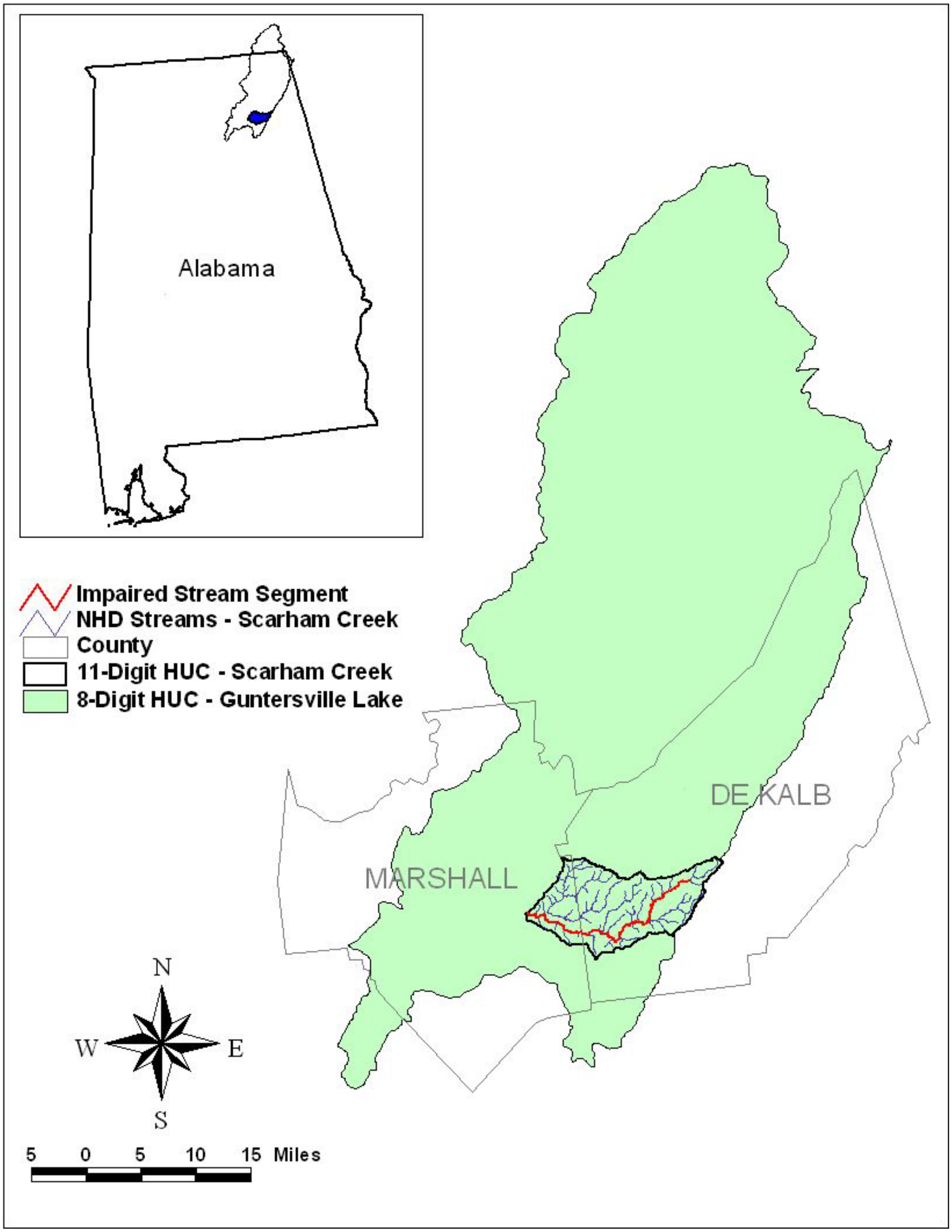
Alabama Department of Environmental Management

# *FINAL*
# Scarham Creek TMDL Development for Fecal Coliform

Water Quality Branch
Water Division
February 2002

# Scarham Creek Watershed (0603001270)
# in the Guntersville Lake Basin (0603001)



## LIST OF ABBREVIATIONS

| | |
|---|---|
| ADEM | Alabama Department of Environmental Management |
| BMP | Best Management Practices |
| CFS | Cubic Feet per Second |
| DEM | Digital Elevation Model |
| DMR | Discharge Monitoring Report |
| EPA | Environmental Protection Agency |
| GIS | Geographic Information System |
| HSPF | Hydrological Simulation Program - FORTRAN |
| HUC | Hydrologic Unit Code |
| LA | Load Allocation |
| LSPC | Loading Simulation Program in C++ |
| MGD | Million Gallons per Day |
| MOS | Margin of Safety |
| MPN | Most Probable Number |
| MRLC | Multi-Resolution Land Characteristic |
| NED | National Elevation Dataset |
| NHD | National Hydrography Dataset |
| NPDES | National Pollutant Discharge Elimination System |
| NRCS | Natural Resources Conservation Service |
| RF3 | Reach File 3 |
| RM | River Mile |
| SWCS | Soil and Water Conservation Services |
| STORET | STORage RETrieval database |
| TMDL | Total Maximum Daily Load |
| USGS | United States Geological Survey |
| WCS | Watershed Characterization System |
| WLA | Waste Load Allocation |

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# 1 Executive Summary

Scarham Creek is located in the northeast portion of Alabama near the Guntersville Lake Reservoir. The Scarham Creek watershed is approximately 90 square miles with the headwater of the watershed in DeKalb County and the downstream area in Marshall County. The 2 major populated areas in the watershed are Geraldine and Crossville.

Scarham Creek appeared on the State of Alabama's first §303(d) use impairment list in 1992. It was listed for pesticides, ammonia, nutrients, siltation, organic enrichment / dissolved oxygen, and pathogens. This report presents only the pathogen TMDL. Scarham Creek is listed on the 1996-§303(d) use impairment list for the same pollutants with the impaired length being 12 miles. On the 1998-§303(d) use impairment list, it was increased to 24 miles. Its use designation is Fish and Wildlife for the entire segment. The sources of impairment are shown on the list as non-irrigated crop production, specialty crop production, feedlots, and animal holding / management areas. The data that listed Scarham Creek as being impaired for pathogens were listed as being collected in 1991.

Fecal coliform data from 1988 through 1998 were used in the TMDL analyses. The data were compiled from the Tennessee Valley Authority Surface Water Quality Screening Assessment and the Sand Mountain / Lake Guntersville NPS Watershed Project.

The following report addresses the results of the TMDL analysis for pathogens. In accordance with ADEM water quality criterion, the bacteria of the fecal coliform group shall not exceed a geometric mean of 1,000 per 100 mL during October to May and 200 per mL from June to September; nor exceed a maximum of 2,000 per 100 ml in any sample in a stream classified as Fish and Wildlife.

**Table 1-1 Maximum Allowable Pollutant Loads by Source**

| Pollutant | Point Source Loads* (counts/year) | Non-point Source Loads (counts/year) |
|---|---|---|
| Fecal Coliform | 2.05E+11 | 4.29E+14 |

* Includes only NPDES permitted loads.

**Table 1-2 Maximum Allowable Pollutant Loads for Non-point Sources**

| Pollutant | Forest (counts/year) | Pasture/Hay (counts/year) | Row Crops (counts/year) | Urban (counts/year) |
|---|---|---|---|---|
| Fecal Coliform | 4.59E+12 | 3.44E+14 | 2.77E+13 | 7.35E+09 |

**Table 1-3 Maximum Allowable Pollutant Loads for Direct Inputs of the Nonpoint Sources**

| Pollutant | Cattle in Streams (counts/year) | Failing Septic Systems (counts/year) |
|---|---|---|
| Fecal Coliform | 3.02E+13 | 2.20E+13 |

# 2 Basis for §303(d) Listing

## 2.1 Introduction

Section 303(d) of the Clean Water Act (CWA) as amended by the Water Quality Act of 1987 and EPA's Water Quality Planning and Management Regulations [(Title 40 of the Code of Federal Regulations (CFR), Part 130)] require states to identify waterbodies which are not meeting water quality criterion applicable to their designated use classifications. The identified waters are prioritized based on severity of pollution with respect to designated use classifications. Total maximum daily loads (TMDLs) for all pollutants causing violation of applicable water quality criterion are established for each identified water. Such loads are established at levels necessary to implement the applicable water quality criterion with seasonal variations and margins of safety. The TMDL process establishes the allowable loading of pollutants, or other quantifiable parameters for a waterbody, based on the relationship between pollution sources and in-stream water quality conditions, so that states can establish water-quality based controls to reduce pollution from both point and non-point sources and restore and maintain the quality of their water resources (USEPA, 1991).

The State of Alabama has identified Scarham Creek as being impaired by pathogens for a length of 12 miles, as reported on the 1996 §303(d) list(s) of impaired waters. It was increased to 24 miles on the 1998 §303(d) list. Scarham Creek is prioritized as "high" on the 1998 §303(d) list. Scarham Creek is located in Marshall and Dekalb County and lies within the Scarham Creek watershed (0603001270) of the Guntersville Lake (0603001) hydrologic unit of the Tennessee River basin.

The TMDL developed for Scarham Creek illustrates the steps that can be taken to address a waterbody impaired by high fecal coliform levels. The TMDL is consistent with a phased-approach: estimates are made of needed pollutant reductions, load reduction controls are implemented, and water quality is monitored for plan effectiveness. Flexibility is built into the plan so that load reduction targets and control actions can be reviewed if monitoring indicates continuing water quality problems.

## 2.2 Problem Definition

The Scarham Creek watershed is approximately 90 square miles. The watershed is comprised primarily of forested areas at 46% of total land use, with pasture/hay areas at 33% and row crops at 21 %. The primary row crops in the Scarham Creek watershed are soybeans and corn. Dekalb County has predominantly corn and Marshall County has predominantly soybean.

| | |
|---|---|
| Waterbody Impaired: | Scarham Creek |
| Water Quality Criterion Violation: | Bacteria |
| Pollutant of Concern: | Fecal Coliform |

Water Use Classification: Fish and Wildlife

The impaired stream segment, Scarham Creek, is classified as Fish and Wildlife. Usage of waters in this classification is described in ADEM Admin. Code R. 335-6-10-.09(5)(a), (b), (c), and (d).

(a) Best usage of waters:

Fishing, propagation of fish, aquatic life, and wildlife, and any other usage except for swimming and water-contact sports or as a source of water supply for drinking or food processing purposes.

(b) Conditions related to best usage:

The waters will be suitable for fish, aquatic life and wildlife propagation. The quality of salt and estuarine waters to which this classification is assigned will also be suitable for the propagation of shrimp and crabs.

(c) Other usage of waters:

It is recognized that the waters may be used for incidental water contact and recreation during June through September, except that water contact is strongly discouraged in the vicinity of discharges or other conditions beyond the control of the Department or the Alabama Department of Public Health.

(d) Conditions related to other usage:

The waters, under proper sanitary supervision by the controlling health authorities, will meet accepted standards of water quality for outdoor swimming places and will be considered satisfactory for swimming and other whole body water-contact sports.

Fecal Coliform Loading Criteria:
Alabama's water quality criterion document (ADEM Admin. Code R. 335-6-10-.09-(5)(e)(7.)) states "bacteria of the fecal coliform group shall not exceed a geometric mean of 1,000 per 100 ml; nor exceed a maximum of 2,000 per 100 ml in any sample. The geometric mean shall be calculated from no less than five samples collected at a given station over a 30-day period at intervals not less than 24 hours. For incidental water contact and recreation during June through September, the bacterial quality of water is acceptable when a sanitary survey by the controlling health authorities reveals no source of dangerous pollution and when the geometric mean fecal coliform organism density does not exceed 100 per 100 ml in coastal waters and 200 per 100 ml in other waters. The geometric mean shall be calculated from no less than five samples collected at a given station over a 30-day period at intervals not less than 24 hours. When the geometric mean fecal coliform organism density exceeds these levels, the bacterial water quality shall be considered acceptable only if a second detailed sanitary survey and evaluation discloses no significant public health risk in the use of the waters. Waters in the immediate vicinity of discharges of sewage or other wastes likely to contain bacteria harmful to humans, regardless of

the degree of treatment afforded these wastes, are not acceptable for swimming or other whole body water-contact sports."

# *3 Technical Basis for TMDL Development*

## *3.1 Water Quality Target Identification*

The water quality target for pathogen TMDLs is determined by the stream's use classification and the water quality criterion described in Section 2.2. The pathogen TMDL will be based on the state's criterion for bacteria, specifically fecal coliform as the indicator bacteria. Fecal coliform is a good indicator of pathogens from animal and human feces. Due to recreational contact in the summer months, there is a seasonal variation of the water quality criterion. Therefore, the target is based on in-stream fecal coliform concentrations and the target varies seasonally. The water quality criterion has two forms of compliance. First, the instantaneous fecal coliform concentration shall not exceed a maximum of 2,000 per 100mL. Second, the geometric mean of the fecal coliform concentration shall not exceed 1,000 per 100mL during October to May and 200 per 100mL during June to September.

## *3.2 Source Assessment*

A source assessment is an important part of defining the TMDL for any pollutant. The data and the sources have to be understood to be able to distinguish between point and nonpoint source impacts. Typically, the point source impacts can be quantified through permit limits and/or direct measurements at a certain location. A source assessment was performed on the Scarham Creek watershed to determine the predominant sources of fecal coliform loading into the system. The Watershed Characterization System (WCS) was used to develop characterization reports, tables, and figures for the watershed. WCS was developed by EPA Region 4 to facilitate these types of data gathering for TMDL report writing. The WCS is an ArcView based program that has multiple datasets for Region 4 states. Datasets include population data (human and livestock), county and state borders, watershed boundaries, agricultural census data, roads, land use coverages, stream networks and characteristics, NPDES permitted locations, soil types and characteristics, and elevation maps. The WCS has built-in tools that allow for characterizations to occur at any watershed level.

### 3.2.1 General Sources of Fecal Coliform

Fecal coliform loadings can be derived from point and nonpoint sources. A point source can be defined as a discernable, confined, and discrete conveyance from which pollutants are or may be discharged to surface waters. Point source contributions can typically be attributed to the following sources:

- Municipal wastewater facilities,
- Illicit discharges,
- Animals having direct access to streams,
- Leaking sewer in urban areas, and
- Failing septic systems in rural areas.

Municipal wastewater treatment facilities are permitted through the National Pollutant Discharge Elimination System (NPDES). Larger treatment facilities have chlorination systems that remove fecal coliform bacteria in the effluent before it is discharged. The treatment facilities treat human waste received from the collection system and then discharge their effluent into a nearby stream. Illicit discharges are facilities that are currently discharging fecal coliform bacteria when they are not permitted or they are violating their defined permit limit by exceeding the fecal coliform concentration.

Agricultural livestock and other unconfined animals (i.e., deer and other wildlife) also often have direct access to streams that pass through pastures. When cattle are not denied access to stream reaches, they represent a major potential source of direct fecal coliform loading to the stream. To account for the potential influence of cattle loads deposited directly in stream reaches within the watersheds, fecal coliform loads from cattle in streams can be calculated as a direct source into the stream.

In urban settings, sewer lines can typically run parallel to the stream in the floodplain. If there is a leaking sewer line, high concentrations of fecal coliform can flow into the stream or leach into the groundwater. Groundwater monitoring wells can signal if there are leaking sewer lines contributing to the problem. Septic systems are common in unincorporated portions of watersheds and may be direct or indirect sources of bacterial pollution via ground and surface waters. Onsite septic systems have the potential to deliver fecal coliform bacteria loads to surface waters due to system failure and malfunction.

Nonpoint sources of fecal coliform bacteria do not have one discharge point, but rather, occur over the entire length of a stream or waterbody. On the land surface, fecal coliform bacteria is built up over time in the sediments and then washed off through rain events. As the runoff transports the sediment over the land surface, more fecal coliform bacteria is collected and carried to the stream. At the same time as the accumulation of fecal coliform bacteria is occurring, the bacteria is also dying and decaying. Therefore, there is some net loading into the stream and is dictated by the watershed hydrology. The nonpoint sources of fecal coliform can be quantified from the following list of contributors:

- Urban runoff,
- Wildlife in forested areas,
- Manure application to row crops and/or pasture,
- Confined Animal Feeding Operations (CAFOs), and
- Livestock grazing.

