South Carolina
Department of Health and Environmental Control

Total Maximum Daily Load Development for Rocky Creek and the Catawba River at Great Falls, SC (Stations: CW-002, CW-236, CW-175, and CW-174) for Fecal Coliform Bacteria (03050103)

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Bureau of Water

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South Carolina Department of Health
and Environmental Control

Executive Summary

The Clean Water Act requires that water bodies that are impaired must be listed under section 303(d) of the act. Waters that are placed on the 303(d) list must have a Total Maximum Daily Load (TMDL) determined for the pollutant of concern. The State of South Carolina has placed Rocky Creek and the Catawba River on the list at several locations, because of impairment by fecal coliform bacteria. Rocky Creek is impaired at water quality monitoring station CW-002 (Upper Rocky Creek), CW-236 (lower Rocky Creek), and CW-175 (Rocky Creek above confluence with the Catawba River). The Catawba River is impaired at CW-174 (Catawba River just upstream of the confluence with Rocky Creek) near Great Falls, SC. Concentrations of fecal coliform exceeded the standard of 400 counts/100ml for more than 10% of the samples. Rocky Creek (HUC 03050103-090) is a Piedmont stream that drains a watershed of 518 km^2 (1.28×10^6 acres) that is predominantly forested, but has a significant amount of agricultural land use, particularly in cattle pasture.

Rocky Creek has one wastewater treatment facility (Chester County - Rocky Creek WWTP) that has a permit to discharge wastewater containing fecal coliform bacteria. The impairment, however, is attributed to nonpoint sources from both urban and agricultural areas. Other significant sources may include failing septic systems, leaking and overflowing sanitary sewers, and animals especially cattle defecating directly into streams. The Catawba River at Great Falls (HUC 03050103-010-050) appears to be impaired due to flow from Rocky Creek which occurs under certain hydrologic conditions. Reduction of loading of fecal coliform to the Rocky Creek should reduce loading to the Catawba River at this location.

The proposed total maximum daily loads represent reductions from the existing loading of 83 - 84 % to Rocky Creek and the Catawba River at Great Falls. The reductions are directed primarily at failing septic systems, leaking or overflowing sanitary sewers, livestock with uncontrolled access to streams, and runoff from urban and pasture lands.

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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 under technology-based pollution controls. The TMDL process establishes the allowable loadings of pollutants or other quantifiable parameters for a water body based on the relationship between pollution sources and in-stream water quality conditions so that states can establish water quality-based controls to reduce pollution and restore and maintain the quality of water resources (USEPA, 1991).

1.2 Watershed Description

Rocky Creek (03050103-090) is located in Chester and Fairfield Counties, SC and drains into the Catawba River (03050103-010-050) just downstream of the Great Falls and Dearborn Hydroelectric Stations (Figure 1) near Great Falls, SC. A tributary of Rocky Creek near Chester, SC, Grassy Run Branch, which is also impaired by fecal coliform, has had a TMDL developed previously (SCDHEC, 1999a).

The land use in the Rocky Creek watershed (Table 1; Figure 2) is predominantly forested (84%); the remaining 16% is cropland (8%), pasture land (5%), and urban (2%) (based on MRLC data). Much of the forested land is abandoned agricultural land that is scrubby hardwoods or pine tree farms. The urban land use is mostly along the western edge of the upper Rocky Creek sub-watershed (Town of Chester) and in the lower end of the watershed (Town of Great Falls) .

1.3 Water Quality Standard

The impaired streams, Rocky Creek and Catawba River, 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 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." (R.61-68).

Rocky Creek Watershed (HUC 03050103-090)

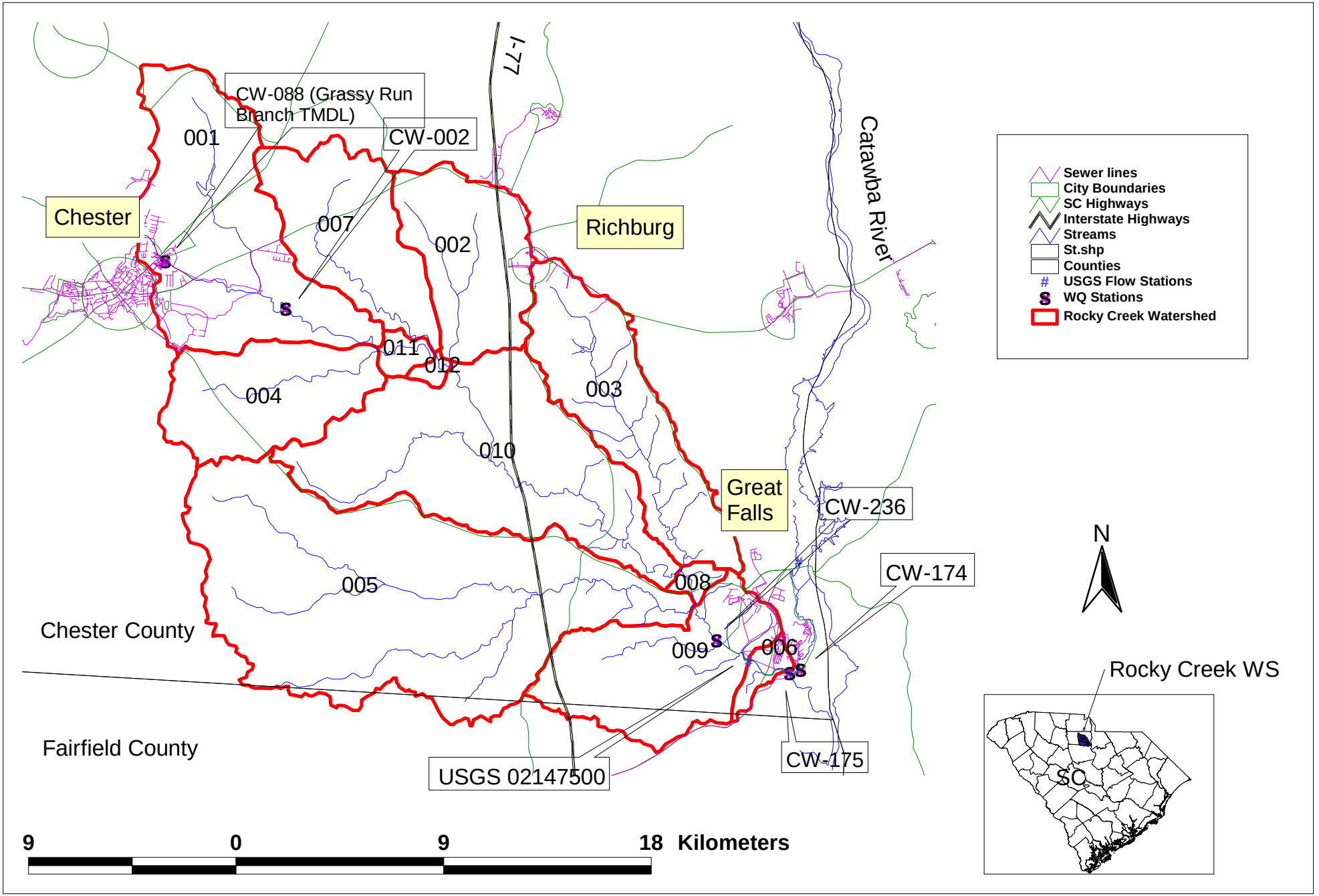

Figure 1. Rocky Creek Watershed in the Catawba River Basin

Table 1. Landuse Distribution in the Rocky Creek Watershed by Subwatershed

Sub-watersheds	Rocky Crk Mouth		Lower Rocky Crk		Beaverdam Creek		Middle Rocky Crk		Upper Rocky Crk		Little Rocky Crk		Barbers Creek		Bull Run Creek		Hooper Creek		Watershed Totals	
Land Use	**by acres / percent**																			
Forest																				
Deciduous Forest	274	28.6	3305	28.3	3098	26.3	5779	25.9	3856	22	8630	24.4	2925	32	2811	30	2433	25	33112	25.9
Evergreen Forest	185	19.2	4071	34.5	4072	34.5	9219	41.4	5223	29	16341	46.2	3191	35	3272	35	3555	37	49128	38.4
Mixed Forest	110	11.5	1949	16.5	1891	16	3395	15.2	2401	13	4988	14.1	1368	15	1581	17	1414	15	19096	14.9
Emerg Herb Wetlands	1	0.1	3	0	7	0.1	4	0	16	0.1	10	0	6	0.1	6	0.1	8	0.1	60	0
Grasses (eg parks & lawns)	13	1.3	36	0.3	10	0.1	0	0	348	1.9	0	0	28	0.3	15	0.2	0	0	449	0.4
Transitional	0	0	74	0.7	412	3.5	1184	5.3	0	0	2572	7.3	16	0.2	0	0	0	0	4258	3.3
Woody Wetlands	18	1.9	74	0.6	45	0.4	384	1.7	103	0.6	166	0.5	39	0.4	26	0.3	56	0.6	911	0.7
Forest totals	601		9512		9535		19965		11947		32707		7573		7711		7466		107014	
Built-up																				
High Inten Com /Ind /Trans	55	5.7	118	1.1	19	0.2	127	0.6	517	2.9	103	0.3	66	0.7	83	0.9	2	0	1090	0.9
High Inten Residential	28	2.9	14	0.1	1	0	0	0	146	0.8	0	0	11	0.1	0	0	0	0	200	0.2
Low Inten Residential	204	21.2	246	2.2	88	0.7	0	0	813	4.5	4	0	110	1.2	69	0.7	18	0.2	1553	1.2
Built-up totals	287		378		108		127		1476		107		187		152		20		2843	
Cropland																				
Row Crops	49	5.1	1209	10.7	949	8.1	1291	5.8	2604	15	1435	4.1	835	9.1	881	9.5	1295	14	10549	8.2
Pasture																				
Pasture/Hay	6	0.6	508	4.5	999	8.5	889	4.2	1544	8.6	1009	2.9	468	5.1	437	4.7	757	7.9	6619	5.2
Open Water	16	1.7	35	0.3	75	0.6	46	0.2	170	0.9	52	0.1	30	0.3	85	0.9	33	0.3	541	0.4
Quar/ Strip Mines/ Gravel Pits	0	0	0	0	81	0.7	0	0	66	0.4	0	0	0	0	0	0	0	0	147	0.1
Bare Rock /Sand /Clay	3	0.3	23	0.2	44	0.4	19	0.1	95	0.5	20	0.1	41	0.5	14	0.2	20	0.2	280	0.2
Totals	961	100	21555	100	11792	100	42429	100	17902	100	35330	100	9134	100	9280	100	9591	100	127994	100

