfall. The critical period is then July 23, 1992 through August 21, 1992. A higher Geometric Mean was predicted for late summer1993 but this resulted from a drought period and was thus an inappropriate target period.

Figure 5. Plot of Simulated Fecal Coliform Geometric Mean



The loads at existing conditions are given for the period at which the highest 30-day geometric mean is predicted and are presented in Table 8.

Table 8. Estimated Nonpoint Source Loading Rates for Existing Conditions (7/23/92-8/21/92)

Watershed	Runoff from land surfaces (Counts /30 days)	Direct Inputs to Streams: Animals	Leaking/Overflowing Sanitary Sewer Systems	Leaking Septic Systems
Mid Bush (S-046)	1.74×10^{14}	3.12×10^{12}	3.56×10^{11}	6.55×10^{11}
Low Bush (S-102)	2.33×10^{14}	5.20×10^{12}	5.26×10^{11}	1.21×10^{12}

6.0 TOTAL MAXIMUM DAILY LOADS

A total maximum daily load (TMDL) for a given pollutant and water body is comprised of the sum of individual waste load allocations (WLAs) for point sources, and load allocations (LAs) for both nonpoint sources and natural background levels (40 CFR 130.2(l)). 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 water body. Conceptually, this definition is represented by the equation:

$$\text{TMDL} = \sum \text{WLAs} + \sum \text{LAs} + \text{MOS}$$

The TMDL is the total amount of pollutant that can be assimilated by a receiving water body while still maintaining applicable water quality standards. In TMDL development, loadings from all pollutant sources that cumulatively amount to no more than the TMDL must be established. This provides the basis to establish water quality-based controls. For most pollutants, TMDLs are expressed as a mass load (e.g., kilograms per day). For bacteria, however, TMDLs are expressed in terms of organism counts or the resulting concentration.

The Bush River TMDL is comprised of the sum of the maximum allocated loads (LA) and maximum allocated waste loads (WLA) estimated to be assimilable at the two points at which the fecal coliform standard is not currently being met. The margin of safety (MOS) used was implicit in conservative assessment assumptions. These loads represent total 30-day bacteria loads under critical conditions. Table 9 lists the TMDL for Bush River.

Table 9. Bush River TMDL

Watershed	WLA	LA	MOS	TMDL
Mid Bush (S-046)	6.2496×10^{11}	1.4885×10^{14}	Implicit	**1.4948×10^{14}**
Low Bush (S-102)	1.8259×10^{12}	1.9961×10^{14}	Implicit	**2.0144×10^{14}**

6.1 Waste Load Allocations

Bush River has three NPDES permitted dischargers of treated sanitary wastewater.

Table 10. Bush River WWTPs

Discharger Name	NPDES Permit #	Permit Flow (MGD)	Permit FC Conc. (#/100ml)
City of Newberry/Bush River Plant	SC0024490	4.80*	200/400
Newberry County Water and Sewer Plt #1	SC0040860	0.50	200/400
Laurens County/Clinton	SC0037974	2.75	200/400

*Includes proposed capacity upgrade

Only the Laurens County/Clinton WWTP has its discharge point above the S-046 water quality station. The City of Newberry and the Newberry County Water and Sewer Plants had discharge points above S-102 but below S-046. The waste load allocations for these facilities are based on their permitted flows and permitted fecal coliform limit (200 counts/100ml). The City of Newberry has begun action on a 1.58 MGD capacity increase. This increased flow volume and waste load were included in the TMDL to account for growth. There have been occasional treatment problems with point sources in the watershed. The Department has employed enforcement mechanisms in the past to correct treatment problems with Bush River WWTP's. Analysis of observed data discharge monitoring reports and compliance inspection reports indicate that point source discharges are not the probable cause of long term fecal coliform standards violations in Bush River. No reduction in point source waste loads are called for in this TMDL.

6.2 Load Allocations

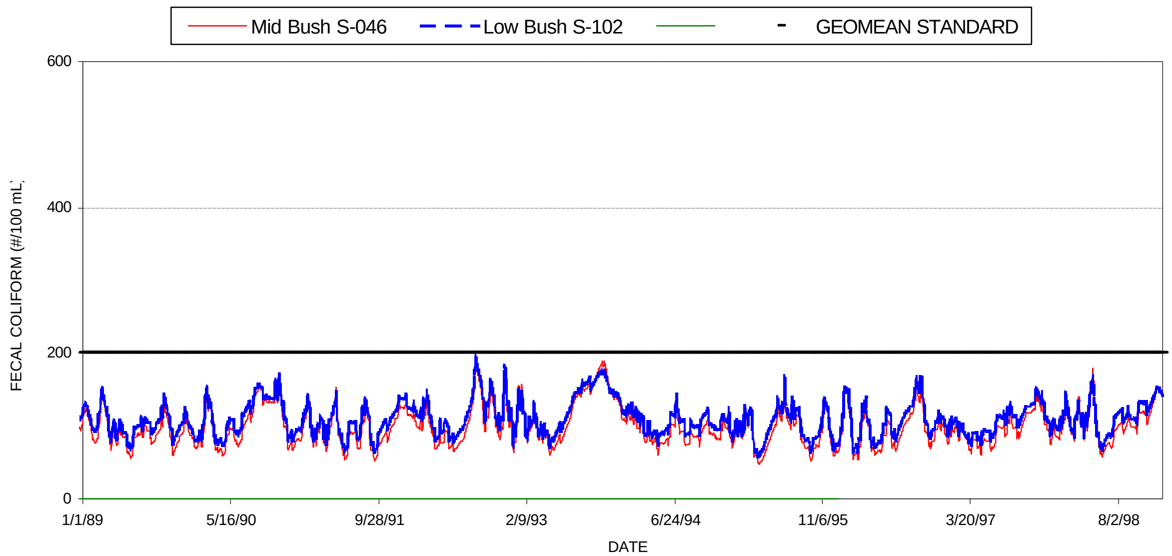
Nonpoint Source loading is the probable cause of non-attainment in the Bush River Watershed. The nonpoint source loading results from urban, rural residential, and agricultural sources.
In order to reduce fecal coliform bacteria in Bush River to a level below the Total Maximum Daily Load, reductions will be required in a variety of sources of nonpoint origin. Reductions required in allocated nonpoint source loading are presented in Table 11.