Fecal coliform loading from urban areas is potentially attributable to multiple sources including storm water runoff, illicit discharges of sanitary waste, runoff from improper disposal of waste materials, leaking septic systems, and domestic animals.

Wildlife deposit feces onto land surfaces where it can be transported during storm events to nearby streams. Wildlife deposits can be from a wide range of species in Alabama, but common wildlife includes deer, raccoons, and waterfowl.

Agricultural animals are also a potential source of several types of fecal coliform loading to streams in the Scarham Creek watershed. Livestock data are reported by county and published by the USDA in the Census of Agriculture (USDA, 1997). The available livestock data include population estimates for cattle, beef cows, dairy cows, hogs, sheep, and poultry (broilers and layers).

### 3.2.2 Point Sources in the Scarham Creek Watershed

ADEM maintains a database of current NPDES permits and GIS files that locate each permitted outfall. This database includes municipal, semi-public/private, industrial, mining, and industrial storm water. Concentrated animal feeding operations (CAFOs) permits are included in the nonpoint source loads. Table 3-1 and Figure 3-1 show the permitted point sources in the watershed that discharge into or upstream of the impaired segment. Table 3-2 contains the permit limitations for the significant point sources that were considered in the model development.

**Table 3-1 Contributing Point Sources of Fecal Coliform to Scarham Creek**

| NPDES Permit | Type of Facility (Industrial, Municipal, Semi-Public/Private, Mining, Industrial Storm Water) | Facility Name | Significant Contributor (Yes/No) |
|---|---|---|---|
| AL0048402 | Semi-Public/Private | Crossville Health Care Inc STP | No |
| AL0051012 | Semi-Public/Private | Crossville High School STP | No |
| AL0061549 | Semi-Public/Private | Geraldine High School STP | No |

**Table 3-2 NPDES Permit Limits for Contributing Point Sources of Fecal Coliform**

| NPDES Permit | Facility Name | Flow (mgd) | Fecal Coliform (#/100mL) Summer | Fecal Coliform (#/100mL) Winter |
|---|---|---|---|---|
| AL0048402 | Crossville Health Care Inc STP | .014 | 200 | 1,000 |
| AL0051012 | Crossville High School STP | .03 | NA | NA |
| AL0061549 | Geraldine High School STP | .03 | 200 | 1,000 |

Notes: NA = Not available.

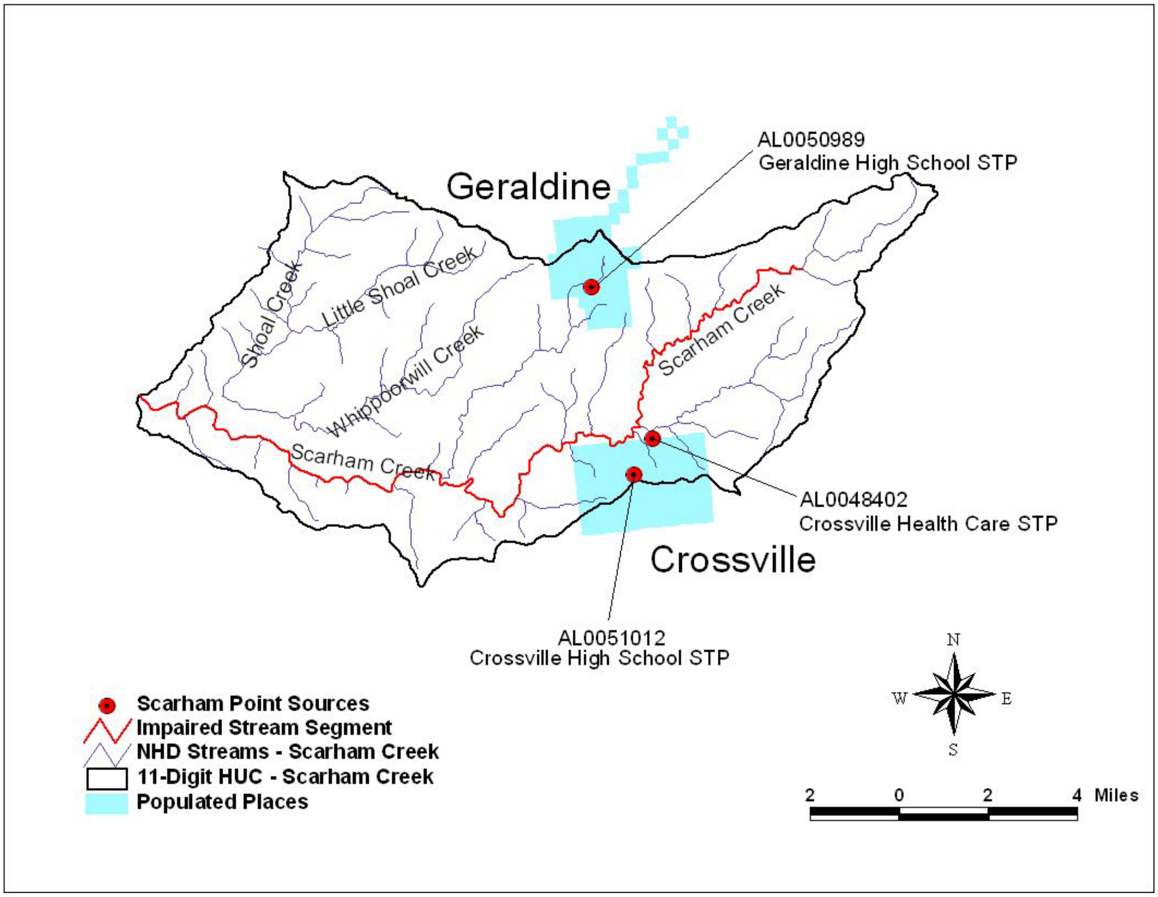


**Figure 3-1 NPDES Point Sources Located in the Scarham Creek Watershed**

### 3.2.3 Non-Point Sources in the Scarham Creek Watershed

Even though the cattle in the streams and failing septic systems are discussed in Section 3.2.1 as direct sources into the stream, they are discussed in this section along with the nonpoint sources.

The land use distribution in the Scarham Creek watershed is important when determining sources of fecal coliform contributions. The 2 urban areas in the watershed, Crossville and Geraldine, have little to no influence on fecal coliform concentrations as urban runoff. As shown in Table 3-3, the urban component is 0.2% of the land use. The land use coverage is dominated by forest at 46% with row crops and pasture comprising the rest at 21% and 33%, respectively.

Table 3-3 displays all of the land use coverages by subwatershed. Figure 3-2 shows the distribution of the land use for the entire watershed.

**Table 3-3 Land Use Coverage for the Scarham Creek Watershed**

| Subwatershed | Cropland | Forest | High Commercial/Industrial/Transportation | High Residential | Low Residential | Pasture | Transitional | Water | Total Acres |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 106.3 | 666.7 | 1.1 | 0.0 | 2.7 | 339.8 | 0.0 | 2.0 | 1118.6 |
| 2 | 52.3 | 190.1 | 4.8 | 0.0 | 0.7 | 136.3 | 0.0 | 0.2 | 384.4 |
| 3 | 350.7 | 1582.5 | 2.7 | 0.0 | 4.2 | 585.1 | 0.0 | 6.7 | 2531.9 |
| 4 | 351.2 | 927.4 | 0.4 | 0.0 | 1.1 | 439.2 | 0.0 | 4.9 | 1724.2 |
| 5 | 989.4 | 1936.1 | 1.6 | 0.0 | 0.9 | 1121.7 | 0.0 | 5.8 | 4055.5 |
| 6 | 1087.3 | 1805.6 | 2.9 | 0.0 | 0.0 | 1151.8 | 0.0 | 22.0 | 4069.5 |
| 7 | 1347.2 | 2124.5 | 3.6 | 0.0 | 0.0 | 1352.4 | 0.0 | 10.0 | 4837.6 |
| 8 | 320.7 | 509.9 | 0.0 | 0.0 | 0.0 | 313.6 | 0.0 | 1.8 | 1146.0 |
| 9 | 537.3 | 1238.9 | 4.0 | 1.3 | 8.9 | 889.6 | 0.0 | 3.8 | 2683.8 |
| 10 | 129.9 | 517.7 | 0.2 | 0.0 | 0.0 | 460.8 | 0.0 | 4.7 | 1113.3 |
| 11 | 341.6 | 1169.3 | 2.7 | 0.0 | 2.2 | 799.9 | 0.0 | 5.1 | 2320.9 |
| 12 | 1025.4 | 2115.2 | 29.1 | 0.4 | 17.8 | 2120.3 | 0.0 | 10.5 | 5318.7 |
| 13 | 1446.6 | 2655.8 | 4.9 | 0.0 | 2.7 | 2941.3 | 0.0 | 12.5 | 7063.8 |
| 14 | 179.5 | 605.6 | 7.6 | 4.2 | 17.1 | 346.0 | 0.0 | 3.1 | 1163.1 |
| 15 | 305.3 | 397.0 | 2.4 | 0.0 | 0.7 | 613.1 | 0.0 | 4.7 | 1323.2 |
| 16 | 1081.0 | 2389.6 | 2.9 | 0.0 | 6.2 | 1448.6 | 0.0 | 4.4 | 4932.8 |
| 17 | 722.5 | 1045.7 | 5.8 | 0.0 | 1.6 | 1285.0 | 0.0 | 15.8 | 3076.3 |
| 18 | 766.4 | 2075.3 | 3.3 | 0.0 | 5.1 | 1040.6 | 0.0 | 7.6 | 3898.3 |
| 19 | 274.7 | 571.5 | 1.1 | 0.0 | 0.7 | 439.9 | 0.0 | 2.2 | 1290.1 |
| 20 | 278.7 | 851.8 | 1.8 | 0.0 | 4.7 | 490.6 | 0.0 | 7.6 | 1635.0 |
| Total (acres) | 11693.9 | 25376.3 | 82.8 | 6.0 | 77.2 | 18315.6 | 0.0 | 135.2 | 55687.0 |
| Percentage | 21.0% | 45.6% | 0.1% | 0.0% | 0.1% | 32.9% | 0.0% | 0.2% | 100.0% |

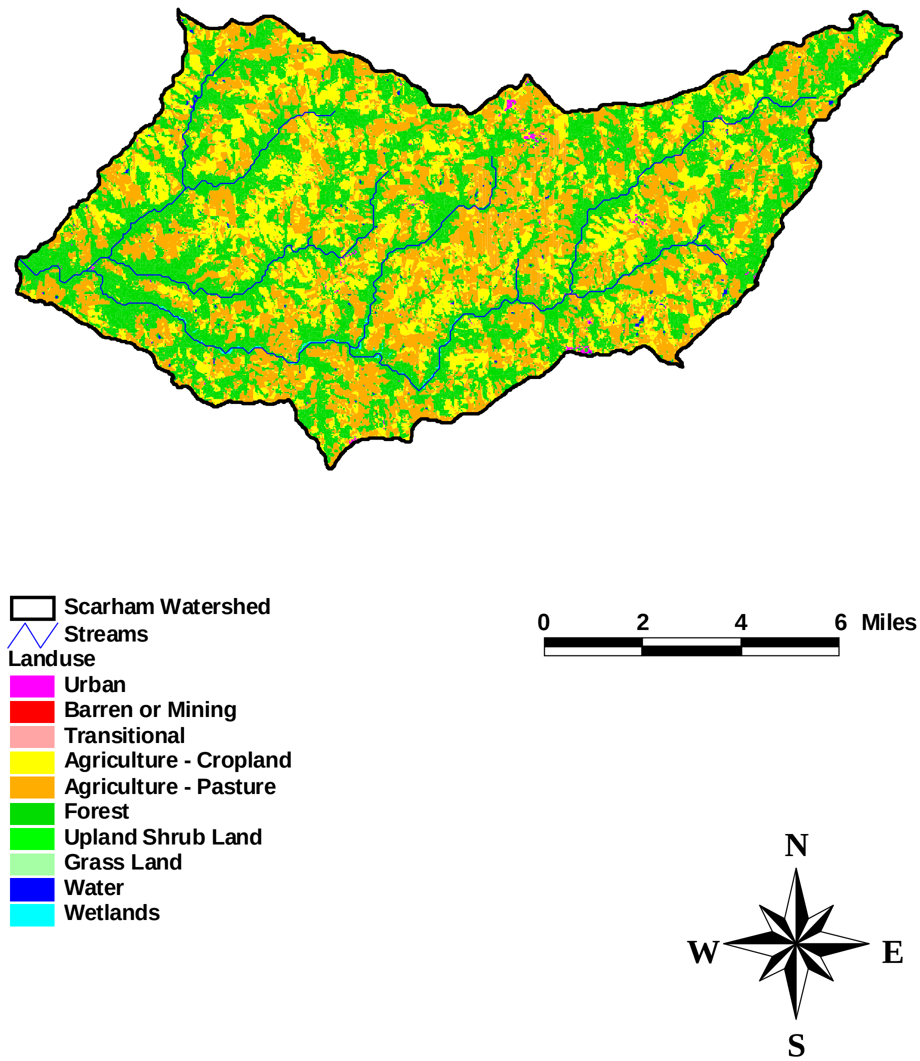


**Figure 3-2 Land Use Coverage in the Scarham Creek Watershed**

Cattle numbers reported in the Census of Agriculture (USDA, 1997) were used to determine the numbers of beef cows, milk cows, and cattle. The total cattle numbers represent other breeds of cattle and calves in addition to dairy and beef. Assumptions regarding agricultural animals and resource management practices were provided by NRCS and previous fecal coliform TMDLs by EPA Region 4 and are summarized as follows:

- As with wildlife, agricultural livestock grazing on pastureland or forestland deposit their feces onto land surfaces where it can be transported during storm events to nearby streams.

- Confined livestock operations also generate manure, which can be applied to pastureland and cropland as a fertilizer. Processed agricultural manure from confined hog, dairy cattle, and some poultry operations is generally collected in lagoons and applied to land surfaces during the growing season, at rates which often vary on a monthly basis.

Data sources for agricultural animals are tabulated by county and are based on information obtained from the Census of Agriculture (USDA, 1997). Fecal coliform loading rates for livestock in the watershed are estimated to be: $1.06 \times 10^{11}$ counts/day/beef cow, $1.24 \times 10^{10}$counts/day/hog, $1.04 \times 10^{11}$ counts/day/dairy cow, $1.38 \times 10^{8}$ counts/day/layer chicken, and $1.22 \times 10^{10}$ counts/day/sheep (NCSU, 1994).

Poultry litter is normally piled for a period before it is applied to the land. For the Scarham Creek watershed the poultry waste was applied to the pasture areas.

Hog farms in the Scarham Creek watershed operate by confining the animals or allowing them to graze in small pastures or pens. It is assumed that all of the hog manure produced by either farming method is applied to the cropland. The row crops in the watershed are soybeans and corn. Typically, application rates of hog manure to cropland vary monthly according to management practices, but it is assumed for this TMDL to be applied during all months.

On dairy farms, the cows are confined for a limited period each day during which time they are fed and milked. This is estimated to be four hours per day for each dairy cow. Manure from dairy cattle is applied to pasture for the Scarham Creek watershed.

Beef cattle are assumed to be in pasture year round. Therefore, beef cow manure is applied only to pastureland and at a constant monthly rate. This rate varies between watersheds, as the rate is a function of the number of beef cows in the watershed. Table 3-4 presents all of the animal numbers extracted from the watershed characterization.

The number of septic systems was calculated on the population estimates by WCS for each of the watersheds. The septic system numbers and loading rates are discussed in detail in Section 4.3.