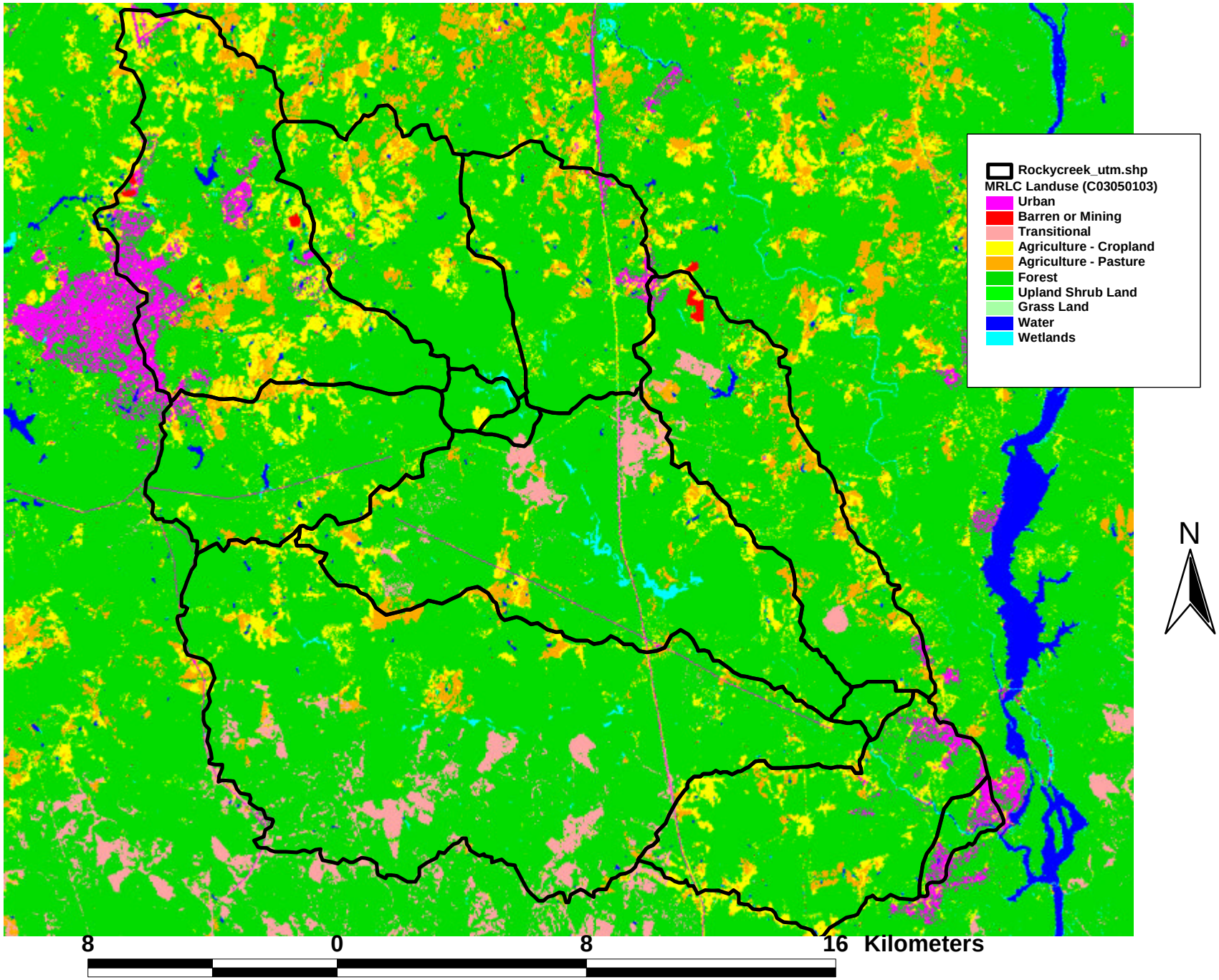

Figure 2. Land uses in the Rocky Creek watershed

2.0 WATER QUALITY ASSESSMENT

The Watershed Water Quality Management Strategy Catawba Basin (SCDHEC 1999b) was used to identify these stream stations as impaired and for listing these water bodies on the 2000 South Carolina 303(d) list. Rocky Creek and the Catawba River were 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 colonies/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 colonies/100 ml are considered impaired and listed for fecal coliform bacteria on South Carolina's 303(d) List. The impaired water bodies are described in Table 2. Only the fecal coliform impairments at CW-002, CW-236, CW-175, and CW-174 are considered in this TMDL. A mass-balance TMDL was developed previously for Grassy Run Branch, which is an urban stream in the Chester area (SCDHEC, 1999a). Table 2 also gives the percentages of samples that exceeded the standard during the assessment period (1994-1998). Station CW-002 on upper Rocky Creek has data for all seasons for the whole assessment period. Stations CW-088, CW-174, and CW-175 have data for May through October of the assessment period. Station CW-236 has data for only two years of the assessment period. Fecal coliform data for these stations are provided in Appendix A.

Table 2. Impaired water bodies.

Stream/Station	Location	Impaired Use	Cause	% FC Std Violations	Sub-watershed
Rocky Creek					
CW-088 *	Grassy Run Branch at SC 72	Recreation Aquatic Life	FC DO	85	Upper Rocky Creek
CW-002	at SR-12-325 east of Chester	Recreation Aquatic Life	FC Bio	38	Upper Rocky Creek
CW-236	at SR-12-138	Recreation	FC	29	Middle Rocky Creek
CW-175	at SR-12-141	Recreation	FC	33	Rocky Creek Mouth
Catawba River					
CW-174	at Duke Power bridge downstream of Great Falls-Dearborn Hydros	Recreation	FC	11	NA
* Grassy Run Branch Fecal Coliform TMDL					

3.0 SOURCE ASSESSMENT AND LOAD ALLOCATION

Fecal coliform bacteria enter surface waters from both point and nonpoint sources. Poorly treated municipal sewage has been a major source of fecal coliform, but with improved treatment and enforcement is not usually the case now. All point sources must have a NPDES permit. In South Carolina NPDES permittees that discharge sanitary wastewater must meet the state standard for fecal coliform at the point of discharge.

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 on the land surface which then

run off during storm events. Other sources are more or less continuous. Potential nonpoint sources of fecal coliform bacteria include animals, manure application, failing septic systems, and leaking sanitary sewers.

3.1 Point Sources

There is one point source in the Rocky Creek watershed. Chester County operates the Rocky Creek wastewater treatment facility on Rocky Creek. This facility has a permited discharge of 1.36 mgd (5150 m^3/d). However this facility has averaged a flow of 0.565 mgd for the period of 1989-2000. For this period the Rocky Creek WWTP averaged a fecal coliform concentration of 54 counts /100ml. For the model runs of existing conditions these values were used. For allocation runs of the model, that is to determine the TMDL, the permitted flow of 1.36 mgd and fecal coliform limit of 200 counts/100ml monthly average were used. The WWTP is approximately 2.1 km upstream of the impaired stream station CW-002. A review of the DMR data for this facility indicates their treated wastewater is not the cause of the impairment. Loading from this point source at permit limits is 3.09 x 10^{11} counts /30 days.

The Great Falls Wastewater Treatment Facility (SC0021211) is located at the mouth of the Rocky Creek; however, it discharges into the Catawba River and is included only in the TMDL for the Catawba River. This facility is permitted to discharge 1.40 mgd of wastewater. The average flow for the period of (1989-2000) is only 0.30 mgd. The average fecal coliform concentration in its wastewater for the same period is 15.2 counts /100 ml. A review of the DMR data for this facility indicates their treated wastewater is not the cause of the impairment of the river at this location. Loading from this facility at permit limits is 3.18 x 10^{11} counts /30 days.

3.2 Nonpoint Sources

3.2.1 Wildlife

Fecal coliform bacteria also originate in forested areas. Generally the sources are wild animals such as deer, racoons, wild turkeys, water fowl, etc. Controls of these sources will be limited to land management BMPs, although forested areas are not specifically targeted in this TMDL.