Table 11. Bush River Load Allocations

Watershed	Existing Load (Counts/30days)	Allocated Load (Counts/30 days)	Percent Reduction %
Mid Bush S-046	1.786×10^{14}	1.489×10^{14}	16.6
Low Bush S-102	2.399×10^{14}	1.996×10^{14}	16.8

Among the potentially controllable sources of fecal coliform load considered were: Animal waste applied to both pasture and cropland, general urban runoff, malfunctioning septic tanks, deposition of fecal matter by in-stream livestock, and leaking sewer lines. A scenario of load reductions modeled to develop this TMDL is presented in Appendix E. If these fecal coliform reductions are achieved, the 200#/100ml geometric standard should be met. Figure 6 presents the NPSM predicted fecal coliform levels under this scenario. Other combinations in percent reductions by source are possible for achieving this TMDL.

Figure 6. Bush River Fecal Coliform Geometric Mean: TMDL



6.3 Seasonal Variability

A 10-year continuous simulation was used for this TMDL using daily precipitation data. Flows for the simulation were calibrated to actual flows measured at a USGS gauging station. Seasonal variations were evaluated in this TMDL over the 10-year period. While the critical period took place in late summer, no consistent seasonal trend was noted.

6.4 Margin of Safety

There are two basic methods for incorporating the 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 ie. set target below the 200/100ml standard. An implicit margin of safety was used in this TMDL. The following conservative assumptions allow for an adequate margin of safety: The use of a critical period within a 10 year simulation period, use of permitted loads for point sources rather than the lesser actual loads, leaking septic systems are considered to be directly connected to stream, all land use is considered to be connected directly to stream, and high pollutant build up rates.

7.0 IMPLEMENTATION

As discussed in the *Implementation Plan for Achieving Total Maximum Daily Load Reductions From Nonpoint Sources for the State of South Carolina*, South Carolina has a number of tools available for implementing this nonpoint source TMDL (SCDHEC 1998).

7.1 Agriculture

SCDHEC's animal agriculture permitting program addresses animal operations and land application of animal wastes. In addition, SCDHEC will work with the existing agencies in the area to provide nonpoint source education in the Bush River watershed. Local sources of nonpoint source education include Clemson Extension Service, the Natural Resource Conservation Service (NRCS), the Newberry and Laurens Soil and Water Conservation Districts, the East Piedmont Resource Conservation and Development Office, and the South Carolina Department of Natural Resources. Clemson Extension Service offers a Farm-A-Syst package to farmers. Farm-A-Syst allows the farmer to evaluate practices on their property and determine the nonpoint source impact they may be having. It recommends best management practices (BMPs) to correct nonpoint source problems on the farm. NRCS can provide cost share money to land owners installing BMPs when EQIP funds are available. SCDHEC employs a Nonpoint Source Educator who can also provide BMP information and a Watershed Manager who can assist area stakeholders and local governments develop strategies for abating the problem. Section 319 funding is made available to individuals and organizations for the installation of agricultural BMPs. BMPs have been demonstrated in S.C. using 319 funds that are effective in limiting livestock impacts to waterways (SCDHEC 1999). As mentioned above in Section 3, sampling results of the Bush River/Camping Creek Watershed Project indicated that one sub-watershed, Big Beaver Dam Creek, may be a significant source of bacterial inputs to Bush River. If such conditions still exist in this watershed, targeting BMPs in this area may result in significant benefits.

7.2 Urban/Suburban:

SCDHEC is empowered under the State Pollution Control Act to perform investigations of and pursue enforcement for activities and conditions which threaten the quality of waters of the state, such as leaking sewer lines. In addition, other interested parties (local governments, universities, local watershed groups, etc.) may apply for section 319 grants to install BMPs that will reduce fecal coliform loading to Bush River. Clemson Extension Service has developed a Home-A-Syst handbook that can help urban or rural homeowners reduce sources of NPS pollution on their property. This document guides homeowners through a self-assessment, including information on proper maintenance practices for septic tanks. SCDHEC's Nonpoint Source Educator and Watershed Manager are available to assist with distribution of these tools as well as provide additional BMP information to local governments and homeowners.

Due to data limitations and uncertainties in the simulation process, it is expected that implementation of this TMDL will take place in a phased manner. DHEC will continue to monitor according to the basin monitoring schedule. The effectiveness of implementation measures and further evaluation of stream water quality may necessitate revisions of this TMDL.

The City of Newberry is currently scheduled to receive a Phase II NPDES stormwater permit. Elements required under this permit are:

- NPS pollution education and outreach
- Public involvement and participation in the implementation of municipal stormwater controls
- Detection and limitation of illicit discharges
- Construction site storm water runoff control
- Post construction storm water management
- Pollution prevention and good housekeeping for municipal operations

When implemented, these measures should result in lower fecal coliform loads to Bush River.