**Table 3-4 Agricultural Census Data for the Scarham Creek Watershed**

| Subwatershed | Cattle | Beef Cow | Milk Cow | Hogs | Sheep | Chickens | Chickens Sold |
|---|---|---|---|---|---|---|---|
| 1 | 182 | 108 | 5 | 28 | 1 | 0 | 71,216 |
| 2 | 74 | 44 | 2 | 12 | 0 | 0 | 28,940 |
| 3 | 320 | 190 | 7 | 48 | 1 | 0 | 125,266 |
| 4 | 237 | 140 | 5 | 36 | 1 | 0 | 92,543 |
| 5 | 604 | 364 | 16 | 244 | 2 | 19,196 | 237,703 |
| 6 | 617 | 375 | 16 | 313 | 2 | 19,196 | 243,716 |
| 7 | 715 | 439 | 21 | 506 | 2 | 19,196 | 283,490 |
| 8 | 168 | 104 | 5 | 147 | 0 | 0 | 66,729 |
| 9 | 470 | 292 | 16 | 414 | 1 | 19,196 | 187,206 |
| 10 | 246 | 149 | 7 | 107 | 1 | 0 | 97,019 |
| 11 | 424 | 263 | 14 | 371 | 1 | 19,196 | 168,772 |
| 12 | 1,116 | 693 | 37 | 981 | 2 | 38,392 | 444,456 |
| 13 | 1,548 | 962 | 50 | 1,362 | 3 | 38,392 | 616,532 |
| 14 | 185 | 115 | 7 | 163 | 0 | 0 | 73,687 |
| 15 | 324 | 202 | 11 | 285 | 1 | 0 | 129,209 |
| 16 | 763 | 474 | 25 | 672 | 2 | 19,196 | 303,947 |
| 17 | 677 | 420 | 23 | 595 | 2 | 19,196 | 269,485 |
| 18 | 554 | 344 | 18 | 488 | 1 | 19,196 | 220,407 |
| 19 | 232 | 144 | 7 | 204 | 1 | 0 | 92,459 |
| 20 | 256 | 159 | 9 | 226 | 1 | 0 | 102,218 |
| Total | 9,710 | 5,981 | 300 | 7,200 | 25 | 230,350 | 3,855,000 |

## *3.3 Loading Capacity – Linking Numeric Water Quality Targets and Pollutant Sources*

EPA regulations define the TMDL loading, or assimilative capacity, as the greatest amount of loading that a waterbody can receive without violating water quality criteria (40 CFR Part 130.2(f)). TMDL endpoints represent the in-stream water quality targets used in quantifying TMDLs and their individual components.

The target for the Scarham Creek TMDL is the fecal coliform water quality criterion. The instantaneous concentration is 2,000 counts per 100mL and the geometric mean is 1,000 counts per 100mL from October through May and 200 counts per 100mL from June through September.

In this TMDL analysis, fecal coliform sources are modeled independently of each other. Cattle in the streams, failing septic systems, and point source loads are not hydrology based, and are therefore considered steady inputs into the model. The runoff from urban, cropland, pasture, and forest areas is based on the calibrated hydrology. All of these potential sources are modeled in a way that can indicate a direct linkage between the instream response of transport and die-off to the fecal coliform sources. This method of modeling allows for sensitivity runs to be made to quantify the relative impact on instream concentrations from each source.

## *3.4 Data Availability and Analysis*

Data were retrieved from the Sand Mountain / Lake Guntersville NPS Watershed Project for the years 1988 through 1998. Stations SC-3 and SC-4, shown in Figure 3-3, were the primary stations used in the TMDL analyses. Flow and fecal coliform were measured at monthly intervals for 10 years. Other stations were measured in the watershed, but these 2 particular stations provided the most appropriate dataset for calibration.

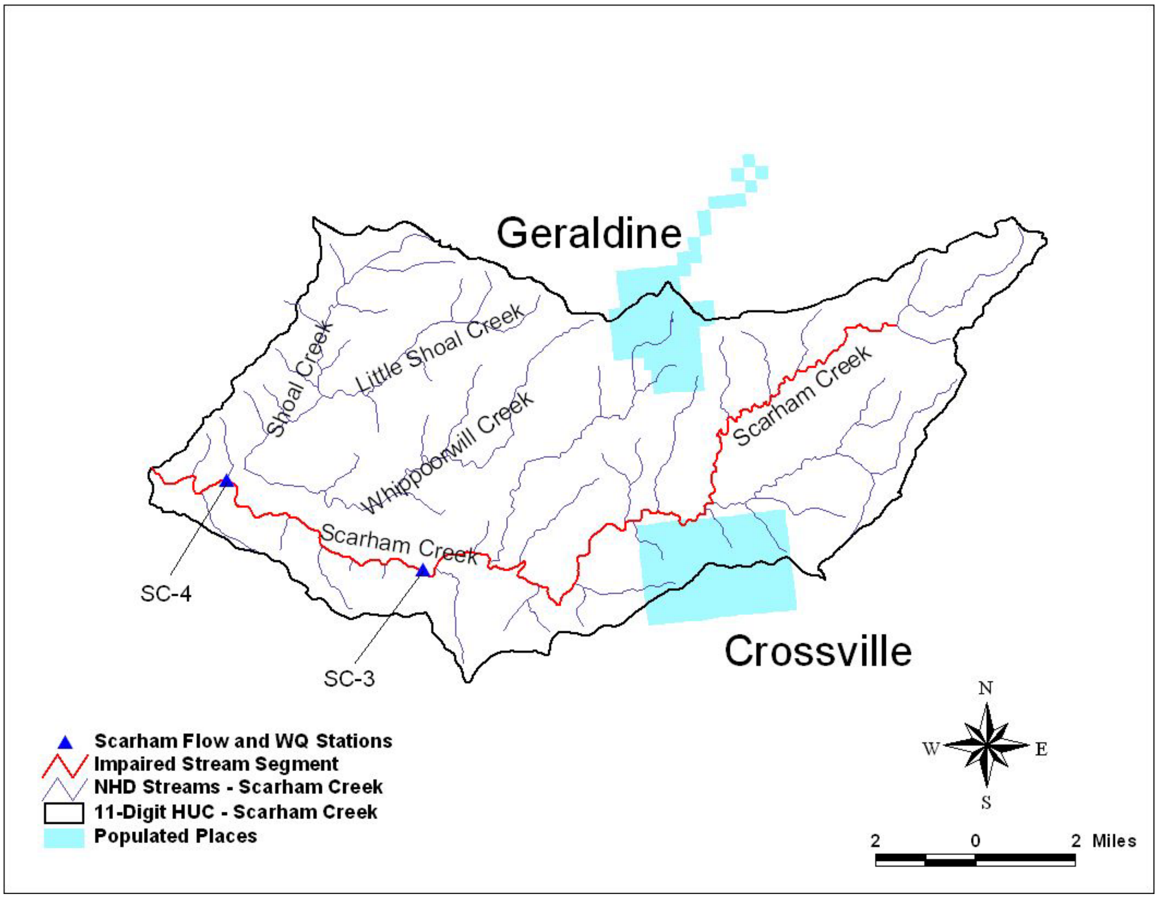


**Figure 3-3 Flow and Water Quality Stations in the Scarham Creek Watershed**

The data analysis reveals that there are runoff related contributions of fecal coliform in Scarham Creek. Figure 3-4 shows a period in 1988 and 1989 that has high fecal coliform concentrations when flows were high. This revealed that it is necessary to provide the linkage to the washoff component of the fecal coliform sources.

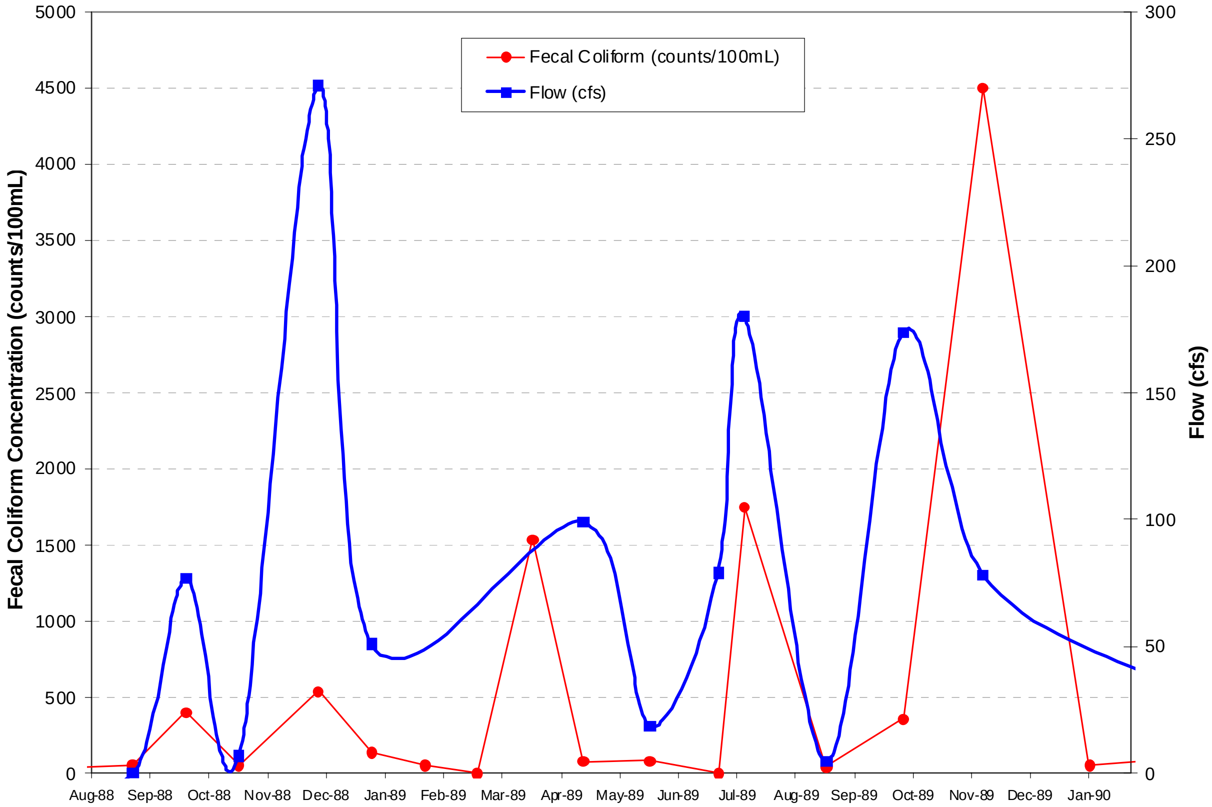


**Figure 3-4 Measured Flow versus Fecal Coliform at SC-3**

## *3.5 Critical Conditions*

The critical condition for nonpoint source fecal coliform loading is an extended dry period followed by a rainfall runoff event. During the dry weather period, fecal coliform bacteria builds up on the land surface, and is washed off by rainfall. The critical condition for point and direct source (discharges, cattle in streams, and failing septic systems) loading occurs during periods of low stream flow when dilution is minimized. Both conditions are simulated in the water quality model. A definitive time period is used to simulate a daily and a continuous 30-day geometric mean concentration to compare to the 2 targets. For the TMDL in Scarham Creek, this time period is 10 years and covers a range of hydrological conditions that includes both low and high stream flows. The time period between June 1996 through June 1998 has been determined to be appropriate for critical conditions because it includes extended low flow periods followed by runoff events.

## *3.6 Margin of Safety (MOS)*

There are two methods for incorporating a MOS in the analysis: a) implicitly incorporating the MOS using conservative model assumptions to develop allocations; or b) by explicitly specifying a portion of the TMDL as the MOS and using the remainder for allocations. An implicit MOS was incorporated in this TMDL. An implicit MOS includes conservative modeling assumptions and a continuous simulation that incorporates a range of meteorological events. Conservative modeling assumptions used include: septic systems discharging directly into the streams, conservative estimates of in-stream decay, point sources discharging at permitted flows and the geometric mean for fecal coliform, and all land areas considered to be connected directly to streams. Fecal coliform decay (die-off) on the land surface is not computed in the model. Therefore, the rates developed by the FCLES and loads delivered to the model do not account for this decay and are a conservative load.

# *4 Hydrology and Water Quality Model Development*

Establishing the relationship between in-stream water quality and source loading is an important component of TMDL development. It allows the determination of the relative contribution of sources to total pollutant loading and the evaluation of potential changes to water quality resulting from implementation of various management options. This relationship can be developed using a variety of techniques ranging from qualitative assumptions based on scientific principles to numerical computer modeling. In this section, the numerical modeling techniques developed to simulate fecal coliform bacteria fate and transport in the watershed are discussed.

## *4.1 Hydrology Model Selection and Setup*

Based on the considerations described above, analysis of the monitoring data, review of the literature, and past pathogens modeling experience, the Loading Simulation Program C++ (LSPC) was used to represent the source-response linkage in the Scarham Creek watershed. LSPC is a comprehensive data management and modeling system that is capable of representing loading from nonpoint and point sources found in the Scarham Creek watershed and simulating in-stream processes. LSPC is based on the Mining Data Analysis System (MDAS), with modifications for non-mining applications such as nutrient and fecal coliform modeling. MDAS was developed by EPA Region 3 through mining TMDL applications in Region 3.

LSPC is a system designed to support TMDL development for areas impacted by nonpoint and point sources. The most critical component of LSPC to TMDL development is the dynamic watershed model, because it provides the linkage between source contributions and in-stream response. The comprehensive watershed model is used to simulate watershed hydrology and pollutant transport as well as stream hydraulics and in-stream water quality. It is capable of simulating flow, sediment, metals, nutrients, pesticides, and other conventional pollutants, as well as temperature and pH for pervious and impervious lands and waterbodies. LSPC was configured for the Scarham Creek watershed to simulate the watershed as a series of the hydrologically connected subwatersheds. Configuration of the model involved subdivision of the Scarham Creek watershed into modeling units and continuous simulation of flow and water quality for these units using meteorological, land use, point source loading, and stream data. The only pollutant simulated was fecal coliform bacteria. This section describes the configuration process and key components of the model in greater detail.

To represent watershed loadings and resulting concentrations of fecal coliform bacteria in Scarham Creek, Shoal Creek, Little Shoal Creek, and Whippoorwill Creek, the watershed was divided into 20 subwatersheds. These subwatersheds are presented in Figure 4-1, and represent hydrologic boundaries. The division was based on the following:

- elevation data (7.5 minute Digital Elevation Model [DEM] from USGS),
- stream connectivity (from the National Hydrography Dataset stream coverage), and
- locations of monitoring stations.

LSPC has been calibrated for hydrology using flow data from 1988 to 1998. The Huntsville and Jackson airport weather data are used as the precipitation and meteorological input for the model. The data from Huntsville are applied to subwatershed 1 and the data from Jackson were applied to subwatersheds 2-20. The hydrology calibration was performed first and involved adjustment of the model parameters used to represent the hydrologic cycle until acceptable agreement was achieved between simulated flows and historic stream flow data measured at SC-3 for the same period of time. There were no flow data measured at SC-4. See Figure 3-3 for the location of the stations and the data is in tabular form in Appendix 9.2 in Table 9-1. Model parameters adjusted include: evapotranspiration, infiltration, upper and lower zone storage, groundwater storage, recession, losses to the deep groundwater system, and interflow discharge.

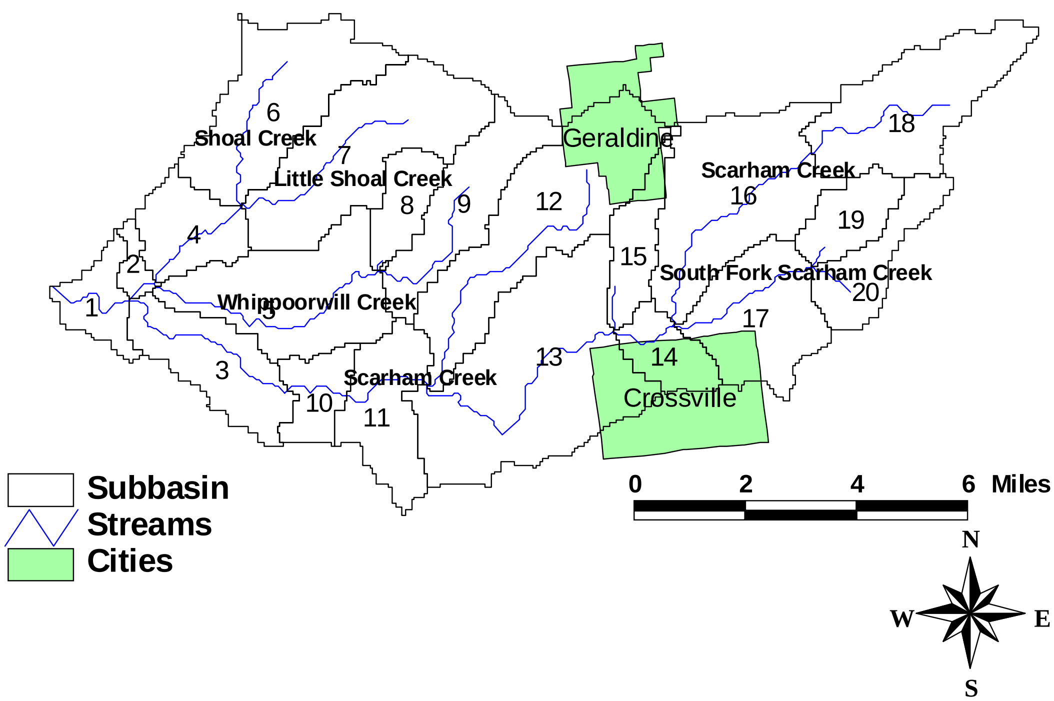


**Figure 4-1 Subwatershed Delineation for Scarham Creek Watershed**

## *4.2 Hydrology Model Summary*

The hydrology was calibrated for a 10-year period from 1988 – 1998 with limited flow data. Continuous flow data, such as the type from a USGS gage, was not available for the Scarham Creek watershed. Through conversations with USGS, a new gage was installed in the downstream portion of the watershed in October 1998, but data are not presently available. USGS is planning to keep the gage at its current location for the 2001 water year.