The Department of Natural Resources in South Carolina estimated a deer density of 45 deer per square mile of deer habitat (personal communication, Charles Ruth, Deer Project Supervisor, DNR, 2/22/01). Deer habitat includes the forest, cropland and pasture land uses. Using the provided deer density and the area of deer habitat available in the watershed, the total estimated number of deer in the watershed is calculated at 8500. The fecal coliform production rate for deer was estimated by linear interpolation using the rate for other animals, such as turkey and cattle, which are available in the Metcalf & Eddy (1991). The interpolation was conducted based on each animal weight. This method gives a rate of 5 x 10^8 counts/animal/day for deer. Using this rate and the assumption of equally distributed population of deer between forest and agricultural land uses, the fecal coliform accumulation rates were determined to be 1.88 x 10^7 counts/acre/day, which represents background fecal coliform loading.

3.2.2 Land Application of Manure

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 creeks are all sources of fecal coliform. 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.

One turkey operation, permitted for 32,000 birds, is located within the watershed in the Hoopers Creek sub-watershed. Litter from this operation is applied to cropland and grass land within the Rocky Creek watershed in compliance with Poultry Waste Management Plans for the farm. One small swine operation that uses a lagoon for waste treatment is also located in this watershed. The fecal coliform spreadsheet tool of WCS was used to calculate the amount of fecal coliform deposited on agricultural land.

3.2.3 Grazing Animals

Of more importance in this watershed than confined animal operations are grazing cattle. Bases the 1997 USDA census we estimated that 3355 cattle, 2296 beef cattle, and 243 dairy cattle are found in the watershed. Livestock, except for the dairy cattle, are not usually confined and so are grazing in the pastures most of the time. Manure deposited by the cattle onto the pasture land are a potential source of nonpoint source pollution. Fecal coliform were estimated to accumulate on pasture land at the rate of 1.2×10^{11} counts /acre /day.

Loading of fecal coliform bacteria from cattle defecating directly into streams was estimated from the agricultural census of cattle and an assumption about the time cattle would be expected to be standing or wading in the streams We assumed a factor of 0.00025 to account for the time that the cattle would be in streams (personal communication, EPA Region 4, 2000). The estimated loadings from the cattle-in-streams were treated as continuous sources and entered into the model by sub-watershed (Table 3).

3.2.4 Failing Septic Systems

Using a GIS we overlayed a census theme over a sewer system them and estimated the number of persons not likely to have municipal sewer treatment available. Because of a lack of data several

Table 3. Livestock-in-streams loading rates for fecal coliform and flow into model.

Sub-watershed	**Sub-watershed #**	**Fecal Coliform Loading Rate**	**Flow Rate**
		(counts/hr)	(cfs)
Upper Rocky Creek	001	6.53E+08	1.27E-06
Barbers Creek	002	2.05E+08	3.98E-07

Beaverdam Creek	003	3.06E+08	5.95E-07
Bull Run Creek	004	2.07E+08	4.03E-07
Little Rocky Creek	005	3.81E+08	7.41E-07
Mouth of Rocky Creek	006	0.00	0.00
Hooper Creek	007	3.24E+08	6.29E-07
Lower Rocky Creek	009 *	2.15E+08	4.18E-07
Middle Rocky Creek	010 **	3.52E+08	6.85E-07

* - Includes Sub-watershed 008
** - Includes Sub-watersheds 011 and 012

assumptions were made: an average waste flow of 70 gal/capita-day (Horsley and Witten, 1996), an average of 2.5 persons per household, a failure rate of 20 % (EPA), that all the wastewater reached the stream, and the concentration of fecal coliform was 10^4 counts/100ml (Horsley and Witten, 1996). Loading from failing septic systems was combined with estimated loading for leaking and overflowing sewers and entered into the model as continuous sources by sub-watersheds (Table 4).

3.2.5 Urban Storm Runoff

In addition to the specific sources of fecal coliform bacteria loading to watersheds from urban areas, there are more generalized increased loading from urban areas relative to forest land. Sources of fecal coliform bacteria in urban areas include pets, particularly from dogs. Much of the increase in loading from these areas is due simply to the increase in impervious surfaces and resulting increase in runoff. Accumulation rates for the built-up land were 5.0×10^8 counts/acre/day for both the pervious and impervious fractions; 65% of built-up land was assumed to be pervious. Most of the built-up land is found in the upper Rocky Creek (001) and the lower Rocky Creek (006 and 009) sub-watersheds.

3.2.6 Leaking and Overflowing Sewers

Other potential sources of fecal coliform bacteria in the Rocky Creek watershed include direct discharges, leaking sanitary sewers, and overflows of sanitary sewers. There is no information on direct discharges. However, in this watershed sanitary sewers are located along much of the upper and lower Rocky Creek and several tributaries (Figure 1). Grassy Run Branch, a tributary of the upper Rocky, drains the urbanized area around the Town of Chester. There are several sewer lines adjacent to and crossing the creek upstream of CW-088. This monitoring station has had the highest percentage of standard exceedances of the stations in the Rocky Creek watershed. As stated above loading from sewers was combined with loading from failing septics and entered into the model as continuous sources by sub-watershed (Table 4).

Table 4. Failing septic, leaking sewers, and other source loading rates for fecal coliform and flow to the model.

Sub-watershed	Sub-watershed #	Fecal Coliform Loading Rate	Flow Rate
		(counts/hr)	(cfs)
Upper Rocky Creek	001	8.05E+07	7.91E-03
Barbers Creek	002	1.85E+07	1.82E-03
Beaverdam Creek	003	2.95E+07	2.90E-03
Bull Run Creek	004	2.48E+07	2.44E-03
Little Rocky Creek	005	5.37E+07	5.28E-03
Mouth of Rocky Creek	006	3.85E+07	3.78E-03
Hooper Creek	007	2.01E+07	1.97E-03
Lower Rocky Creek	009 *	6.28E+07	6.17E-03
Middle Rocky Creek	010 **	1.38E+07	1.36E-03

* - Includes Sub-watershed 008
** - Includes Sub-watersheds 011 and 012

3.3 Catawba River at Great Falls

The available evidence indicates that the source of the impairment of the Catawba River at Great Falls is Rocky Creek. CW-174 fecal coliform concentrations tend to follow Rocky Creek fecal coliform concentrations (Figure 3). The Catawba River upstream of CW-174 is not impaired for fecal coliform. Because the adjacent drainage area for this section of the Catawba is quite small, direct runoff is unlikely the source of impairment. A probable mechanism for the elevated fecal coliform concentrations at station CW-174, is that water from Rocky Creek high in fecal coliform backs up into or infuses into the Catawba River channel toward the Great Falls and Dearborn Hydroelectric Stations (Figure 4). This could occur when flow is high in Rocky Creek and there is little or no flow from the Great Falls and Dearborn hydroelectric stations. Therefore a reduction in loading of fecal coliform to Rocky Creek should also reduce the loading to the Catawba at this

station. Thus, if Rocky Creek meets the standard at CW-175 (just above its confluence with the Catawba River); then the Catawba River at CW-174 should also meet the standard.

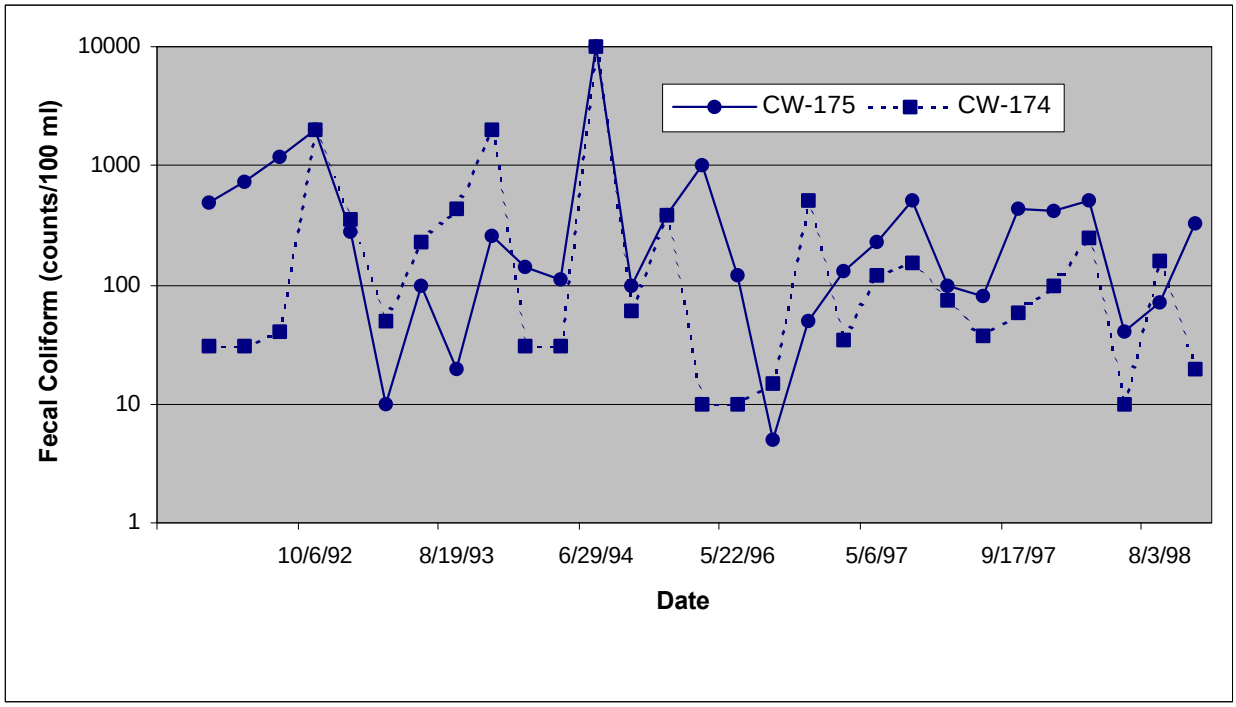

Figure 3. Comparison of fecal coliform bacteria in the Catawba River at Great Falls (CW-174) with Rocky Creek (CW-175).