7.3. Funding/Assistance:

Local governments have a variety of funding options available for application towards water resource protection including: General revenue, issuance of bonds, special taxes, utility fees, and impact fees. Additionally, the State Clean Water Revolving Fund makes low interest loans available to local governments for certain water quality improvement projects. The USDA's Conservation Reserve Program can provide assistance to land owners wishing to establish buffers along stream areas. Local governments, homeowners groups, watershed groups, and individuals have potential access to private funding for environmental improvement projects through various foundations (SCDNR 1996, Symko et al 1997, Environmental Finance Center at UNC 1999).

NPS reduction projects can be implemented with the aid of section 319 funds. Funded through a section of the Clean Water Act, EPA awards each state funds for the development of a state nonpoint source program. SCDHEC administers the program and provides resources to a variety of cooperators to implement projects that specifically address NPS pollution problems. Project proposals are solicited, evaluated and awarded on an annual basis (SCDHEC 2001).

8.0 REFERENCES

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Appendices

A. Fecal Coliform Data: S-102, S-046

B. Example: Land Application Spreadsheet

C. Example: Direct Livestock Loading to Stream Spreadsheet

D. Examples: WCS Spreadsheet Tools

E. Sample Load Allocation Scenario

Appendix A
Fecal Coliform Data: S-102, S-046

Appendix B
Example: Land Application Spreadsheet

Attachment C
Example: Direct Livestock Loading to Stream Spreadsheet

Appendix D
Examples: WCS Spreadsheet Tools

Attachment E
Sample Load Allocation Scenario

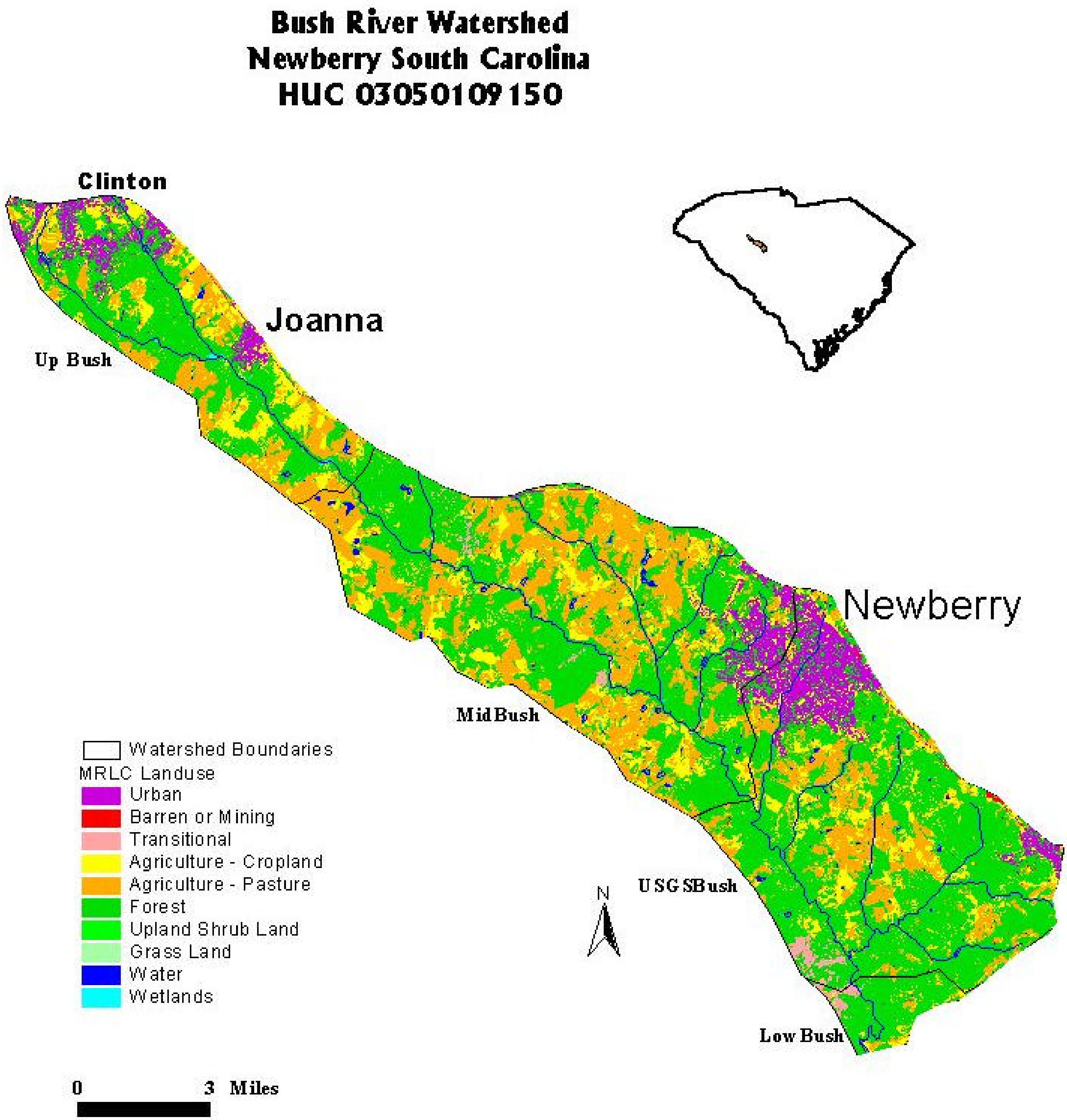

Figure 2. Land Use Map.