The flow data was collected monthly and most of the measurements were not measured during peak flow events. Therefore, the hydrology calibration was focused on capturing the base flow conditions and the few peaks that were measured.

The hydrology calibration is shown in Appendix 9.3 in Figure 9-1 for a 10-year period.

## *4.3 Water Quality Model Selection and Setup*

A dynamic computer model was selected for fecal coliform analysis in order to: a) simulate the time varying nature of fecal coliform deposition on land surfaces and transport to receiving waters; b) incorporate seasonal effects on the production and fate of fecal coliform bacteria; and c) identify the critical condition for the TMDL analysis. Several computer-based tools were also utilized to generate input data for the model. In-stream decay of fecal coliform bacteria is included in the model at a rate of 0.5 per day. This rate represents a literature value reported by Baudisova (1997).

In addition to LSPC, the WCS was used to display, analyze, and compile available information to support water quality model simulations. Results of the WCS characterization are input to a spreadsheet developed by Tetra Tech, Inc. called the Fecal Coliform Loading Estimation Spreadsheet (FCLES). The FCLES is used to estimate modeling parameters associated with fecal coliform buildup and washoff loading rates. The spreadsheet is also used to estimate direct sources of fecal coliform loading to water bodies from leaking/failing septic systems and animals having access to streams, in particular grazing beef cattle. Information from the WCS and spreadsheet tool have been used as initial input for variables in the LSPC model.

For modeling purposes, the fecal coliform sources are represented by the following components:
- runoff loads from land uses (build-up of fecal coliform and washoff due to runoff),
- point source loads from NPDES permitted discharges, and
- direct source loads from cattle in the streams and failing septic systems.

The LSPC model is a build-up and wash-off model. It represents the pollutant by accumulating the pollutant over time, storing the pollutant to some maximum limit, and then transporting the pollutant through overland flow to the stream. The model represents these processes with an accumulation rate (ACQOP) and the storage limit (SQOLIM). The FCLES tool calculates both of these values by using the livestock numbers and manure application rates, which come from literature values and the WCS data. WSQOP is defined as the rate of surface runoff (in/hr) that results in 90% washoff in 1 hour. The lower the value, the more easily washoff occurs. This parameter is user-defined and was determined for each land use by EPA recommended ranges.

The ACQOP and SQOLIM can be varied monthly or be a constant through the simulation. If specific data such as timing of manure applications, livestock rotations, and crop rotations are known, these rates can be calculated monthly. For the Scarham Creek watershed modeling, the rates were input as constant values. There does not appear to be a clear rotation schedule of cattle and crops in the watershed. The hog manure was assumed to be applied to the row crops year round.

Typically, the point source loads for model calibrations are computed with the following priorities: (1) Daily values from the discharger, (2) Discharge Monitoring Reports (DMRs) with monthly average values, (3) NPDES permitted values with not to exceed or geometric means, or (4) an appropriate water quality criterion (geometric mean to approximate a conservative monthly average). The daily flow and daily fecal coliform would be the most appropriate with the permitted flow and fecal coliform water quality criterion being the least appropriate. Fecal coliform monitoring data were not available for the three facilities in the Scarham Creek watershed. Table 4-1 lists the loads used in the model calibration. Since the three discharges are not major contributors of fecal coliform, the permitted flow and summer geometric mean fecal coliform were used to load the model.

**Table 4-1 Point Source Loads Used in Modeling**

| NPDES Permit | Facility Name | Model Flow (mgd) | Model Fecal Coliform (counts/100mL) | Fecal Coliform Load (counts/day) |
|---|---|---|---|---|
| AL0048402 | Crossville Health Care Inc STP | .014 | 200 | 1.06E8 |
| AL0051012 | Crossville High School STP | .03 | 200 | 2.28E8 |
| AL0061549 | Geraldine High School STP | .03 | 200 | 2.28E6 |

The direct source loads for the Scarham Creek watershed were determined to be cattle in the streams and failing septic systems. From conversations with NRCS and SWCS, cattle "commonly have access to the streams." The fecal coliform loading concentration for cattle reaching the stream is 7.38E+08 counts per 100mL. This concentration was developed from a literature value for production rates for beef cattle of 1.06E11 count per animal per day (NCSU, 1994) and a total mass of beef cattle waste of 31.68 pounds per animal per day (ASAE, 1998). The density of cattle waste (including urine) is approximated as the density of water. The FCLES tool assumes that cattle are in the stream 2% of the day (30min/60X24); 50% of the cows have access to stream; and 25% defecate in the stream. Table 4-2 presents the fecal coliform loads that were put into the model for calibration. The grazing cattle column in the table are the total numbers from WCS with the associated distribution across the watershed, refer to Figure 4-1 for subwatershed locations.

**Table 4-2 Cattle in the Stream Load in the Scarham Creek Watershed**

| Subwatershed | Grazing Cattle | Cattle Waste Load (lbs/day) | Fecal Coliform Load (counts/day) | Fecal Coliform Load (counts/year) |
|---|---|---|---|---|
| 1 | 108 | 0.89 | 2.98E+09 | 1.09E+12 |
| 2 | 44 | 0.36 | 1.22E+09 | 4.44E+11 |
| 3 | 190 | 1.56 | 5.25E+09 | 1.91E+12 |
| 4 | 140 | 1.15 | 3.87E+09 | 1.41E+12 |
| 5 | 364 | 3.00 | 1.01E+10 | 3.67E+12 |
| 6 | 375 | 3.09 | 1.04E+10 | 3.78E+12 |
| 7 | 439 | 3.62 | 1.21E+10 | 4.43E+12 |
| 8 | 104 | 0.86 | 2.88E+09 | 1.05E+12 |
| 9 | 292 | 2.41 | 8.07E+09 | 2.94E+12 |
| 10 | 149 | 1.23 | 4.12E+09 | 1.51E+12 |
| 11 | 263 | 2.17 | 7.27E+09 | 2.65E+12 |
| 12 | 693 | 5.71 | 1.92E+10 | 7.00E+12 |
| 13 | 962 | 7.92 | 2.66E+10 | 9.71E+12 |
| 14 | 115 | 0.95 | 3.18E+09 | 1.16E+12 |
| 15 | 202 | 1.66 | 5.59E+09 | 2.04E+12 |
| 16 | 474 | 3.90 | 1.31E+10 | 4.78E+12 |
| 17 | 420 | 3.46 | 1.16E+10 | 4.24E+12 |
| 18 | 344 | 2.83 | 9.52E+09 | 3.47E+12 |
| 19 | 144 | 1.19 | 3.98E+09 | 1.45E+12 |
| 20 | 159 | 1.31 | 4.40E+09 | 1.60E+12 |
| TOTAL | 5,981 | 49.26 | 1.65E+11 | 6.04E+13 |

Septic systems are computed from the WCS database by extrapolating the population of the people in the watershed outside of urban areas. The assumption is that the residential areas in populated areas (cities) are on sewer systems and the ones outside of populated areas are on septic systems. The density of people per septic system is assumed to be 2.37 and the average fecal coliform concentration reaching the stream (from septic overcharge) is 10,000 counts per 100mL (Horsely & Whitten, 1996). Also, a typical septic overcharge flow rate of 70 gallons per day per person (Horsely & Whitten, 1996) was assumed. Table 4-3 presents the septic loads used for model calibration for each of the subwatersheds. Refer to Figure 4-1 for the location of the subwatersheds.

**Table 4-3 Septic Load in the Scarham Creek Watershed**

| Subwatershed | Failing Septics | People Served | Septic flow (gal/day) | Fecal Load (counts/day) | Fecal Load (counts/year) |
|---|---|---|---|---|---|
| 1 | 17.8 | 42 | 2,953 | 1.12E+09 | 4.09E+11 |
| 2 | 6 | 14 | 995 | 3.77E+08 | 1.38E+11 |
| 3 | 40.5 | 96 | 6,719 | 2.55E+09 | 9.30E+11 |
| 4 | 27.4 | 65 | 4,546 | 1.72E+09 | 6.29E+11 |
| 5 | 63 | 149 | 10,452 | 3.96E+09 | 1.45E+12 |
| 6 | 63.3 | 150 | 10,501 | 3.98E+09 | 1.45E+12 |
| 7 | 73.3 | 174 | 12,160 | 4.61E+09 | 1.68E+12 |
| 8 | 17 | 40 | 2,820 | 1.07E+09 | 3.90E+11 |
| 9 | 40.2 | 95 | 6,669 | 2.53E+09 | 9.23E+11 |
| 10 | 17.3 | 41 | 2,870 | 1.09E+09 | 3.97E+11 |
| 11 | 34.8 | 82 | 5,773 | 2.19E+09 | 7.99E+11 |
| 12 | 121.1 | 287 | 20,090 | 7.62E+09 | 2.78E+12 |
| 13 | 129.2 | 306 | 21,434 | 8.13E+09 | 2.97E+12 |
| 14 | 43.4 | 103 | 7,200 | 2.73E+09 | 9.97E+11 |
| 15 | 25.3 | 60 | 4,197 | 1.59E+09 | 5.81E+11 |
| 16 | 73.6 | 174 | 12,210 | 4.63E+09 | 1.69E+12 |
| 17 | 61.8 | 146 | 10,253 | 3.89E+09 | 1.42E+12 |
| 18 | 58.3 | 138 | 9,672 | 3.67E+09 | 1.34E+12 |
| 19 | 19.2 | 46 | 3,185 | 1.21E+09 | 4.41E+11 |
| 20 | 24.4 | 58 | 4,048 | 1.53E+09 | 5.60E+11 |
| TOTAL | 956.9 | 2,266 | 158,750 | 6.02E+10 | 2.20E+13 |

## *4.4 Water Quality Model Summary*

### 4.4.1 Calibrated Model

The model was calibrated for water quality by comparing the fecal coliform concentrations from the model verses the observed data. Appropriate model parameters were adjusted to obtain acceptable agreement between simulated fecal coliform concentrations and observed data collected at the SC-3 and SC-4 sampling stations indicated in Figure 3-3. The parameters that were adjusted to obtain a calibrated model were the build-up and washoff of fecal coliform from the land use coverages and the direct loads such as cattle in the streams and the failing septic systems as described in Section 4.3. There are 10 years of fecal coliform data from both sites available for calibration. The 10 years of data were used for the calibration, but close attention was paid to the critical periods in 1996 – 1998. Figure 4-2 is the calibrated run to the existing conditions for June 1996 through June 1998 at SC-3. The results are presented on a logarithmic scale so that the base conditions can be viewable in the plot. It was important in the calibration to achieve a baseline condition of fecal coliform concentrations along with the peak runoff events. Figure 4-3 presents the same comparison at SC-4. The 2-year, 10-year, and geometric mean plots are shown in Appendix 9.4 in Figures 9-2 through 9-11.

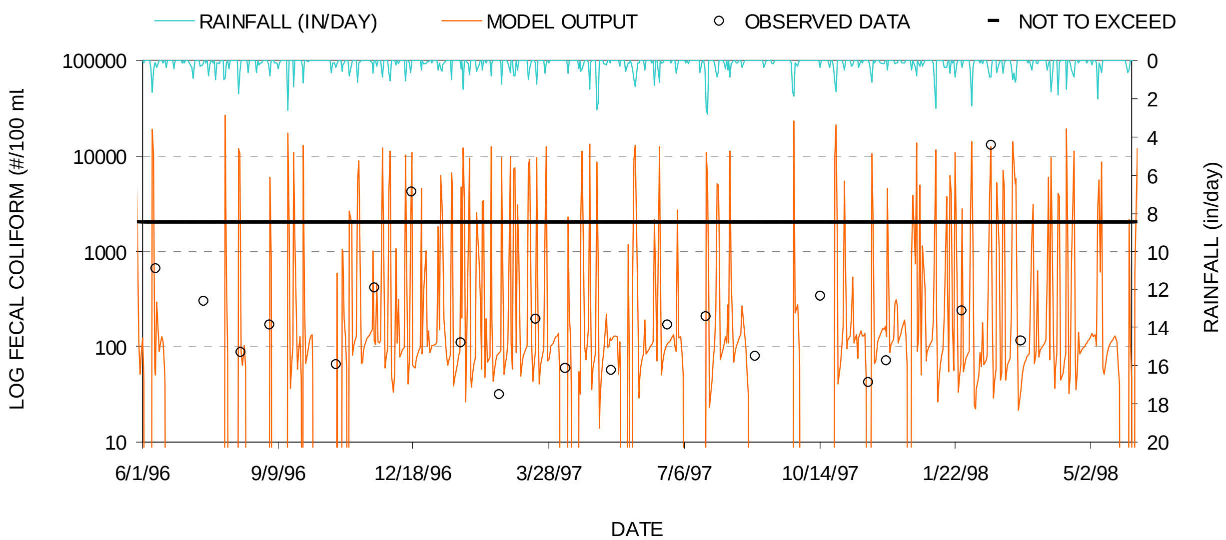


**Figure 4-2 Model versus Observed Fecal Coliform at SC-3 for 2 Years (Logarithmic Scale)**

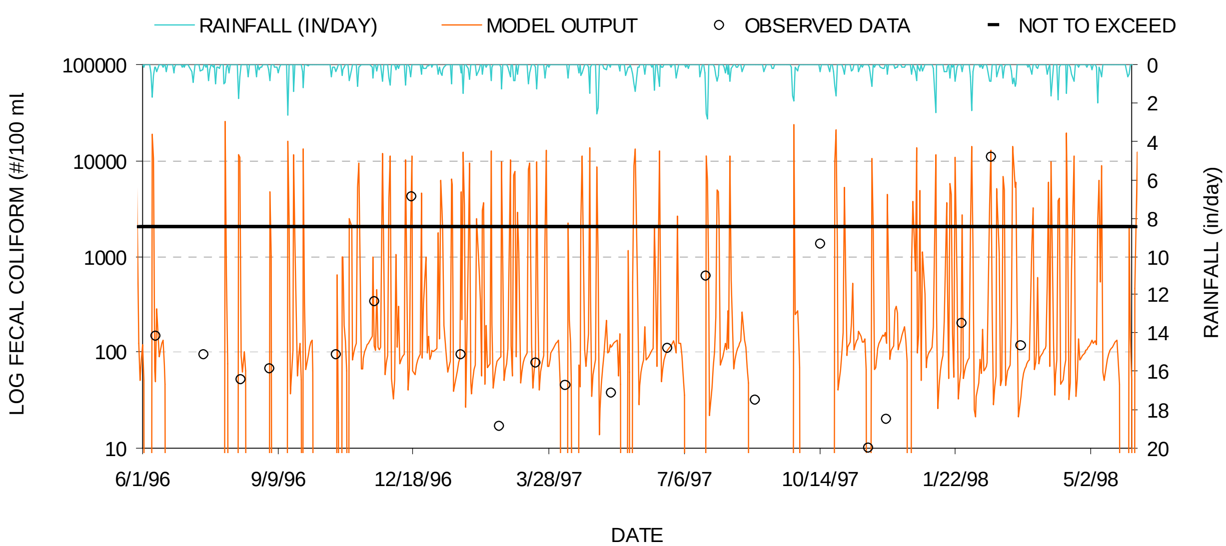


**Figure 4-3 Model versus Observed Fecal Coliform at SC-4 for 2 Years (Logarithmic Scale)**

### 4.4.2 Load Reduction Model

The calibrated model represents the existing conditions in Scarham Creek. The calibrated model was used as a starting point for the load reduction scenarios. Multiple model runs were developed to analyze point and direct source sensitivity compared to runoff sensitivity. Figure 4-4 presents the comparison. The steady sources in the figure legend refer to the point source discharges, cattle in the streams, and the failing septic systems. These loads did not vary monthly in the model due to lack of data to prove the variations, so they are modeled as steady-state loads. The model output line shows the impact that runoff can have on the fecal coliform concentrations.