4.0 Modeling

Watersheds with varied land uses and numerous potential sources of pollutants typically require a complex model to ascertain the affect of source loadings on in-stream water quality. This relationship must be understood to some degree in order to develop an effective TMDL. In this section, the numerical modeling techniques that have been developed to simulate fecal coliform bacteria fate and transport in the watershed are discussed as applied to the Rocky Creek watershed.

4.1 Model Selection

The US EPA has assembled a variety of tools to use in the development of TMDLs. The watershed in question is a relatively large basin with significant land uses with the potential to cause impairment of water quality. For this situation we utilized the GIS based dynamic modeling tool - Watershed Characterization System (WCS), which is a version of BASINS (US EPA, 1998) that has additional source loading calculation tools, updated data, and is focused on a given state. The Watershed Characterization System (WCS), a geographic information system (GIS) tool, was used

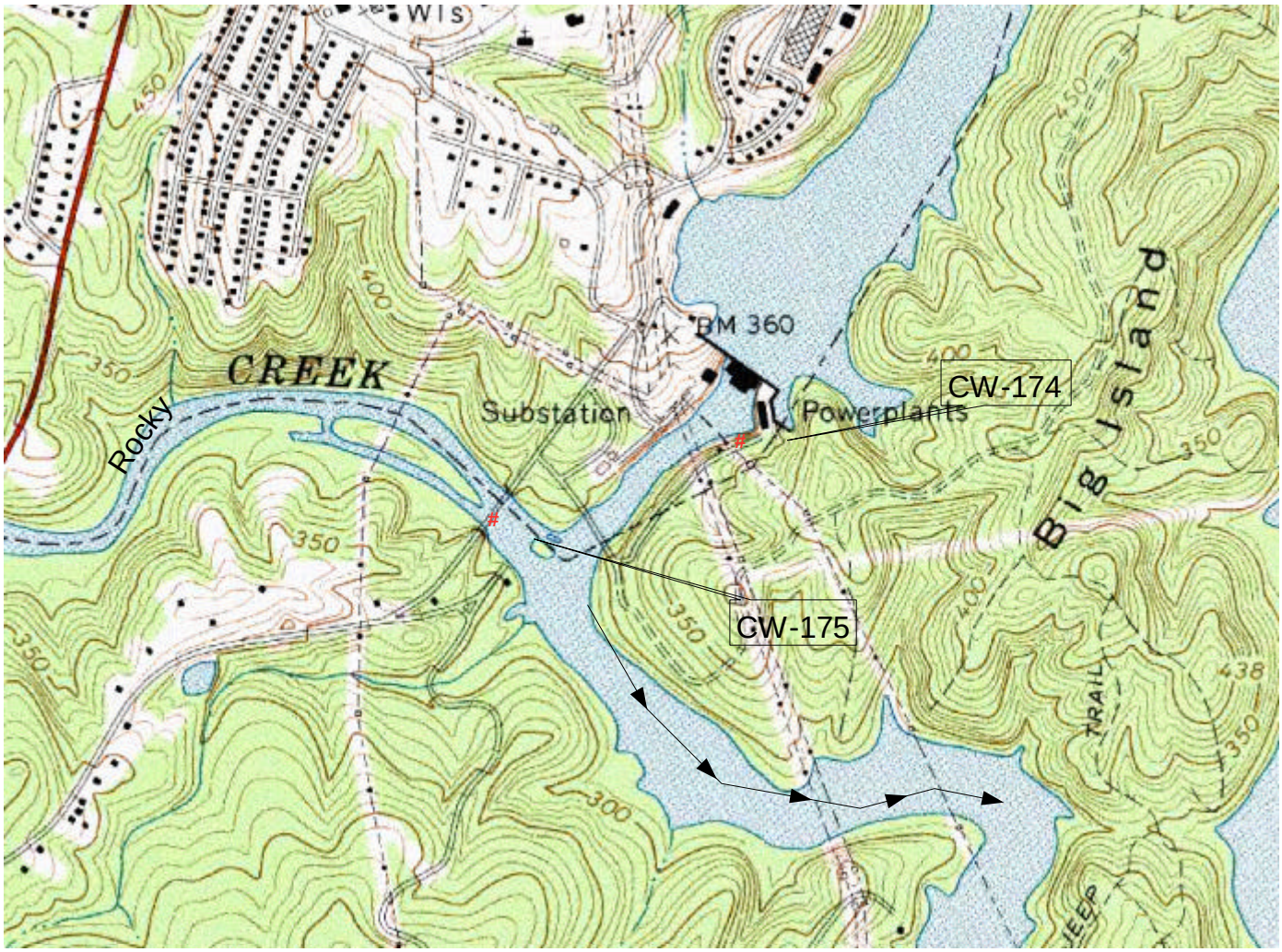

Figure 4. Confluence of Rocky Creek and the Catawba River

to display and analyze GIS information including land use, land type, point source discharges, soil types, population, and stream characteristics. The WCS was used to identify and summarize the sources of fecal coliform bacteria in the watershed, as well the other factors that affect its fate and transport.

Information collected using WCS was used in a series of spreadsheet applications designed to compute fecal coliform bacteria loading rates in the watershed from varying land uses including urban, agricultural, and forestry as described in Section 3.0. Computed loading rates were used in a hydrologic and water quality model, NPSM (Non-Point Source Model which is built around Hydrologic Simulation Program Fortran or HSPF), to simulate the deposition and transport of fecal coliform bacteria, and the resulting water quality response. NPSM simulates nonpoint source runoff as well as the transport and flow of pollutants in stream reaches. A necessary feature of NPSM is its ability to integrate both point and nonpoint sources of fecal coliform bacteria and determine the in-stream water quality response.

4.2 Model Set Up

The Rocky Creek watershed was delineated into twelve watersheds in order to characterize the relative fecal coliform bacteria contributions from the significant contributing subwatersheds (see Figure 1). The Catawba River was not included in the model because the impairment was apparently due only to flow from Rocky Creek. Three sub-watersheds were very small and only delineated because of the stream configuration. For most modeling purposes these small watersheds was included in the adjacent larger watersheds (008 with 009; 011 & 012 with 010). Watershed delineation was based on the RF3 stream coverage and elevation data. In addition, this discretization allows for management and load reduction alternatives to be varied by subwatershed. A continuous simulation period from January 1, 1988 to December 31, 1998, was used in the analysis. The period from January 1, 1988 to December 31, 1988, was used to allow the model results to stabilize. The period from January 1, 1989 to December 31, 1998, was used to identify the critical condition period from which to develop the TMDL.

An important factor driving model results is the precipitation data contained in the meteorological file used in the simulations. 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. Weather data from the Winnsboro meteorological station were used in the simulations. This station is outside of the watershed, which contributed to difficulties in calibrating the model such as matching peak flows during the summer and using computed data to replace missing data.

4.3 Model Calibration

The calibration of the watershed model involves both hydrology and water quality components. The hydrology calibration is performed first. Simulated stream flows are compared to historic stream flow data from a U.S. Geological Survey (USGS) stream gauging station over the same period of time. Calibration of the hydrologic model is accomplished by adjusting model parameters (e.g., evapotranspiration, infiltration, upper and lower zone storage, groundwater storage and recession, and interflow discharge) used to represent the hydrologic cycle, until an acceptable

agreement is achieved between simulated and observed stream flows. The USGS gage (USGS 02147500) on Rocky Creek 2.5 km upstream of its confluence with the Catawba River near Great Falls was used to calibrate the flow model. Results of the hydrology calibration are included in Appendix B.

Fecal coliform bacteria data are available for three stations on Rocky Creek. Data from the most downstream station (CW-175) were used to calibrate the water quality model. The model output was also checked at the two upstream stations. Model calibration results are shown in Appendix B. Results show that the model adequately simulates fecal coliform bacteria in response to rainfall events and suspected inputs. Often a high observed value is not simulated in the model due to lack of rainfall at the meteorological station as compared to the rainfall occurring in the watershed, or an unknown source that is not included in the model. A comparison of simulated water quality concentrations and observed concentrations for sampling stations in the watershed are shown in Appendix B.

4.4 Critical Conditions

EPA regulations at 40 CFR 130.7(c)(1) require that TMDLs to take into account critical conditions for stream flow, loading, and water quality parameters. The intent of this requirement is to ensure that the water quality is protected during times when it is most vulnerable. The selection of a critical environmental condition sometimes corresponds to a specific stream flow condition. However, for this TMDL the 30-day period for which the model predicts the largest violation of the geometric mean standard was identified (EPA 1991). Basing the TMDL on this period ensures that the standard can be met throughout the period of simulation. The critical period for this TMDL was the 30-day period prior to and including May 2, 1998 (Figure 5). Note that the two large peaks in 1993 are not used to determine the critical period, because these two peaks are due to model instability when the simulated flow approaches zero and consequently fecal coliform concentrations become extremely large.

5.0 Modeling Results

5.1 Existing Conditions

An examination of the model output indicates that the primary sources of fecal coliform loading to Rocky Creek are nonpoint sources related to agricultural and urban activities. Existing loading from nonpoint sources to Rocky Creek are presented in Table 5.

