# TOTAL MAXIMUM DAILY LOADS

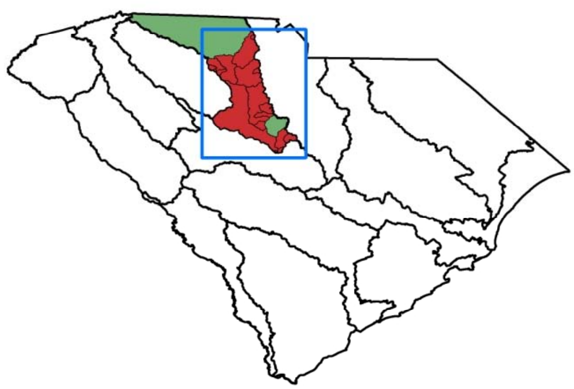
# FOR

# FECAL COLIFORM

# FOR

## Turkey Creek, Meng Creek, Browns Creek, Gregorys Creek, Dry Fork, Sandy River, Elizabeth Lake, Little River, Winnsboro Branch, Jackson Creek, and Mill Creek watersheds and the lower portion of the Upper Broad River, South Carolina

**HYDROLOGIC UNIT CODE: 03050106 (B-086, B-136, B-064, B-243, B-155, B-335, B-046, B-074, B-075, B-110, B-316, B-280, B-337, B-145, B-350, B-123, B-077, B-102, B-338)**



Broad River Basin

**September 2005**

**SCDHEC Technical Report Number: 028-05**

United States Environmental Protection Agency

Region 4 serving the southeast

In compliance with the provisions of the Federal Clean Water Act, 33 U.S.C §1251 et.seq., as amended by the Water Quality Act of 1987, P.L. 400-4, the U.S Environmental Protection Agency is hereby establishing a Total Maximum Daily Load (TMDL) for Fecal Coliform for Turkey Creek, Meng Creek, Browns Creek, Gregorys Creek, Dry Fork, Sandy River, Elizabeth Lake, Little River, Winnsboro Branch, Jackson Creek, Mill Creek, and the lower portion of the Upper Broad River in the Broad River Basin. Subsequent actions must be consistent with this TMDL.

James D. Giattina, Director
Water Management Division

Date

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# ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| AFO | Animal feeding operation |
| ASAE | American Society of Agricultural Engineers |
| BMP | Best management practice |
| CAFO | Concentrated Animal Feeding Operation |
| CFR | Code of Federal Regulations |
| cfs | Cubic feet per second |
| cfu | Colony-forming units |
| CWA | Clean Water Act |
| DMR | Discharge monitoring report |
| HUC | Hydrologic unit code |
| IH | Interstate highway |
| LA | Load allocation |
| LDC | Load duration curve |
| mg | Million gallons |
| ml | Milliliter |
| MOS | Margin of safety |
| MS4 | Municipal separate storm sewer system |
| NOAA | National Oceanic and Atmospheric Administration |
| NPDES | National Pollutant Discharge Elimination System |
| NSFC | National Small Flows Clearinghouse |
| OSWD | Onsite wastewater disposal |
| PRG | Percent reduction goal |
| SC | South Carolina |
| SCDHEC | South Carolina Department of Health and Environmental Control |
| SH | State highway |
| SSO | Sanitary sewer overflow |
| TMDL | Total maximum daily load |
| USC | United States Code |
| USDA | U.S. Department of Agriculture |
| USEPA | U.S. Environmental Protection Agency |
| USGS | U.S. Geological Survey |
| WLA | Wasteload allocation |
| WMA | Wildlife management area |
| WQM | Water quality monitoring |
| WQS | Water quality standard |
| WWTP | Wastewater Treatment Plant |

# SECTION 1
# INTRODUCTION

## 1.1 Background

Section 303(d) of the Clean Water Act (CWA) and U.S. Environmental Protection Agency (USEPA) Water Quality Planning and Management Regulations (40 Code of Federal Regulations [CFR] Part 130) require States to develop total maximum daily loads (TMDL) for water bodies not meeting designated uses where technology-based controls are in place. TMDLs establish 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 States can implement water quality-based controls to reduce pollution from both point and nonpoint sources and restore and maintain the quality of its water resources (USEPA 1991).

This report documents the data and assessment utilized to establish TMDLs for fecal coliform bacteria for certain water bodies in the Broad River Basin in accordance with requirements of Section 303(d) of the CWA, Water Quality Planning and Management Regulations (40 CFR Part 130), USEPA guidance, and South Carolina (SC) Department of Health and Environmental Control (SCDHEC) guidance and procedures. States are required to submit all TMDLs to USEPA for review and approval. Once USEPA approves a TMDL, the water body may then be moved to Category 4a of a State's Integrated Water Quality Monitoring and Assessment Report, where it remains until compliance with water quality standards (WQS) is achieved (USEPA 2003).

The purpose of this TMDL report is to assist SCDHEC with establishing pollutant load allocations for impaired water bodies. TMDLs determine the pollutant loading a water body can assimilate without exceeding the WQS for that pollutant. TMDLs also establish the pollutant load allocation necessary to meet the WQS established for a water body based on the relationship between pollutant sources and in-stream water quality conditions. A TMDL consists of a wasteload allocation (WLA), a load allocation (LA), and a margin of safety (MOS). The WLA is the fraction of the total pollutant load apportioned to point sources, and includes stormwater discharges regulated under the National Pollutant Discharge Elimination System (NPDES) as point sources. The LA is the fraction of the total pollutant load apportioned to nonpoint sources. The MOS is a percentage of the TMDL that accounts for the uncertainty associated with model assumptions and data limitations.

SCDHEC included 19 water quality monitoring (WQM) stations from the 8-digit Hydrologic Unit Code (HUC) 03050106 within the lower Broad River Basin on the 2004 South Carolina §303(d) list for exceedances of fecal coliform bacteria WQS. Figures 1-1 and 1-2 are orientation maps showing locations of the 303(d)-listed WQM stations that are not meeting the instantaneous fecal coliform WQSs of 400 colony-forming units (cfu)/100 milliliters (ml) for primary contact recreation. The TMDLs in this report will affect water bodies in York, Chester, Union, Fairfield, Newberry, and Richland Counties. (Note that in Figures 1-1 and 1-2, WQM stations B-074, B-046 and B-075 appear on both maps for location orientation purposes only).

**Figure 1-1 Turkey Creek, Meng Creek, Browns Creek, Gregory Creek, Sandy Creek, Dry Fork and Broad River Watersheds**

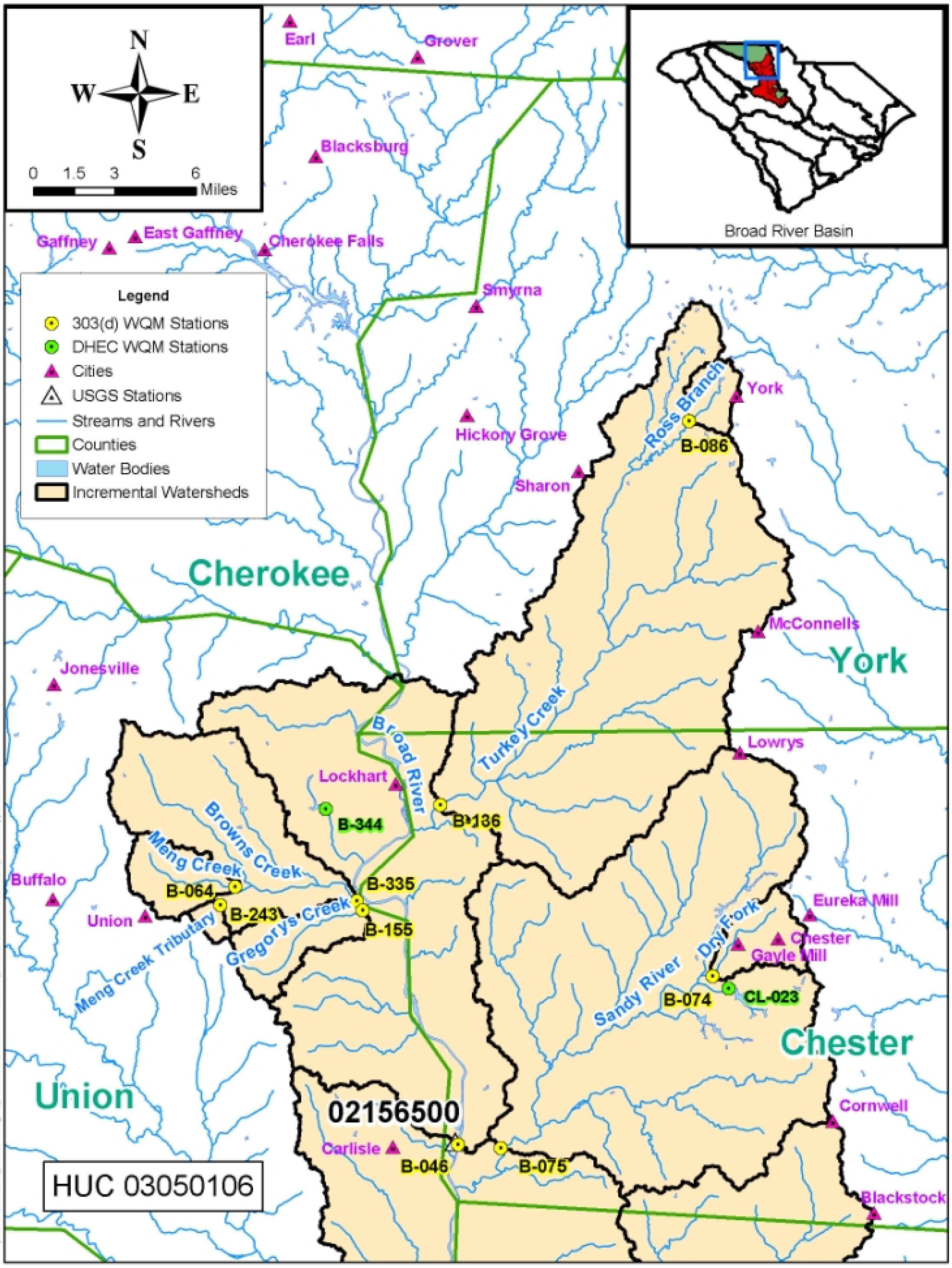
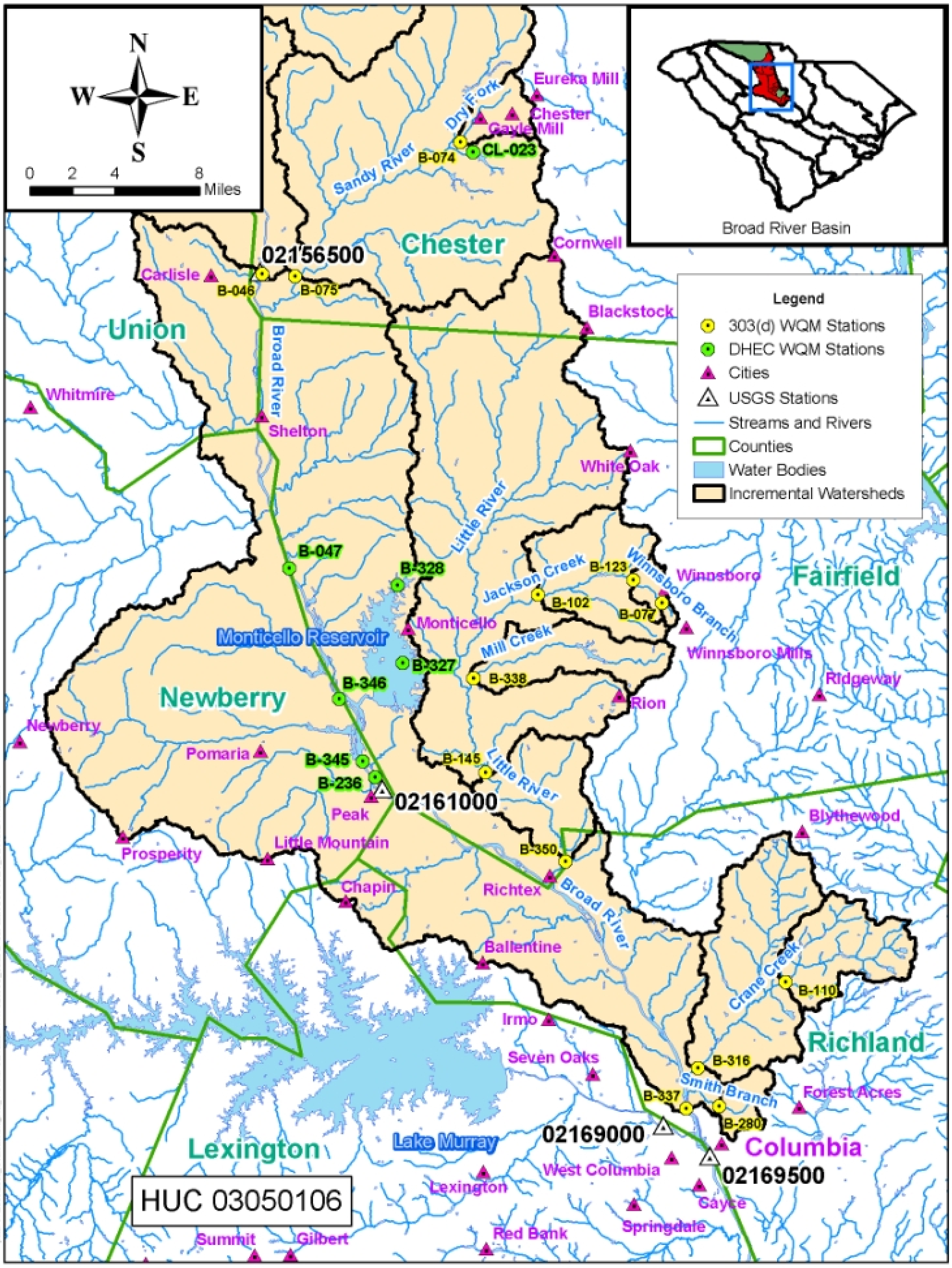


**Figure 1-2 Elizabeth Lake, Crane Creek, Smith Branch, Broad River, Little River, Winnsboro Branch, Jackson Creek, and Mill Creek Watersheds**



The 303(d)-listed WQM stations associated with these water bodies are shown in Table 1-1 below and are generally listed upstream to downstream. The WQM stations are grouped by HUCs identified with 11 digits. The presence of fecal coliform bacteria in aquatic environments indicates the receiving water is contaminated with human or animal fecal material. Fecal coliform bacteria contamination is an indication that a potential health risk exists for individuals exposed to the water. Implementation of fecal coliform bacteria loading controls will be necessary to restore the primary contact recreation use designated for each water body listed in Table 1-1.

**Table 1-1 Water Quality Monitoring Stations on 2004 303(d) List for Fecal Coliform in the Broad River Basin**

| Water Body Name | SCDHEC WQM Stations | WQM Station Locations |
|---|---|---|
| HUC 03050106020 | | |
| Ross Branch | B-086 | Ross Branch to Turkey Creek at SC 49 SW of York |
| Turkey Creek | B-136 | Turkey Creek AT SC 9, 14 mi NW of Chester |
| HUC 03050106030 | | |
| Meng Creek | B-064 | Meng Creek at SC 49 2.5 mi E of Union |
| Meng Creek | B-243 | Trib to Meng Ck at Clvrt on S-44-384 3 mi E of Union |
| Browns Creek | B-155 | Browns Creek at S-44-86, 8 mi E of Union |
| Gregorys Creek | B-335 | Gregorys Creek at S-44-86, 8 mi E of Union |
| HUC 03050106010 | | |
| Broad River | B-046 | Broad River at SC 72/215/121 3 mi E of Carlisle |
| HUC 03050106040 | | |
| Dry Fork | B-074 | Dry Fork at S-12-304 2 mi SW of Chester |
| Sandy River | B-075 | Sandy River at SC 215 2.5 mi AB Jct with Broad River |
| HUC 03050106060 | | |
| Elizabeth Lake Spillway | B-110 | Elizabeth Lake at Spillway on US 21 |
| Crane Creek | B-316 | Crane Creek at S-40-43 under I-20 - North Cola |
| Smith Branch | B-280 | Smith Branch at N Main St (US 21) in Cola |
| Broad River | B-337 | Broad River at US 176 (Broad River Rd) in Columbia |
| HUC 03050106070 | | |
| Little River | B-145 | Little River at S-20-60 3.1 mi SW of Jenkinsville |
| Little River | B-350 | Little River at SC215, 1.5 mi NE of confl. w/ Broad River |
| HUC 03050106080 | | |
| Winnsboro Branch | B-123 | Winnsboro Branch at US 321-AB Winnsboro Mills Outfall |
| Winnsboro Branch | B-077 | Winnsboro Branch below Plant Outfall |
| Jackson Creek | B-102 | Jackson Creek at S-20-54, 5 mi W of Winnsboro |
| Mill Creek | B-338 | Mill Creek at S-20-48, 10 mi SW of Winnsboro |

## 1.2 Watershed Description

**General**

Figure 1-3 depicts the upper and lower Broad River Basin which encompasses 21 11-digit HUCs and 2,252 square miles within SC, excluding the Enoree River, and Tyger River Basins. The Broad River flows across the Piedmont region of SC.

Of the approximate 1.4 million acres within the Broad River Basin, 72.1 percent is forested, 13.4 percent is agricultural, 6.9 percent is urban, 5.3 percent is scrub/shrub land, 1.8 percent is water, and 0.5 percent is barren land. The urban land percentage is composed chiefly of the Cities of Spartanburg, Gaffney, and Chester, and portions of the Cities of York, Union, and Columbia (SCDHEC 2005).

In the Broad River Basin (upper and lower), there are approximately 2,500 stream miles and 14,600 acres of lake waters. The upper Broad River flows across the North Carolina/South Carolina state line and accepts drainage from Buffalo Creek, Cherokee Creek, Kings Creek, Thicketty Creek, Bullock Creek, and the Pacolet River. These tributaries are all upstream of the study area being addressed by the TMDLs in this report. The Broad River then accepts drainage from Turkey Creek, Browns Creek, Sandy River, Little River, Jackson Creek, Mill Creek, and Cedar Creek before converging with the Saluda River in Columbia, SC (SCDHEC 2005). With the exception of Cedar Creek, these tributaries are addressed by the TMDLs in this report.