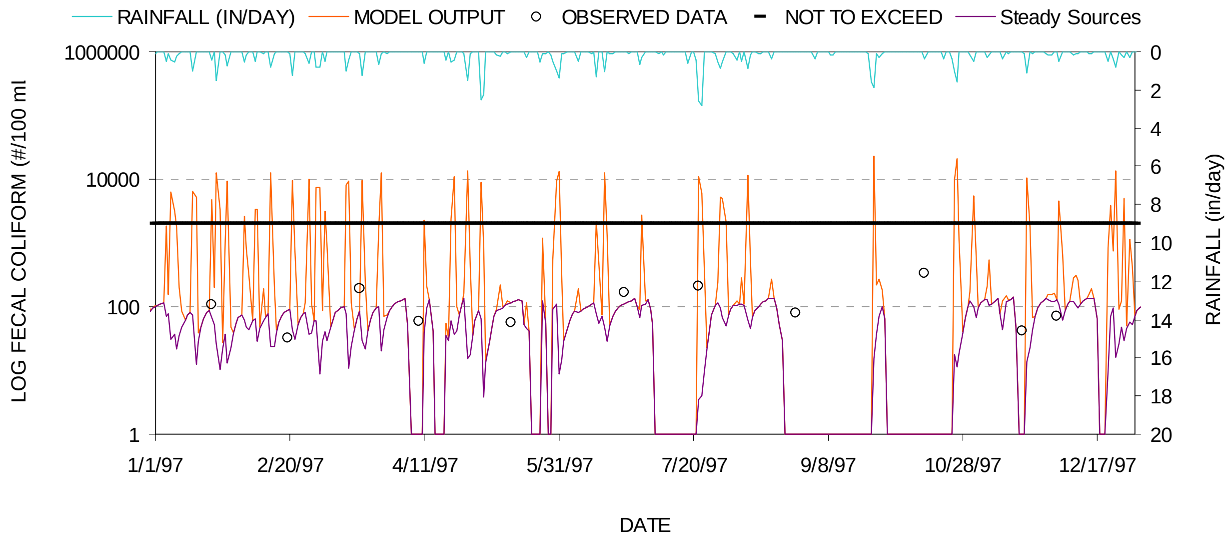


**Figure 4-4 Sensitivity of Fecal Coliform Runoff versus Point and Direct Sources at SC-3 in Scarham Creek**

From the sensitivity analysis, it is apparent that runoff violates the instantaneous criterion and point and direct sources violate the geometric mean criterion in the summer months. The model does not show any violations of the geometric mean criterion in the winter months. Therefore, for load reduction scenarios, the runoff from the land has been reduced to meet the 2,000 counts per 100 mL as the instantaneous limit. Considering the summer geometric mean of 200 counts per 100 mL in the summer months, cattle in the stream and failing septic systems have been reduced to meet this limit.

The existing fecal coliform load for the listed segment is represented as the sum of the daily discharge load of the direct sources (cattle access to streams and failing septic systems), the point sources loads, and the daily fecal coliform load indirectly going to surface waters from all land uses (e.g., surface runoff) for 1997.

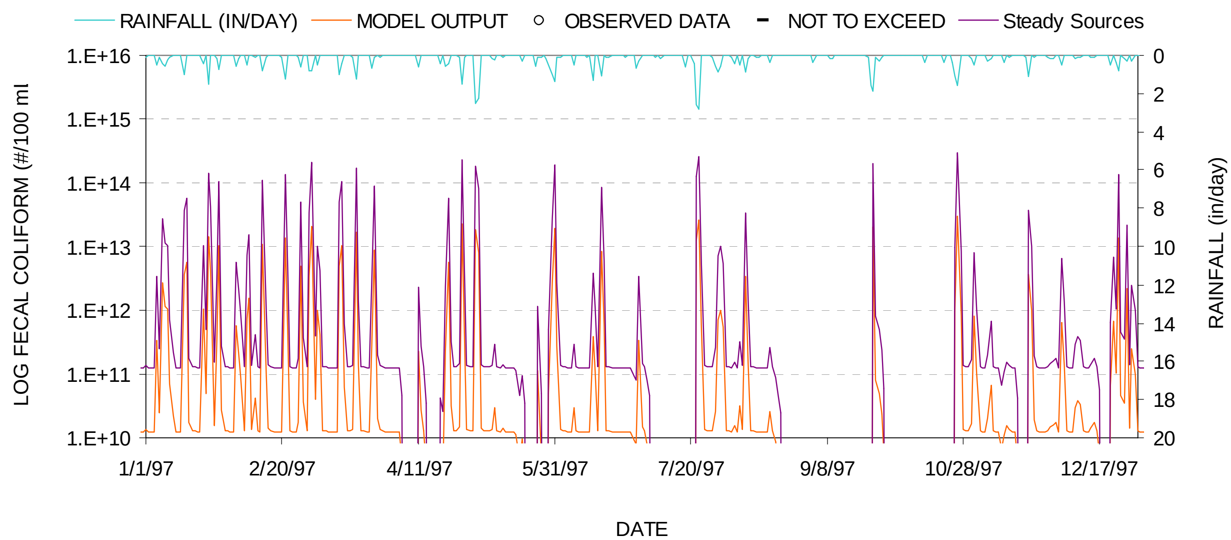


**Figure 4-5 Existing Load versus Allocated Load at SC-3 for 1997**

### 4.4.3 Required Reductions

From the reduction scenarios discussed in the previous section, the existing load and allocated loads have been determined. Instead of reducing the fecal coliform load globally, certain sources were addressed. These particular sources have been identified from developing the sensitivity runs to understand the system and what sources drive/dominate the fecal coliform impairment. Therefore, load reductions can be presented by a percent reduction of the existing load for each source.

A summary of the required reductions for point and non-point source loads is presented in Table 4-4. The existing and allocated loads are 3.56E+15 and 3.18E+15 counts per year. The loads, and therefore the TMDL, are shown in units of counts per year. It was determined that due to the variability of the daily load due to watershed runoff, the annual load for the critical time period would be appropriate along with Figure 4-5. This figure is a plot of the daily load (counts per day) of fecal coliform for the existing conditions and the TMDL.

**Table 4-4 Required Load Reductions for Point and Non-Point Sources**

| Source | Existing Loading Fecal Coliform (counts/year) | Estimated Percent Reduction | Allocated Load (counts/year) |
|---|---|---|---|
| Cropland | 2.77E+13 | 0% | 2.77E+13 |
| Forest | 4.59E+12 | 0% | 4.59E+12 |
| Pasture | 3.44E+15 | 90% | 3.44E+14 |
| Urban Pervious | 3.68E+09 | 0% | 3.68E+09 |
| Urban Impervious | 3.67E+09 | 0% | 3.67E+09 |
| Failing Septic Systems | 2.20E+13 | 0% | 2.20E+13 |
| Cattle in the Stream | 6.04E+13 | 50% | 3.02E+13 |
| Point Sources | 2.05E+11 | 0% | 2.05E+11 |
| **Total Existing Load** | **3.56E+15** | **Load Allocation** | 4.29E+14 |
| | | **Wasteload Allocation** | 2.05E+11 |
| | | **TMDL** | 4.29E+14 |

The required reductions will be sought through TMDL implementation with follow up monitoring to determine the effectiveness of implementation. Follow up monitoring as discussed further in this document will be conducted according to basin rotation.

### *4.5 Seasonal Variation*

Seasonal variation was incorporated in the continuous water quality model by daily meteorological data input to drive the hydrology and a 10-year simulation time period. The runoff events are allocated to the instantaneous target and the direct and point source loads are allocated to the geometric means. The summer months were the limiting factor in order to meet the geometric mean all year.

## *5 Conclusions*

The TMDL process quantifies the amount of a pollutant that can be assimilated in a waterbody, identifies sources of the pollutant, and recommends regulatory or other actions to be taken to achieve compliance with applicable water quality criteria based on the relationship between pollution sources and in-stream water quality conditions. A TMDL can be expressed as the sum of all point source loads (WLAs), nonpoint source loads (LAs), and an appropriate margin of safety (MOS), which takes into account any uncertainty concerning the relationship between effluent limitations and water quality:

TMDL = WLAs + LAs + MOS

The objective of a TMDL is to allocate loads among known pollutant sources throughout a watershed so that appropriate control measures can be implemented and water quality criteria achieved. 40 CFR §130.2 (i) states that TMDLs can be expressed in terms of mass per time (e.g., pounds per day), toxicity, or other appropriate measure. For fecal coliform bacteria, the TMDLs are expressed as counts per year. The TMDL represents the maximum load that can occur over the year while maintaining the water quality criteria. The fecal coliform allocated load is more indicative of the TMDL because it represents daily fluctuations due to hydrology.

# *6 TMDL Implementation*

## *6.1 Non-Point Source Approach*

Scarham Creek is impaired by nonpoint sources from land use runoff and cattle in the streams. For 303(d) listed waters impaired solely or primarily by nonpoint source (NPS) pollutants, necessary reductions will be sought during TMDL implementation using a phased approach. Voluntary, incentive-based mechanisms will be used to implement NPS management measures in order to assure that measurable reductions in pollutant loadings can be achieved for the targeted impaired water. Cooperation and active participation by the general public and various industry, business, and environmental groups is critical to successful implementation of TMDLs. Local citizen-led and implemented management measures offer the most efficient and comprehensive avenue for reduction of loading rates from nonpoint sources. Therefore, TMDL implementation activities will be coordinated through interaction with local entities in conjunction with Clean Water Partnership efforts.

The primary TMDL implementation mechanism used will employ concurrent education and outreach, training, technology transfer, and technical assistance with incentive-based pollutant management measures. The ADEM Office of Education and Outreach (OEO) will assist in the implementation of TMDLs in cooperation with public and private stakeholders. Planning and oversight will be provided by or coordinated with the Alabama Department of Environmental Management's (ADEM) Section 319 nonpoint source grant program in conjunction with other local, state, and federal resource management and protection programs and authorities. The CWA Section 319 grant program may provide limited funding to specifically ascertain NPS pollution sources and causes, identify and coordinate management programs and resources, present education and outreach opportunities, promote pollution prevention, and implement needed management measures to restore impaired waters.

Depending on the pollutant of concern, resources for corrective actions may be provided, as applicable, by the Alabama Cooperative Extension System (education and outreach); the USDA-Natural Resources Conservation Service (NRCS) (technical assistance) and Farm Services Agency (FSA) (federal cost-share funding); and the Alabama Soil and Water Conservation Committee (state agricultural cost share funding and management measure implementation assistance) through local Soil and Water Conservation Districts, or Resource Conservation and Development Councils (funding, project implementation, and coordination). Additional assistance from such agencies as the Alabama Department of Public Health (septic systems), Alabama Department of Agriculture and Industries, and the Alabama Department of Industrial Relations and Dept of Interior - Office of Surface Mining (abandoned minelands), Natural Heritage Program and US Fish and Wildlife Service (threatened and endangered species), may also provide practical TMDL implementation delivery systems, programs, and information.

Land use and urban sprawl issues will be addressed through the Nonpoint Education Source for Municipal Officials (NEMO) outreach program. Memorandums of Agreement (MOAs) may be used as a tool to formally define roles and responsibilities.

Additional public/private assistance is available through the Alabama Clean Water Partnership Program (CWP). The CWP program uses a local citizen-based environmental protection approach to coordinate efforts to restore and protect the state's resources in accordance with the goals of the Clean Water Act. Interaction with the state or river basin specific CWP will facilitate TMDL implementation by providing improved and timely communication and information exchange between community-based groups, units of government, industry, special interest groups, and individuals. The CWP can assist local entities to plan, develop, and coordinate restoration strategies that holistically meet multiple needs, eliminate duplication of efforts, and allow for effective and efficient use of available resources to restore the impaired waterbody or watershed.

Other mechanisms that are available and may be used during implementation of this TMDL include local regulations or ordinances related to zoning, land use, or storm water runoff controls. Local governments can provide funding assistance through general revenues, bond issuance, special taxes, utility fees, and impact fees. If applicable, reductions from point sources will be addressed by the NPDES permit program. The Alabama Water Pollution Control Act empowers ADEM to monitor water quality, issue permits, conduct inspections, and pursue enforcement of discharge activities and conditions that threaten water quality. In addition to traditional "end-of-pipe" discharges, the ADEM NPDES permit program addresses animal feeding operations and land application of animal wastes. For certain water quality improvement projects, the State Clean Water Revolving Fund (SRF) can provide low interest loans to local governments.

Long-term physical, chemical, and biological improvements in water quality will be used to measure TMDL implementation success. As may be indicated by further evaluation of stream water quality, the effectiveness of implemented management measures may necessitate revisions of this TMDL. The ADEM will continue to monitor water quality according to the rotational river basin monitoring schedule as allowed by resources. In addition, assessments may include local citizen-volunteer monitoring through the Alabama Water Watch Program and/or data collected by agencies, universities, or other entities using standardized monitoring and assessment methodologies. Core management measures will include, but not be limited to water quality improvements and designated use support, preserving and enhancing public health, enhancing ecosystems, pollution prevention and load reductions, implementation of NPS controls, and public awareness and attitude/behavior changes.

## *6.2 Point Source Approach*

Point source reductions are not necessary to meet the TMDL for Scarham Creek.

# 7 Follow Up Monitoring

ADEM has adopted a basin approach to water quality management; an approach that divides Alabama's fourteen major river basins into five groups. Each year, the ADEM water quality resources are concentrated in one of the basin groups. One goal is to continue to monitor §303(d) listed waters. This monitoring will occur in each basin according to the schedule in Table 7-1.

**Table 7-1 Monitoring Schedule for Alabama River Basins**

| River Basin Group | Schedule |
|---|---|
| Cahaba / Black Warrior | 2002 |
| Tennessee | 2003 |
| Choctawhatchee / Chipola / Perdido-Escambia / Chattahoochee | 2004 |
| Tallapoosa / Alabama / Coosa | 2005 |
| Escatawpa / Upper Tombigbee / Lower Tombigbee / Mobile | 2006 |

Monitoring will help further characterize water quality conditions resulting from the implementation of best management practices in the watershed.

# 8 Public Participation

A thirty-day public notice will be provided for this TMDL. During this time, copies of this TMDL will be available upon request, and the public will be invited to provide comments on the TMDL.