5.2 Critical Conditions

The critical condition for Rocky Creek was determined from the plot of the 10 year simulation of fecal coliform (Figure 6). The 30-day critical period in the model is the time period immediately preceding and including the largest simulated violation of the geometric mean

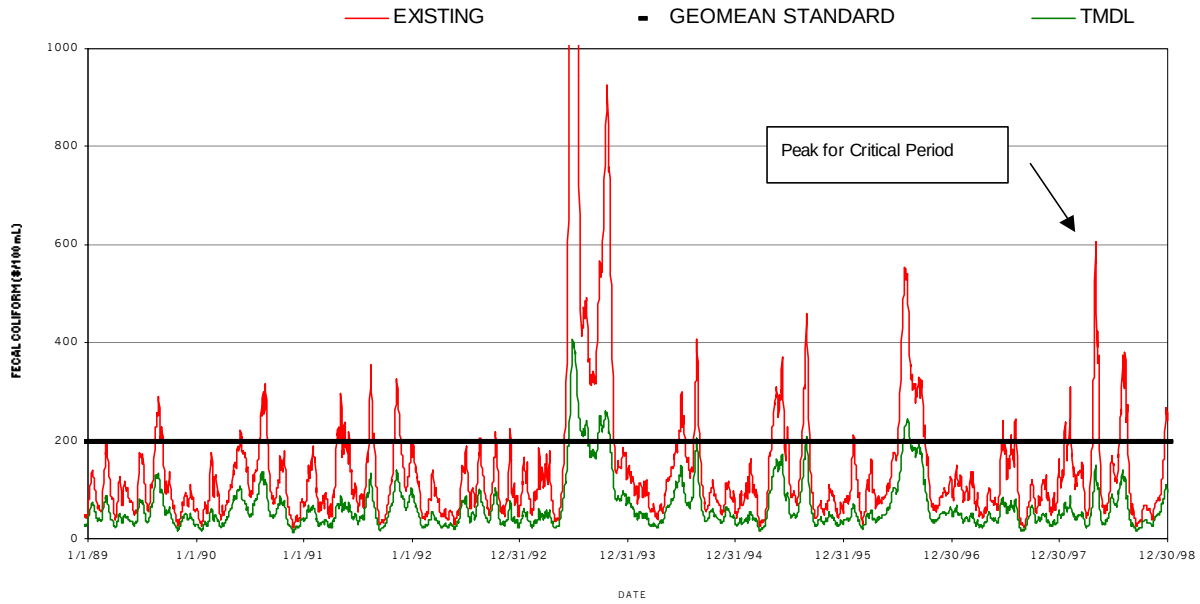

Figure 5. Predicted existing and proposed TMDL fecal coliform concentrations (30 day running geometric means) at CW-175. The critical period is also indicated.

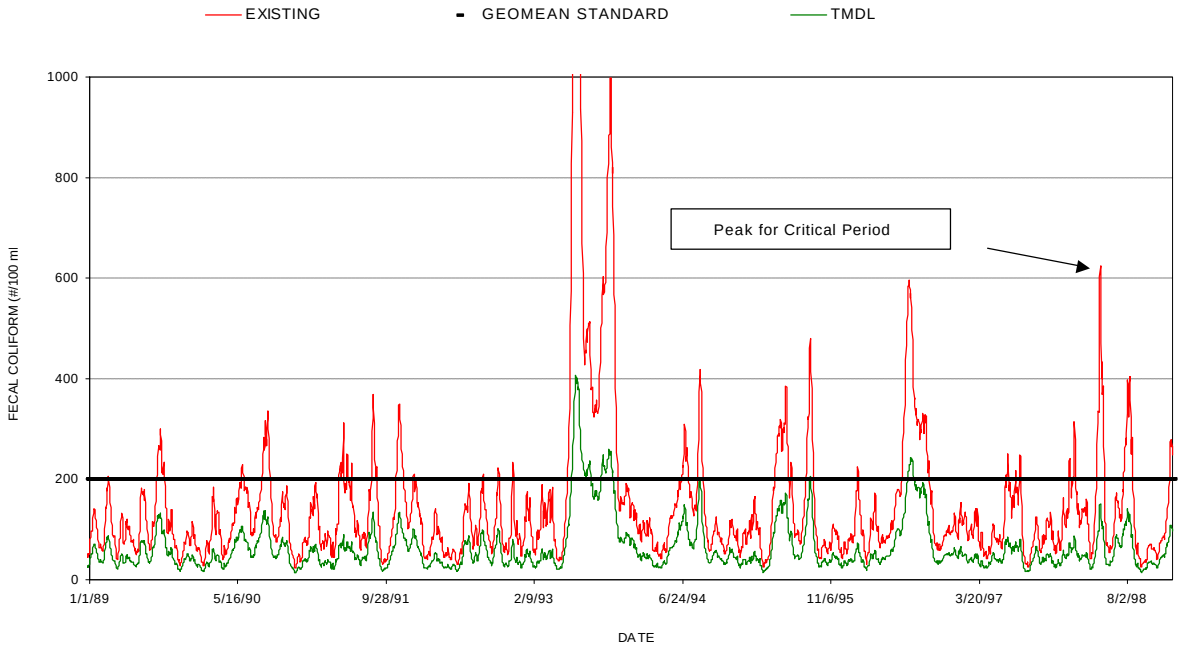

Figure 6. Predicted existing and proposed TMDL fecal coliform concentrations (30 day running geometric means) at CW-236. The critical period is also indicated.

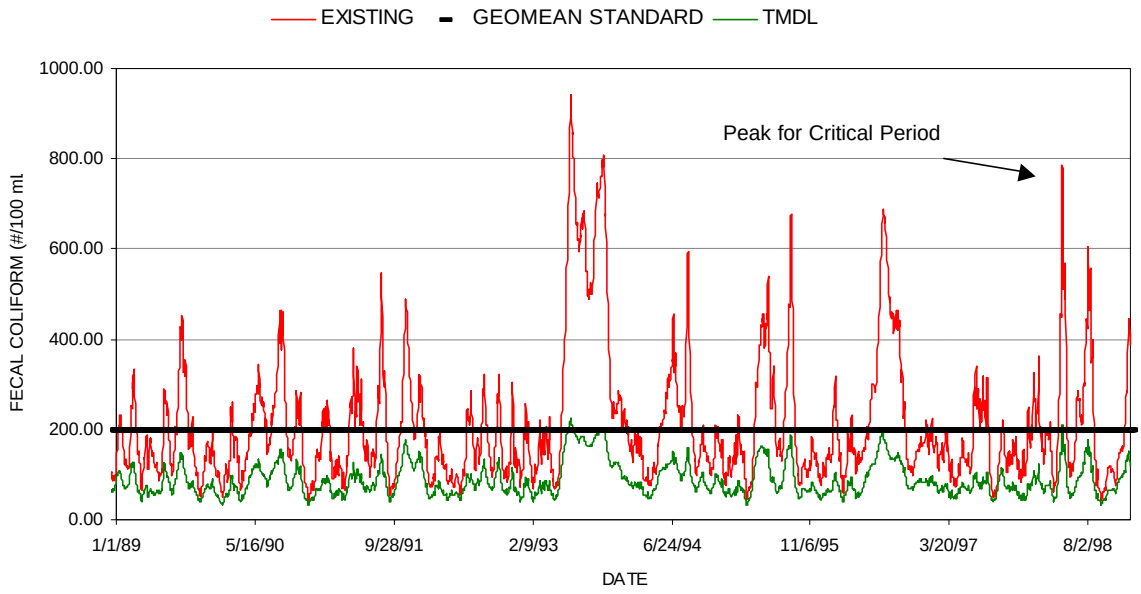

Figure 7. Predicted existing and proposed TMDL fecal coliform concentrations (30 day running geometric means) at CW-002. The critical period is also indicated.

standard (EPA 1991), excluding the invalid peaks. Achieving the water quality standard during this period ensures that the water quality standard can be achieved for the ten year period. In evaluating critical conditions, periods of extreme drought and flooding are not considered. For the listed segment, the highest violation of the 30-day geometric mean occurred on May 2, 1998. The critical period is then April 3, 1998 through May 2, 1998.

5.3 Model Uncertainty

There are several sources of uncertainty in the Rocky Creek model. These include the rainfall data from outside the watershed, limited water quality data - especially during high flow

Table 5. Nonpoint Source Loading to Rocky Creek (counts/30 days)

Rocky Creek stations (all are accumulative)	**Runoff from Land**	**Failing Septic Systems & Leaking Sewers**	**Other Sources (livestock-in-streams, etc)**
CW-002	8.36×10^{14}	5.80×10^{10}	4.70×10^{11}
CW-236	3.59×10^{15}	2.19×10^{11}	1.91×10^{12}
CW-175	3.59×10^{15}	2.46×10^{11}	1.91×10^{12}

conditions, inherent variability in fecal coliform sampling, and little or no information on sources like failing or leaking septic systems and sanitary sewer overflows. These uncertainities should be considered in evaluating the recommendations in this TMDL.

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 water body. Conceptually, this definition is represented by the equation:

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

The TMDL is the total amount of pollutant that can be assimilated by the receiving water body 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 Wasteload Allocations

The Chester County - Rocky Creek Wastewater Treatment Plant (SC0036056) is the only discharger in the Rocky Creek watershed that is permitted to discharge fecal coliform bacteria. This facility in the upper Rocky Creek sub-watershed is permitted for a flow of 1.36 mgd (2.108 cfs). The WLA for the Rocky Creek watershed is 3.09×10^{11} counts /30 days.