Appendix A
Fecal Coliform Data: S-102, S-046

S-102

Date	Time	Value (#FC/100ml)
10/3/88	1115	3000
5/11/89	859	3000
6/9/89	1300	940
7/5/89	1025	8000
8/25/89	1040	400
9/15/89	1135	220
10/27/89	1130	240
5/24/90	1145	260
6/25/90	1245	940
7/5/90	1105	200
8/16/90	1115	6400
9/20/90	1330	2400
10/4/90	1145	690
5/9/91	1135	700
6/13/91	1040	420
7/24/91	1100	470
8/16/91	1000	1500
9/25/91	1140	7800
10/8/91	1220	300
5/1/92	1030	1300
6/26/92	940	200
7/10/92	1050	570
8/18/92	1100	3000
9/16/92	1100	240
10/22/92	1145	300
5/26/93	1325	300
6/17/93	1310	230
7/20/93	1155	160
8/13/93	1055	15000
8/18/93	1230	430
9/9/93	1335	240
10/21/93	1125	220
5/26/94	1225	140

S-046

Date	Time	Value (#FC/100ml)
7/27/90	1255	270
8/24/90	1300	1500
9/14/90	1210	1100
10/4/90	1230	200
5/16/91	1000	660
6/26/91	1125	250
7/19/91	1330	1500
8/23/91	1130	310
9/19/91	1135	150
10/3/91	1050	380
5/7/92	1325	560
6/4/92	1010	600
7/21/92	1240	90
8/6/92	1135	80
9/24/92	1150	2700
10/22/92	1150	130
5/18/93	1315	240
6/22/93	1120	97
7/28/93	1125	860
8/17/93	1135	440
9/8/93	1055	320
10/20/93	1230	110
5/17/94	1240	270
6/29/94	1030	50000
7/12/94	1235	720
8/9/94	1305	560
9/26/94	1345	300
10/18/94	1235	300
5/5/95	1120	298
6/26/95	1137	410
7/18/95	1229	280
8/10/95	1122	390
9/26/95	1415	140

6/29/94	1425	110000
7/27/94	1225	140
8/16/94	1255	62000
9/23/94	1110	500
10/18/94	1340	280
10/16/96	1000	210
11/14/96	1300	330
12/4/96	850	3400
1/6/97	1355	940
2/25/97	1205	230
3/17/97	1200	540
4/2/97	1150	170
5/21/97	1100	290
6/3/97	1320	290
7/1/97	1110	460
8/28/97	1025	370
9/18/97	1200	220
10/13/97	1110	280

10/10/95	1005	290
5/23/96	915	260
6/12/96	1100	240
7/18/96	1120	160
8/13/96	930	960
9/24/96	1245	220
10/16/96	1210	170
5/14/97	1130	220
6/18/97	1215	120000
6/25/97	1205	170
7/8/97	1030	450
8/21/97	945	220
9/17/97	1105	120
10/15/97	825	140
5/20/98	1125	280
6/2/98	1100	1600
7/8/98	1110	180
8/5/98	1055	220
9/1/98	1220	71
10/29/98	935	580

Appendix B
Example: Land Application Spreadsheet

This sheet contains information relevant to land application of waste produced by agricultural animals in the study area.

Application of hog manure, beef cattle manure, dairy cattle manure, horse manure, poultry litter, and manure from import are considered.
Manure generated by in-county animals is assumed to be applied fresh (thus fecal content from fresh manure is used in calculations).
Manure values can be varied using a multiplication factor, in order to consider die-off due to known treatment/storage methods.
Manure imported into the county is assigned a fecal coliform content based on known storage/treatment methods.
The information is presented based on monthly variability of waste application.
It is assumed that cattle manure, poultry litter, and imported manure are applied to both Cropland and Pastureland. Hog manure is assumed to be applied only to cropland. Horse manure is assumed to be applied only to pastureland.

Hog Manure Available for Wash-off

Storage/treatment of manure prior to application may affect the fecal coliform content in the manure.
The multiplier below can be used to increase or decrease the fecal content in manure that is applied (to consider storage/treatment)

Manure fecal content multiplier 0.850

This is the fraction of the annual manure application that is applied each month.

	January	February	March	April	May	June	July	August	September	October	November	December	
Fraction of manure applied each month	0.000	0	0.075	0.1575	0.1335	0.1335	0.1335	0.1335	0.1585	0.075	0	0	1

The fraction of manure available for runoff is dependent on the method of manure application. The fraction available is computed below based on incorporation into soil. These are assumed values.

Fraction incorporated into soil (assumed) 0.800
Fraction available for runoff 0.335 = (1 - [fraction incorporated]) + ([fraction incorporated] * 0.5)

The following is the resulting fraction of annual manure application available for runoff each month based on the monthly fraction applied and incorporation into the soil.