**Physiographic Regions**

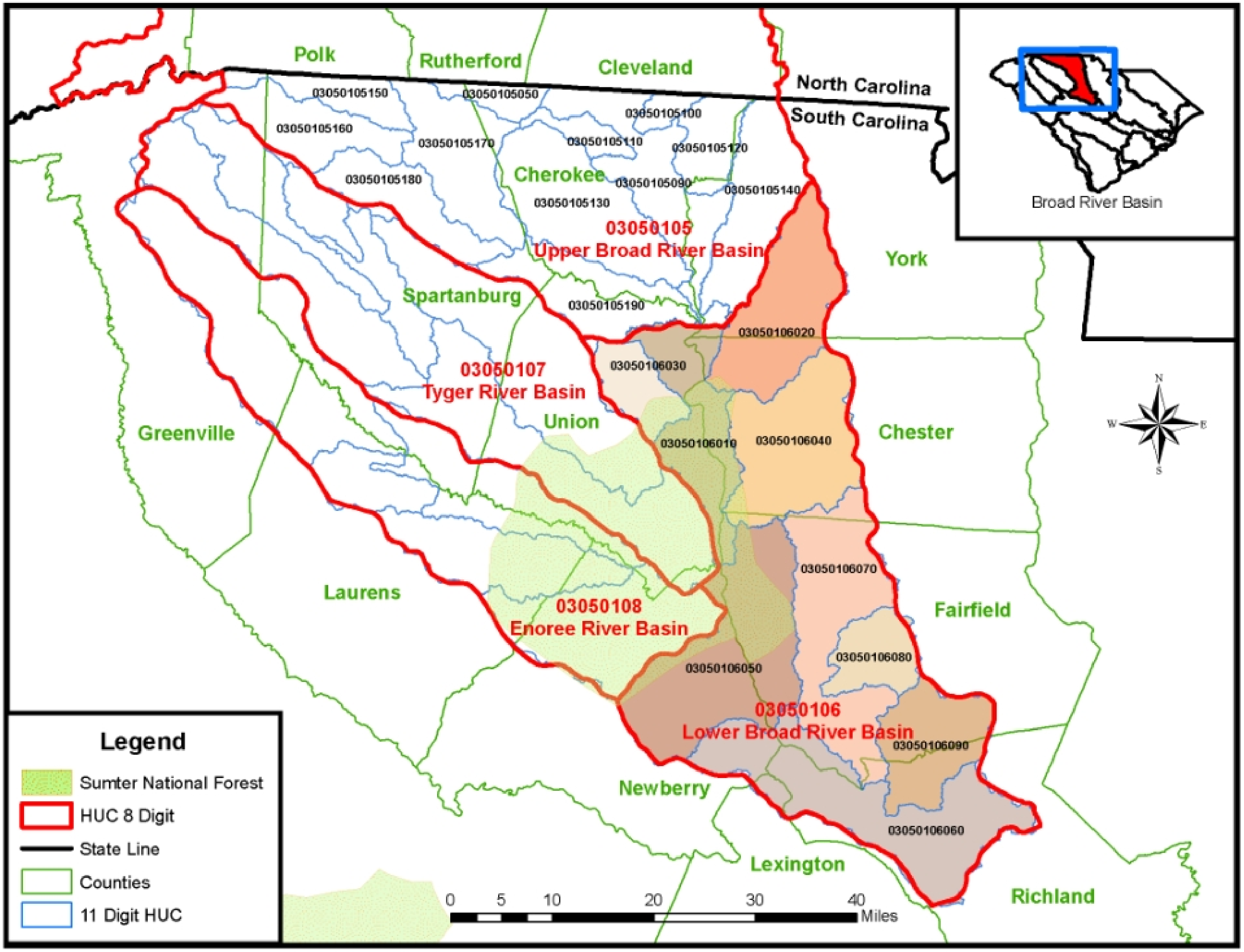
SC has been divided into six major land resource areas by the U.S. Department of Agriculture (USDA) Soil Conservation Service. The major land resource areas are physiographic regions that have soil, climate, water resources, and land uses in common. The physiographic region that defines the Broad River Basin is the Piedmont which consists of gently rolling to hilly slopes with narrow stream valleys dominated by forests, farms, and orchards; elevations range from 375 to 1,000 feet above mean sea level (SCDHEC 2001).

**Soil Types**

The dominant soil associations, or those soil series comprising, together, over 40 percent of the land area, were recorded for each watershed in percent descending order. The individual soil series for the Broad River Basin are described as follows (SCDEHC 2001):

- Alpin soil is well drained and excessively drained, sandy soil with a loamy or sandy subsoil.
- Badin soil is moderately deep, well drained, moderately permeable, clayey soil that formed on ridge tops and side slopes in material weathered from Carolina Slate or other fine-grained rock.
- Cecil soil is deep, well drained, gently sloping to sloping soil that has red subsoil.
- Georgeville soil is gently sloping to sloping, well-drained and moderately well-drained.

**Figure 1-3 Broad River Basin: 8- and 11-Digit HUCs**



- Goldston soil is dominantly sloping to steep, well-drained to excessively drained.
- Helena soil is gently sloping to sloping, moderately well-drained to well-drained.
- Herndon soil is gently sloping to sloping, well-drained and moderately well-drained.
- Hiwassee soil is well-drained, moderately sloping with a moderately deep clayey subsoil.
- Madison soil is well-drained, moderately sloping with a moderately deep clayey subsoil.
- Pacolet soil is well drained, moderately steep with a moderately deep clayey subsoil.
- Tatum soil is predominantly sloping to steep, well-drained to excessively drained, with a loamy subsoil, moderately deep or shallow to weathered rock.
- Wilkes soil is predominantly strongly sloping to steep, and well-drained.
- Winnsboro soil is well drained, gently sloping to steep, moderately deep to deep clayey.

**Slope and Erodibility**

The definition of soil erodibility differs from that of soil erosion. Soil erosion may be more influenced by slope, rainstorm characteristics, cover, and land management than by soil properties. Soil erodibility refers to the properties of the soil itself which cause it to erode more or less easily than others when all other factors are constant. This is an important characteristic because it allows for an understanding of whether any given soil type is prone to erosion and thus likely to transport fecal coliform to receiving waters. The soil erodibility factor, K, is the rate of soil loss per erosion index unit as measured on a unit plot, and represents an average value for a given soil. The K factor value reflects the combined effects of all the soil properties that significantly influence the ease of soil erosion by rainfall and runoff if not protected. The K factor values closer to 1.0 represent higher soil erodibility and a greater need for best management practices (BMP) to minimize erosion and contain those sediments that erode. The range of K-factor values in the Broad River Basin is from 0.15 to 0.39 (SCDHEC 2001) suggesting that the soils are not highly prone to erosion during periods of stormwater runoff.

**Rainfall**

Normal yearly rainfall in the lower Broad River Basin during the period 1971 to 2000 ranged from 46.72 inches in Chester to 47.43 inches in Columbia (SCDNR 2005).

**Land Use**

Tables 1-2 and 1-3 summarize general land use categories and associated percentages for the contributing watersheds upstream of each 303(d)-listed WQM station. The land use/land cover data were derived from 1996 U.S. Geological Survey (USGS) Multi-Resolution Land Characteristic land use data (USGS 2005). Figures 1-4 and 1-5 depict the land use categories occurring within the watersheds described in this report. A summary of the land use characteristics for the watershed associated with each WQM station is provided below. Only the major land use categories are identified in the narrative summaries below. For multiple WQM stations on the same water body, the acreage totals in Table 1-2 only represent the subwatershed associated with each WQM station below the next upstream station.

**B-086 - Ross Branch to Turkey Creek at SC 49, Southwest of York**

Ross Branch, located in York County, is the primary drainage way for the west side of the Town of York and a tributary to Turkey Creek. The headwater of Ross Branch is Lake Carolyn, located northwest of the intersection of State Highway (SH) 05 and U.S. Highway 321 (SCDHEC 2001).

The watershed for WQM station B-086 contains 2,596 acres. Approximately 19 percent of the watershed is urban (Town of York), and 44 percent is forest. Pastures and row crops compose approximately 16 and 18 percent, respectively. The predominant soil types consist of an association of the Wilkes-Cecil-Madison series. The K-factor of the soil averages 0.26, and the slope of the terrain averages 12 percent, with a range of 2-40 percent.

**B-136 - Turkey Creek at SC 9, 14 Miles Northwest of Chester**

Turkey Creek originates near the Town of York, flowing out of Caldwell Lake and accepting drainage from Ross Branch (Lake Carolyn), Dry Fork, Little Turkey Creek (McClures Branch, Lindsey Creek), and Bryson Creek. Farther downstream, Blue Branch enters Turkey Creek followed by Rainey Branch (Palmer Branch), Susybole Creek (Little Susybole Creek), Mill Creek (Rodens Creek), and McKelvy Creek. There are a few ponds and lakes (totaling 100.5 acres) in this watershed, and a total of 190.9 stream miles. The southern tip of the watershed lies within the Sumter National Forest (SCDHEC 2001).

The watershed for WQM station B-136, located in Chester County, contains 87,998 acres. Less than 1 percent is residential associated with the small towns of Sharon, McConnells, and Lowrys. Approximately 79 percent is forest. Pastures and row crops are approximately 5 percent and 6 percent, respectively. The predominant soil type consists of an association of the Wilkes-Cecil-Madison series. The K-factor of the soil averages 0.26, and the slope of the terrain averages 12 percent, with a range of 2-40 percent (SCDHEC 2001).

**B-064 - Meng Creek at SC 49, 2.5 Miles East of Union**

Meng Creek, located in Union County, drains the northeastern quadrant of the Town of Union. The creek is a tributary to Big Browns Creek which merges with Little Browns Creek to form Browns Creek. WQM station B-064 is above the confluence with Big Browns Creek at SH 49.

The watershed for WQM station B-064 contains 5,077 acres. Approximately 20 percent is urban (Town of Union), and approximately 67 percent is forest. Pastures and row crops cover approximately 2 percent and 10 percent, respectively. The predominant soil type consists of an association of the Madison-Cecil-Wilkes series. The K-factor of the soil averages 0.26, and the slope of the terrain averages 13 percent, with a range of 2 percent to 40 percent (SCHDEC 2001).

**B-243 - Tributary to Meng Creek at Culvert on S-44-384, 3 Miles East of Union**

The watershed for WQM station B-243, located in Union County, contains 910 acres. Approximately 13 percent of the watershed is urban (southeast side of the City of Union), and approximately 77 percent is forest. Pastures and row crops compose approximately 1 percent and 8 percent, respectively.

**B-155 - Browns Creek at S-44-86, 8 Miles East of Union**

The watershed for WQM station B-155 contains 21,692 acres. Less than 1 percent is residential. Approximately 71 percent is forest, with the southern part of the watershed lying within of the Sumter National Forest. Pastures and row crops occupy approximately 9 percent and 17 percent, respectively.

**B-335 - Gregorys Creek at S-44-86, 8 Miles East of Union**

The watershed for WQM station B-335, which is entirely within Union County, contains 6,094-acres. Approximately 91 percent of the watershed is forest. Pastures and row crops cover approximately 1 percent and 5 percent, respectively.

**B-046 - Broad River at SC 72/215/121, 3 Miles East of Carlisle**

This segment of the Broad River Basin begins at the southern tip of Cherokee County and ends at the SH 72 bridge, approximately 3 miles east of the Town of Carlisle. The watershed for WQM station B-046 contains 68,154 acres. Less than 1 percent is occupied by houses and businesses. Approximately 79 percent is forest, with the lower half containing a portion of the Sumter National Forest. Pastures and row crops are found in approximately 4 percent and 6 percent of the total area, respectively. The predominant soil type consists of an association of the Wilkes-Pacolet-Winnsboro series. The K-factor of the soil averages 0.24, and the slope of the terrain averages 21 percent, with a range of 6 percent to 40 percent (SCDHEC 2001).

**B-074 - Dry Fork at S-12-304, 2 Miles Southwest of Chester**

Dry Fork is a tributary of Sandy River. The watershed for WQM station B-074 contains 4,676 acres. This watershed drains the west side of the Town of Chester, which composes 41 percent to the total area and also includes the community of Gayle Mill. Forest land occupies 49 percent of the watershed, and pastures and row crops cover approximately 2 percent and 7 percent, respectively.

**B-075 - Sandy River at SC 215, 2.5 Miles above Confluence with Broad River**

The Sandy River accepts drainage from Chapel Branch and flows through Chester Reservoir (80 acres) near the City of Chester. Downstream from the reservoir, Dry Fork enters the Sandy River followed by Caney Fork Creek (Chester State Park Lake, Twomile Branch, Threemile Branch), Carter Branch, Bear Branch (Mountain Lakes), and Seely Creek (Julies Fork, Walkers Mill Branch, Rock Branch, Bond Branch, Long Branch, Gum Spring Branch). Farther downstream, Sandy River accepts drainage from Rocky Branch, Brushy Fork Creek (Smith Creek, Starne Branch), the Little Sandy River (Mobley Creek, Coon Creek), and Johns Creek. Chester State Park is located in this watershed and extends over Twomile Branch and Threemile Branch near the City of Chester. There are several ponds and lakes (10-138 acres) in this watershed used for recreational and municipal purposes, and a total of 156.2 stream miles (SCDHEC 2001). The southern tip of the watershed lies within the Sumter National Forest. The watershed for WQM station B-075 contains 91,355 acres. Less than 1.5 percent is occupied by residential or commercial land use. Approximately 84 percent of the total area is forest. Pastures and row crops cover approximately 5 percent and 7 percent, respectively. The predominant soil type consists of an association of the Wilkes-Madison series. The K-factor of the soil averages 0.26; the slope of the terrain averages 14 percent, with a range of 2 percent to 40 percent (SCDHEC 2001).

**B-110 - Elizabeth Lake at Spillway on U.S. Highway 21**

The upper Crane Creek watershed, located in Richland County, contains 13,680 acres and several small lakes, including Elizabeth Lake. Elizabeth Lake is surrounded primarily by forest and undeveloped lands. The five lakes in the upper Crane Creek watershed are surrounded or partially surrounded by subdivisions. Approximately 14 percent of the total area is occupied by residential or commercial/industrial structures. Pastures and row crops cover approximately 1 percent and 21 percent, respectively. Forest covers approximately 57 percent of the watershed.

**B-316 - Crane Creek at S-40-43 under I-20, North Columbia**

The Crane Creek watershed has a high potential for economic growth. The WQM station is under the Interstate Highway (IH) 20 bridge in Richland County. The watershed for WQM station B-316 contains 28,997 acres. Approximately 17 percent is urban (City of Columbia), and approximately 69 percent is forest. Pastures and row crops occupy approximately 1 percent and 7 percent, respectively.

**B-280 - Smith Branch at North Main St (U.S. Highway 21) in Columbia**

Smith Branch is the most downstream tributary to the Broad River described in this report. WQM station B-280, located in Richland County, contains 3,583 acres and is the most urbanized watershed of the study area. Approximately 81 percent of the watershed is urban (City of Columbia), approximately 15 percent is forest, and row crops compose approximately 2 percent.

**B-337 - Broad River at U.S. Highway 176 (Broad River Road) in Columbia**

The watershed for WQM station B-337 is the largest included in this report containing, 160,261 acres and comprising all of HUCs 03050106 -050, and -060. This WQM station of the Broad River accepts drainage from its upper reaches (HUCs 03050105-094, 03050106-010, 03050106-050) together with Mayo Creek, Crims Creek (Rocky Creek, Summers Branch), Wateree Creek (Risters Creek), Boone Creek, Freshley Branch, Mussel Creek, and the Little River Watershed. Hollingshead Creek (Boyd Branch, Wildhorse Branch, Metz Branch, Hope Creek, Bookman Creek) enters the river next followed by the Cedar Creek watershed, Nipper Creek, Nicholas Creek (Swygert Branch, Moccasin Branch), Slatestone Creek, and Burgess Creek. Crane Creek and Smith Branch enter the river at the base of the watershed near the City of Columbia. Sorghum Branch, Dry Branch (Crescent Lake, Stevensons Lake), Elizabeth Lake (60 acres), and Cumbess Creek drain into Crane Creek followed by North Crane Creek. North Cane Creek accepts drainage from Beasley Creek (Robertson Branch, Lot Branch, Hawkins Branch), Swygert Creek, Dry Fork Creek, and Long Branch. There are several ponds and lakes (10-60 acres) in this watershed used for recreational and irrigational purposes, and a total of 311.6 stream miles.

Approximately 3 percent of the watershed is occupied by houses and businesses, which includes northwest Columbia, the Town of Peak, and portions of the towns of Chapin, Little Mountains, and Pomaria, (combined total of 4,197 acres). Approximately 82 percent is forest. Pastures and row crops are approximately 2 percent and 3 percent, respectively.

**B-145 - Little River at S-20-60, 3.1 Miles Southwest of Jenkinsville**

Big Creek and Little Creek join to form the headwaters of the Little River near the Town of Blackstock. Downstream of the confluence, the Little River accepts drainage from Camp Branch, Brushy Fork Creek (Dumpers Creek), the West Fork Little River (Weir

Creek, Spring Branch, Williams Creek, Opossum Branch), Lick Branch, and Harden Branch. The Jackson Creek watershed drains into Little River, next followed by Crumpton Creek, the Mill Creek Watershed, Morris Creek, and Gibson Branch (Manns Branch, Russell Creek). There are a few ponds and lakes in this watershed used for recreational and industrial purposes. The watershed for WQM station B-145 contains 106,711 acres. Less than 1 percent of the total area is residential. Approximately 85 percent is forest. Pastures and row crops cover approximately 2 percent and 3 percent, respectively. The predominant soil type consists of an association of the Wilkes-Cecil series. The K-factor of the soil averages 0.26; the slope of the terrain averages 14 percent, with a range of 2 percent to 40 percent (SCDHEC 2001).

**B-350 - Little River at SC215, 1.5 Miles Northeast of Confluence with Broad River**

This downstream segment of the Little River drains into the Broad River. Home Branch is a tributary. The watershed for WQM station B-350 contains 13,862 acres. Less than 1 percent of the watershed is urban land use. Approximately 87 percent of the watershed is covered by forest and 3 percent by row crops. Approximately 9 percent is classified as transitional land use, areas of sparse vegetative cover (less than 25 percent of cover) that are dynamically changing from one land cover to another, often because of land development activities (USGS 2005a).

**B-123 - Winnsboro Branch at U.S. Highway 321, Above Winnsboro Mills Outfall**

Winnsboro Branch, located in Fairfield County, is a tributary to Jackson Creek. WQM station B-123 monitors the upper portion of Winnsboro Branch and is the smallest watershed in the study area at only 440 acres. Approximately 65 percent of the watershed is urban land use (Town of Winnsboro). Approximately 26 percent is forest. Pastures and row crops are approximately 2 and 3 percent, respectively.

**B-077 - Winnsboro Branch below Plant Outfall**

The water quality of the lower part of Winnsboro Branch is monitored at WQM station B-077. The watershed, located in Fairfield County, contains 2,114 acres. Approximately 27 percent of the watershed is houses and businesses (Town of Winnsboro). Approximately 55 percent is forest. Pastures and row crops compose approximately 4 percent and 10 percent, respectively.

**B-102 - Jackson Creek at S-20-54, 5 Miles West of Winnsboro**

Jackson Creek, located in Fairfield County, is a tributary of Little River. The watershed for WQM station B-102 contains 16,752 acres. Approximately 3 percent of this acreage is occupied by houses and businesses. Approximately 85 percent is forest. Pastures and row crops compose approximately 4 percent and 6 percent, respectively.

**B-338 - Mill Creek at S-20-48, 10 Miles Southwest of Winnsboro**

Mill Creek is a tributary to the Little River. The watershed for WQM station B-338, located in Fairfield County, contains 12,675 acres. Only 2 percent of this acreage is occupied by houses and businesses. Approximately 75 percent is forest. Pastures and row crops cover approximately 8 percent each.