# *Appendix 9.1 - References*

# References

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# *Appendix 9.2 - Flow and Fecal Coliform Data Used in TMDL Analyses*

**Table 9-1 Measured Flow Data at SC-3**

| Stream Name | Station | Date | Stream Flow (cfs) |
|---|---|---|---|
| Scarham Cr | SC-3 | 05/10/88 | 36 |
| Scarham Cr | SC-3 | 06/22/88 | 0 |
| Scarham Cr | SC-3 | 08/23/88 | 0.34 |
| Scarham Cr | SC-3 | 09/20/88 | 76.98 |
| Scarham Cr | SC-3 | 10/18/88 | 7.06 |
| Scarham Cr | SC-3 | 11/29/88 | 271 |
| Scarham Cr | SC-3 | 12/27/88 | 51 |
| Scarham Cr | SC-3 | 04/18/89 | 99 |
| Scarham Cr | SC-3 | 05/23/89 | 19 |
| Scarham Cr | SC-3 | 06/28/89 | 79.03 |
| Scarham Cr | SC-3 | 07/12/89 | 180.27 |
| Scarham Cr | SC-3 | 08/24/89 | 4.64 |
| Scarham Cr | SC-3 | 10/04/89 | 174 |
| Scarham Cr | SC-3 | 11/15/89 | 78 |
| Scarham Cr | SC-3 | 02/14/90 | 38 |
| Scarham Cr | SC-3 | 03/14/90 | 36 |
| Scarham Cr | SC-3 | 04/03/90 | 34 |
| Scarham Cr | SC-3 | 04/28/92 | 38.8 |
| Scarham Cr | SC-3 | 05/06/92 | 13 |
| Scarham Cr | SC-3 | 06/17/92 | 26 |
| Scarham Cr | SC-3 | 08/04/92 | 14.02 |
| Scarham Cr | SC-3 | 10/20/92 | *23 |
| Scarham Cr | SC-3 | 01/20/93 | 157 |
| Scarham Cr | SC-3 | 02/23/93 | 97 |
| Scarham Cr | SC-3 | 04/13/93 | 102.06 |
| Scarham Cr | SC-3 | 05/12/93 | 56 |
| Scarham Cr | SC-3 | 06/02/93 | 16 |
| Scarham Cr | SC-3 | 08/31/93 | *0 |
| Scarham Cr | SC-3 | 11/09/93 | *8 |
| Scarham Cr | SC-3 | 12/08/93 | *28 |
| Scarham Cr | SC-3 | 01/05/94 | 47.88 |
| Scarham Cr | SC-3 | 03/22/94 | 83 |
| Scarham Cr | SC-3 | 04/19/94 | 144 |
| Scarham Cr | SC-3 | 05/24/94 | *10 |
| Scarham Cr | SC-3 | 06/21/94 | *0 |
| Scarham Cr | SC-3 | 07/19/94 | 15.3 |
| Scarham Cr | SC-3 | 08/09/94 | *70 |
| Scarham Cr | SC-3 | 09/13/94 | *28 |
| Scarham Cr | SC-3 | 10/18/94 | 41.68 |
| Scarham Cr | SC-3 | 11/15/94 | 35.01 |

Note - * Estimated flow value.

**Table 9-1 (continued) Measured Flow Data at SC-3**

| Stream Name | Station | Date | Stream Flow (cfs) |
|---|---|---|---|
| Scarham Cr | SC-3 | 12/06/94 | *160 |
| Scarham Cr | SC-3 | 01/11/95 | 71 |
| Scarham Cr | SC-3 | 02/15/95 | *68 |
| Scarham Cr | SC-3 | 04/11/95 | 17.15 |
| Scarham Cr | SC-3 | 05/10/95 | *55 |
| Scarham Cr | SC-3 | 06/13/95 | *12 |
| Scarham Cr | SC-3 | 07/19/95 | *0 |
| Scarham Cr | SC-3 | 08/16/95 | *0 |
| Scarham Cr | SC-3 | 09/06/95 | *0 |
| Scarham Cr | SC-3 | 10/17/95 | *40 |
| Scarham Cr | SC-3 | 12/12/95 | *75 |
| Scarham Cr | SC-3 | 01/17/96 | 85 |
| Scarham Cr | SC-3 | 03/13/96 | 149 |
| Scarham Cr | SC-3 | 04/24/96 | 102 |
| Scarham Cr | SC-3 | 05/21/96 | 10 |
| Scarham Cr | SC-3 | 06/11/96 | 55 |
| Scarham Cr | SC-3 | 08/13/96 | 13 |
| Scarham Cr | SC-3 | 09/03/96 | 15 |
| Scarham Cr | SC-3 | 10/22/96 | 3 |
| Scarham Cr | SC-3 | 11/19/96 | 90 |
| Scarham Cr | SC-3 | 01/22/97 | 65 |
| Scarham Cr | SC-3 | 02/19/97 | 46 |
| Scarham Cr | SC-3 | 03/18/97 | 115 |
| Scarham Cr | SC-3 | 04/09/97 | 111 |
| Scarham Cr | SC-3 | 05/13/97 | 88 |
| Scarham Cr | SC-3 | 06/24/97 | 67 |
| Scarham Cr | SC-3 | 07/22/97 | 12 |
| Scarham Cr | SC-3 | 08/27/97 | 0 |
| Scarham Cr | SC-3 | 09/23/97 | 28 |
| Scarham Cr | SC-3 | 10/14/97 | 13 |
| Scarham Cr | SC-3 | 11/19/97 | 71 |
| Scarham Cr | SC-3 | 12/02/97 | 69 |
| Scarham Cr | SC-3 | 01/27/98 | 125 |

Note - * Estimated flow value.

**Table 9-2 Measured Fecal Coliform Data at SC-3**

| Stream Name | Station | Date | Fecal Coliform (count/100mL) |
|---|---|---|---|
| Scarham Cr | SC-3 | 04/13/88 | 3500 |
| Scarham Cr | SC-3 | 05/10/88 | 1900 |
| Scarham Cr | SC-3 | 06/22/88 | 21 |
| Scarham Cr | SC-3 | 08/23/88 | 54 |
| Scarham Cr | SC-3 | 09/20/88 | 400 |
| Scarham Cr | SC-3 | 10/18/88 | 52 |
| Scarham Cr | SC-3 | 11/29/88 | 540 |
| Scarham Cr | SC-3 | 12/27/88 | 140 |
| Scarham Cr | SC-3 | 01/24/89 | 54 |
| Scarham Cr | SC-3 | 03/22/89 | 1540 |
| Scarham Cr | SC-3 | 04/18/89 | 77 |
| Scarham Cr | SC-3 | 05/23/89 | 84 |
| Scarham Cr | SC-3 | 07/12/89 | >1750 |
| Scarham Cr | SC-3 | 08/24/89 | 45 |
| Scarham Cr | SC-3 | 10/04/89 | 360 |
| Scarham Cr | SC-3 | 11/15/89 | >4500 |
| Scarham Cr | SC-3 | 01/10/90 | 53 |
| Scarham Cr | SC-3 | 02/14/90 | 80 |
| Scarham Cr | SC-3 | 03/14/90 | 29 |
| Scarham Cr | SC-3 | 04/03/90 | 67 |
| Scarham Cr | SC-3 | 05/16/90 | >600 |
| Scarham Cr | SC-3 | 03/24/92 | 120 |
| Scarham Cr | SC-3 | 05/06/92 | 70 |
| Scarham Cr | SC-3 | 06/17/92 | 216 |
| Scarham Cr | SC-3 | 08/04/92 | 2700 |
| Scarham Cr | SC-3 | 10/20/92 | 53 |
| Scarham Cr | SC-3 | 11/12/92 | 80 |
| Scarham Cr | SC-3 | 12/08/92 | 124 |
| Scarham Cr | SC-3 | 01/20/93 | 128 |
| Scarham Cr | SC-3 | 02/23/93 | 148 |
| Scarham Cr | SC-3 | 03/23/93 | >600 |
| Scarham Cr | SC-3 | 04/13/93 | 20 |
| Scarham Cr | SC-3 | 05/12/93 | 60 |
| Scarham Cr | SC-3 | 06/02/93 | 1180 |
| Scarham Cr | SC-3 | 07/21/93 | 5600 |
| Scarham Cr | SC-3 | 08/31/93 | 2600 |
| Scarham Cr | SC-3 | 09/21/93 | 32 |
| Scarham Cr | SC-3 | 10/13/93 | 1 |
| Scarham Cr | SC-3 | 11/09/93 | 21 |
| Scarham Cr | SC-3 | 12/08/93 | 30 |
| Scarham Cr | SC-3 | 01/05/94 | 86 |
| Scarham Cr | SC-3 | 03/22/94 | 40 |

**Table 9-2 (continued) Measured Fecal Coliform Data at SC-3**

| Stream Name | Station | Date | Fecal Coliform (count/100mL) |
|---|---|---|---|
| Scarham Cr | SC-3 | 04/19/94 | 246 |
| Scarham Cr | SC-3 | 05/24/94 | 132 |
| Scarham Cr | SC-3 | 06/21/94 | 160 |
| Scarham Cr | SC-3 | 07/19/94 | 140 |
| Scarham Cr | SC-3 | 09/13/94 | 650 |
| Scarham Cr | SC-3 | 10/18/94 | 90 |
| Scarham Cr | SC-3 | 01/11/95 | 296 |
| Scarham Cr | SC-3 | 02/15/95 | 260 |
| Scarham Cr | SC-3 | 03/08/95 | 10500 |
| Scarham Cr | SC-3 | 04/11/95 | 31 |
| Scarham Cr | SC-3 | 05/10/95 | 116 |
| Scarham Cr | SC-3 | 06/13/95 | 2600 |
| Scarham Cr | SC-3 | 07/19/95 | 140 |
| Scarham Cr | SC-3 | 08/16/95 | 1320 |
| Scarham Cr | SC-3 | 09/06/95 | 300 |
| Scarham Cr | SC-3 | 10/17/95 | 92 |
| Scarham Cr | SC-3 | 11/14/95 | 210 |
| Scarham Cr | SC-3 | 12/12/95 | 132 |
| Scarham Cr | SC-3 | 01/17/96 | 216 |
| Scarham Cr | SC-3 | 02/14/96 | 140 |
| Scarham Cr | SC-3 | 03/13/96 | 70 |
| Scarham Cr | SC-3 | 04/24/96 | 310 |
| Scarham Cr | SC-3 | 05/21/96 | 230 |
| Scarham Cr | SC-3 | 06/11/96 | 660 |
| Scarham Cr | SC-3 | 07/16/96 | 300 |
| Scarham Cr | SC-3 | 08/13/96 | 88 |
| Scarham Cr | SC-3 | 09/03/96 | 168 |
| Scarham Cr | SC-3 | 10/22/96 | 65 |
| Scarham Cr | SC-3 | 11/19/96 | 410 |
| Scarham Cr | SC-3 | 12/17/96 | 4200 |
| Scarham Cr | SC-3 | 01/22/97 | 110 |
| Scarham Cr | SC-3 | 02/19/97 | 32 |
| Scarham Cr | SC-3 | 03/18/97 | 196 |
| Scarham Cr | SC-3 | 04/09/97 | 60 |
| Scarham Cr | SC-3 | 05/13/97 | 56 |
| Scarham Cr | SC-3 | 06/24/97 | 168 |
| Scarham Cr | SC-3 | 07/22/97 | 210 |
| Scarham Cr | SC-3 | 08/27/97 | 80 |
| Scarham Cr | SC-3 | 10/14/97 | 340 |
| Scarham Cr | SC-3 | 11/19/97 | 42 |
| Scarham Cr | SC-3 | 12/02/97 | 72 |
| Scarham Cr | SC-3 | 01/27/98 | 240 |
| Scarham Cr | SC-3 | 02/17/98 | 12,700 |
| Scarham Cr | SC-3 | 03/11/98 | 180 |

**Table 9-3 Measured Fecal Coliform Data at SC-4**

| Stream Name | Station | Date | Fecal Coliform (count/100mL) |
|---|---|---|---|
| Scarham Cr | SC-4 | 04/12/88 | 10000 |
| Scarham Cr | SC-4 | 05/10/88 | 40 |
| Scarham Cr | SC-4 | 06/22/88 | 430 |
| Scarham Cr | SC-4 | 08/23/88 | 3 |
| Scarham Cr | SC-4 | 09/20/88 | 225 |
| Scarham Cr | SC-4 | 10/18/88 | 30 |
| Scarham Cr | SC-4 | 11/29/88 | 340 |
| Scarham Cr | SC-4 | 12/27/88 | 60 |
| Scarham Cr | SC-4 | 01/24/89 | 21 |
| Scarham Cr | SC-4 | 03/22/89 | >2230 |
| Scarham Cr | SC-4 | 04/18/89 | 45 |
| Scarham Cr | SC-4 | 05/23/89 | 117 |
| Scarham Cr | SC-4 | 06/28/89 | 410 |
| Scarham Cr | SC-4 | 07/12/89 | >1950 |
| Scarham Cr | SC-4 | 08/24/89 | 38 |
| Scarham Cr | SC-4 | 10/04/89 | 490 |
| Scarham Cr | SC-4 | 11/15/89 | 270 |
| Scarham Cr | SC-4 | 01/10/90 | 26 |
| Scarham Cr | SC-4 | 02/14/90 | 143 |
| Scarham Cr | SC-4 | 03/14/90 | 68 |
| Scarham Cr | SC-4 | 04/03/90 | 24 |
| Scarham Cr | SC-4 | 05/16/90 | 145 |
| Scarham Cr | SC-4 | 03/24/92 | 152 |
| Scarham Cr | SC-4 | 05/06/92 | 128 |
| Scarham Cr | SC-4 | 06/17/92 | 80 |
| Scarham Cr | SC-4 | 08/04/92 | 60 |
| Scarham Cr | SC-4 | 10/20/92 | 4 |
| Scarham Cr | SC-4 | 11/12/92 | 98 |
| Scarham Cr | SC-4 | 12/08/92 | 252 |
| Scarham Cr | SC-4 | 01/20/93 | 100 |
| Scarham Cr | SC-4 | 02/23/93 | 68 |
| Scarham Cr | SC-4 | 03/23/93 | >620 |
| Scarham Cr | SC-4 | 04/13/93 | 0 |
| Scarham Cr | SC-4 | 05/12/93 | 20 |
| Scarham Cr | SC-4 | 06/02/93 | 25 |
| Scarham Cr | SC-4 | 07/21/93 | 484 |
| Scarham Cr | SC-4 | 08/31/93 | 2260 |
| Scarham Cr | SC-4 | 09/21/93 | 340 |
| Scarham Cr | SC-4 | 10/13/93 | 112 |
| Scarham Cr | SC-4 | 11/09/93 | 18 |
| Scarham Cr | SC-4 | 12/08/93 | 16 |
| Scarham Cr | SC-4 | 01/05/94 | 36 |
| Scarham Cr | SC-4 | 03/22/94 | 10 |
| Scarham Cr | SC-4 | 04/19/94 | 164 |
| Scarham Cr | SC-4 | 05/24/94 | 16 |
| Scarham Cr | SC-4 | 06/21/94 | 31 |
| Scarham Cr | SC-4 | 07/19/94 | 78 |
| Scarham Cr | SC-4 | 09/13/94 | 36 |
| Scarham Cr | SC-4 | 10/18/94 | 44 |

**Table 9-3 (continued) Measured Fecal Coliform Data at SC-4**

| Stream Name | Station | Date | Fecal Coliform (count/100mL) |
|---|---|---|---|
| Scarham Cr | SC-4 | 11/15/94 | 26 |
| Scarham Cr | SC-4 | 12/06/94 | 5 |
| Scarham Cr | SC-4 | 01/11/95 | 236 |
| Scarham Cr | SC-4 | 02/15/95 | 62 |
| Scarham Cr | SC-4 | 03/08/95 | >1200 |
| Scarham Cr | SC-4 | 04/11/95 | 12 |
| Scarham Cr | SC-4 | 05/10/95 | 40 |
| Scarham Cr | SC-4 | 06/13/95 | 680 |
| Scarham Cr | SC-4 | 07/19/95 | 60 |
| Scarham Cr | SC-4 | 08/16/95 | 42 |
| Scarham Cr | SC-4 | 09/06/95 | 6 |
| Scarham Cr | SC-4 | 10/17/95 | 48 |
| Scarham Cr | SC-4 | 11/14/95 | 132 |
| Scarham Cr | SC-4 | 12/12/95 | 98 |
| Scarham Cr | SC-4 | 01/17/96 | 160 |
| Scarham Cr | SC-4 | 02/14/96 | 60 |
| Scarham Cr | SC-4 | 03/13/96 | 44 |
| Scarham Cr | SC-4 | 04/24/96 | 200 |
| Scarham Cr | SC-4 | 05/21/96 | 20 |
| Scarham Cr | SC-4 | 06/11/96 | 148 |
| Scarham Cr | SC-4 | 07/16/96 | 96 |
| Scarham Cr | SC-4 | 08/13/96 | 52 |
| Scarham Cr | SC-4 | 09/03/96 | 68 |
| Scarham Cr | SC-4 | 10/22/96 | 94 |
| Scarham Cr | SC-4 | 11/19/96 | 340 |
| Scarham Cr | SC-4 | 12/17/96 | 4120 |
| Scarham Cr | SC-4 | 01/22/97 | 94 |
| Scarham Cr | SC-4 | 02/19/97 | 17 |
| Scarham Cr | SC-4 | 03/18/97 | 77 |
| Scarham Cr | SC-4 | 04/09/97 | 45 |
| Scarham Cr | SC-4 | 05/13/97 | 38 |
| Scarham Cr | SC-4 | 06/24/97 | 110 |
| Scarham Cr | SC-4 | 07/22/97 | 630 |
| Scarham Cr | SC-4 | 08/27/97 | 32 |
| Scarham Cr | SC-4 | 10/14/97 | 1340 |
| Scarham Cr | SC-4 | 11/19/97 | 10 |
| Scarham Cr | SC-4 | 12/02/97 | 20 |
| Scarham Cr | SC-4 | 01/27/98 | 200 |
| Scarham Cr | SC-4 | 02/17/98 | 10800 |
| Scarham Cr | SC-4 | 03/11/98 | 118 |