The Chester County - Great Falls WWTP discharges into the Catawba River between station CW-174 and the mouth of the Rocky Creek. The loading from this small facility is 3.18×10^{11} counts /30 days.

6.2 Load Allocation

Nonpoint sources were arranged into three groups for the model. Sources that accumulate on the land and are then washed into streams or ponds are considered under 'Runoff from Land' in Table 6. Failing septic systems, leaking sewers, and overflowing sewers, which may discharge directly intostreams, are listed separately. Finally, livestock, primarily cattle in this watershed, which can

deposit fecal coliform directly into the water body are listed in the next column. Loading from runoff is the largest component of the Load Allocation (nonpoint sources) because it is driven by rainfall.

The loading presented in Table 7 represents one scenario where reductions came predominantly from runoff from pasture and built-up land and from the septic-sewer category. Reductions were also made in loading from cattle-in-streams. The reductions were greater in the upper Rocky Creek sub-watershed. The most effective management strategies to reduce loading to Rocky Creek would include elimination of sanitary sewer leaks, reduction in sanitary sewer overflows, repair or elimination of failing septic systems, limiting access to streams by livestock, and restoration of adequate stream buffers where necessary.

Table 6. Load allocation components (counts /30 days)

Stations	**Runoff from Land**	**Septic Systems & Sewers**	**Cattle-in-Streams**	**LA**
CW-002	1.32×10^{14}	5.8×10^{9}	4.7×10^{10}	1.32×10^{14}
CW-236	6.10×10^{14}	7.26×10^{10}	7.17×10^{11}	6.11×10^{14}
CW-175	6.11×10^{14}	7.81×10^{10}	7.17×10^{11}	6.12×10^{14}
CW-174	6.11×10^{14}	7.81×10^{10}	7.17×10^{11}	6.12×10^{14}

6.3 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 this TMDL the MOS is implicit through the use of a 10-year simulation period and by using conservative assumptions in developing the model. Several conservative assumptions were used in this model. For the allocation the WWTP's discharge was assumed to be the maximum, ie permit limits. Other conservative assumptions are that all cattle have access to the streams, conservative parameters for HSPF.

6.4 TMDL

Total maximum daily loads for fecal coliform for each of the four stream points is the sum of the WLA, the LA, and the MOS (Table 7). The TMDLs represent 83 - 84 % reductions from the existing loading to the water bodies. The greater reduction in loading from nonpoint sources is required in the upper Rocky Creek sub-watershed (001).

Table 7. TMDL components (counts /30 days)

Stations	WLA	LA	MOS	TMDL	Reduction
Rocky Creek CW-002	3.09×10^{11}	1.32×10^{14}	Implicit	1.32×10^{14}	84 %
Rocky Creek CW-236	3.09×10^{11}	6.11×10^{14}	Implicit	6.11×10^{14}	83 %
Rocky Creek CW-175	3.09×10^{11}	6.12×10^{14}	Implicit	6.12×10^{14}	83 %
Catawba River CW-174	6.27×10^{11}	6.12×10^{14}	Implicit	6.13×10^{14}	83 %

6.5 Seasonal Variability

The model simulation covered a 10 year continual period so that all seasons were included. The simulation period included both wet and dry years. Monthly varying values were used for evapo-transpiration, roughness coefficients, and interception storage capacity.

7.0 Implementation

South Carolina has several tools available to reduce loading of fecal coliform bacteria due to agricultural activities as discussed in the *Implementation Plan for Achieving Total Maximum Daily Load Reductions From Nonpoint Sources for the State of South Carolina*. Specifically, 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 Rocky Creek watershed. Local sources of nonpoint source education include Clemson Extension Service, the Natural Resource Conservation Service (NRCS) 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. Fencing cattle out of streams and restoring a adequate stream buffer have been shown to reduce pollution entering streams. NRCS can provide cost share money to land owners installing BMPs. SCDHEC employs a nonpoint source educator who can also provide BMP information.

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.
In addition, other interested parties (universities, local watershed groups, etc.) may apply for section 319 grants to install BMPs that will reduce fecal coliform loading to Rocky Creek.

SCDHEC will work with existing agencies in the region to provide nonpoint source education in the Rocky Creek watershed to reduce pollution from built-up areas. Local sources of nonpoint source education include Clemson Extension Service, the Natural Resource Conservation Service (NRCS), the Fairfield and Richland County Soil and Water Conservation Districts, and the South Carolina Department of Natural Resources. In addition, Clemson Extension has developed a Home-A-Syst handbook that can help urban or rural homeowners reduce sources of NPS pollution on their property. This document guides homeowners through a self-assessment, including information on proper maintenance practices for septic tanks. SCDHEC also employs a nonpoint source educator who can assist with distribution of these tools as well as provide additional BMP information. In built-up areas, failing septic systems should be repaired or replaced. Also, maintenance of sanitary sewers and prevention of sewer overflows (from blockages) should be emphasized.

Using existing authorities and mechanisms, these measures will be implemented in the Rocky Creek Watershed in order to bring about a 83 to 84% reduction in fecal coliform bacteria loading to Rocky Creek and the Catawba River at Great Falls. The reductions will be targeted at urban sources and livestock sources.

DHEC will continue to monitor, according to the basin monitoring schedule, the effectiveness of implementation measures and evaluate stream water quality as the implementation strategy progresses. This TMDL may be revised if additional monitoring data and better modeling tools become available.

8.0 References

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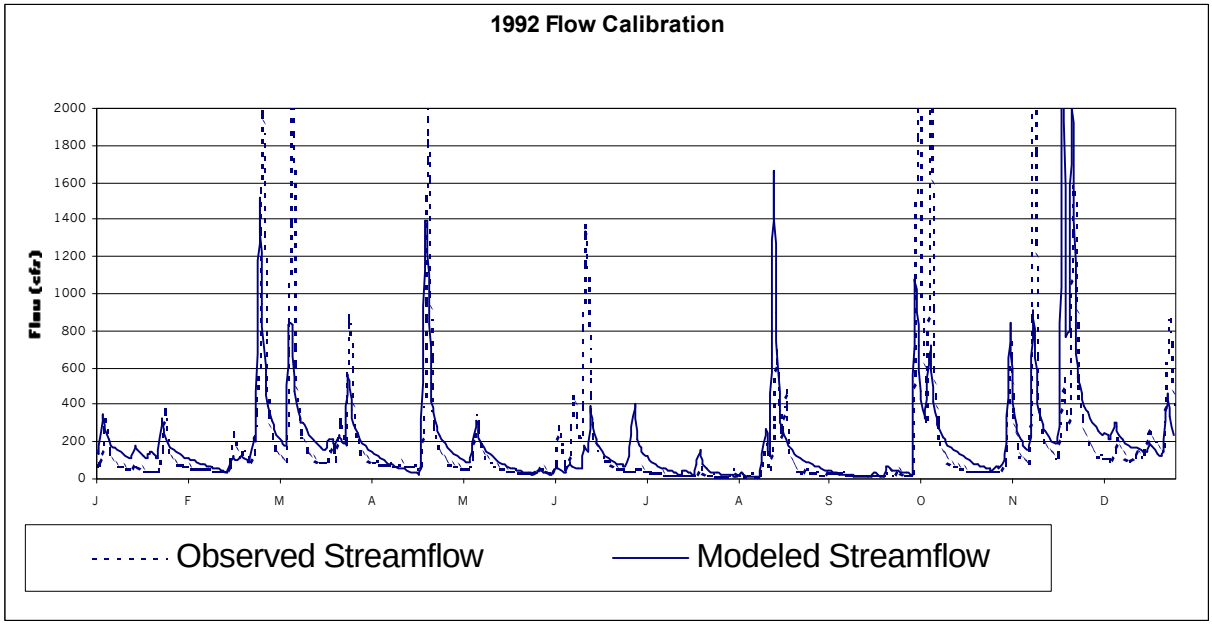
Appendix A Fecal Coliform Monitoring Data