**Table 1-2 Land Use Summary for Watersheds of 303(d)-Listed WQM Stations in the Lower Broad River**

| Description | Code | B-086 | B-136 | B-064 | B-243 | B-155 | B-335 | B-046 | B-074 | B-075 |
|---|---|---|---|---|---|---|---|---|---|---|
| Open Water | 11 | 30 | 224 | 20 | 0 | 67 | 3 | 1,176 | 13 | 560 |
| Open Water Percent | 11 | 1.15 | 0.25 | 0.40 | 0.02 | 0.31 | 0.05 | 1.73 | 0.29 | 0.61 |
| Low Intensity Residential | 21 | 288 | 166 | 641 | 69 | 129 | 1 | 175 | 927 | 342 |
| Low Intensity Residential Percent | 21 | 11.10 | 0.19 | 12.63 | 7.60 | 0.59 | 0.01 | 0.26 | 19.83 | 0.37 |
| High Intensity Residential | 22 | 109 | 6 | 108 | 18 | 3 | 0 | 15 | 462 | 6 |
| High Intensity Residential Percent | 22 | 4.19 | 0.01 | 2.12 | 1.94 | 0.02 | 0.00 | 0.02 | 9.88 | 0.01 |
| High Intensity Commercial/Industrial/Transportation | 23 | 87 | 75 | 267 | 29 | 52 | 7 | 128 | 509 | 231 |
| High Intensity Commercial/Indust./Trans. Percent | 23 | 3.34 | 0.09 | 5.27 | 3.23 | 0.24 | 0.12 | 0.19 | 10.89 | 0.25 |
| Bare Rock/Sand/Clay | 31 | 15 | 114 | 20 | 4 | 42 | 10 | 68 | 25 | 150 |
| Bare Rock/Sand/Clay Percent | 31 | 0.57 | 0.13 | 0.39 | 0.40 | 0.19 | 0.17 | 0.10 | 0.54 | 0.16 |
| Quarries/Strip Mines/Gravel Pits | 32 | 0 | 57 | 0 | 0 | 65 | 8 | 17 | 0 | 5 |
| Quarries/Strip Mines/Gravel Pits Percent | 32 | 0.00 | 0.06 | 0.00 | 0.00 | 0.30 | 0.12 | 0.02 | 0.00 | 0.01 |
| Transitional | 33 | 0 | 7,780 | 0 | 0 | 29 | 110 | 5,179 | 0 | 2,545 |
| Transitional Percent | 33 | 0.00 | 8.84 | 0.00 | 0.00 | 0.13 | 1.80 | 7.60 | 0.00 | 2.79 |
| Deciduous Forest | 41 | 340 | 31,902 | 1,698 | 491 | 7,972 | 1,831 | 22,312 | 446 | 27,371 |
| Deciduous Forest Percent | 41 | 13.10 | 36.25 | 33.44 | 53.97 | 36.75 | 30.05 | 32.74 | 9.55 | 29.96 |
| Evergreen Forest | 42 | 481 | 24,080 | 1,030 | 87 | 4,917 | 2,780 | 22,369 | 1,299 | 34,491 |
| Evergreen Forest Percent | 42 | 18.53 | 27.36 | 20.28 | 9.60 | 22.67 | 45.61 | 32.82 | 27.78 | 37.75 |
| Mixed Forest | 43 | 323 | 13,200 | 653 | 119 | 2,670 | 962 | 8,961 | 509 | 14,611 |
| Mixed Forest Percent | 43 | 12.43 | 15.00 | 12.85 | 13.02 | 12.31 | 15.79 | 13.15 | 10.89 | 15.99 |
| Pasture/Hay | 81 | 406 | 4,650 | 79 | 9 | 1,872 | 66 | 2,542 | 101 | 4,317 |
| Pasture/Hay Percent | 81 | 15.62 | 5.28 | 1.56 | 0.96 | 8.63 | 1.08 | 3.73 | 2.16 | 4.73 |
| Row Crops | 82 | 465 | 5,282 | 502 | 74 | 3,755 | 304 | 4,354 | 332 | 6,388 |
| Row Crops Percent | 82 | 17.90 | 6.00 | 9.88 | 8.17 | 17.31 | 4.99 | 6.39 | 7.10 | 6.99 |
| Other Grasses (Urban/recreational) | 85 | 46 | 102 | 43 | 10 | 15 | 0 | 13 | 36 | 23 |
| Other Grasses (Urban/recreational) Percent | 85 | 1.75 | 0.12 | 0.84 | 1.06 | 0.07 | 0.00 | 0.02 | 0.77 | 0.03 |
| Woody Wetlands | 91 | 7 | 331 | 17 | 0 | 99 | 12 | 812 | 13 | 284 |
| Woody Wetlands Percent | 91 | 0.28 | 0.38 | 0.34 | 0.02 | 0.46 | 0.20 | 1.19 | 0.28 | 0.31 |
| Emergent Herbaceous Wetlands | 92 | 1 | 27 | 0 | 0 | 4 | 0 | 32 | 2 | 32 |
| Emergent Herbaceous Wetlands Percent | 92 | 0.04 | 0.03 | 0.01 | 0.00 | 0.02 | 0.01 | 0.05 | 0.04 | 0.03 |
| | | | | | | | | | | |
| Total Acres | | 2,596 | 87,998 | 5,077 | 910 | 21,692 | 6,094 | 68,154 | 4,676 | 91,355 |

**Table 1-2 Land Use Summary for Watersheds of 303(d)-Listed WQM Stations in the Lower Broad River (cont'd)**

| Description | Code | B-110 | B-316 | B-280 | B-337 | B-145 | B-350 | B-123 | B-077 | B-102 | B-338 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Open Water | 11 | 257 | 192 | 0 | 5,205 | 187 | 13 | 0 | 8 | 51 | 232 |
| Open Water Percent | 11 | 1.88 | 0.66 | 0.00 | 3.25 | 0.18 | 0.10 | 0.04 | 0.38 | 0.30 | 1.83 |
| Low Intensity Residential | 21 | 1,135 | 2,335 | 719 | 2,220 | 87 | 10 | 117 | 300 | 226 | 48 |
| Low Intensity Residential Percent | 21 | 8.30 | 8.05 | 20.06 | 1.39 | 0.08 | 0.08 | 26.70 | 14.20 | 1.35 | 0.38 |
| High Intensity Residential | 22 | 413 | 1,343 | 1,184 | 819 | 0 | 0 | 69 | 119 | 28 | 2 |
| High Intensity Residential Percent | 22 | 3.02 | 4.63 | 33.04 | 0.51 | 0.00 | 0.00 | 15.62 | 5.64 | 0.17 | 0.01 |
| High Intensity Commercial/Industrial/Transportation | 23 | 416 | 1,199 | 939 | 1,159 | 154 | 1 | 96 | 153 | 196 | 96 |
| High Intensity Commercial/Indust./Trans. Percent | 23 | 3.04 | 4.13 | 26.22 | 0.72 | 0.14 | 0.01 | 21.91 | 7.25 | 1.17 | 0.76 |
| Bare Rock/Sand/Clay | 31 | 89 | 131 | 68 | 269 | 67 | 3 | 2 | 19 | 30 | 15 |
| Bare Rock/Sand/Clay Percent | 31 | 0.65 | 0.45 | 1.90 | 0.17 | 0.06 | 0.03 | 0.51 | 0.88 | 0.18 | 0.12 |
| Quarries/Strip Mines/Gravel Pits | 32 | 27 | 114 | 0 | 903 | 44 | 3 | 0 | 0 | 0 | 4 |
| Quarries/Strip Mines/Gravel Pits Percent | 32 | 0.20 | 0.39 | 0.00 | 0.56 | 0.04 | 0.02 | 0.00 | 0.00 | 0.00 | 0.03 |
| Transitional | 33 | 0 | 100 | 0 | 8,890 | 10,650 | 1,260 | 0 | 0 | 51 | 630 |
| Transitional Percent | 33 | 0.00 | 0.34 | 0.00 | 5.55 | 9.98 | 9.09 | 0.00 | 0.00 | 0.30 | 4.97 |
| Deciduous Forest | 41 | 3,419 | 8,414 | 76 | 42,273 | 28,271 | 3,777 | 27 | 380 | 3,942 | 2,753 |
| Deciduous Forest Percent | 41 | 24.99 | 29.02 | 2.13 | 26.38 | 26.49 | 27.24 | 6.25 | 17.96 | 23.53 | 21.72 |
| Evergreen Forest | 42 | 2,917 | 8,013 | 268 | 67,147 | 48,028 | 6,309 | 53 | 530 | 7,416 | 5,021 |
| Evergreen Forest Percent | 42 | 21.32 | 27.63 | 7.49 | 41.90 | 45.01 | 45.51 | 12.07 | 25.09 | 44.27 | 39.62 |
| Mixed Forest | 43 | 1,584 | 3,516 | 160 | 21,217 | 14,067 | 1,933 | 32 | 254 | 2,947 | 1,769 |
| Mixed Forest Percent | 43 | 11.58 | 12.13 | 4.47 | 13.24 | 13.18 | 13.94 | 7.36 | 12.04 | 17.59 | 13.96 |
| Pasture/Hay | 81 | 155 | 293 | 0 | 3,807 | 1,874 | 145 | 11 | 91 | 728 | 979 |
| Pasture/Hay Percent | 81 | 1.14 | 1.01 | 0.00 | 2.38 | 1.76 | 1.04 | 2.40 | 4.30 | 4.35 | 7.72 |
| Row Crops | 82 | 2,882 | 2,088 | 65 | 5,105 | 2,913 | 357 | 15 | 211 | 1,014 | 1,032 |
| Row Crops Percent | 82 | 21.07 | 7.20 | 1.82 | 3.19 | 2.73 | 2.58 | 3.38 | 9.97 | 6.05 | 8.14 |
| Other Grasses (Urban/recreational) | 85 | 39 | 140 | 101 | 235 | 7 | 0 | 15 | 30 | 13 | 12 |
| Other Grasses (Urban/recreational) Percent | 85 | 0.28 | 0.48 | 2.83 | 0.15 | 0.01 | 0.00 | 3.51 | 1.41 | 0.08 | 0.10 |
| Woody Wetlands | 91 | 345 | 1,067 | 2 | 956 | 355 | 52 | 1 | 18 | 106 | 71 |
| Woody Wetlands Percent | 91 | 2.52 | 3.68 | 0.05 | 0.60 | 0.33 | 0.37 | 0.26 | 0.84 | 0.63 | 0.56 |
| Emergent Herbaceous Wetlands | 92 | 1 | 54 | 0 | 55 | 7 | 0 | 0 | 1 | 5 | 11 |
| Emergent Herbaceous Wetlands Percent | 92 | 0.01 | 0.19 | 0.00 | 0.03 | 0.01 | 0.00 | 0.00 | 0.04 | 0.03 | 0.09 |
| | | | | | | | | | | | |
| Total Acres | | 13,680 | 28,997 | 3,583 | 160,261 | 106,711 | 13,862 | 440 | 2,114 | 16,752 | 12,675 |

**Figure 1-4 Land Use Map for: Turkey Creek, Meng Creek, Browns Creek, Gregory Creek, Sandy Creek, Dry Fork and Broad River Watersheds**

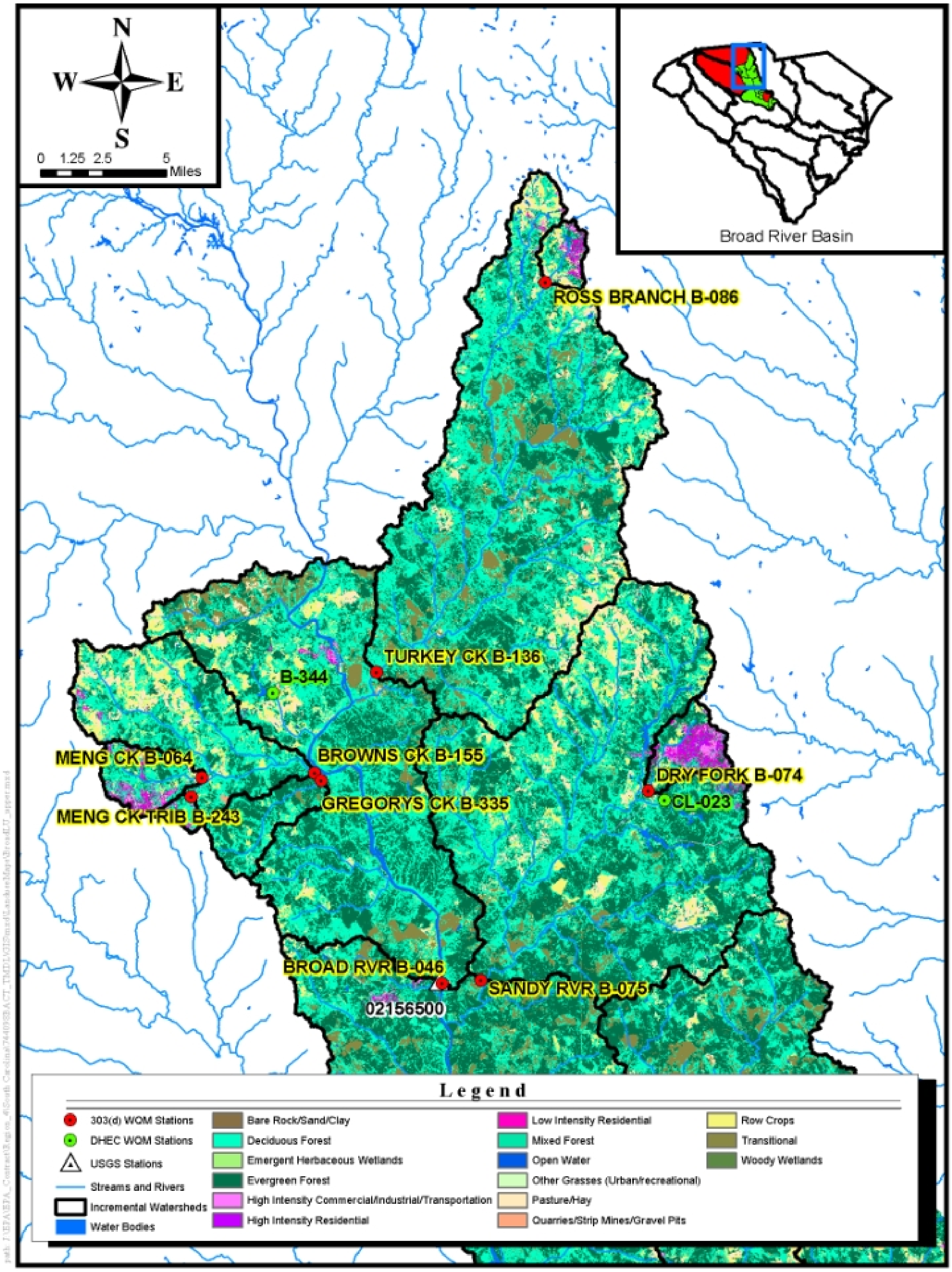
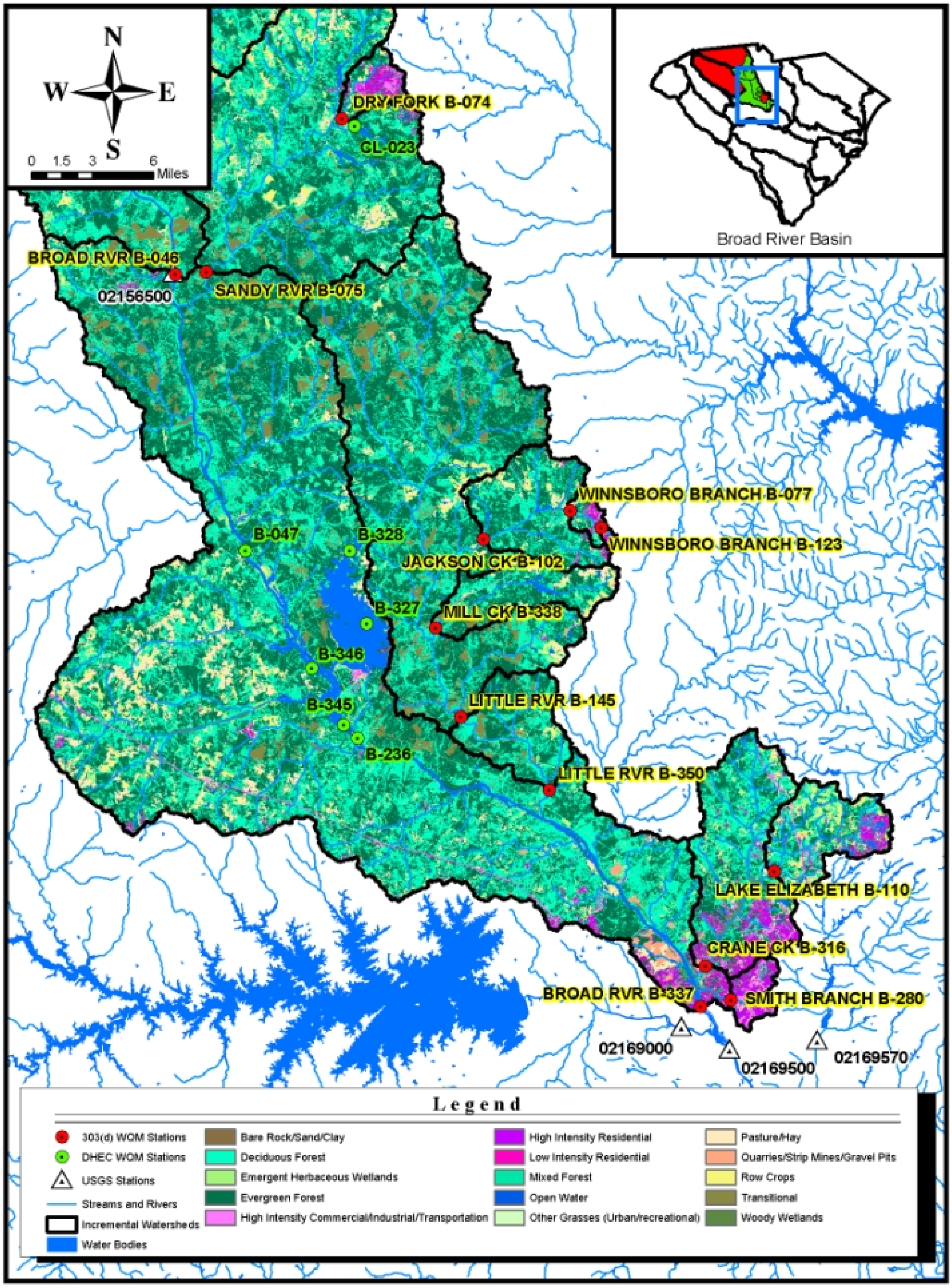


**Figure 1-5 Land Use Map for: Elizabeth Lake, Crane Creek, Smith Branch, Broad River, Little River, Winnsboro Branch, Jackson Creek, and Mill Creek Watersheds**



# SECTION 2
# WATER QUALITY ASSESSMENT

## 2.1 Water Quality Standards

Water quality standards for SC were promulgated in the South Carolina Pollution Control Act, Section 48-1-10 *et seq*. Chapter 61, R61-68 (SCDHEC 2001a). All water bodies in the Broad River Basin are designated as freshwater. Waters of this class are defined in Regulation 61-68, §610, *Water Classifications and Standards,* and designated uses are described as follows:

> *Freshwater 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. These waters are suitable for fishing and the survival and propagation of a balanced indigenous aquatic community of fauna and flora. This class is also suitable for industrial and agricultural uses.* (SCDHEC 2001a)

South Carolina's numeric criteria for fecal coliform bacteria to protect for primary contact recreation use in freshwater are:

> *Not to exceed a geometric mean of 200 cfu/100ml, based on five consecutive samples during any 30 day period; nor shall more than 10 percent of the total samples during any 30 day period exceed 400 cfu/100ml.* (SCDHEC 2001a)

The State of South Carolina Integrated Report for 2004 identified the WQM stations requiring fecal coliform TMDLs (SCDHEC 2004). Fecal coliform bacteria monitoring data collected primarily by the SCDHEC Bureau of Water from 1998 through 2002 were used in the 2004 303(d) listing procedure. While SC WQSs stipulate two separate water quality criteria for assessing primary contact recreation, there are insufficient data available to calculate the 30-day geometric mean since most water quality samples are collected once a month. As a result, monitoring stations with greater than 10 percent of the samples exceeding 400 cfu/100 ml were considered impaired and were placed on the list for TMDL development. Targeting the instantaneous criterion of 400 cfu/100 ml as the water quality goal corresponds to the basis for 303(d) listing and is expected to be protective of the geometric mean criterion as well.