COUNTY ID	January	February	March	April	May	June	July	August	September	October	November	December
45059	0.000	0	0.025155	0.0528255	0.0447759	0.0447759	0.0447759	0.0447759	0.0531609	0.025155	0	0
45071	0.000	0	0.025155	0.0528255	0.0447759	0.0447759	0.0447759	0.0447759	0.0531609	0.025155	0	0
County3	0.000	0	0.025155	0.0528255	0.0447759	0.0447759	0.0447759	0.0447759	0.0531609	0.025155	0	0
County4	0.000	0	0.025155	0.0528255	0.0447759	0.0447759	0.0447759	0.0447759	0.0531609	0.025155	0	0
County5	0.000	0	0.025155	0.0528255	0.0447759	0.0447759	0.0447759	0.0447759	0.0531609	0.025155	0	0
County6	0.000	0	0.025155	0.0528255	0.0447759	0.0447759	0.0447759	0.0447759	0.0531609	0.025155	0	0
County7	0.000	0	0.025155	0.0528255	0.0447759	0.0447759	0.0447759	0.0447759	0.0531609	0.025155	0	0
County8	0.000	0	0.025155	0.0528255	0.0447759	0.0447759	0.0447759	0.0447759	0.0531609	0.025155	0	0
County9	0.000	0	0.025155	0.0528255	0.0447759	0.0447759	0.0447759	0.0447759	0.0531609	0.025155	0	0
County10	0.000	0	0.025155	0.0528255	0.0447759	0.0447759	0.0447759	0.0447759	0.0531609	0.025155	0	0

Beef Cattle Manure Available for Wash-off

Storage/treatment of manure prior to application may affect the fecal coliform content in the manure.
The multiplier below can be used to increase or decrease the fecal content in manure that is applied (to consider storage/treatment)

Manure fecal content multiplier 0.850 (a value of 1 assumes fresh application)

This is the fraction of the annual manure application that is applied each month.

	January	February	March	April	May	June	July	August	September	October	November	December	
Fraction of manure applied each month	0.083	0.0833	0.0833	0.0833	0.0833	0.0834	0.0834	0.0834	0.0834	0.0833	0.0833	0.0833	1

The fraction of manure available for runoff is dependent on the method of manure application. The fraction available is computed below based on incorporation into soil. These are assumed values.

Fraction incorporated into soil (assumed) 0.750
Fraction available for runoff 0.010 = (1 - [fraction incorporated]) + ([fraction incorporated] * 0.5)

% Applied to Cropland: 0.75 % Applied to Pastureland: 0.25 **1**

The following is the resulting fraction of annual manure application available for runoff each month based on the monthly fraction applied and incorporation into the soil.

COUNTY ID	January	February	March	April	May	June	July	August	September	October	November	December
45059	0.001	0.00081634	0.0008163	0.0008163	0.0008163	0.0008173	0.0008173	0.0008173	0.00081732	0.0008163	0.0008163	0.0008163
45071	0.001	0.00081634	0.0008163	0.0008163	0.0008163	0.0008173	0.0008173	0.0008173	0.00081732	0.0008163	0.0008163	0.0008163

Attachment C
Example: Direct Livestock Loading to Stream Spreadsheet

This sheet contains information related to the direct contribution of cattle fecal coliform bacteria to streams.
The direct contribution of fecal coliform from cattle to a stream can be represented as a direct source in the model. Required input for direct sources in NPSM are flow (cfs) and loading rate (#/hr

In the Bush River Watershed both beef and Dairy cattle are grazing and therefore have access to streams. They have access to streams based on information in the Cattle Farming worksheet.

Assume the following:

Beef Cattle Waste: 46 (lbs/animal/day)
The density of cattle manure (including urine) is approximately the density of water: 62.4 (lbs/cubic foot)

CATTLE AS A DIRECT SOURCE

January	**# grazing beef cattle**	**# grazing dairy cattle**	**# beef cattle in streams**	**# dairy cattle in streams**	**FC Loading Rate (#/hr)**	**Waste Flow (cfs)**
001	864	406	0.22	0.09	1.29E+09	2.59E-06
002	721	81	0.18	0.02	8.53E+08	1.70E-06
003	1407	645	0.35	0.14	2.09E+09	4.19E-06
004	89	42	0.02	0.01	1.33E+08	2.67E-07
005	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
006	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
007	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
008	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
009	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
010	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

February	**# grazing beef cattle**	**# grazing dairy cattle**	**# beef cattle in streams**	**# dairy cattle in streams**	**FC Loading Rate (#/hr)**	**Waste Flow (cfs)**
001	864	406	0	0	1.29E+09	2.59E-06
002	721	81	0	0	8.53E+08	1.70E-06
003	1407	645	0	0	2.09E+09	4.19E-06
004	89	42	0	0	1.33E+08	2.67E-07
005	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
006	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
007	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
008	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
009	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
010	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

March	**# grazing beef cattle**	**# grazing dairy cattle**	**# beef cattle in streams**	**# dairy cattle in streams**	**FC Loading Rate (#/hr)**	**Waste Flow (cfs)**
001	864	406	0	0	1.29E+09	2.59E-06
002	721	81	0	0	8.53E+08	1.70E-06
003	1407	645	0	0	2.09E+09	4.19E-06
004	89	42	0	0	1.33E+08	2.67E-07
005	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
006	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
007	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
008	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
009	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
010	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

Appendix D
Examples: WCS Spreadsheet Tools

Simulation Name:	Run16	**Simulation Period:**	01/1/92 - 12/31/92
		Watershed Area (ac):	74199.71
Total Simulated In-stream Flow:	**15.85**	Total Observed In-stream Flow:	**15.62**
Total of highest 10% flows:	**8.81**	Total of Observed highest 10% flows:	**8.68**
Total of lowest 50% flows:	**2.67**	Total of Observed Lowest 50% flows:	**2.18**
Simulated Summer Flow Volume (months 7-9):	**3.15**	Observed Summer Flow Volume (7-9):	**3.12**
Simulated Fall Flow Volume (months 10-12):	**4.35**	Observed Fall Flow Volume (10-12):	**4.38**
Simulated Winter Flow Volume (months 1-3):	**4.07**	Observed Winter Flow Volume (1-3):	**4.47**
Simulated Spring Flow Volume (months 4-6):	**4.29**	Observed Spring Flow Volume (4-6):	**3.65**
Total Simulated Storm Volume:	**12.32**	Total Observed Storm Volume:	**12.77**
Simulated Summer Storm Volume (7-9):	**2.28**	Observed Summer Storm Volume (7-9):	**2.47**