Fecal Coliform Data for Rocky Creek, Chester County, SC														
Concentration expressed as counts/100 ml														
CW-002 Rocky Creek at S-12-335, 3.4 mi E of Chester				CW-236 Rocky Creek at S-12-138				CW-175 Rocky Creek on S-12-141, SE of Great Falls				CW-174 Catawba River below Great Falls - Dearborn Hydros		
Date	Time	Conc		Date	Time	Conc		Date	Time	Conc		Date	Time	Conc
1/29/90	1113	270		11/5/92	1100	3300		5/1/90	1201	120		5/1/90	1147	18
2/28/90	1403	580		12/2/92	950	220		6/21/90	1042	40		6/21/90	1030	96
3/28/90	1041	490		1/7/93	947	540		7/26/90	1120	25		7/26/90	1102	51
4/5/90	1340	270		2/18/93	1540	180		8/28/90	1456	5		8/28/90	1445	50
5/1/90	1338	360		3/24/93	1505	3300		9/4/90	1147	3		9/4/90	1126	50
6/21/90	1128	310		4/29/93	1455	55		10/25/90	1052	162		10/25/90	1036	1100
7/26/90	1248	150		5/11/93	1430	430		5/30/91	940	100		5/30/91	925	30
8/28/90	1330	530		6/23/93	1420	110		6/24/91	1520	330		6/24/91	1510	16
9/4/90	1305	170		7/27/93	1510	340		7/15/91	1430	25		7/15/91	1440	10
10/25/90	1159	2000		8/19/93	1345	840		8/8/91	1018	620		8/8/91	1030	4000
11/27/90	1324	330		9/21/93	1400	1000		9/4/91	855	1000		9/4/91	840	10
12/10/90	1324	1200		10/20/93	1320	270		10/3/91	1505	640		10/3/91	1450	5
1/2/91	1344	590		3/9/98	1320	2000		5/7/92	1035	480		5/7/92	1050	30
2/4/91	1130	350		4/2/98	1040	500		6/17/92	1510	730		6/17/92	1445	30
3/4/91	1310	3300		6/1/98	1350	270		7/14/92	1500	60		8/20/92	1305	40
4/1/91	1220	6600		7/14/98	950	80		8/20/92	1315	1200		9/24/92	1430	20
5/30/91	1047	360		8/3/98	1340	220		9/24/92	1450	400		10/6/92	1010	2000
6/24/91	1215	1400		9/16/98	1435	220		10/6/92	1020	2000		5/11/93	1510	280
7/15/91	1020	340		10/21/98	945	200		5/11/93	1450	360		6/23/93	1500	10
8/8/91	1150	6600						6/23/93	1450	50		7/27/93	1530	100
9/4/91	1035	130						7/27/93	1520	230		8/19/93	1418	20
10/3/91	1010	300						8/19/93	1410	430		9/21/93	1430	260
11/25/91	1300	100						9/21/93	1420	2000		10/20/93	1345	140
12/16/91	1140	470						10/20/93	1405	30		5/19/94	1409	30
1/9/92	1005	300						5/19/94	1420	110		6/29/94	1425	10000
2/25/92	1452	3300						6/29/94	1415	10000		7/14/94	1429	60
3/12/92	1245	3300						7/14/94	1432	100		8/25/94	1455	380
4/2/92	1245	60						8/25/94	1440	380		9/22/94	1534	10
5/7/92	1235	1400						9/22/94	1530	990		10/25/94	1500	8
6/17/92	1220	140						10/25/94	1446	500		5/31/95	1450	140
7/14/92	1305	80						5/31/95	1436	2000		6/28/95	2500	220
8/20/92	1530	270						6/28/95	1500	210		7/18/95	918	1300

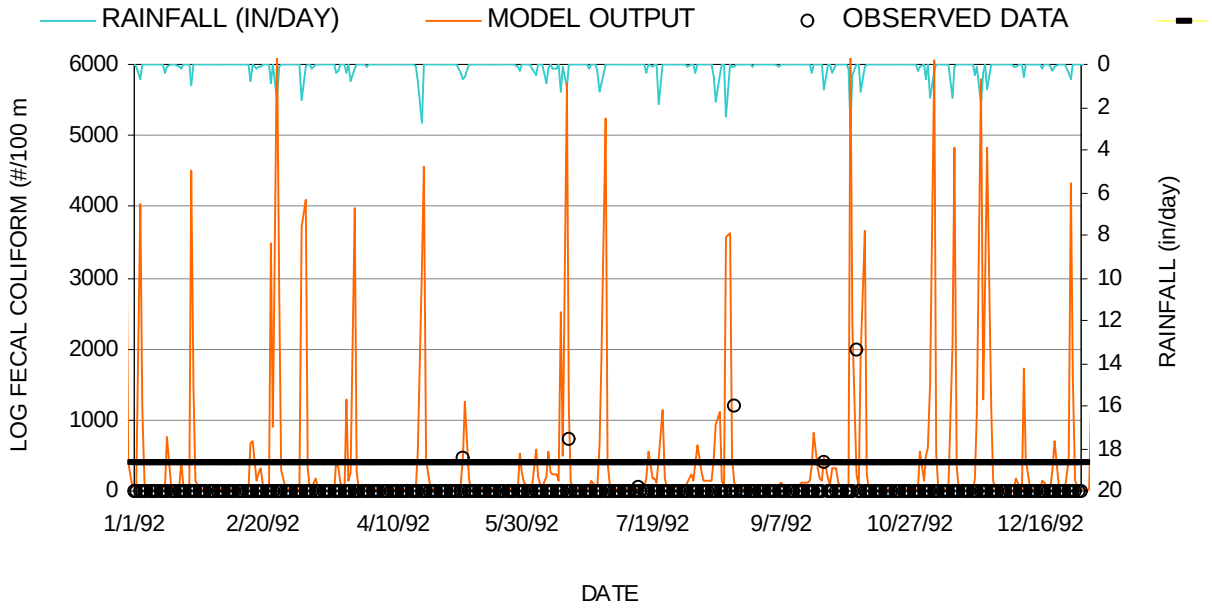
CW-002 Rocky Creek				CW-236 Rocky Creek				CW-175 Rocky Creek				CW-174 Catawba Riv		
Date	Time	Conc		Date	Time	Conc		Date	Time	Conc		Date	Time	Conc
9/24/92	1240	2000						7/18/95	912	63		8/23/95	1235	40
10/6/92	1205	200						8/23/95	1226	260		9/12/95	1012	40
11/5/92	1345	10300						9/12/95	1030	3300		10/26/95	1445	120
12/1/92	1020	100						10/26/95	1435	120		5/22/96	1425	10
1/7/93	1252	100						5/22/96	1410	120		6/27/96	950	15
2/18/93	1320	200						6/27/96	945	5		8/7/96	905	510
3/24/93	1335	1500						8/7/96	917	50		9/24/96	1445	35
4/29/93	1200	180						9/24/96	1235	130		5/6/97	1500	120
4/11/93	1255	430						5/6/97	1455	230		6/17/97	1425	150
6/23/93	1330	140						6/17/97	1440	520		7/21/97	1430	74
7/27/93	1310	310						7/21/97	1450	100		8/28/97	1145	38
8/19/93	1145	310						8/28/97	1200	80		9/17/97	930	58
9/21/93	1225	2500						9/17/97	925	440		10/21/97	935	100
10/20/93	1045	30						10/21/97	950	420		6/1/98	1400	250
11/2/93	1010	540						6/1/98	1410	510		7/14/98	920	10
12/16/93	1050	260						7/14/98	930	40		8/3/98	1410	160
1/27/94	1000	110						8/3/98	1400	70		9/16/98	1410	20
2/2/94	1450	130						9/16/98	1420	330		10/21/98	920	20
3/17/94	955,	70						10/21/98	930	180				
4/21/94	1030	320												
5/5/94	1050	1000												
5/24/94	915,	7800												
5/25/94	920,	36000												
6/15/94	1500	60												
6/29/94	1300	7500												
7/14/94	1315	200												
8/25/94	1320	320												
9/22/94	1446	150												
11/3/94	1411	110												
11/29/94	1325	2200												
12/8/94	1440	300												
1/4/95	1447	260												
2/2/95	1425	40												
3/2/95	1442	3600												
4/25/95	1405	1200												
5/31/95	1310	640												
6/28/95	1330	550												
7/18/95	1017	330												
8/22/95	1359	220												
9/12/95	1142	3800												
10/16/95	1347	330												
11/1/95	1015	140												
12/12/95	1400	820												
1/21/96	1040	380												
2/8/96	1205	370												
3/7/96	1105	12000												
5/23/96	950	20												
7/1/96	945	180												
10/7/96	939	160												
11/19/96	942	4700												
12/16/96	1004	20												
1/2/97	1035	590												

CW-002 Rocky Creek				CW-236 Rocky Creek				CW-175 Rocky Creek				CW-174 Catawba Riv		
Date	Time	Conc		Date	Time	Conc		Date	Time	Conc		Date	Time	Conc
2/3/97	1230	590												
2/11/97	1430	100												
3/3/97	1230	590												
4/10/97	1130	130												
5/7/97	1245	2000												
5/21/97	1445	200												
6/2/97	1030	5580												
7/17/97	1015	200												
8/27/97	1340	420												
9/10/97	1330	330												
10/23/97	1145	330												
11/13/97	1150	2000												
1/5/98	1417	460												
2/26/98	1045	90												
3/9/98	1115	7800												
4/2/98	1330	300												
5/20/98	1020	200												
7/29/98	1000	310												
8/24/98	1030	230												
9/28/98	1025	110												
10/14/98	1028	70												
11/9/98	1045	35												

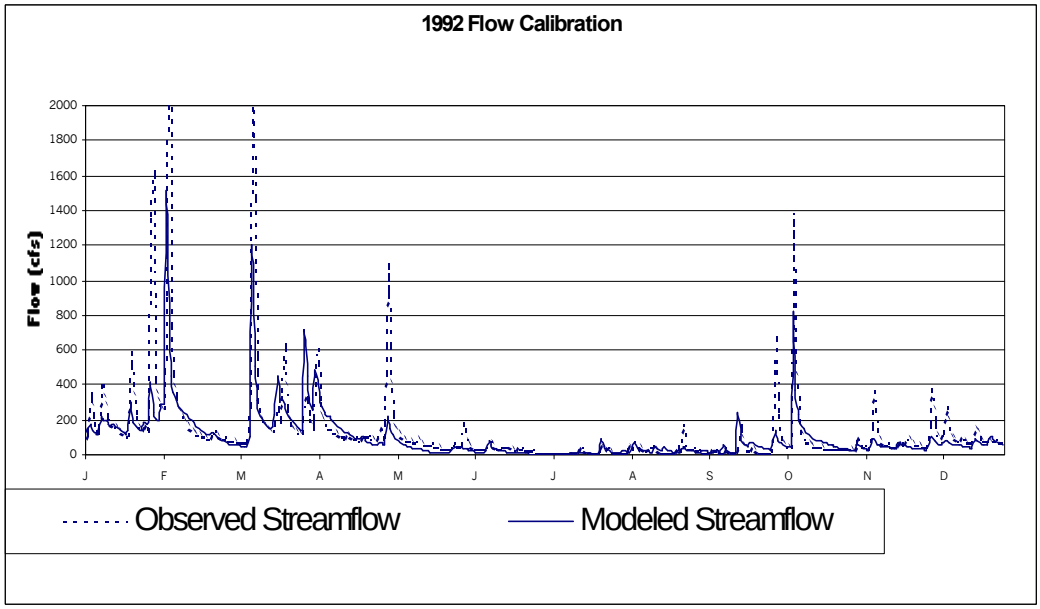
Appendix B Flow and Fecal Coliform Calibration Graphs