## 2.2 Assessment of Existing Water Quality Data

Table 2-1 summarizes data supporting the decision to place the WQM stations targeted in this report on the SCDHEC 2004 303(d) list. Additional ambient fecal coliform data for each WQM station from 1990 to 2002 are provided in Appendix A. Ambient fecal coliform data were provided by SCDHEC and obtained from USEPA Storage and Retrieval Database (USEPA 2005).

Some of the fecal coliform data were for the most part collected only during May through October (B-086, B-064, B-243, B-335, B-074, B-110, B-145, B-123, and B-077), while other stations were sampled throughout the year (B-136, B-155, B-046, B-075, B-316, B-280, B-337, B-350, B-102, and B-338). However, because bacteria load delivery mechanisms such as rainfall runoff occur over the course of the year, it is assumed that winter loading should be similar with that of periods for which data do exist (SCDHEC 2003).

Between 11 and 100 percent of the samples collected at the 19 WQM stations from 1998 to 2002 exceeded the WQS for primary contact recreation. Eight of 19 stations exceeded the WQS in more than 50 percent of the samples collected. All samples collected at WQM station B-086 (below the Town of York) and 94 percent of the samples collected at WQM station B-064 (below the Town of Union) exceeded the 400 cfu/100 ml WQS between May 1998 and October 2000. Potential sources of fecal coliform are discussed in Section 3 of this report.

**Table 2-1 Fecal Coliform Bacteria Observed from 1998 through 2002**

| WQM Station | Total Number of Samples | Maximum Concentration cfu/100 ml | Total Number of Samples > 400 cfu/100 ml | Percentage of Samples > 400 cfu/100 ml |
|---|---|---|---|---|
| B-086 | 18 | 6,600 | 18 | 100% |
| B-136 | 33 | 4,200 | 8 | 24% |
| B-064 | 17 | 4,000 | 12 | 71% |
| B-243 | 17 | 1,900 | 13 | 76% |
| B-155 | 36 | 3,300 | 8 | 22% |
| B-335 | 13 | 3,300 | 6 | 46% |
| B-046 | 59 | 3,900 | 14 | 24% |
| B-074 | 23 | 3,300 | 17 | 74% |
| B-075 | 40 | 8,100 | 13 | 33% |
| B-110 | 18 | 1,500 | 2 | 11% |
| B-316 | 35 | 6,000 | 4 | 11% |
| B-280 | 36 | 40,000 | 32 | 89% |
| B-337 | 37 | 2,300 | 5 | 14% |
| B-145 | 24 | 3,000 | 5 | 21% |
| B-350 | 25 | 4,000 | 7 | 28% |
| B-123 | 18 | 20,000 | 13 | 72% |
| B-077 | 19 | 3,800 | 11 | 58% |
| B-102 | 37 | 2,200 | 7 | 19% |
| B-338 | 36 | 2,800 | 20 | 56% |

Additional analyses were performed using fecal coliform data and precipitation data from the period 1994 through 2002 to develop a better understanding of the potential relationship between rainfall and elevated fecal coliform bacteria loads in individual watersheds. Precipitation data from local National Oceanic and Atmospheric Administration (NOAA) weather stations were plotted against SCDHEC ambient fecal coliform data at each WQM station to evaluate the potential statistical relationship. Rainfall data for a 3-day period (2 days prior to and the day of each fecal coliform sample collection date) selected from weather stations proximal to each WQM station were averaged. Data from the NOAA weather monitoring stations at Columbia Metro Airport, Columbia Owens Airport, Rock Hill/York County Airport, and downtown Greenville, SC, were used to generate the plots (NOAA 2005). Plots for each WQM station and a map showing the location of the NOAA weather stations and their station identification numbers are provided in Appendix B.

This comparison of fecal coliform concentration with the 3-day average rainfall was not conducted for seven of the WQM stations (B-086, B-064, B-243, B-335, B-B074, B-075, B-077 because no rainfall occurred on any dates of the fecal coliform samples recorded from these stations. Nor were plots prepared for WQM stations B-136, B-155 and B-046 since only one rainfall event was measured in association with a fecal coliform sampling event.

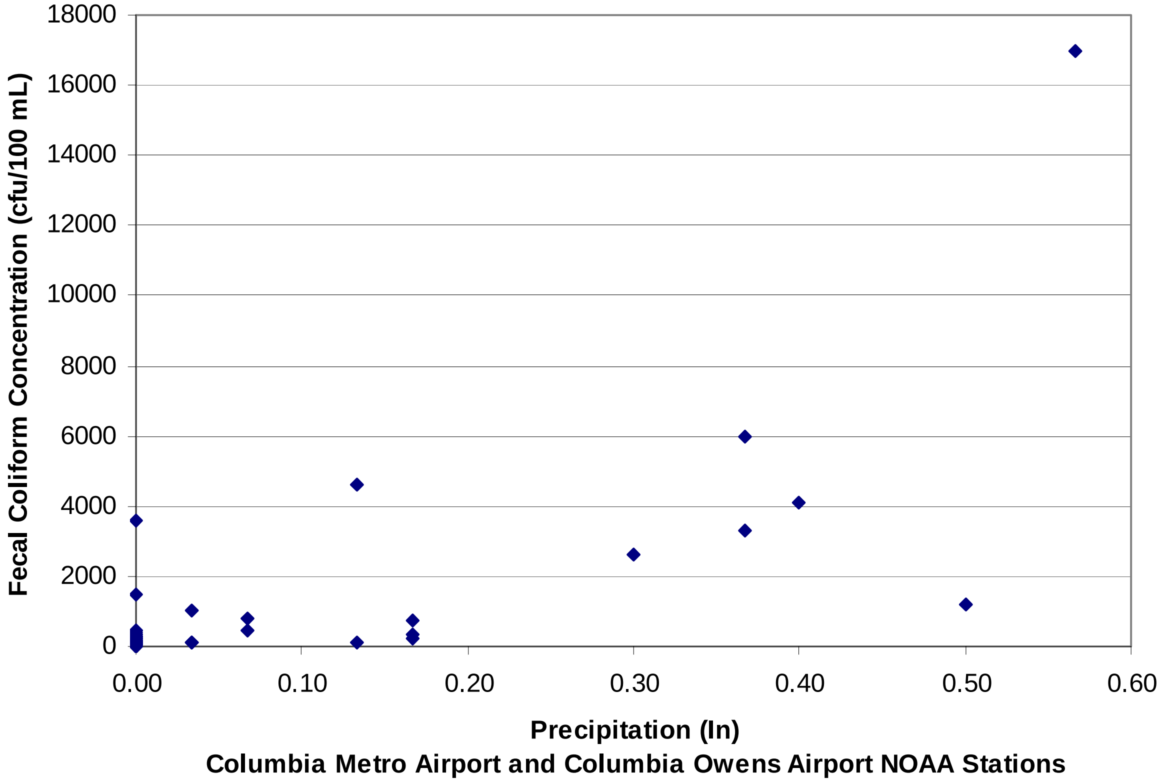
Based on an examination of the data shown in the plots for the stations listed above it is difficult to demonstrate a correlation between rainfall and fecal coliform concentrations. However, some general conclusions could be derived from this data analysis:

- Nearly all ambient fecal coliform samples for the stations listed above were collected under dry conditions; the majority of fecal coliform samples exceeding the WQS occurred under dry weather conditions;
- It is difficult to discern a direct correlation between rainfall and fecal coliform concentrations at each WQM station without more localized precipitation data from within each watershed.

For WQM stations B-110 and B-123 there are a few instances where it appears that fecal coliform exceedances of the WQS are associated with peak runoff events. The days on which measured rainfall resulted in elevated fecal coliform concentrations is limited primarily because of small data sets. This lack of a relationship also suggests that fecal coliform may be associated with sources (point or nonpoint) that are not significantly affected by rainfall. Plots for these two stations (B-110, B-123) showing a marginal relationship are provided in Appendix B.

Seven WQM stations (B-316, B-280, B-337, B-145, B-350, B-102, B-338) appear to show a relationship between fecal coliform concentrations and precipitation. Higher fecal coliform concentrations at those seven stations appear to be associated with an increase in precipitation, indicating that fecal coliform loading is associated with surface runoff related to rainfall. Figure 2-1 for B-316 (Crane Creek) is an example plot depicting higher fecal coliform concentrations in association with higher precipitation levels. A comparison of ambient fecal coliform data and NOAA precipitation data (80 data points) at WQM station B-316 between 1994 and 2000 indicated there were 11 days in which the 3-day average rainfall exceeded 0.1 inch, and on those dates the fecal coliform measurement exceeded the WQS. There were three other exceedances that occurred between 1994 and 2000; however, those all occurred when there was no measurable rainfall recorded. This suggests a relationship between wet weather conditions and higher fecal coliform concentrations; although to fully determine this relationship a continuous time series of precipitation would need to be evaluated. Plots for the remaining six stations, B-280, B-337, B-145, B-350, B-102, and B-338, depicting this relationship are also provided in Appendix B.

**Figure 2-1 Comparison of Precipitation and Fecal Coliform Concentrations in Crane Creek (B-316)**




Inferences from the comparison of fecal coliform concentration with rainfall data for the other six WQM stations are summarized below.

**WQM Station B-280 (Smith Branch).** Comparison of ambient fecal coliform data and NOAA precipitation data (82 data points) for the period examined (1994 and 2001) revealed 15 days in which the 3-day average rainfall exceeded 0.1 inch, and on those dates the fecal coliform measurements exceeded the WQS. There were 59 other exceedances that occurred between 1994 and 2002; however, those occurred when there was no measurable rainfall recorded. This suggests that higher fecal coliform concentrations may be associated with wet weather conditions, but there are also sources affecting water quality during dry conditions.

**WQM Station B-337 (Broad River)**

Comparison of ambient fecal coliform data and NOAA precipitation data (46 data points) for the period examined (1994 and 2002) revealed 4 days in which the 3-day average rainfall exceeded 0.1 inch, and on those dates the fecal coliform measurements exceeded the WQS. There were two other exceedances; however, those occurred when there was no measurable rainfall recorded. This suggests that higher fecal coliform concentrations may be associated with wet weather conditions, but there are also sources affecting water quality during dry conditions.

**WQM Station B-145 (Little River)**

Comparison of ambient fecal coliform data and NOAA precipitation data (54 data points) for the period examined (1994 and 2002) revealed only 5 days in which the 3-day average rainfall exceeded 0.1 inch, and on those dates the fecal coliform measurements exceeded the WQS. There were six other exceedances; however, those occurred when there was no measurable rainfall recorded. This suggests that higher fecal coliform concentrations may be associated with wet weather conditions, but there are also sources affecting water quality during dry conditions.

**WQM Station B-350 (Little River)**

Comparison of ambient fecal coliform data and NOAA precipitation data (25 data points) for the period examined (2001 and 2002) revealed 7 days in which the 3-day average rainfall exceeded 0.1 inch, and on those dates the fecal coliform measurements exceeded the WQS. There was only one other exceedance; however, there was no measurable rainfall recorded. This suggests a relationship between wet weather conditions and higher fecal coliform concentrations; although to fully determine this relationship, a continuous time series of precipitation would need to be evaluated.

**WQM Station B-102 (Jackson Creek)**

Comparison of ambient fecal coliform data and NOAA precipitation data (48 data points) for the period examined (1994 and 2002) revealed 7 days in which the 3-day average rainfall exceeded 0.1 inch, and on those dates the fecal coliform measurements exceeded the WQS. There were three other exceedances; however, those occurred when there was no measurable rainfall recorded. This suggests that higher fecal coliform concentrations may be associated with wet weather conditions, but there are also sources affecting water quality during dry conditions.

**WQM Station B-338 (Mill Creek)**

Comparison of ambient fecal coliform data and NOAA precipitation data (47 data points) for the period examined (1994 and 2002) revealed 10 days in which the 3-day average rainfall exceeded 0.1 inch, and on those dates the fecal coliform measurements exceeded the WQS. There were 17 other exceedances; however, those all occurred when there was no measurable rainfall recorded. This suggests that higher fecal coliform concentrations may be associated with wet weather conditions, but that there may also be sources affecting water quality during dry conditions.

**Relationships between fecal coliform exceedances at select WQM Stations**

Fecal coliform data were also assessed to discern if any relationships existed between fecal coliform concentrations at select pairs of upstream and downstream WQM stations. This data analysis could not be conducted for all WQM stations proximal to one another because the available fecal coliform data were not collected on the same date.

**B-243 and B-064.** Figure 2-2 is a plot showing fecal coliform data from the same dates for both Meng Creek (B-064) and the Tributary to Meng Creek (B-243) based on data collected between 1990 and 2000. This plot is designed to show any potential relationship between exceedances occurring at the upstream WQM station (Tributary to Meng Creek) and the downstream receiving water (Meng Creek). This is an important part of the source assessment because it helps to explain contributions of fecal coliform from upstream sources. Based on this plot, of the 47 exceedances observed at Meng Creek (B-064), 34 of the samples collected on the same day at the upstream station B-243 exceeded the WQS. This shows a direct relationship between upstream fecal coliform and downstream fecal coliform concentrations. While there were no precipitation data to establish a specific relationship between rainfall runoff and fecal coliform at these two stations, Figure 2-2 demonstrates that upstream monitoring locations have an effect on downstream fecal coliform concentrations.

**B-123 and B-077.** Figure 2-3 is a plot showing fecal coliform data from the same dates for both Winnsboro Branch upstream (B-123) and Winnsboro Branch downstream (B-077) based on data collected between 1990 and 2000. Based on this plot, of the 38 exceedances observed at Winnsboro Branch downstream (B-077), 34 of the samples collected on the same day at the upstream station B-123 exceeded the WQS. This shows a direct relationship between upstream fecal coliform and downstream fecal coliform concentrations. While there were no precipitation data to establish a specific relationship between rainfall runoff and fecal coliform at these two stations, Figure 2-3 demonstrates that upstream monitoring locations have an effect on downstream fecal coliform concentrations.

## 2.3 Establishing the Water Quality Target

40 CFR §130.7(c)(1) states that "TMDLs shall be established at levels necessary to attain and maintain the applicable narrative and numerical water quality standards." For the WQM stations requiring TMDLs in this report, defining the water quality target is straightforward and dictated by the fecal coliform numeric criteria established for the protection and maintenance of the primary contact recreation use as defined in the SC WQSs (see Subsection 2.1). However, because available fecal coliform data were collected on an approximate monthly basis (see Appendix A) instead of five samples over 30 days, data for these TMDLs are analyzed and presented in relation to the instantaneous criterion of 400 cfu/100 ml, which requires that no more than 10 percent of the samples can exceed this numeric criterion. Therefore, the water quality target for each impaired WQM station will be expressed as: 380 cfu/100ml for the instantaneous criterion, which is 5 percent lower than the water quality criteria of 400 cfu/100ml. The 5 percent explicit MOS was reserved from the water quality criteria in developing load duration curves (LDC). The instantaneous criterion was targeted as a conservative approach and should be protective of both the instantaneous and 30-day geometric mean fecal coliform bacteria standards (SCDHEC 2003).

This water quality target will be used to determine the allowable bacteria load which is derived by using the actual or estimated flow record multiplied by the instream fecal coliform criteria minus a 5 percent MOS. The line drawn through the allowable load data points is the water quality target which represents the maximum load for any given flow that still satisfies the WQS (SCDHEC 2003).