Errors (Simulated-Observed)		*Recommended Criteria*
Error in total volume:	**1.47**	10
Error in 50% lowest flows:	**18.23**	10
Error in 10% highest flows:	**1.46**	15
Seasonal volume error - Summer:	**0.75**	30
Seasonal volume error - Fall:	**-0.58**	30
Seasonal volume error - Winter:	**-9.86**	30
Seasonal volume error - Spring:	**14.85**	30
Error in storm volumes:	**-3.67**	20
Error in summer storm volumes:	**-8.51**	50

ACQOP and SQOLIM by Landuse

This sheet contains values for ACQOP (or MON-ACCUM if monthly) and SQOLIM (or MON-SQOLIM if monthly). These parameters represent the rate of fecal coliform accumulation and the maximur

The value for SQOLIM is derived from Horsley & Whitten 1986, where the following equation was used to represent surface die-off of fecal coliform bacteria:

$N_t = N_0(10^{(-kt)})$ where: N_t = number of fecal coliforms at time t
N_0 = number of fecal coliforms at time 0
t = time in days
k = first order die-off rate constant. Typical values for warm months = 0.51/day and for cold months = 0.36/day

Using the above equation and assuming the die-off rates presented, the maximum buildup during warm months is approximately 1.5 x daily buildup rate and for colder months is 1.8 x daily buildup rate
Assume that warmer months are April through September while colder months are October through March.

Assume a buildup limit of 1.8 x daily buildup rate for non-monthly varying SQOLIM.

CROPLAND

January

	ACQOP (#/acre/day)	SQOLIM (#/acre)
45059	9.38E+06	1.69E+07
45071	9.38E+06	1.69E+07
County3	0.00E+00	0.00E+00
County4	0.00E+00	0.00E+00
County5	0.00E+00	0.00E+00
County6	0.00E+00	0.00E+00
County7	0.00E+00	0.00E+00
County8	0.00E+00	0.00E+00
County9	0.00E+00	0.00E+00
County10	0.00E+00	0.00E+00

February

	ACQOP (#/acre/day)	SQOLIM (#/acre)
45059	1.75E+08	3.15E+08
45071	7.88E+08	1.42E+09
County3	0.00E+00	0.00E+00
County4	0.00E+00	0.00E+00
County5	0.00E+00	0.00E+00
County6	0.00E+00	0.00E+00
County7	0.00E+00	0.00E+00
County8	0.00E+00	0.00E+00
County9	0.00E+00	0.00E+00
County10	0.00E+00	0.00E+00

March

	ACQOP (#/acre/day)	SQOLIM (#/acre)
45059	1.48E+08	2.66E+08
45071	1.67E+09	3.01E+09
County3	0.00E+00	0.00E+00
County4	0.00E+00	0.00E+00
County5	0.00E+00	0.00E+00
County6	0.00E+00	0.00E+00
County7	0.00E+00	0.00E+00

PASTURELAND

January

	ACQOP (#/acre/day)	SQOLIM (#/acre)
45059	5.38E+10	9.69E+10
45071	5.25E+10	9.46E+10
County3	#DIV/0!	#DIV/0!
County4	#DIV/0!	#DIV/0!
County5	#DIV/0!	#DIV/0!
County6	#DIV/0!	#DIV/0!
County7	#DIV/0!	#DIV/0!
County8	#DIV/0!	#DIV/0!
County9	#DIV/0!	#DIV/0!
County10	#DIV/0!	#DIV/0!

February

	ACQOP (#/acre/day)	SQOLIM (#/acre)
45059	5.38E+10	9.69E+10
45071	5.25E+10	9.46E+10
County3	#DIV/0!	#DIV/0!
County4	#DIV/0!	#DIV/0!
County5	#DIV/0!	#DIV/0!
County6	#DIV/0!	#DIV/0!
County7	#DIV/0!	#DIV/0!
County8	#DIV/0!	#DIV/0!
County9	#DIV/0!	#DIV/0!
County10	#DIV/0!	#DIV/0!

March

	ACQOP (#/acre/day)	SQOLIM (#/acre)
45059	5.38E+10	9.69E+10
45071	5.25E+10	9.46E+10
County3	#DIV/0!	#DIV/0!
County4	#DIV/0!	#DIV/0!
County5	#DIV/0!	#DIV/0!
County6	#DIV/0!	#DIV/0!
County7	#DIV/0!	#DIV/0!

FOREST

All Months

	ACQOP (#/acre/day)	SQOLIM (#/acre)
45059	9.38E+06	1.69E+07
45071	9.38E+06	1.69E+07
County3	0.00E+00	0.00E+00
County4	0.00E+00	0.00E+00
County5	0.00E+00	0.00E+00
County6	0.00E+00	0.00E+00
County7	0.00E+00	0.00E+00
County8	0.00E+00	0.00E+00
County9	0.00E+00	0.00E+00
County10	0.00E+00	0.00E+00

BUILT-UP

All Months

45059
45071
County3
County4
County5
County6
County7
County8
County9
County10

CALCULATION OF RUNOFF FROM PERVIOUS AND IMPERVIOUS LAND SEGMENTS - NONCONN Bush River Model
if all subwatersheds are in the same county, then SOQUAL and POQUAL need only be output for one subwatershed, and loading rates can calculated by summing the loads from the various landuses and then dividing by the respective landuse area. The resulting loads are in units of counts/acre-30days