## *Appendix 9.3 - Model Results for Hydrology Calibration*

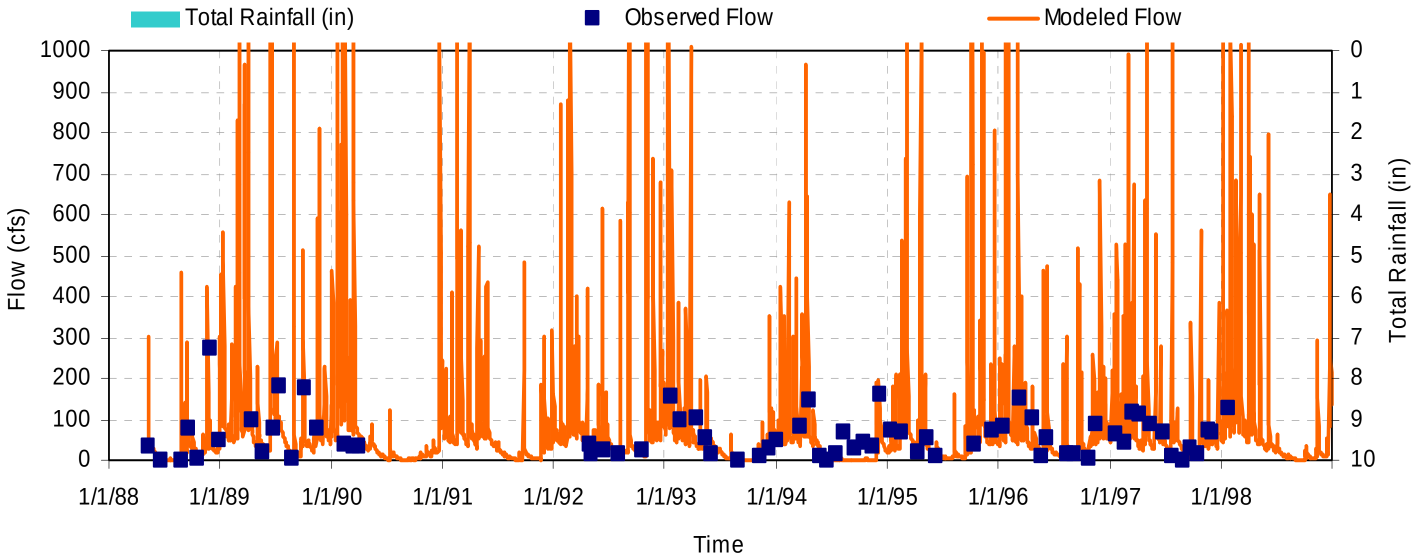


**Figure 9-1 Modeled versus Observed Flow at SC-3 for 10 Years**

# *Appendix 9.4 - Model Results for Fecal Coliform Calibrations*

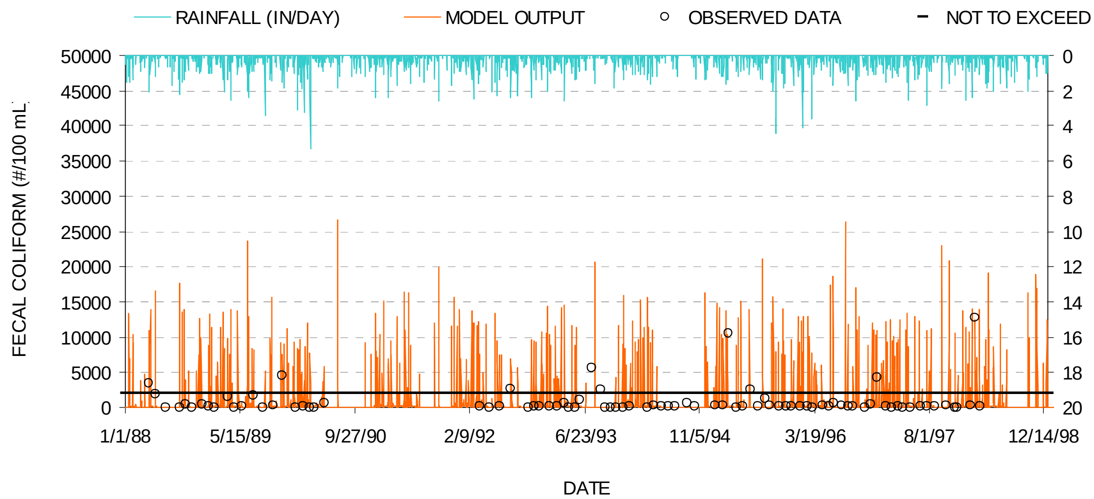


**Figure 9-2 Predicted versus Observed Fecal Coliform at SC-3 for 10 Years**

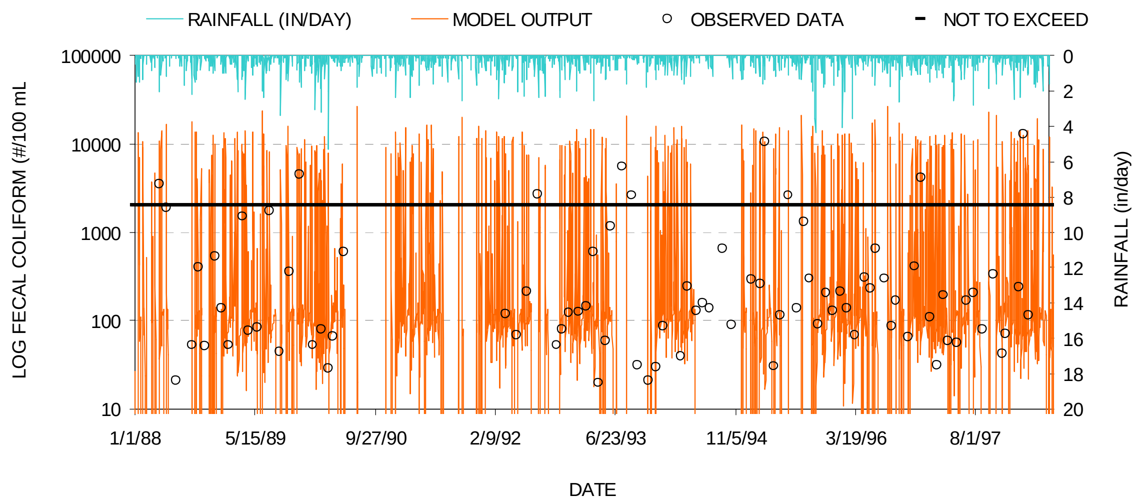


**Figure 9-3 Predicted versus Observed Fecal Coliform at SC-3 for 10 Years (Logarithmic Scale)**

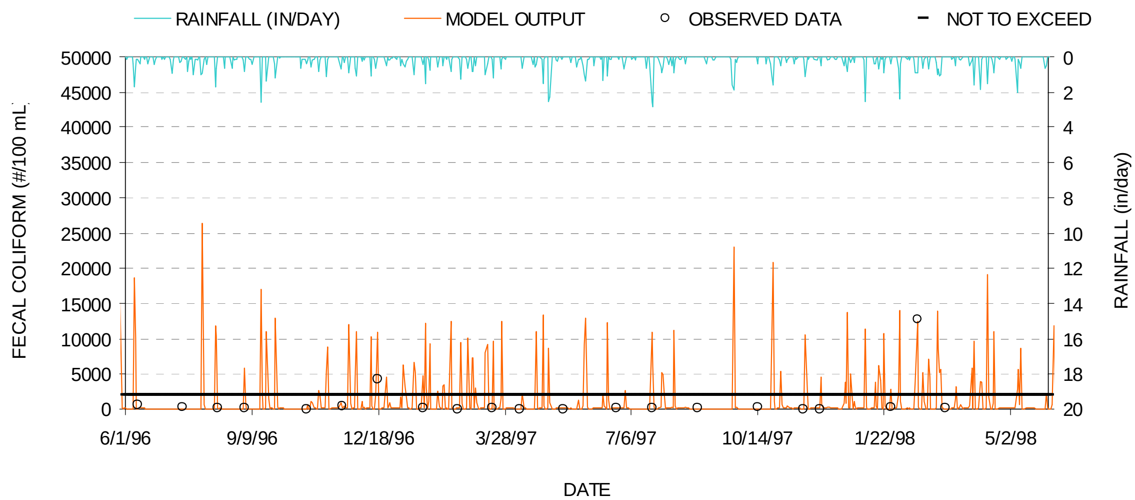


**Figure 9-4 Predicted versus Observed Fecal Coliform at SC-3 for 2 Years**

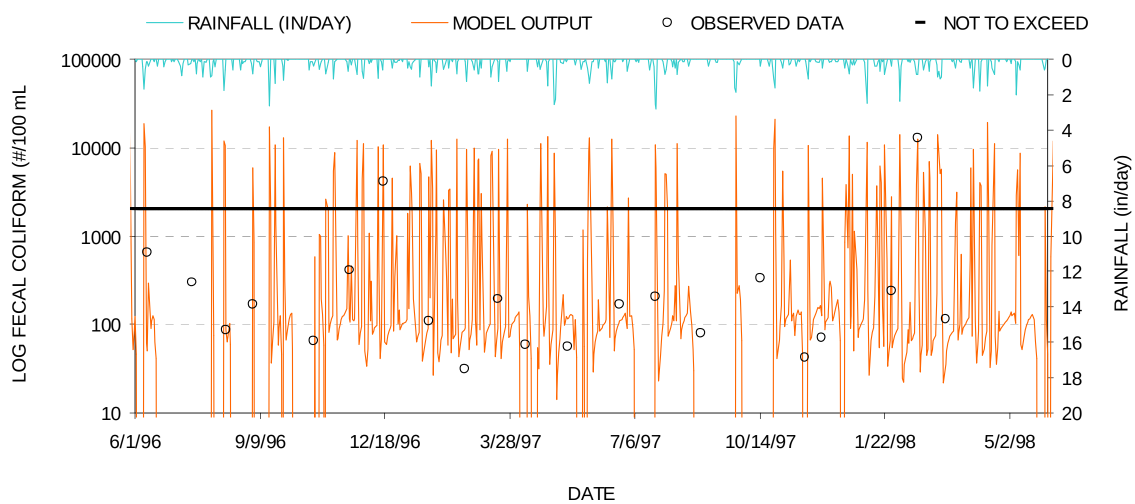


**Figure 9-5 Predicted versus Observed Fecal Coliform at SC-3 for 2 Years (Logarithmic Scale)**

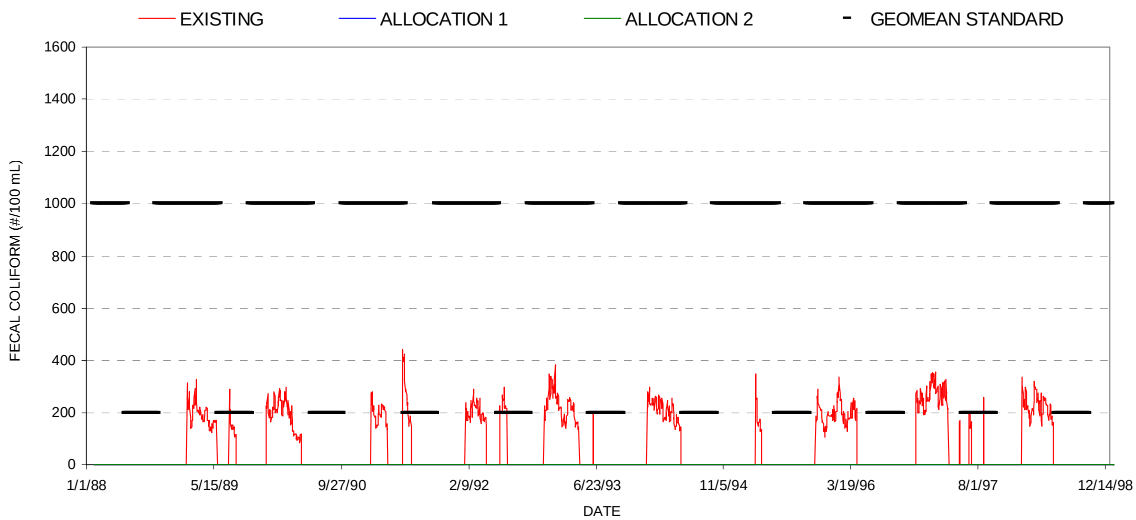


**Figure 9-6 Predicted Geometric Mean Fecal Coliform at SC-3 for 10 Years**

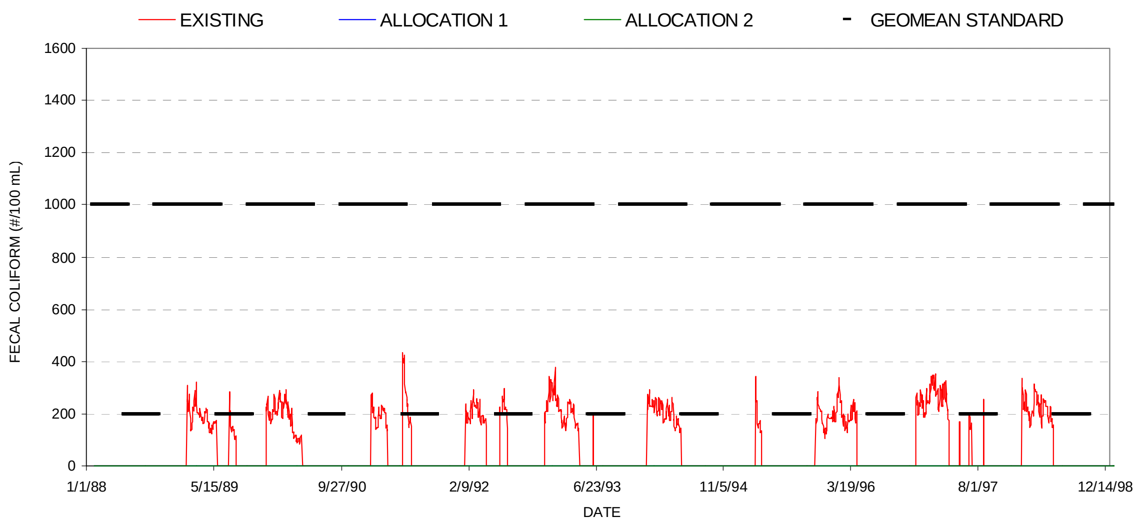


**Figure 9-7 Predicted Geometric Mean Fecal Coliform at SC-4 for 10 Years**

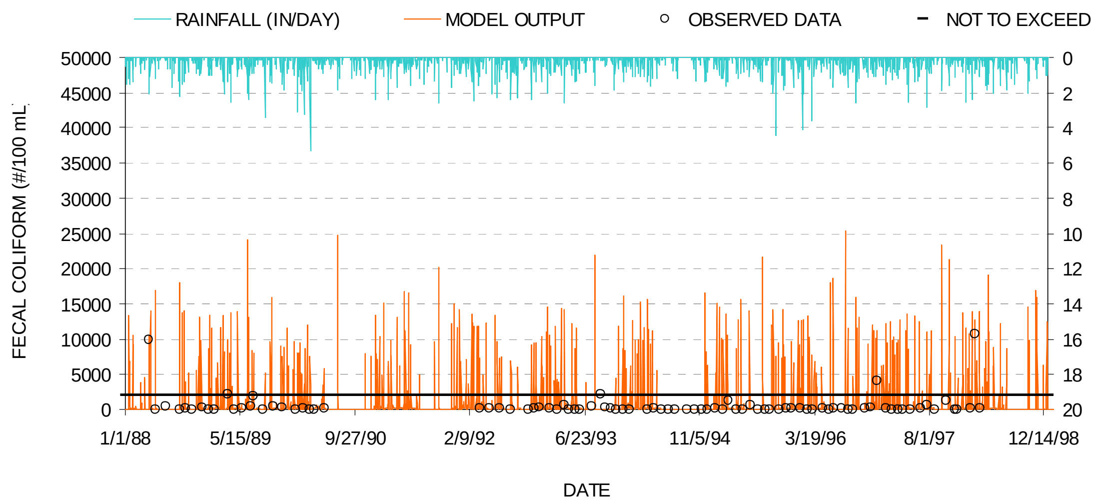


**Figure 9-8 Predicted versus Observed Fecal Coliform at SC-4 for 10 Years**

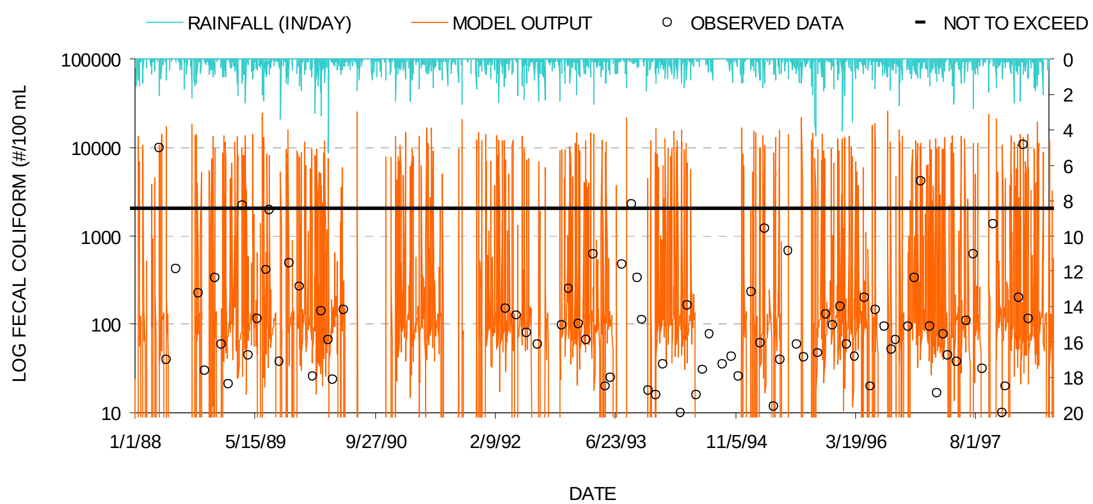