**Figure 2-2 Comparison of Fecal Coliform Concentrations at B-243 and B-064**

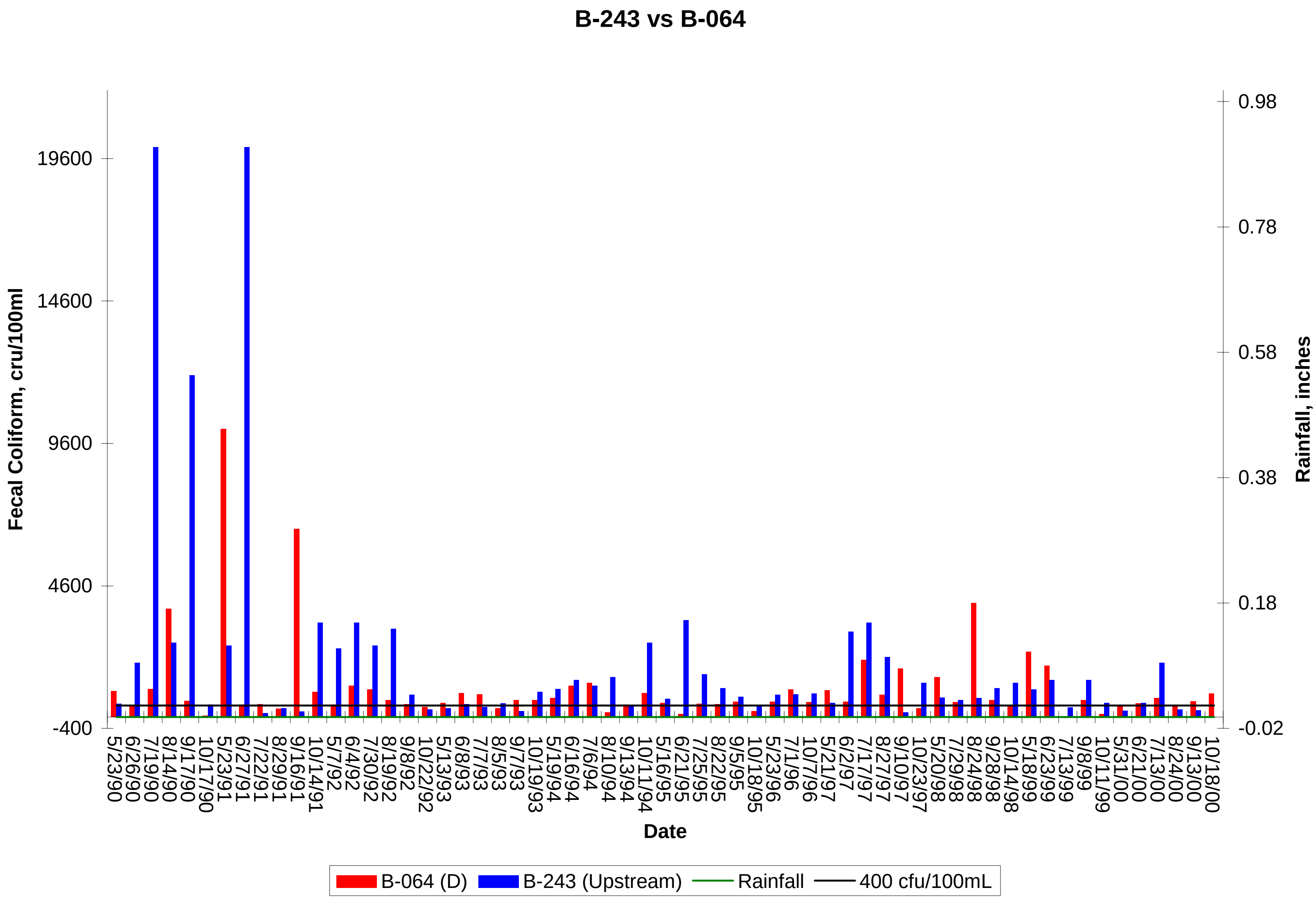
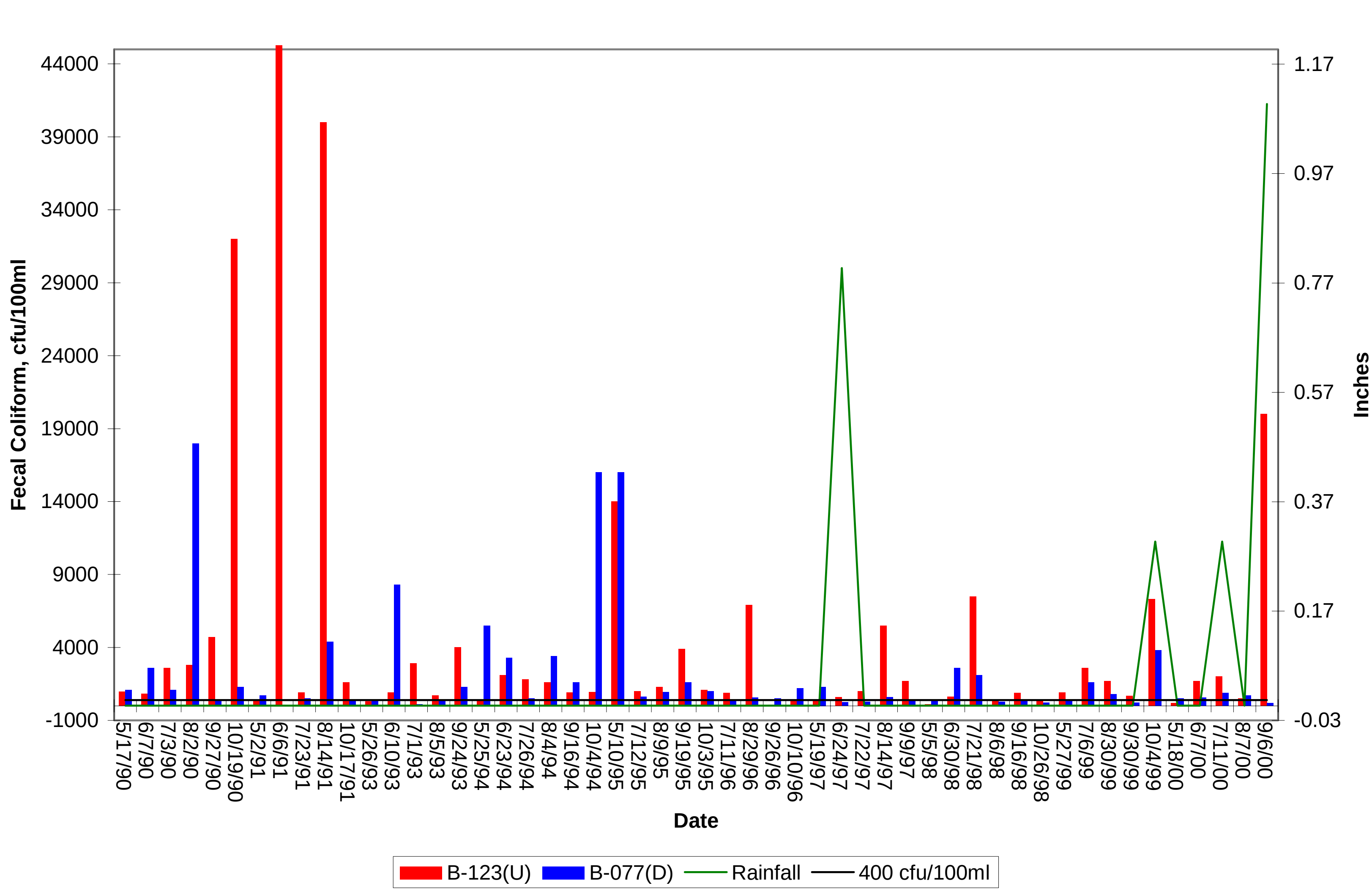


**Figure 2-3 Comparison of Fecal Coliform Concentrations at B-123 and B-077**



# SECTION 3
# POLLUTANT SOURCE ASSESSMENT

A source assessment characterizes known and suspected sources of pollutant loading to impaired water bodies. Sources within a watershed are categorized and quantified to the extent that information is available. Fecal coliform bacteria originate from warm-blooded animals and some plant life. Although fecal coliform bacteria are not harmful, they are present in mammal waste that also contains other harmful bacteria and viruses. Sources of fecal coliform bacteria may be point or nonpoint in nature. Point sources are permitted through the NPDES program. NPDES-permitted facilities that discharge treated wastewater are required to monitor fecal coliform bacteria concentrations in accordance with their permit.

Nonpoint sources are diffuse sources that typically cannot be identified as entering a water body at a single location. These sources may involve land activities that contribute fecal coliform bacteria to surface water as a result of stormwater runoff. The following discussion describes what is known regarding point and nonpoint sources of fecal coliform bacteria in the impaired watersheds.

## 3.1 Point Source Discharges

There are two types of point sources discharging fecal coliform bacteria into the streams addressed in this report; they are continuous point sources and Municipal Separate Storm Sewer Systems (MS4). Continuous point source discharges such as wastewater treatment plants (WWTP), could result in discharge of elevated concentrations of fecal coliform bacteria if the disinfection unit is not properly maintained, is of poor design, or if flow rates are above the disinfection capacity. Stormwater runoff from MS4 areas, which is now regulated under the USEPA NPDES Stormwater Program, can also contain high fecal coliform bacteria concentrations and is discussed in Subsection 3.1.2. The following is a brief discussion of each type of point source discharge.

### 3.1.1 Continuous Point Sources

Table 3-1 lists 16 active NPDES point sources continuously discharging upstream of six of the 19 WQM stations. The locations of the active NPDES facilities upstream of each WQM station are shown in Figures 3-1 and 3-2.

Discharge Monitoring Reports (DMR) were used to determine the number of fecal coliform analyses performed from 1998 through 2004, the maximum concentration during this period, the number of violations occurring when the monthly geometric mean concentration exceeded 200 cfu/100 ml, and the number of violations when a daily concentration exceeded 400 cfu/100 ml. The DMR data for each WWTP are provided in Appendix C. For the most part, these data indicate only occasional fecal coliform permit violations occurring at some of the facilities located in the watersheds listed in Table 3-1. Mack Estates (on Sandy River) has not discharged since 1999. Nevertheless, this facility may have contributed to fecal coliform exceedances reported in 1998 and 1999. There were only four fecal coliform samples reported in the DMR.

## Table 3-1 Permitted Facilities Discharging Fecal Coliform Bacteria

| Water Quality Monitoring Station / Permittee | NPDES Permit Number | Receiving Water | Flow (mgd) | Number of Discharge Monitoring Reports** | Maximum Concentration cfu/100 ml | Monthly Average >200 cfu/100 ml | Maximum Daily Concentration >400 cfu/100 ml | Percent of Samples Exceeding Permit Limits |
|---|---|---|---|---|---|---|---|---|
| HUC 03050106020 | | | | | | | | |
| **B-086 Ross Branch to Turkey Creek at SC 49 SW of York** | | | | | | | | |
| No Active NPDES Dischargers with Fecal Coliform Limits | | | | | | | | |
| **B-136 Turkey Creek AT SC 9, 14 mi NW of Chester** | | | | | | | | |
| MACK ESTATES (Has not discharged since 1999) | SC0043095 | Sandy River | 0.2 | 4 | 1100 | 1 | 1 | 50% |
| HUC 03050106030 | | | | | | | | |
| **B-064 Meng Creek at SC 49 2.5 mi E of Union** | | | | | | | | |
| No Active NPDES Dischargers with Fecal Coliform Limits | | | | | | | | |
| **B-243 Trib to Meng Ck at Clvrt on S-44-384 3 mi E of Union** | | | | | | | | |
| No Active NPDES Dischargers with Fecal Coliform Limits | | | | | | | | |
| **B-155 Browns Creek at S-44-86, 8 mi E of Union** | | | | | | | | |
| UNION/MENG CREEK (NEW) | SC0047236 | Big Browns Creek | 1.0 | 72 | 1600 | 0 | 1 | 1% |
| **B-335 Gregorys Creek at S-44-86, 8 mi E of Union** | | | | | | | | |
| No Active NPDES Dischargers with Fecal Coliform Limits | | | | | | | | |
| HUC 03050106010 | | | | | | | | |
| **B-046 Broad River at SC 72/215/121 3 mi E of Carlisle** | | | | | | | | |
| Lockhart Treatment Facility | SC0003051 | Broad River | 0.17 | 60 | 580 | 0 | 1 | 2% |
| Chemtrade Perf Chemicals/Leeds | SC0022756 | Broad River | 0.058* | 72 | 1600 | 0 | 2 | 3% |
| Cone Mills Corp/Carlisle Plant | SC0001368 | Broad River | 2.13* | 72 | 1030 | 0 | 2 | 3% |
| HUC 03050106040 | | | | | | | | |
| **B-074 Dry Fork at S-12-304 2 mi SW of Chester** | | | | | | | | |
| No Active NPDES Dischargers with Fecal Coliform Limits | | | | | | | | |
| **B-075 Sandy River at SC 215 2.5 mi AB Jct with Broad River** | | | | | | | | |
| Chester/Sandy River WWTP | SC0036081 | Sandy River | 2.133 | 72 | 119 | 0 | 0 | 0% |
| HUC 03050106060 | | | | | | | | |
| **B-110 Elizabeth Lake at Spillway on US 21** | | | | | | | | |
| No Active NPDES Dischargers with Fecal Coliform Limits | | | | | | | | |
| **B-316 Crane Creek at S-40-43 under I-20 - North Cola** | | | | | | | | |
| Richtex Corporation | SC0031640 | Crane Creek | 0.007* | 37 | 820 | 3 | 2 | 14% |
| **B-280 Smith Branch at N Main St (US 21) in Cola** | | | | | | | | |
| No Active NPDES Dischargers with Fecal Coliform Limits | | | | | | | | |
| **B-337 Broad River at US 176 (Broad River Rd) in Columbia** | | | | | | | | |
| Chapin, Town Of | SC0040631 | Wateree Creek | 1.2 | 73 | 357 | 0 | 0 | 0% |
| Richland Co/Broad River WWTP | SC0046621 | Broad River | 2.5 | 72 | 740 | 0 | 5 | 7% |
| Raintree Acres Sd/Midlands Utl | SC0039055 | Broad River | 0.14 | 74 | 640 | 1 | 3 | 5% |
| Sce&G V C Summer Nuclear Station | SC0030856 | Montecello Reservoir | 0.0037 | 72 | 280 | 0 | 0 | 0% |
| Sce&G/Summer Nuclear Training | SC0038407 | Mayo Creek | 0.0006* | 71 | 520 | 0 | 1 | 1% |
| Forest Hills Sd/Elbo Inc | SC0024571 | Charles Creek | 0.02 | 3 | 10 | 0 | 0 | 0% |
| NCW&SA/Broad Rv. WWTP Phase 1a | SC0048020 | Tributary to Cannons Creek | 0.05 | 40 | 5100 | 0 | 1 | 3% |
| NCW&SA/Cannons Creek WWTP (New Facility) | SC0048313 | Cannons Creek | 0.95 | 0 | 0 | 0 | 0 | 0% |

## Table 3-1 Permitted Facilities Discharging Fecal Coliform Bacteria (cont'd)

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| HUC 03050106070 | | | | | | | | |
| **B-145 Little River at S-20-60 3.1 mi SW of Jenkinsville** | | | | | | | | |
| No Active NPDES Dischargers with Fecal Coliform Limits | | | | | | | | |
| **B-350 Little River at SC215, 1.5 mi NE of confl. w/ Broad River** | | | | | | | | |
| No Active NPDES Dischargers with Fecal Coliform Limits | | | | | | | | |
| HUC 03050106080 | | | | | | | | |
| **B-123 Winnsboro Branch at US 321-AB Winnsboro Mills Outfall** | | | | | | | | |
| No Active NPDES Dischargers with Fecal Coliform Limits | | | | | | | | |
| **B-077 Winnsboro Branch below Plant Outfall** | | | | | | | | |
| Winnsboro/Jackson Creek Plant | SC0020125 | Winnsboro Branch | 1.6 | 72 | 395 | 0 | 0 | 0% |
| **B-102 Jackson Creek at S-20-54, 5 mi W of Winnsboro** | | | | | | | | |
| No Active NPDES Dischargers with Fecal Coliform Limits | | | | | | | | |
| **B-338 Mill Creek at S-20-48, 10 mi SW of Winnsboro** | | | | | | | | |
| No Active NPDES Dischargers with Fecal Coliform Limits | | | | | | | | |

* Maximum of reported monthly average flow rates

** Each DMR provides two fecal coliform values; the average of all samples for the month and the maximum of the samples.

**Figure 3-1 Locations of NPDES Dischargers, MS4s, and Animal Feeding Operations in Turkey Creek, Meng Creek, Browns Creek, Gregorys Creek, Sandy River, Dry Fork and Broad River Watersheds**

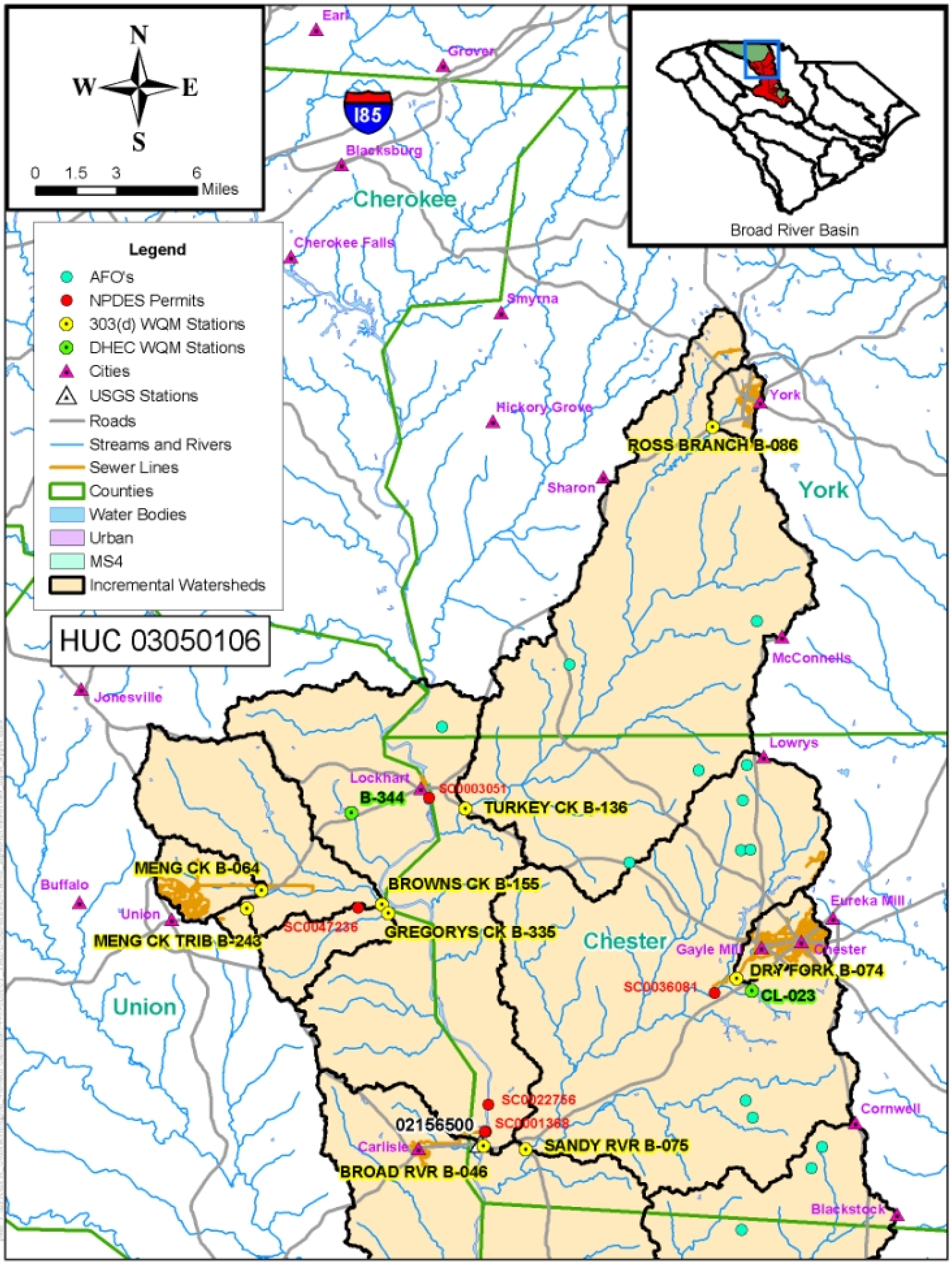
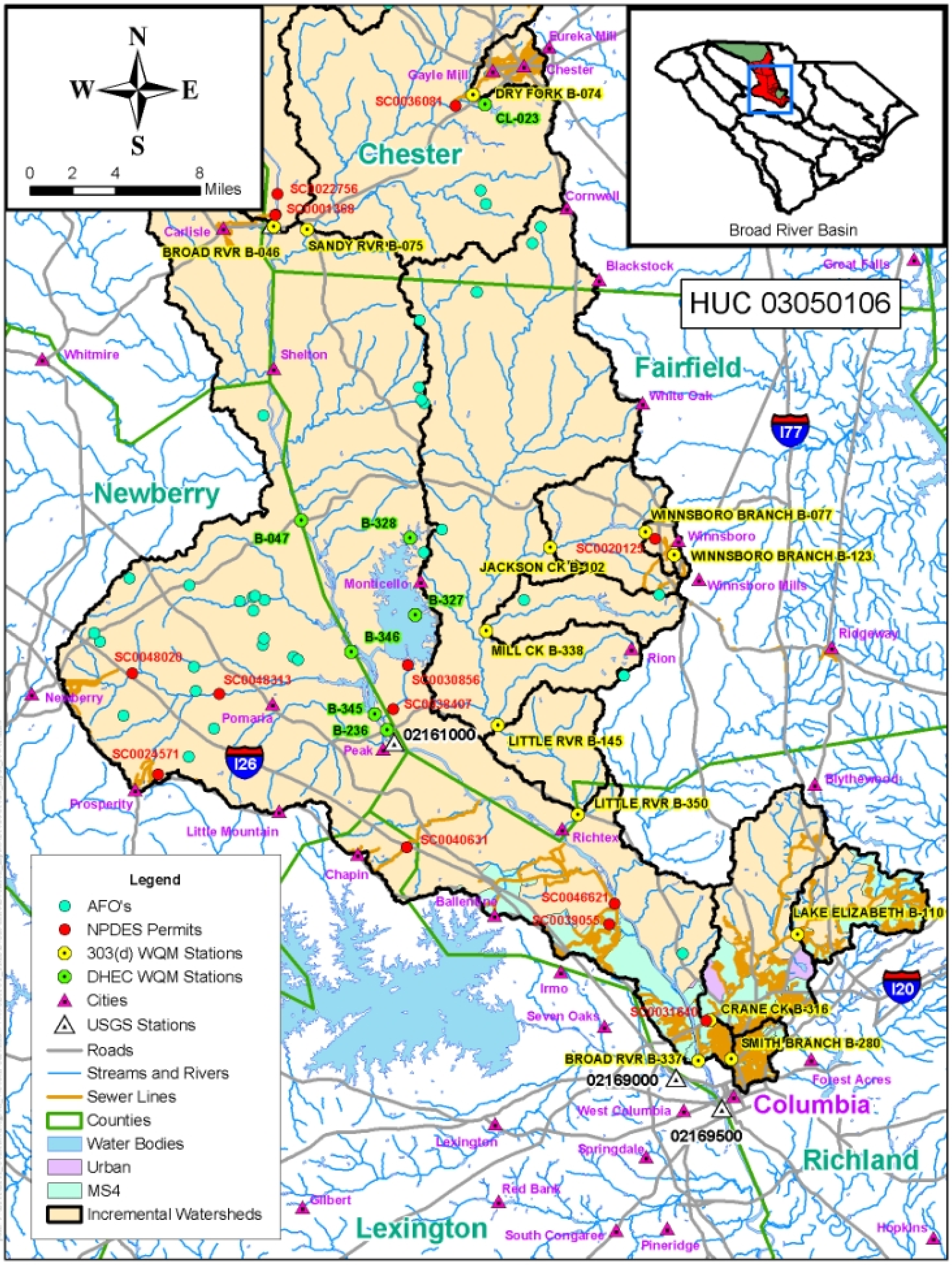