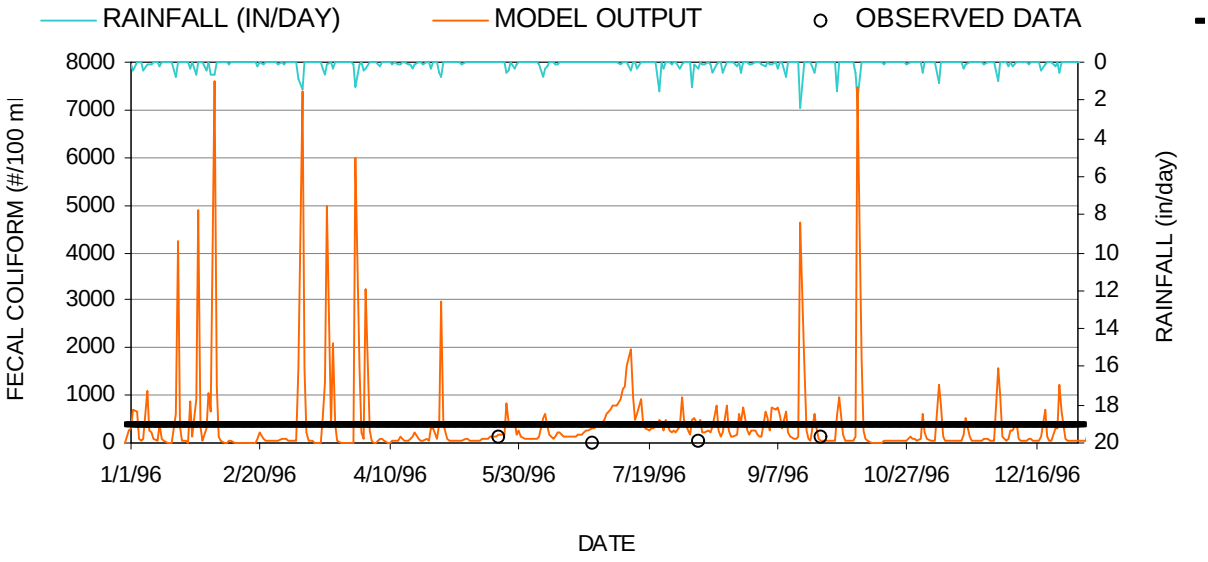
Hydrologic Calibration (1992)



Fecal Coliform Calibration (1992)



Hydrologic Calibration (1992)



Fecal Coliform Calibration (1996)

Appendix C

Population estimates for Rocky Creek Watershed
Derived from overlay of census data and sewer line themes.

Sub-watershed	#		Population	
			Total	Unsewered
Upper Rocky Creek	001		4451	1458
Barbers Creek	002		617	335
Beaverdam Creek	003		816	534
Bull Run Creek	004		449	449
Little Rocky Creek	005		973	973
Rocky Creek Mouth *	006		901	697
Hoopers Creek	007		364	364
Lower Rocky Creek a **	008		--------	--------
Lower Rocky Creek	009		1699	1138
Middle Rocky Creek	010		412	250
Middle Rocky Creek b **	011		--------	--------
Middle Rocky Creek a **	012		--------	--------
Totals			10682	6198

* This sub-watershed is the area downstream of the USGS gauging station.
** The inputs from these very small sub-watersheds were included in the larger sub-watersheds of the same name

Load Allocations used in Proposed Reductions for Failing Septic Systems - Leaking Sewers and Livestock-in-streams Sources

Cattle-in-Streams											
		Existing Loading				**Allocation Loading**				**Reduction %**	
Sub-WS Numb		**FC Loading Rates**									
		(#/hr)		**(#/30 days)**		**(#/hr)**		**(#/30 days)**			
001		6.53E+08		4.70E+11		6.53E+07		4.70E+10		90%	10%
002		2.05E+08		1.48E+11		1.03E+08		7.38E+10		50%	50%
003		3.06E+08		2.20E+11		1.53E+08		1.10E+11		50%	50%
004		2.07E+08		1.49E+11		1.04E+08		7.45E+10		50%	50%
005		3.81E+08		2.74E+11		1.91E+08		1.37E+11		50%	50%
006		0.00E+00		0.00E+00		0.00E+00		0.00E+00		80%	20%
007		3.24E+08		2.33E+11		1.62E+08		1.17E+11		50%	50%
009		2.15E+08		1.55E+11		4.30E+07		3.10E+10		80%	20%
010		3.52E+08		2.53E+11		1.76E+08		1.27E+11		50%	50%

Failing Septic & Leaking Sewer											
		Existing Loading				**Allocation Loading**				**Reduction %**	
Sub-WS Numb		**FC Loading Rates**									
	(#/hr)	**(#/hr)**		**(#/30 days)**		**(#/hr)**		**(#/30 days)**			
001		8.05E+07		5.80E+10		8.05E+06		5.80E+09		90%	10%
002		1.85E+07		1.33E+10		9.25E+06		6.66E+09		50%	50%
003		2.95E+07		2.12E+10		1.48E+07		1.06E+10		50%	50%
004		2.48E+07		1.79E+10		1.24E+07		8.93E+09		50%	50%
005		5.37E+07		3.87E+10		2.69E+07		1.93E+10		50%	50%
006		3.85E+07		2.77E+10		7.70E+06		5.54E+09		80%	20%
007		2.01E+07		1.45E+10		1.01E+07		7.24E+09		50%	50%
009		6.28E+07		4.52E+10		1.26E+07		9.04E+09		80%	20%
010		1.38E+07		9.94E+09		6.90E+06		4.97E+09		50%	50%

Note: Sub-watershed # 008 is included in 009; and 011 and 012 are included in 010.

Sub-WS Numb	**Name of Sub-Watershed**		**Cattle-in-Streams**	**Failing Septic Sys & Lkg Sewers**
001	Upper Rocky Creek	**TMDLs**	**(counts/30 days)**	
002	Barbers Creek			
003	Beaverdam Creek			
004	Bull Run Creek	**CW-002**	**4.70E+10**	**5.80E+09**
005	Little Rocky Creek			
006	Mouth of Rocky Creek	**CW-236**	**7.17E+11**	**7.26E+10**
007	Hooper Creek			
009	Lower Rocky Creek	**CW-175**	**7.17E+11**	**7.81E+10**
010	Middle Rocky Creek			

Appendix D Record of Public Participation

The following notice was placed in *The State* newspaper, on DHEC's website, and mailed to interested parties:

AVAILABILTY OF PROPOSED TOTAL MAXIMUM DAILY LOAD FOR WATERS AND POLLUTANTS OF CONCERN IN THE STATE OF SOUTH CAROLINA

Brown Creek in York County
Bush River in Newberry and Laurens Counties
Rocky Creek in Chester and Fairfield Counties

Section 303(d)(1) of the Clean Water Act (CWA), 33 U.S.C. '1313(d)(1)(C), and the implementing regulation of the US Environmental Protection Agency (EPA, 40 C.F.R. ' 130.7(c) (1), require the establishment of total maximum daily loads (TMDLs) for waters identified as impaired pursuant to ' 303(d)(1)(A) of the CWA. Each of these TMDLs is to be established at a level necessary to implement applicable water quality standards with seasonal variations and a margin of safety, to account for lack of knowledge concerning the relationship between effluent limitations and water quality. At this time, the South Carolina Department of Health and Environmental Control (DHEC) has developed proposed TMDLs for the '303(d)(1)(A) waters:

Brown Creek, York County, Fecal Coliform Bacteria, 03050101-180-030; Bush River, Newberry and Laurens Counties, Fecal Coliform Bacteria, 03050109-150; Rocky Creek, Chester and Fairfield Counties, Fecal Coliform Bacteria, 03050103-090.

Upon review of any public comment and revision, if necessary, the Department will submit these TMDLs to EPA for approval as final TMDLs.

Persons wishing to comment on the proposed TMDLs or to offer new data regarding the proposed TMDLs are invited to submit the same in writing no later than June 14, 2001, to:

South Carolina Department of Health and Environmental Control
Bureau of Water
2600 Bull St.
Columbia, S.C. 29201
Attn: Colt Bowles

Mr. Bowles=s phone number is 803-898-4142. His E-mail address is bowlescb@columb32.dhec.state.sc.us.

Copies of individual TMDLs can be obtained by calling, writing, or e-mailing Mr. Bowles at the address above or from the Bureau of Water web site: http://www.scdhec.net/water/. The administrative record, including technical information, data and analyses supporting the proposed TMDLs, are available for review. Requests to review this information must be submitted in writing to DHEC=s Freedom of Information Office at 2600 Bull Street, Columbia, SC 29201 or requests can be submitted via FAX to the Freedom of Information Office at 803.898.3816. Reproduction of documents is available at a cost of $0.25 per page.