**Figure 9-9 Predicted versus Observed Fecal Coliform at SC-4 for 10 Years (Logarithmic Scale)**

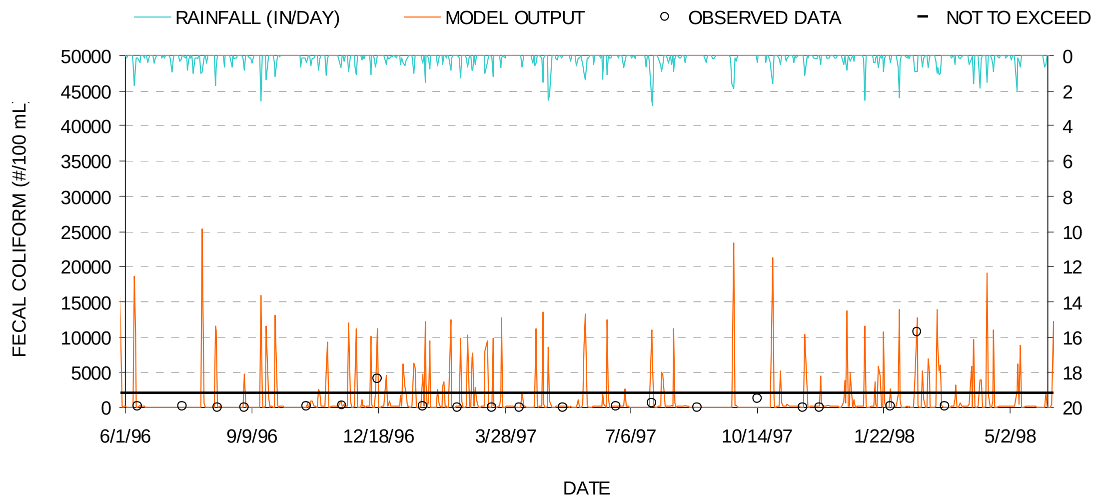


**Figure 9-10 Predicted versus Observed Fecal Coliform at SC-4 for 2 Years**

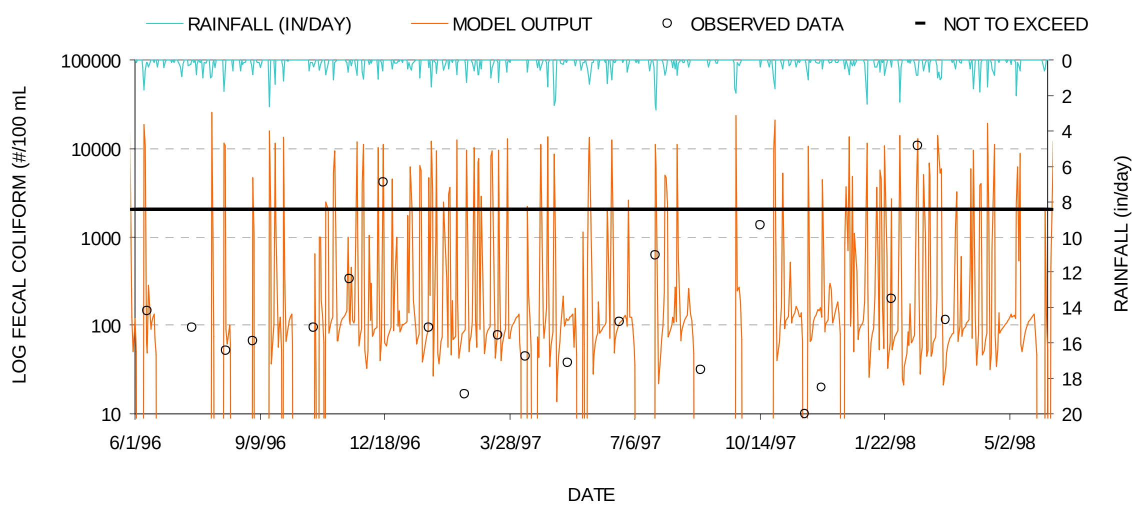


**Figure 9-11 Predicted versus Observed Fecal Coliform at SC-4 for 2 Years (Logarithmic Scale)**

# *Appendix 9.5 - TMDL Allocation Results*

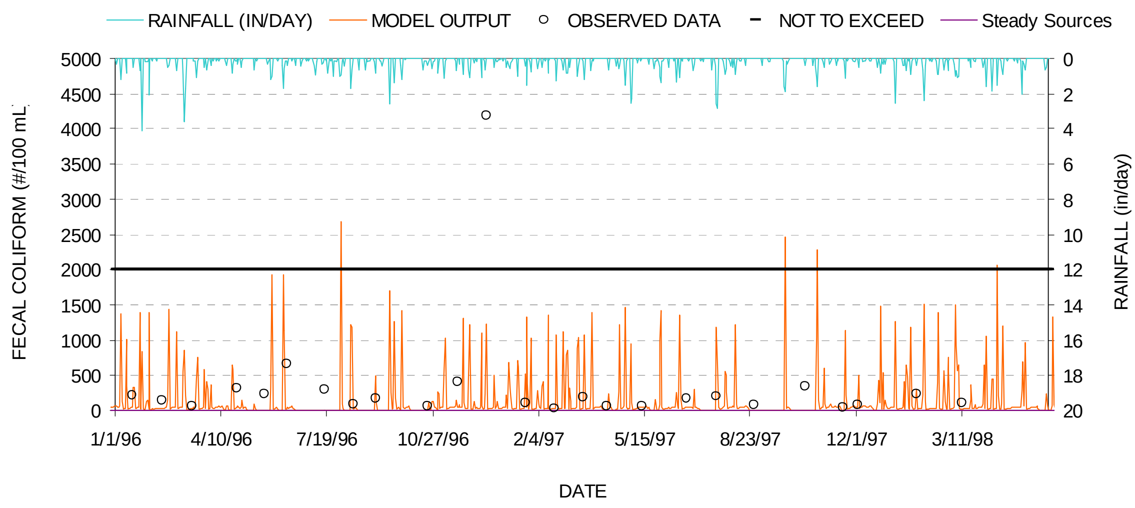


**Figure 9-12 TMDL Allocation with 90%Reduction to Pasture and 50% Reduction to Cattle in the Streams for 2 Years**

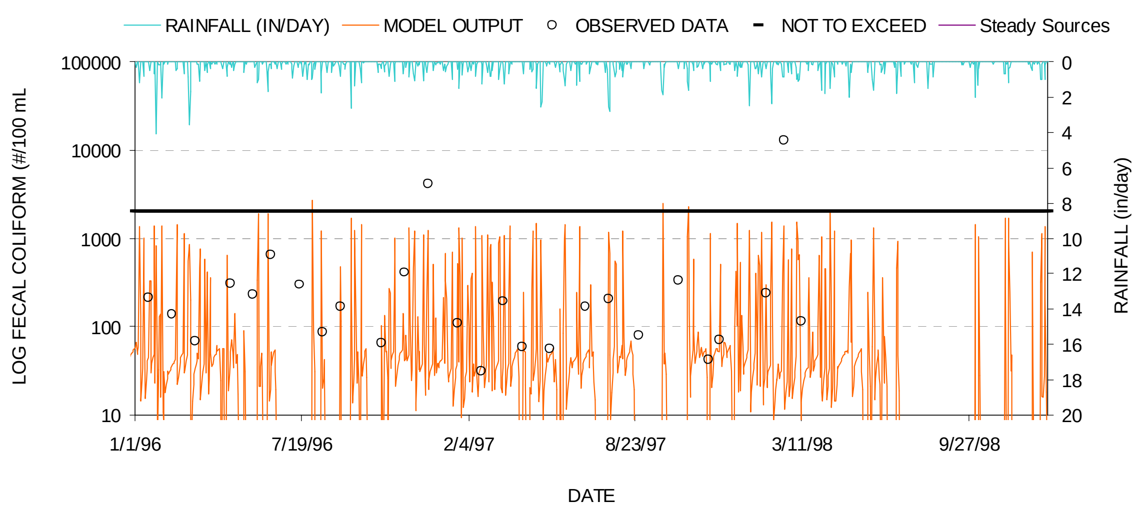


**Figure 9-13 Allocation with 90%Reduction to Pasture and 50% Reduction to Cattle in the Streams for 2 Years (Logarithmic Scale)**

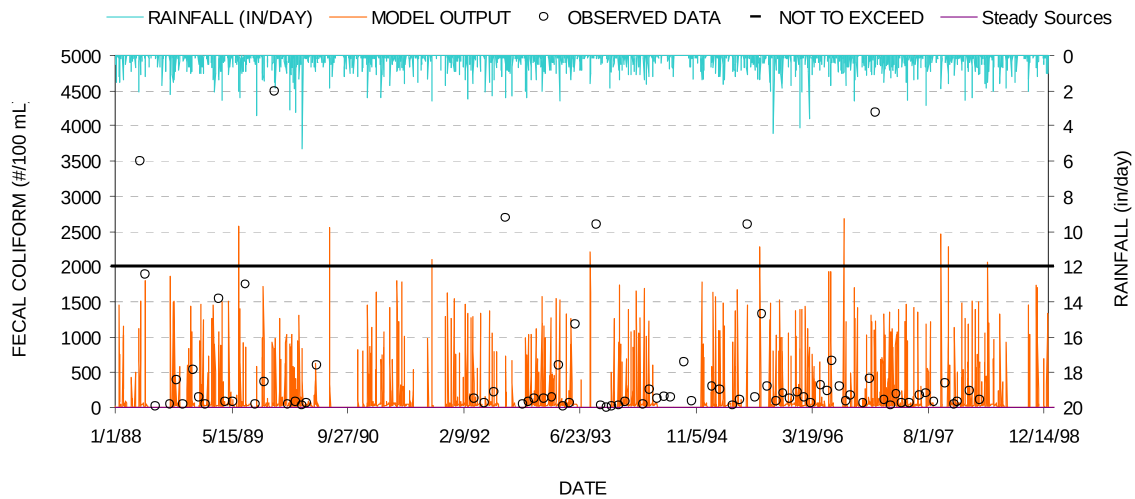


**Figure 9-14 Allocation with 90%Reduction to Pasture and 50% Reduction to Cattle in the Streams for 10 Years (Logarithmic Scale)**

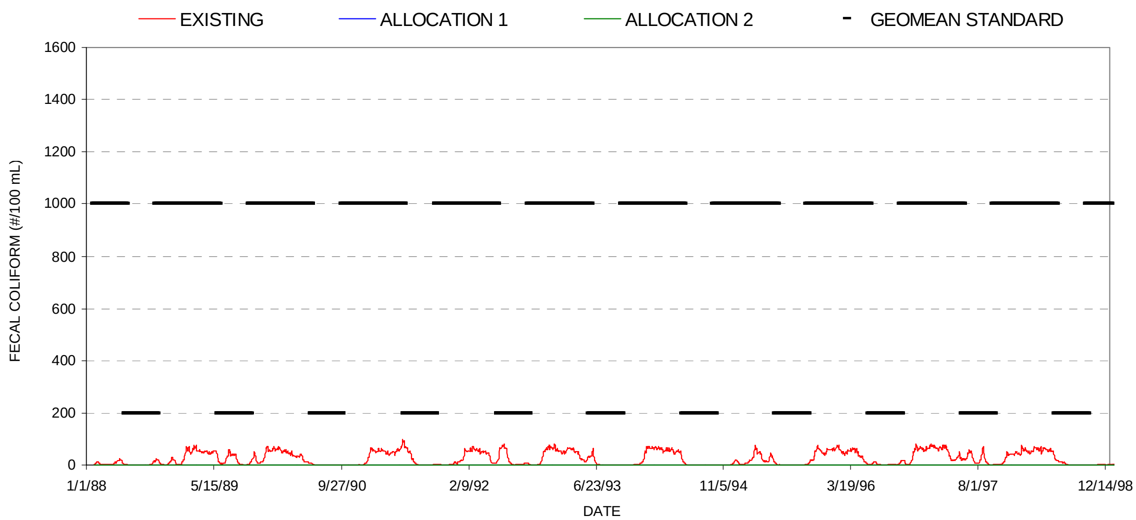


**Figure 9-15 Geometric Mean of Fecal Coliform with 90%Reduction to Pasture and 50% Reduction to Cattle in the Streams for 10 Years**

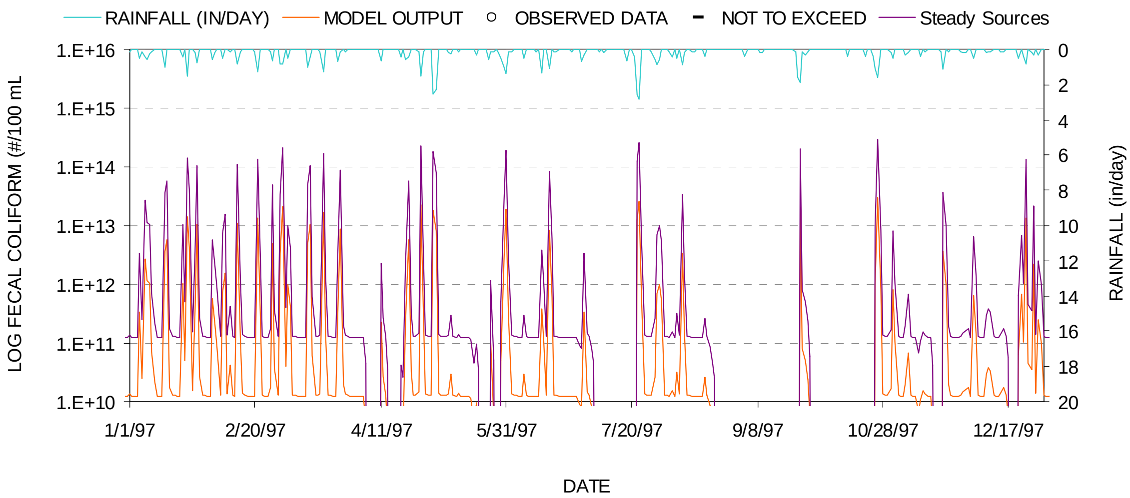


**Figure 9-16 Allocation Load versus Existing Conditions Load for the Scarham Creek Watershed**