**Figure 3-2 Locations of NPDES Dischargers, MS4s, and Animal Feeding Operations in Elizabeth Lake, Crane Creek, Smith Branch, Broad River, Little River, Winnsboro Branch, Jackson Creek, and Mill Creek Watersheds**



Some NPDES permits only require monitoring and reporting. For those permits, USEPA's permit compliance system database was used to determine the maximum monthly average flow rate for each WWTP from 2002 through 2004. Where permit Fact Sheets were available, the design flow of the WWTP was used. Inactive permits or industrial dischargers are not included in Table 3-1, because they do not contribute fecal coliform loading.

Table 3-2 summarizes the existing load estimates for each NPDES facility. Existing point source loads were estimated by multiplying monthly average flow rates by the monthly geometric mean of fecal coliform bacteria discharged using a unit conversion factor. An exception was the Cone Mills County, Carlisle Plant (SC0001368). The WWTP only reports the maximum daily flow; therefore, the maximum daily flow was used to estimate the existing load. In addition, the NCW&SA/Cannons Creek WWTP upstream of WQM station B-337 is under construction and is currently not discharging to Cannons Creek. Therefore, this facility is not considered a previous or current source of fecal coliform loading. The monthly geometric mean fecal coliform values were extracted from the DMR of each point source. The 90$^{th}$ percentile value was used to express the estimated existing load in cfu per day.

### 3.1.2 Municipal Separate Storm Sewer Systems

In 1990 the USEPA developed rules establishing Phase I of the NPDES Stormwater Program, designed to prevent harmful pollutants from being washed by stormwater runoff into MS4s (or from being dumped directly into the MS4) and then discharged into local water bodies (SCDHEC 2002). Phase I of the program required operators of medium and large MS4s (those generally serving populations of 100,000 or greater) to implement a stormwater management program as a means to control polluted discharges. Approved stormwater management programs for medium and large MS4s are required to address a variety of water quality-related issues, including roadway runoff management, municipal-owned operations, and hazardous waste treatment. The City of Columbia and Richland County have a Phase I MS4 permit and portions of B-110, B-337, B-316 and B-280 watersheds are covered under this permit. Each designated local government is required to develop and implement a stormwater management program that includes public education, illicit discharge detection and elimination, storm sewer system and land use mapping, and analytical monitoring (NCDENR 2005).

Phase II of the rule extends coverage of the NPDES stormwater program to certain small MS4s. Small MS4s are defined as any MS4 that is not a medium or large MS4 covered by Phase I of the NPDES Stormwater Program. Phase II requires operators of regulated small MS4s to obtain NPDES permits and develop a stormwater management program. Programs are designed to reduce discharges of pollutants to the "maximum extent practicable," protect water quality, and satisfy appropriate water quality requirements of the CWA. Small MS4 stormwater programs must address the following minimum control measures:

- Public Education and Outreach;
- Public Participation/Involvement;
- Illicit Discharge Detection and Elimination;
- Construction Site Runoff Control;

- Post- Construction Runoff Control; and
- Pollution Prevention/Good Housekeeping.

**Table 3-2 Estimated Existing Fecal Coliform Loading from NPDES Facilities (1998-2004)**

| Water Quality Monitoring Station / Permittee | NPDES Permit Number | Receiving Water | 90th percentile load (cfu/day) |
|---|---|---|---|
| HUC 03050106030 | | | |
| **B-155 Browns Creek at S-44-86, 8 mi E of Union** | | | |
| Union/Meng Creek (New) | SC0047236 | Big Browns Creek | 4.76E+08 |
| HUC 03050106010 | | | |
| **B-046 Broad River at SC 72/215/121 3 mi E of Carlisle** | | | |
| Lockhart Treatment Facility | SC0003051 | Broad River | 2.58E+07 |
| Chemtrade Perf Chemicals/Leeds | SC0022756 | Broad River | 1.34E+07 |
| Cone Mills Corp/Carlisle Plant | SC0001368 | Broad River | 3.45E+09 |
| HUC 03050106040 | | | |
| **B-075 Sandy River at SC 215 2.5 mi AB Jct with Broad River** | | | |
| Chester/Sandy River WWTP | SC0036081 | Sandy River | 1.50E+09 |
| HUC 03050106060 | | | |
| **B-316 Crane Creek at S-40-43 under I-20 - North Cola** | | | |
| Richtex Corporation | SC0031640 | Crane Creek | 2.66E+07 |
| **B-337 Broad River at US 176 (Broad River Rd) in Columbia** | | | |
| Chapin, Town of | SC0040631 | Wateree Creek | 1.11E+08 |
| Richland Co/Broad River WWTP | SC0046621 | Broad River | 9.71E+08 |
| Raintree Acres SD/Midlands UTL | SC0039055 | Broad River | 5.47E+07 |
| SCE&G V C Summer Nuclear Station | SC0030856 | Montecello Reservoir | 8.67E+05 |
| SCE&G/Summer Nuclear Training | SC0038407 | Mayo Creek | 3.25E+05 |
| Forest Hills SD/Elbo Inc. | SC0024571 | Charles Creek | 9.02E+06 |
| NCW&SA/Broad RV. WWTP Phase 1A | SC0048020 | Tributary to Cannons Creek | 9.81E+06 |
| NCW&SA/Cannons Creek WWTP (Under construction) | SC0048313 | Cannons Creek | NA |
| HUC 03050106080 | | | |
| **B-077 Winnsboro Branch below Plant Outfall** | | | |
| Winnsboro/Jackson Creek Plant | SC0020125 | Winnsboro Branch | 3.66E+08 |

A study under USEPA's National Urban Runoff Project indicated that average fecal coliform concentration from 14 watersheds in different areas within the United States was approximately 15,000 cfu/100 ml in stormwater runoff (USEPA 1983). Runoff from urban areas not permitted under the MS4 program can be a significant source of fecal coliform bacteria. Water quality data collected from streams draining many of the nonpermitted communities show existing loads of fecal coliform bacteria at levels greater than the State's instantaneous standards. BMPs such as buffer strips and proper disposal of domestic animal waste reduce fecal coliform bacteria loading to water bodies. Sanitary sewer overflows (SSO), typically associated with urban growth areas, are also a potential source of fecal coliform loading to streams. SSOs have existed since the introduction of separate sanitary sewers, and most are caused by blockage of the pipes by grease and tree roots. A summary of MS4s, SSOs, and the potential for fecal coliform bacteria from urbanized areas is provided below and is organized by county.

**York County:** Portions of watersheds associated with two 303(d) listed WQM stations addressed in this report, B-086 and B-136, are in York County. However there are no MS4 areas within York County that fall within these two watersheds. York County is required to obtain a Phase II MS4 permit for the Rock Hill area which is outside the project study area. Only a very small portion of an urbanized cluster within York County (the Town of York) lies within the watershed of WQM station B-086. Urbanized clusters are not automatically required to obtain a Phase II MS4 permit. A portion of the Town of York is drained by Ross Branch (B-086). There were 64 reported SSOs in York County between September 1998 and November 2004, and none were reported to have occurred in this watershed; however, not all SSOs are reported to SCDHEC (SCDHEC 2005a).
**Chester County:** There are no designated Phase I or II MS4 urban areas in Chester County. One of the six NPDES facilities located in the Chester County watersheds addressed in this report identified SSOs. The Chester Metro Sandy Creek WWTP (SC0036081), located upstream of WQM station B-075, reported 47 SSOs from its collection system between September 1998 and September 2004. Fifteen of the 47 SSOs were believed to be greater than 1,000 gallons and spilled into a receiving water of Sandy River. The wastewater collection system serves the City of Chester and surrounding area.
**Union County:** There are no designated Phase I or II MS4s urban areas in Union County. The collection system serving the new Union Meng Creek WWTP, which actually discharges into Big Browns Creek (tributary to Browns Creek, B-155), had eight SSOs from December 1998 through April 2000. Parts of the collection system lie within the watersheds of Meng Creek (B-064), a tributary to Meng Creek (B-243), Big Browns Creek, and Browns Creek (B-155). The estimated volumes of two SSOs were 20,000 gallons (reported March 31, 1999) and 50,000 gallons (reported January 25, 2000). Water samples collected within Browns Creek at WQM station B-55 March 13 and April 7, 1999 did not contain a spike in the fecal coliform concentration. Nevertheless, fecal coliform concentrations from May 1998 through December 2002 at B-155 were above 200 and 400 cfu/100 ml in 24 out of 36 samples (67 percent) and eight out of 36 samples (22 percent), respectively. The facility serves the Town of Union and surrounding area.
**Fairfield County:** There are no Phase II MS4 areas within Fairfield County. Fairfield County has four NPDES WWTPs with fecal coliform limits discharging to watersheds addressed in this report. The Town of Winnsboro reported nine SSOs from September 2000 through December 2004 that may have affected water quality at B-102. All quantity estimations were below 1,000 gallons. The Royal Hill subdivision WWTP near the Town of Adger had two SSOs on November 30, 2001, (quantity unknown) and July 2, 2003 (approximately 400 gallons).
**Newberry County:** There are no urbanized areas, and therefore, no MS4s in portions of the watersheds within Newberry County addressed in this report. There were no reported SSOs for the three NPDES facilities in the watersheds within Newberry County. The town of Newberry (WQM station B-337) may be required to obtain a Phase II MS4 permit, pending evaluation by SCDHEC.
**Richland County:** Richland County contains the Columbia urbanized area (Phase I MS4) and four NPDES facilities that discharge into the watersheds addressed in this

report. The collection system of the Richland County WWTP (SC0046621) primarily lies between IH 26 and the Broad River downstream of the confluence of Little River and Nicholas Creek. This WWTP reported 12 SSOs from October 23, 2000 through September 8, 2004. There were three SSOs above 1,000 gallons that entered a receiving water to B-337. These SSOs did not coincide with any recorded fecal coliform WQS exceedances at station B-337. The Midlands Utility Raintree Acres subdivision WWTP (SC0039055), north of Nicholas Creek, reported 10 SSOs from January 27, 1999 through March 17, 2003. Eight of the SSOs were of unknown quantity except one (300 gallons) and spilled to a receiving water of the Broad River.

## 3.2 Nonpoint Sources

Nonpoint sources include those that cannot be identified as entering the water body at a specific location. Because fecal coliform is associated with warm-blooded animals, nonpoint sources of fecal coliform may originate from both rural and urbanized areas. The following discussion highlights possible major nonpoint sources contributing fecal coliform in each watershed. These sources include wildlife, agricultural activities and domesticated animals, land application fields, urban runoff, failing onsite wastewater disposal (OSWD) systems, and pets. The following subsections describe probable nonpoint sources of fecal coliform. Table 3-3 lists the WQM stations that are impaired from nonpoint sources of fecal coliform only, since the contributing watersheds do not contain an NPDES discharger with a fecal coliform limit.

**Table 3-3 303(d) Listed WQM Stations Impaired by Nonpoint Sources Only**

| WQM Station | Streams with No NPDES Fecal Coliform Discharge | County |
|---|---|---|
| B-086 | Ross Branch to Turkey Creek | York |
| B-136 | Turkey Creek | York, Chester |
| B-064 | Meng Creek | Union |
| B-243 | Tributary to Meng Creek | Union |
| B-335 | Gregorys Creek | Chester |
| B-074 | Dry Fork | Chester |
| B-110 | Elizabeth Lake | Richland |
| B-280 | Smith Branch | Richland |
| B-145 | Little River | Fairfield |
| B-350 | Little River | Fairfield |
| B-123 | Winnsboro Branch | Fairfield |
| B-077 | Winnsboro Branch | Fairfield |
| B-338 | Mill Creek | Fairfield |

### 3.2.1 Wildlife

Fecal coliform bacteria are produced by warm blooded animals such as deer, feral hogs, wild turkey, raccoons, other small mammals, and avian species. The SC Department of Natural Resources conducted a study in 2000 to estimate whitetail deer density based on suitable habitat (SCDNR 2000). This study assumed that deer habitat includes forests, croplands, and pastures. According to a study conducted by Yagow (1999), fecal coliform production rate for deer is 347 x $10^6$ cfu/head-day. Although only a portion of the fecal coliform produced by deer may enter into a water body, the large population of deer in the watersheds may be a significant source of fecal coliform loading. Table 3-4 lists the estimated deer density per square mile for each watershed.

**Table 3-4 Estimated Deer Density by Watershed**

| Station | Estimated Deer Density per Square Mile |
|---|---|
| B-086 | 30 - 45 |
| B-136 | 30 - 45+ |
| B-064 | 30 - 45+ |
| B-243 | 30 - 45+ |
| B-155 | 30 - 45+ |
| B-335 | 30 - 45+ |
| B-046 | 30 - 45+ |
| B-074 | 30 - 45+ |
| B-075 | 30 - 45+ |
| B-110 | 15 - 30 |
| B-316 | <15 |
| B-280 | 15 - 30 |
| B-337 | <15 -30 |
| B-145 | 30 - 45+ |
| B-350 | 30 - 45+ |
| B-123 | 30 - 45+ |
| B-077 | 30 - 45+ |
| B-102 | 30 - 45+ |
| B-338 | 30 - 45+ |

Approximately 70,000 ducks, mostly wood ducks, green-winged teal, mallards, and ringnecks, wintered in SC in January 2003 (Strange 2003). This is substantially lower than the long term average of 200,000 (Strange 2003). Fairfield County contains three wildlife management areas (WMA) along the Broad River: Broad River, Monticello Reservoir, and Parr Reservoir (SCDNR 2005a). The Broad River WMA is a popular duck hunting area. The wide array of avian species that frequent these WMAs do not appear to be contributing to fecal coliform loading, since the nearest downstream SCDHEC WQM station (B-346) is not listed on the 2004 303(d) list for fecal coliform exceedances.

There are currently no available data for other wildlife and avian species known to inhabit these watersheds which could potentially contribute to the fecal coliform load. Given the representative statistics for deer population and the large amount of rural area (forest, cropland, and pasture) in the watersheds included in this report, wildlife may contribute a significant portion of the overall fecal coliform load.

### 3.2.2 Agricultural Activities and Domesticated Animals

Domesticated animals produce significant amounts of waste and are recognized as a source of fecal coliform loading. For example, according to a livestock study conducted by the American Society of Agricultural Engineers (ASAE 1998), the following fecal coliform production rates were estimated:

- cattle release approximately 100 billion fecal coliform per animal per day;
- horses - 400 million per animal per day;
- pigs - 11 billion per animal per day;
- chickens – 1.4 billion per animal per day;
- turkeys - 1 billion per animal per day; and
- sheep - 12 billion per animal per day.

Manure generated by livestock in pastures or in animal feedlots, is typically used as fertilizer on crop lands, forests, and pastures, and is therefore a potential source of fecal coliform loading. The CWA does not regulate nonpoint source runoff from agriculture lands receiving agronomic applications of manure (CWA §502(14)). Furthermore, for the purposes of this pollutant source assessment, insufficient data are available to estimate fecal coliform concentrations in stormwater runoff from land application fields where manure is applied.

Stormwater leaving a concentrated animal feeding operation (CAFO) is regulated under the NPDES program; however, there are currently no NPDES-permitted CAFOs in SC. The SCDHEC currently maintains a statewide list of AFOs categorized by the type of facility (cattle, swine, poultry) and size which is defined by the specific number of animal units (large, medium, small).

Table 3-5 lists the dairy, swine, turkey, and poultry AFO facilities located in each HUC. All the AFOs are classified as no discharge facilities, and there are often fields for land application of manure associated with each AFO. While there are no AFO facilities identified in the watersheds of WQM stations B-064, B-243, B-155, B-335, B-086, B-074, B-123, B-077, B-102, B-350, B-110, B-316 and B-280 by the SCDHEC database, land application fields and cattle on small farms are present in some of these watersheds. Three facilities are large poultry or turkey feeding operations. Fifteen are medium and 19 are small AFOs. The AFO labeled “slaughter” is most likely a swine and cattle operation due to the low number of animals.