MODEL SEGMENT 003 (Bush River) was used to output SOQUAL (urban impervious) and POQUAL for the other landuses

CRITICAL VIOLATION:	8/21/92	(as determined from the 10-year geometric mean plot)
CRITICAL PERIOD:	7/23/92-8/21/92	(per EPA regulations, critical period is the 30-days before the violation date)

1. Model Output

SEGMENT	DATE	URBAN-imp	URBAN-perv	CROP	PASTURE	FOREST
003:	7/23/92	1.43E+10	1.12E+08	6.69E+08	2.02E+09	1.16E+09
003:	7/24/92	7.04E+08	1.07E+08	6.37E+08	1.92E+09	1.10E+09
003:	7/25/92	2.18E+08	9.88E+07	5.80E+08	1.75E+09	9.83E+08
003:	7/26/92	9.80E+07	9.41E+07	5.49E+08	1.66E+09	9.30E+08
003:	7/27/92	5.31E+07	8.88E+07	5.14E+08	1.55E+09	8.90E+08
003:	7/28/92	3.24E+07	8.99E+07	5.27E+08	1.59E+09	8.92E+08
003:	7/29/92	2.14E+07	8.68E+07	5.08E+08	1.53E+09	8.58E+08
003:	7/30/92	1.50E+07	8.26E+07	4.80E+08	1.45E+09	8.23E+08
003:	7/31/92	1.10E+07	7.62E+07	4.37E+08	1.32E+09	7.78E+08
003:	8/1/92	5.54E+08	7.63E+07	4.41E+08	1.33E+09	7.67E+08
003:	8/2/92	5.36E+09	7.56E+07	4.29E+08	1.30E+09	7.46E+08
003:	8/3/92	5.49E+08	7.35E+07	4.17E+08	1.26E+09	7.25E+08
003:	8/4/92	1.81E+08	6.76E+07	3.78E+08	1.14E+09	6.84E+08
003:	8/5/92	8.46E+07	6.63E+07	3.71E+08	1.12E+09	6.69E+08
003:	8/6/92	4.71E+07	6.85E+07	3.91E+08	1.18E+09	6.71E+08
003:	8/7/92	2.93E+07	6.26E+07	3.51E+08	1.06E+09	6.32E+08
003:	8/8/92	1.96E+07	5.79E+07	3.32E+08	1.00E+09	6.02E+08
003:	8/9/92	1.39E+07	5.22E+07	3.12E+08	9.43E+08	5.75E+08
003:	8/10/92	1.03E+07	5.07E+07	3.04E+08	9.17E+08	5.59E+08
003:	8/11/92	7.84E+06	4.96E+07	2.97E+08	8.95E+08	5.44E+08
003:	8/12/92	1.19E+10	4.79E+07	2.86E+08	8.64E+08	5.26E+08
003:	8/13/92	3.27E+10	1.08E+10	2.48E+11	2.72E+12	9.58E+08
003:	8/14/92	2.38E+10	4.09E+09	1.27E+11	1.33E+12	3.04E+09
003:	8/15/92	1.15E+09	8.30E+08	4.34E+09	1.32E+10	2.18E+09
003:	8/16/92	3.04E+08	4.09E+08	2.23E+09	6.76E+09	1.57E+09
003:	8/17/92	3.51E+10	4.82E+10	8.46E+12	9.16E+13	4.27E+10
003:	8/18/92	2.14E+09	1.04E+09	8.08E+09	2.43E+10	1.46E+10
003:	8/19/92	4.06E+08	5.40E+08	4.08E+09	1.23E+10	7.28E+09
003:	8/20/92	3.49E+10	7.53E+09	5.91E+11	6.42E+12	9.13E+09
003:	8/21/92	9.16E+09	6.86E+08	5.58E+09	1.68E+10	9.46E+09
30-DAY TOTALS (CNTS/30 DAY):		**1.74E+11**	**7.57E+10**	**9.46E+12**	**1.02E+14**	**1.07E+11**

2. CALCULATE LOADING RATES TO APPLY TO OTHER WATERSHEDS IN THE MODEL:

	URBAN IMP	URBAN -PERV	CROP	PASTURE	FOREST
cnts/acre-30day	3.33E+08	1.02E+08	2.62E+09	9.42E+09	6.80E+06

3. WATERSHED AREAS

WATERSHED AREAS (IN ACRES) FROM "LAND USE" WORKSHEET IN FCLES_SUBS.XLS AND/OR NPSM LANDUSE EDITOR:

MODEL SEGMENT:	URBAN IMP	URBAN -PERV	CROP	PASTURE	FOREST
001:	1205.003	1724.4	2693.449	4259.805	16193.732
002:	560.646	801.715	2239.91	3109.23	7679.79
003:	522.366	745.707	3608.332	10847.255	15733.552
004:	71.568	102.341	161.9	138.104	1800.91
Totals	**2359.583**	**3374.163**	**8703.591**	**18354.394**	**41407.984**

4. CALCULATE RUNOFF FROM ALL SUBWATERSHEDS

RUNOFF FROM ALL WATERSHEDS = RUNOFF RATE FOR LANDUSE CLASS * LANDUSE AREA FOR THAT WATERSHED

UNITS ARE COUNTS PER 30 DAYS

WATERSHED:	URBAN IMP	URBAN -PERV	CROP	PASTURE	FOREST
001:	4.01E+11	1.75E+11	7.06E+12	4.01E+13	1.10E+11
002:	1.87E+11	8.14E+10	5.87E+12	2.93E+13	5.22E+10
003:	1.74E+11	7.57E+10	9.46E+12	1.02E+14	1.07E+11
004:	2.38E+10	1.04E+10	4.24E+11	1.30E+12	1.22E+10