**Table 3-5 Animal Feeding Operations**

| NPDES | AFO TYPE | DESIGN COUNT | AFO SIZE | COUNTY NAME | HUC |
|---|---|---|---|---|---|
| **HUC 03050106** | | | | | |
| ND0061051 | DAIRY | 135 | small | Chester | 03050106010 |
| ND0065293 | SWINE | 32 | small | York | 03050106020 |
| ND0066354 | TURKEY | 40,000 | medium | York | 03050106020 |
| ND0065684 | TURKEY | 42,000 | medium | Chester | 03050106020 |
| ND0076511 | TURKEY | 9,720 | small | Chester | 03050106020 |
| ND0071901 | DAIRY | 200 | medium | Chester | 03050106040 |
| ND0079626 | TURKEY | 56,000 | large | Chester | 03050106040 |
| ND0017019 | DAIRY | 25 | small | Chester | 03050106040 |
| ND0080845 | DAIRY | 200 | medium | Chester | 03050106040 |
| ND0077631 | TURKEY | 16,000 | small | Chester | 03050106040 |
| ND0077640 | TURKEY | 16,000 | small | Chester | 03050106040 |
| ND0077275 | TURKEY | 16,000 | small | Newberry | 03050106050 |
| ND0005118 | DAIRY | 130 | small | Fairfield | 03050106050 |
| ND0075051 | TURKEY | 25,000 | medium | Fairfield | 03050106050 |
| ND0075141 | TURKEY | 45,000 | medium | Fairfield | 03050106050 |
| ND0003921 | SWINE | 180 | small | Newberry | 03050106050 |
| ND0007277 | SWINE | 250 | small | Newberry | 03050106050 |
| ND0014826 | DAIRY | 120 | small | Newberry | 03050106050 |
| ND0016799 | SWINE | 10 | small | Newberry | 03050106050 |
| ND0061093 | DAIRY | 100 | small | Newberry | 03050106050 |
| ND0076589 | SWINE | 250 | small | Newberry | 03050106050 |
| ND0082449 | BROILERS | 114,800 | medium | Newberry | 03050106050 |
| ND0074322 | TURKEY | 25,000 | medium | Fairfield | 03050106050 |
| ND0002712 | BROILERS | 28,987 | small | Newberry | 03050106050 |
| ND0005592 | SLAUGHTER | 120 | NA | Newberry | 03050106050 |
| ND0006424 | SWINE | 8 | small | Newberry | 03050106050 |
| ND0008630 | SWINE | 26 | small | Newberry | 03050106050 |
| ND0008656 | SWINE | 0 | NA | Newberry | 03050106050 |
| ND0016802 | DAIRY | 175 | small | Newberry | 03050106050 |
| ND0064181 | SWINE | 26 | small | Newberry | 03050106050 |
| ND0074772 | BROILERS | 104,000 | medium | Newberry | 03050106050 |
| ND0083283 | BROILERS | 159,000 | large | Newberry | 03050106050 |
| ND0083526 | DAIRY | 100 | small | Newberry | 03050106050 |
| ND0008664 | SWINE | 15 | small | Newberry | 03050106050 |
| ND0014362 | DAIRY | 90 | small | Newberry | 03050106050 |
| ND0016691 | LAYERS | 100,000 | large | Newberry | 03050106050 |
| ND0075345 | TURKEY | 25,000 | medium | Richland | 03050106060 |
| ND0077321 | TURKEY | 16,000 | small | Chester | 03050106070 |
| ND0077917 | TURKEY | 16,000 | small | Chester | 03050106070 |
| ND0078280 | TURKEY | 16,000 | small | Chester | 03050106070 |
| ND0074322 | TURKEY | 25,000 | medium | Fairfield | 03050106070 |

| NPDES | AFO TYPE | DESIGN COUNT | AFO SIZE | COUNTY NAME | HUC |
|---|---|---|---|---|---|
| ND0075051 | TURKEY | 25,000 | medium | Fairfield | 03050106070 |
| ND0075205 | TURKEY | 45,000 | medium | Fairfield | 03050106070 |
| ND0078786 | TURKEY | 16,000 | small | Fairfield | 03050106070 |
| ND0068331 | TURKEY | 25,000 | medium | Fairfield | 03050106080 |
| ND0075329 | TURKEY | 25,000 | medium | Fairfield | 03050106080 |
| ND0075752 | TURKEY | 22,500 | medium | Fairfield | 03050106080 |

The following describes the estimated manure production of various livestock within the watersheds of this report.

**Cattle:** Between 1997 and 2002 the number of cattle farms in York County, SC decreased by about 29 percent from 612 to 436 based on the U.S. Department of Agriculture (USDA) census data (USDA 2002). The number of cattle in York County decreased from 22,496 to 19,211 during the same 5-year period. Between 1997 and 2002 the number of cattle farms in Chester County also decreased by about 20 percent from 305 to 266 based on USDA census data (USDA 2002). However, the number of cattle in Chester County increased from 13,443 to 14,331 during the same 5-year period. The number of cattle in Union County decreased from 9,312 to 7,134 between 1997 and 2002 (USDA 2002). The number of cattle in Fairfield County experienced a slight decrease between 1997 and 2002 from 6,612 to 6,009. Between 1997 and 2002 the number of cattle farms in Newberry County decreased by about 19 percent from 474 to 386 (USDA 2002). The number of cattle in Newberry County decreased from 25,890 to 24,137 during the same 5-year period. The number of cattle in Richland County decreased by almost 60 percent between 1997 and 2002, from 6,792 to 2,771 (USDA 2002). These county-wide census numbers are provided for informational purposes to demonstrate that cattle are present in the watersheds of the WQM stations addressed in this report.

A 1,000-pound beef or dairy cow produces approximately 11 tons and 15 tons of manure per year, respectively (OSU 1992). Assuming the average cow weighs 750 pounds and manure production is 12 tons per year, 100 cows would produce approximately 2.5 tons per day. Table 3-6 provides the estimated manure production from cattle for each watershed. The number of cattle within each WQM station watershed was estimated by dividing the number of cattle in each county by the total acres of pasture land in each county. This cattle density value was then multiplied by the number of acres of pasture land in each watershed.

**Table 3-6 Estimated Tons of Manure by WQM Station**

| WQM Station | Number of Cattle and Calves in Watershed | Tons of Manure Deposited Daily in Watershed |
|---|---|---|
| B-086 | 185 | 5 |
| B-136 | 2,422 | 60 |
| B-064 | 41 | 1 |
| B-243 | 5 | <1 |

| WQM Station | Number of Cattle and Calves in Watershed | Tons of Manure Deposited Daily in Watershed |
|---|---|---|
| B-155 | 943 | 23 |
| B-335 | 33 | 1 |
| B-046 | 1,292 | 32 |
| B-074 | 69 | 2 |
| B-075 | 2,942 | 73 |
| B-110 | 40 | 1 |
| B-316 | 75 | 2 |
| B-280 | 0 | 0 |
| B-337 | 6,536 | 161 |
| B-145 | 1,377 | 34 |
| B-350 | 105 | 3 |
| B-123 | 8 | <1 |
| B-077 | 67 | 2 |
| B-102 | 538 | 13 |
| B-338 | 715 | 18 |

According to a report by the SC Water Resources Center, the lower Broad River has a serious water quality problem due to high levels of fecal coliform (Allen and Lu 1998). The report documents the spatial relationships of human, cattle, poultry, and hogs to fecal coliform concentrations in the major watersheds of SC. There was little correlation between the location of poultry and hog farms to instream fecal coliform concentrations above the WQSs. This may be related to the fact that poultry and hogs do not have nor need access to water bodies for drinking water. Conversely, there was a significant correlation between humans and cattle to high fecal coliform concentrations, with human density having the more significant correlation. This correlation is verified in Figure 3-2. Three SCDHEC WQM stations (B-346, B-345, and B-236) southwest of Monticello Reservoir, are not on the 2004 303(d) list for impairment of water contact recreation for fecal coliform. Table 3-6 identifies 25 AFOs (turkey, chickens, swine, and cattle) within the watersheds of these three stations (HUC 03050106050). Therefore, the presence of an AFO may or may not be a source of instream fecal coliform. Nevertheless, the Allen report indicates a correlation between pastured cattle and high fecal coliform concentrations in water bodies. It is a common practice for pastured cattle to water in the creeks of the many WQM stations addressed in this report.

**Poultry:** In Table 3-5 above, poultry facilities include turkeys, broilers, and layers. The poultry facilities listed in Table 3-5 total more than 500,000 birds. The USDA 2002 Agriculture Census data estimated approximately 1,260,000 chickens in Newberry County (USDA 2002). In 1997 there were an estimated 80,417 chickens in Chester County (USDA 2002). Richland County, Union County, Fairfield County, and York County had small numbers of poultry at 581, 555, 130, and 2,463 chickens, respectively (USDA 2002). The ASAE manure production rate estimate for chickens is 11.4 billion fecal coliform per chicken per day (ASAE 1998). The USDA census data indicate that poultry farms are scattered throughout the watersheds addressed in this report. However, since poultry are not evenly distributed throughout each county, it is difficult to discern the magnitude of fecal coliform loading chickens may be contributing within a given watershed.

There are approximately 840 fields totaling 10,341 acres permitted for animal waste application from poultry, swine, and dairy facilities within these watersheds. Table 3-7 provides a summary of the land application field acreage based on SCDHEC data within the watersheds of select WQM stations.

**Table 3-7 Acreage of Land Application Fields within Watersheds of Select WQM Stations**

| WQM Station | Acres of Land Application Fields | AFO Type |
|---|---|---|
| B-086 | 208 | Turkey |
| B-136 | 516 | Turkey |
| B-064 | 0 | |
| B-243 | 0 | |
| B-155 | 0 | |
| B-335 | 0 | |
| B-046 | 610 | Turkey |
| B-074 | 0 | |
| B-075 | 2,555 | Turkey, Dairy |
| B-110 | 0 | |
| B-316 | 120 | Turkey |
| B-280 | 0 | |
| B-337 | 3,551 | Turkey, Dairy, Poultry, Swine |
| B-145 | 2,314 | Turkey |
| B-350 | 43 | Turkey |
| B-123 | 0 | |
| B-077 | 0 | |
| B-102 | 164 | Turkey |
| B-338 | 259 | Turkey |

All these land application fields may not actually be in use; SCDHEC estimates represent a total number of permitted land application sites and not operating disposal sites. Improperly applied manure is a possible source of fecal coliform bacteria within the SC portion of the three watersheds. It is important to note that insufficient data are available to adequately estimate fecal coliform concentrations in stormwater runoff from land application fields where manure is applied. These operations are permitted; therefore, problems are managed through SCDHEC enforcement mechanisms.

The combination of the poultry population and the acreage of land application fields indicate that poultry operations could be a potential source of fecal coliform loading in some of the watersheds.

**Horses:** In 2002, there were 1,919 horses in York County, 1,531 horses in Richland County, and 806 horses in Chester County (USDA 2002). Union, Newberry, and Fairfield Counties had less than 500 horses each. A single horse produces 350 pounds of manure per week (Card 2004). The 2002 horse manure production in York County, Richland County, and Chester County was approximately 48, 38, and 20 tons per day, respectively. These numbers suggest that horses may be contributing fecal coliform loadings within the watersheds of WQM stations B-086, B-136, B-074, B-135, B-075, and B-046.

### 3.2.3 Failing Onsite Wastewater Disposal Systems and Illicit Discharges

Table 3-8 provides estimations of the number of OSWD systems (primarily septic systems) in each watershed based on U.S. Census data. The table also estimates the density of the OSWD systems. The density of OSWD systems within each watershed was estimated by dividing the number of OSWD systems in each census tract by the number of acres in each census tract. This density was then applied to the number of acres of each census tract within a WQM station watershed. Most census tracts are fully within a watershed. Census tracts crossing a watershed boundary required an additional calculation to estimate the number of OSWD systems based on the proportion of the census tracking falling within each watershed. This step involved adding all the OSWD systems for each whole or partial census tract. Since subdivisions are built on large land tracts (hundreds of acres) the number of OSWD systems per 100 acres is easier to visualize; therefore, the following equation was used to estimate the number of OSWD systems summarized in Table 3-8:

*OSWD systems per 100 acres = (number of OSWD systems / number of acres in the watershed) x 100 acres*

Each type of OSWD system (septic system, surface irrigation, and cesspools) has its unique problems. More than 95 percent of the OSWD systems in each watershed are septic systems (U.S. Census 2000). OSWD system failures are proportional to the adequacy of a State’s minimum design criteria (Hall 2002). Failures include surface ponding or runoff of untreated waste prior to the effluent mixing with groundwater. Fecal coliform contaminated groundwater discharges to creeks through springs and seeps. Most studies estimated that the minimum lot size necessary to ensure against contamination is roughly one-half to one acre (Hall 2002). Some studies, however, found that lot sizes in this range or even larger would cause contamination of ground or surface water (University of Florida 1987). It has been estimated that areas with more than 40 OSWD systems per square mile (6.25 septic systems per 100 acres) can be considered to have potential contamination problems (Canter and Knox 1986). Table 3-8 identifies 4 out of 19 watersheds with OSWD system densities greater than 6.25 septic systems per 100 acres.

**Table 3-8 OSWD System Density**

| Watershed | Onsite Wastewater Systems | Onsite Wastewater Systems per 100-acres |
|---|---|---|

| | | |
|---|---|---|
| B-086 | 81 | 3.1 |
| B-136 | 1,664 | 1.9 |
| B-064 | 289 | 5.7 |
| B-243 | 124 | 13.6 |
| B-155 | 859 | 4.0 |
| B-335 | 167 | 2.7 |
| B-046 | 815 | 1.2 |
| B-074 | 151 | 3.2 |
| B-075 | 1,266 | 1.4 |
| B-110 | 536 | 3.9 |
| B-316 | 2,851 | 9.8 |
| B-280 | 612 | 17.1 |
| B-337 | 6,166 | 3.8 |
| B-145 | 896 | 0.8 |
| B-350 | 221 | 1.6 |
| B-123 | 32 | 5.7 |
| B-077 | 63 | 9.9 |
| B-102 | 283 | 1.6 |
| B-338 | 181 | 1.4 |

In 1995, the SCDHEC conducted a survey of 5-year-old conventional and modified OSWD systems, representing designs most commonly used in the State (SCDHEC 1995). A total of 649 systems were examined during the first 4 months of 1995. During that period, actual rainfall amounts met or exceeded the normal for the period. This allowed for examination of the systems under high stress conditions. Of the 649 systems examined, there were 47 OSWD systems (7.2%) characterized as malfunctioning (SCDHEC 1999). This number included systems that were discharging to the ground surface, backing up into a building, discharging via "straight pipe," or showing evidence of prior system repair or signs of periodic or seasonal failure. In comparison, the 1995 American Housing Survey conducted by the U.S. Census Bureau estimated that 10 percent of occupied homes with OSWD systems experienced malfunctions during the year nationwide (U.S. Census 1995).

The SCDHEC, Regulation 61-56 does not require a minimum lot size, but requires minimum setbacks, such as property lines that dictate the required size of each individual lot. The minimum setback distance to a surface water body is 50 linear feet. There is no single family residence requirement to reserve a backup area should the original system fail. According to the National Small Flows Clearinghouse (NFSC), the SC does not require an inspection of OSWD systems prior to sale of the property (NSFC 1996). Dense residential subdivisions relying on OSWD systems are typically near sewered metropolitan areas. Failing OSWD systems may be contributing to fecal coliform WQS exceedances in these areas. Fecal coliform loading from failing OSWD systems can be transported to streams in a variety of ways, including runoff from surface ponding or through groundwater springs and seeps.

### 3.2.4 Domestic Pets

Pets can be a major contributor of fecal coliform to streams. On average nationally, there are 0.58 dogs per household and 0.66 cats per household (American Veterinary Medical

Association 2004). Using the U.S. census data (U.S. Census Bureau 2000), dog and cat populations can be estimated for the counties listed in Table 3-9.
A study in a Washington, D.C. suburb found that dogs produce approximately 0.42 pounds of fecal waste per day (Thorpe 2003). A comparable number for waste produced by cats was not available, therefore only the estimated tons per day of dog waste produced is provided in Table 3-9. The large estimated population of dogs and cats in Richland County is expected given the urbanized area and large number of households associated with the City of Columbia. Consequently, fecal coliform from domestic pets transported by runoff from urban and suburban areas in the watersheds can be a significant source of loading in urbanized areas.

**Table 3-9 Estimated Number of Household Pets**

| County | Number of Households | Number of Dogs | Number of Cats | Tons of Dog Waste per Day |
|---|---|---|---|---|
| Chester | 12,800 | 7,424 | 8,448 | 1.6 |
| Fairfield | 8,774 | 5,089 | 5,790 | 1.1 |
| Richland | 120,101 | 69,659 | 79,267 | 14.6 |
| Union | 12,087 | 7,010 | 7,977 | 1.5 |
| York | 61,051 | 35,410 | 40,294 | 7.4 |

## 3.3 Summary of Fecal Coliform Sources and WQM Stations on Impaired Streams

The following data and information were used to describe point and nonpoint sources of fecal coliform and to estimate existing fecal coliform loading at each WQM station.

- Watershed land use and land cover;
- Watershed soil characteristics;
- Agricultural census data, including livestock populations;
- Households served by OSWD systems and OSWD system failure rates;
- Animal feeding operations;
- Domestic pet census data;
- NPDES permitted point sources and discharge monitoring reports; and
- MS4 regulations.

Based on the foregoring information and data presented and analyzed in this report, the following inferences can be made regarding the sources (point and nonpoint) and magnitude of fecal coliform contributions to the 303(d)-listed WQM stations listed in this report. Residential areas not classified as MS4s are categorized as nonpoint sources.

### 3.3.1 Ross Branch and Turkey Creek

Ross Branch, which drains the northwest section of the Town of York, is a tributary to Turkey Creek. These two watersheds lie within HUC 03050106020.

**WQM Station B-086, Ross Branch**

Ross Branch is the primary drainage way for the west side of the Town of York and a tributary to Turkey Creek. The headwater of Ross Branch is Lake Carolyn, located northwest of the intersection of SH 05 and U.S. Highway 321 (SCDHEC 2001).

The watershed for WQM station B-086 is small at 2,596-acres, and the estimated median flow is only 4 cubic feet per second (cfs). Urban land use (19 percent) within the watershed (Town of York) includes OSWD systems and sanitary sewer lines and a population of domestic pets. With the remaining land use of the watershed being forest, pastures, and row crops, there are a number of nonhuman sources also contributing to fecal coliform loading, including wildlife and livestock. It is estimated there are 185 cattle in this watershed. The deer population in the surrounding area ranges from 30 to 45 per square-mile.

Eighteen water samples were collected from station B-086 from May 1998 through October 2000. Analysis indicated 100 percent of the water samples contained fecal coliform concentrations above the WQS. There is no NPDES discharger in this watershed. The York WWTP discharges to a watershed outside of Ross Branch, and there were no reported SSOs in this watershed. There are an estimated 81 OSWD systems in the watershed.

Sources may be a combination of leaking sewer(s), failing OSWD system(s), land application fields, or cattle watering in the creek. In addition, fecal coliform loadings from nonhuman sources such as pets and wildlife, transported by rainfall runoff events, are most likely also contributing to the exceedance of fecal coliform WQSs. Since all the water samples contained excessive fecal coliform it is most probable there is one source causing most, if not all, of the exceedances which occurred during dry weather.

**WQM Station B-136, Turkey Creek**

Turkey Creek originates north of the Town of York, flowing out of Caldwell Lake and accepting drainage from Ross Branch (Lake Carolyn), Dry Fork, Little Turkey Creek (McClures Branch, Lindsey Creek), and Bryson Creek. Farther downstream, Blue Branch enters Turkey Creek followed by Rainey Branch (Palmer Branch), Susybole Creek (Little Susybole Creek), Mill Creek (Rodens Creek), and McKelvy Creek. The southern tip of the watershed resides within the Sumter National Forest (SCDHEC 2001). It is estimated there are 2,422 cattle in this watershed. The deer population ranges from 30 to more than 45 per square-mile.