Attachment E
Sample Load Allocation Scenario

Table 12. Midbush Watershed S-046

Load Source	Existing Load	Allocated Load	Percent Reduction
Runoff from Cropland	1.769×10^{13}	1.530×10^{13}	13.5%
Runoff from Pasture	1.557×10^{14}	1.313×10^{14}	15.7%
Direct Animal inputs	3.210×10^{12}	8.630×10^{11}	73.1%
General Urban Runoff	6.076×10^{11}	5.181×10^{11}	14.7%
Malfunctioning Septics	6.550×10^{11}	3.276×10^{11}	50.4%
Leaking Sewer Lines	3.560×10^{11}	2.490×10^{11}	30.1%

Table 13 Lowbush Watershed S-102

Load Source	Existing Load	Allocated Load	Percent Reduction
Runoff from Cropland	2.634×10^{13}	2.281×10^{13}	13.4%
Runoff from Pasture	2.048×10^{14}	1.727×10^{14}	15.8%
Direct Animal inputs	5.200×10^{12}	1.700×10^{12}	67.0%
General Urban Runoff	1.320×10^{12}	1.130×10^{12}	15.0%
Malfunctioning Septics	1.210×10^{12}	6.050×10^{11}	50.0%
Leaking Sewer Lines	5.260×10^{11}	2.660×10^{11}	49.4%

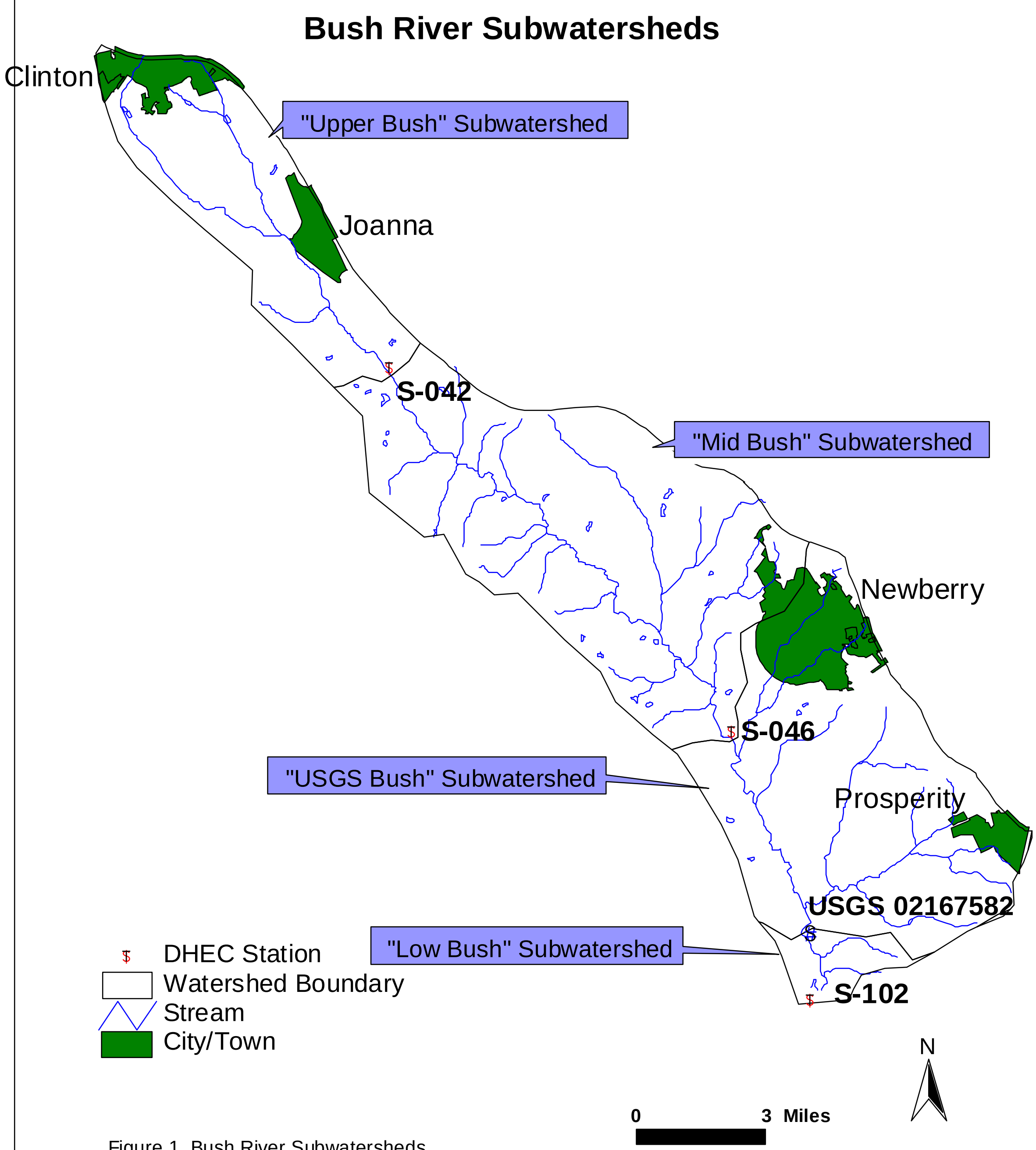

Figure 1. Bush River Subwatersheds