The watershed for WQM station B-136 contains 87,998 acres and the estimated median flow is 143 cfs.. Less than 1 percent is residential and comprises the towns of Sharon, McConnells, and Lowrys. Approximately 79 percent is forest. Pastures and row crops are approximately 5 and 6 percent, respectively.

Thirty-three water samples were collected at station B-136 from May 1998 through November 2002. Eight (24 percent) of the samples exceeded the fecal coliform criterion for primary contact recreation. There is no active NPDES-permitted WWTP discharging fecal coliform, and no SSOs were reported within this watershed. There are an estimated 1,664 OSWD systems within this watershed. The most probable source of fecal coliform is a combination of nonpoint sources including land application fields, failing OSWD systems, wildlife, and cattle watering in creeks.

### 3.3.2 Meng Creek and Tributary, Browns Creek, Gregorys Creek and Broad River

The watersheds of Meng Creek, Browns Creek, Gregorys Creek, and a portion of the Broad River are located in HUCs 03050106030 and 03050106010.

**WQM Station B-064, Meng Creek**

Meng Creek drains the northeastern quadrant of the City of Union. The creek is a tributary to Big Browns Creek which merges with Little Browns Creek to form Browns Creek. WQM station B-064 is above the confluence with Big Browns Creek at SH 49. The watershed for WQM station B-064 contains 5,077 acres, and the estimated median flow is 8 cfs. The urban land use (20 percent) within the watershed (Union, SC) includes OSWD systems, sanitary sewer lines, and a population of domestic pets. With the remaining land use of the watershed being forest (67 percent), pastures, and row crops, there are a number of nonhuman sources also contributing to fecal coliform loading. The estimated cattle population in the watershed is insignificant at only 41 cattle. The deer population ranges from 30 to more than 45 per square-mile.

Analysis of 17 water samples collected at station B-064 from May 1998 through October 2000 indicated fecal coliform counts in 12 of the samples (71 percent) were above the 400 cfu/100 ml WQS. There are no active NPDES-permitted WWTPs discharging to the watershed. There is no designated Phase I or II MS4s within this watershed. Stormwater runoff from the City of Union is considered a nonpoint source. The wastewater collection system serving the Union Meng Creek WWTP had eight SSOs from December 1998 through April 2000. Only a portion (approximately 30 percent) of the collection system lies within the Meng Creek watershed. The estimated volumes of two SSOs were 20,000 gallons (reported March 31, 1999) and 50,000 gallons on January 25, 2000, but records did not indicate which water body received the sewage. Water samples were not collected within Meng Creek at WQM station B-064 during those two months. The Union Meng Creek WWTP serves the City of Union and surrounding area. There are an estimated 289 OSWD systems within the watershed. With only nonpoint source fecal coliform loading causing the nonsupport of primary contact recreation, the most probable categories include a combination of residential stormwater runoff, failing OSWD systems, SSOs, leaking sewers, pets, and wildlife.

**WQM Station B-243, Tributary to Meng Creek**

This small tributary of Meng Creek drains the east side of the City of Union. The watershed for WQM station B-243 is only 910 acres, and the estimated median flow is only 1.4 cfs. Approximately 13 percent of the watershed is residences and businesses, and approximately 77 percent is forest. Pastures and row crops make up approximately 1 percent and 8 percent, respectively. The estimated number of cattle is insignificant. The deer population ranges from 30 to more than 45 per square-mile.

Analysis of water samples from WQM station B-243, collected from May 1998 through October 2000, indicated fecal coliform counts in 13 out of 17 samples (76 percent) were above the 400 cfu/100 ml WQS. There is no active NPDES-permitted WWTP discharging fecal coliform into this watershed. There are no designated Phase I or II MS4 urban areas within this watershed. Stormwater runoff from the City of Union is considered a nonpoint source. The collection system serving the City of Union also lies within this watershed. The SSOs that may be within the Meng Creek watershed (B-064) described above could have actually occurred within this tributary's watershed. There are an estimated 124 OSWD systems within the watershed of WQM station B-243 which equates to approximately 13.6 OSWD systems per 100 acres. With only nonpoint source fecal coliform loading causing the nonsupport of primary contact recreation, the most probable categories include a combination of residential stormwater runoff, failing OSWD systems, leaking sewers, pets, and wildlife.

**WQM Station B-155, Browns Creek**

The watershed for WQM station B-155 contains 21,692 acres and the estimated median flow is 44 cfs.. Less than 1 percent is residential. Approximately 71 percent is forest, with the lower part containing a portion of the Sumter National Forest. Pastures and row crops occupy approximately 9 and 17 percent, respectively. The estimated number of cattle in this watershed is 934. The deer population ranges from 30 to more than 45 per square-mile.

There are no designated Phase I or II MS4 urban areas in the B-155 watershed. The collection system serving the new Union Meng Creek WWTP, which actually discharges to Big Browns Creek (tributary to Browns Creek, B-155), had eight SSOs from December 1998 through April 2000. Parts of the collection system lie with the watersheds of Meng Creek (B-064), a tributary to Meng Creek (B-243), Big Browns Creek, and Browns Creek (B-155). The estimated volumes of two SSOs were 20,000-gallons (reported March 31, 1999) and 50,000-gallons (reported on January 25, 2000). Water samples collected within Browns Creek at WQM station B-155 on March 13 and April 7, 1999 did not contain a spike in the fecal coliform concentration. Nevertheless, fecal coliform concentrations from May 1998 through December 2002 at B-155 were above the 400 cfu/100 ml WQS in 24 (22 percent) of 36 samples. The Union Meng Creek WWTP serves the City of Union and surrounding area. There are an estimated 859 OSWD systems within this watershed. The sources of fecal coliform contributing to nonsupport of primary contact recreation most probably include a combination of residential stormwater runoff, failing OSWD systems SSOs, leaking sewers, pets, cattle in creeks, and wildlife.

**WQM Station B-335, Gregorys Creek**

The watershed for WQM station B-335 contains 6,094 acres. Most of the watershed is on private land within the Sumter National Forest. Approximately 91 percent of the watershed is forest with pastures and row crops covering approximately 1 percent and 5 percent, respectively. The estimated cattle population in this watershed is insignificant. The deer population ranges from 30 to more than 45 per square-mile.

Thirteen water samples were collected at station B-335 from May 1998 through October 1999. Six (46 percent) of the samples contained excessive fecal coliform. There is no active NPDES-permitted WWTP discharging fecal coliform. There were no SSOs reported within this watershed. As a result, the fecal coliform loading in this watershed is entirely from nonpoint sources. There are an estimated 167 OSWD systems within this watershed. The most probable sources of fecal coliform contributing to nonsupport of primary contact recreation are failing OSWD systems and wildlife.

**WQM Station B-046, Broad River**

This segment of the Broad River watershed begins at the southern tip of Cherokee County and ends at the SH 72 bridge, approximately 3 miles east of the Town of Carlisle.

Upstream of HUC 03050106010, TMDLs for fecal coliform have already been established for HUCs 03050105190 and 03050105090 which ensures that the Broad River will be fully supporting the primary contact recreation use at the northern boundary of HUC 03050106010. The Broad River forms the border for Union County on the west side and Chester County on the east side. The watershed for WQM station B-046 contains 68,154 acres. Less than 1 percent is occupied by residential and commercial land use. Approximately 79 percent is forest, with the lower half located in the Sumter National Forest. Pastures, row crops, and transitional land use cover approximately 4, 6 and 7 percent, respectively. It is estimated there are 1,292 cattle in this watershed. The deer population ranges from 30 to more than 45 per square-mile.

Fourteen, or 24 percent of the 59 water samples collected at station B-046 from January 998 through December 2002, had excessive fecal coliform. There are three NPDES dischargers with fecal coliform limits. The Lockhart WWTP (SC003051) reported one fecal coliform permit violation out of 60 effluent analyses. The Chemtrade Performance Chemicals Leeds WWTP (SC0022576) reported two fecal coliform permit violations out of 72 analyses. And the Cone Mills Corporation Carlisle WWTP (SC0001368) reported two fecal coliform permit violations out of 72 analyses. No SSOs were reported for these three NPDES facilities. The data suggest that NPDES dischargers are not contributing to the fecal coliform WQS exceedances. There are no designated Phase I or II MS4 urban areas in Union County or Chester County. Stormwater runoff from the Town of Carlisle enters the Broad River downstream of WQM station B-046. There are an estimated 815 OSWD systems in this watershed. There are extensive recreational areas adjacent to the Broad River about 8 miles upstream (U.S. Forest Service 2003).

The sources of fecal coliform most probably include a combination of land application fields, failing OSWD systems, cattle in creeks, and wildlife. The extensive recreational activity along the Broad River may also be a source of fecal coliform loading.

### 3.3.3 Dry Fork and Sandy River

The watersheds discussed in this subsection are within HUC 03050106040 which is located almost entirely within Chester County, SC.

**WQM Station B-074, Dry Fork**

Dry Fork is a tributary to Sandy River. The watershed for WQM station B-074 contains 4,676 acres, and the estimated median flow is 6 cfs. This watershed contains the west side of the Town of Chester, which composes 41 percent of the total area. Forested land use occupies 49 percent, with pastures and row crops covering approximately 2 percent and 7 percent, respectively. The large urban area also suggests a sizeable pet population within the watershed. It is estimated there are only 69 cattle in this watershed. The deer population ranges from 30 to more than 45 per square-mile outside the residential area.

Seventeen, or 74 percent of the 24 ambient water samples collected at WQM station B-074 from May 1998 through October 2000 exceeded the fecal coliform WQS of 400 cfu/100 ml. There is no active NPDES-permitted WWTP with fecal coliform limits discharging into Dry Fork. As a result, fecal coliform loading in this watershed is entirely from nonpoint sources. The Chester Sewer District's WWTP discharges downstream into Sandy River, but a large part of the sewage collection system is within this watershed. The Chester Metro Sandy Creek WWTP (SC0036081) reported 47 SSOs from its collection system during September 1998 through September 2004. Fifteen of the 47 SSOs were believed to be greater than 1,000 gallons, and spilled into an unreported waterbody. The estimated number of OSWD systems is 151. The sources of fecal coliform contributing to nonsupport of primary contact recreation most probably include a combination of SSOs, residential nonpoint source stormwater runoff, failing OSWD systems, leaking sewers, pets, and wildlife.

**WQM Station B-075, Sandy River**

The Sandy River drains mostly undeveloped land and some of the Town of Chester. The watershed for WQM station B-075 contains 91,355 acres. Less than 1.5 percent is occupied by residential and commercial land use. Approximately 84 percent of the total area is forest. Pastures and row crops account for approximately 5 percent and 7 percent, respectively. It is estimated there are 2,942 cattle in this watershed. The deer population ranges from 30 to more than 45 per square-mile.

Thirteen, or 33 percent of the 40 water samples collected from WQM station B-075 exceeded the 400 cfu/100 ml WQS. There are no designated Phase I or II MS4 urban areas within the watershed. The Chester Sewer District NPDES-permitted WWTP discharges into this watershed. The WWTP reported no fecal coliform permit violations out of 72 analyses. The estimated number of OSWD systems is 1,266.

The sources of fecal coliform contributing to nonsupport of primary contact recreation probably include a combination of nonpoint sources such as land application fields, cattle in creeks, failing OSWD systems, and wildlife.

### 3.3.4 Elizabeth Lake at Spillway, Crane Creek, Smith Branch, and Broad River

The watersheds discussed in this subsection are within HUC 03050106060. While all the WQM stations in HUC 03050106050 are supporting primary contact recreation use, source assessment of fecal coliform loading from HUC 03050106050 was evaluated since it is upstream of the 303(d)-listed WQM station B-337 in HUC 03050106060.

**WQM Station B-110, Elizabeth Lake (upper Crane Creek)**

This watershed contains a portion of the City of Columbia Phase I MS4. Water quality data for fecal coliform concentrations in stormwater from MS4 outfalls were not available.

The upper Crane Creek watershed contains 13,680 acres and several small lakes, including Elizabeth Lake. Elizabeth Lake is primarily surrounded by forest and undeveloped land. The five lakes in the upper watershed are surrounded or partially surrounded by subdivisions. Approximately 14 percent of the total area is occupied by residential or commercial/industrial land use. Pastures and row crops cover approximately 1 percent and 21 percent, respectively. Forest covers approximately 57 percent. The urban area also suggests a sizeable pet population within the watershed. It is estimated there are only 40 cattle in this watershed. The deer population ranges from 15 to 30 per square-mile.

Two, or 11 percent of the 18 water samples collected at WQM station B-110 from May 1998 through October 2000 exceeded the fecal coliform WQS of 400 cfu/100 ml. There is no active NPDES-permitted WWTP discharging fecal coliform in this watershed. There were no SSOs reported within this watershed. The estimated number of OSWD systems in this watershed is 536. Although this WQM station barely surpassed the threshold of no more than 10 percent of the instantaneous samples exceeding the WQS (400 cfu/100 ml), the most probable sources of fecal coliform loading are from stormwater runoff within MS4 areas and nonpoint sources such as failing OSWD systems, leaking sewers, pets, and wildlife.

**WQM Station B-316, Crane Creek**

This watershed contains a portion of the City of Columbia and Richland County Phase I MS4s. According to Figure 3-2, the areas along Crane Creek are sewered.

The Crane Creek watershed has a high potential for economic growth. The WQM station B-316 is under the I-20 bridge. The watershed for WQM station B-316 contains 28,997 acres. Approximately 17 percent is urban (City of Columbia), and approximately 69 percent is forest. Pastures and row crops occupy approximately 1 percent and 7 percent, respectively. It is estimated there are 75 cattle in this watershed. The deer population is less than 15 per square-mile.

Four, or 11 percent of the 35 water samples collected at this station from January 1998 through December 2000, exceeded the fecal coliform WQS of 400 cfu/100 ml. The Richtex Corporation NPDES-permitted WWTP discharges into this watershed. The WWTP reported five fecal coliform permit violations out of 37 effluent analyses. One permit violation (850 cfu/100 ml) occurred during the July 1999. A water sample collected on July 13, 1999 at B-316 contained 3,800 cfu/100 ml. The WWTP may have contributed to the WQS exceedance on this day. There were no SSOs reported within this watershed. There are an estimated 2,851 OSWD systems within this watershed resulting in 9.8 OSWD systems per 100 acres. Although the WQS is exceeded infrequently at this WQM station, the most probable sources of fecal coliform loading are from MS4 point sources, failing OSWD systems, leaking sewers, and pets.

**WQM Station B-280, Smith Branch**

In this report, Smith Branch is the most downstream tributary of the Broad River. The branch drains a dense urban area within the City of Columbia designated as an MS4 area. The watershed for WQM station B-280 contains 3,583 acres and the estimated median flow is only 4.4 cfs.. Approximately 81 percent of the watershed is urban (City of Columbia), and approximately 15 percent is forest. Pastures and row crops are approximately 2 percent. The large urban area suggests a sizeable pet population within the watershed. No cattle are presumed to be located in this watershed. The deer population ranges from 15 to 30 deer per square-mile.

Thirty-two, or 89 percent of the 36 water samples collected at this station from January 1998 through December 2000 exceeded the fecal coliform WQS of 400 cfu/100 ml. There is no active NPDES-permitted WWTP discharging fecal coliform in this watershed. There were no SSOs reported within this watershed. There are an estimated 612 OSWD systems within this watershed resulting in 17.1 OSWD systems per 100 acres. The sources of fecal coliform contributing to nonsupport of primary contact recreation most probably include a combination of MS4 point sources, failing OSWD systems, leaking sewers, pets, and wildlife.

**WQM Station B-337, Broad River**

The Broad River watershed for WQM station B-337 is the largest in this report. This watershed comprises 160,261 acres and includes HUC 03050106050 in the pollutant source assessment. Upstream of HUC 03050106050, TMDLs for fecal coliform have already been established for HUCs 03050108, the Enoree River Basin, and 03050107, the Tyger River Basin, which ensure that the Broad River will receive freshwater inflow from these two basins, fully supporting the primary contact recreation use at the western boundary of HUC 03050106050. Only 3 percent of the watershed is occupied by residential and commercial land use, including northwest Columbia, the Town of Peak, portions of the towns of Chapin, Little Mountains, and Pomaria, (combined total of 4,197 acres). Approximately 82 percent is forest. Pastures and row crops are approximately 2 percent and 3 percent, respectively. It is estimated there are 6,536 cattle in this watershed. While there are a large number of AFOs located in HUC 03050106050, poultry and swine facilities are not considered significant sources of fecal coliform loading. The deer population ranges from less than 15 to 30 per square-mile. Five, or 14 percent of the 37 water samples collected at this station from November 1998 through December 2002 exceeded the fecal coliform WQS of 400 cfu/100 ml. There are eight NPDES-permitted WWTP dischargers with fecal coliform limits in this watershed. Richland County contains the Columbia urbanized area (Phase I MS4) and four NPDES facilities that discharge into the watersheds outlined in this report. The collection system of the Richland County WWTP (SC0046621) primarily lies between IH 26 and Broad River downstream of the confluence of Little River and Nicholas Creek. The Richland County WWTP reported five fecal coliform permit violations from January 1998 through December 2003. No permit violation coincided with a WQS exceedances at B-337. The WWTP also reported 12-SSOs from October 23, 2000 through September 8, 2004. There were three SSOs above 1,000 gallons that entered a water body. Those SSOs did not coincide with any recorded fecal coliform WQS exceedances at station B-337. The Midlands Utility Raintree Acres subdivision WWTP (SC0039055), north of Nicholas Creek, reported 10 SSOs from January 27, 1999 through March 17, 2003. Eight of the SSOs were of unknown quantity except one (300 gallons) which spilled to a water body. Those eight SSOs did not coincide with a WQS exceedance at B-337. The other six NPDES-permitted WWTPs reported one or less fecal coliform violations and no SSOs. There are an estimated 6,166 OSWD systems in this watershed. The primary sources of fecal coliform causing the WQS exceedances are located below WQM station B-236, which is not on the 303(d) list for fecal coliform. The sources of fecal coliform contributing to nonsupport of primary contact recreation most probably include a combination of land application fields, MS4 stormwater runoff, SSOs, failing OSWD systems, leaking sewers, pets, cattle in creeks, and wildlife.

### 3.3.5 Little River

The watersheds discussed in this subsection are within HUC 03050106070 which is located almost entirely in Fairfield County, SC.

**WQM Station B-145, Little River**

Big Creek and Little Creek join to form the headwaters of the Little River near the Town of Blackstock. Downstream of the confluence, the Little River accepts drainage from Camp Branch, Brushy Fork Creek (Dumpers Creek), the West Fork Little River (Weir Creek, Spring Branch, Williams Creek, Opossum Branch), Lick Branch, and Harden Branch. The Jackson Creek watershed drains into Little River next followed by Crumpton Creek, the Mill Creek watershed, Morris Creek, and Gibson Branch (Manns

Branch, Russell Creek). There are a few ponds and lakes in this watershed used for recreational and industrial purposes.

The watershed for WQM station B-145 contains 106,711 acres. Less than 1 percent of the total area is residential. Approximately 85 percent is forest. Pastures and row crops cover approximately 2 percent and 3 percent, respectively. It is estimated there are 1,377 cattle in this watershed. The deer population ranges from 30 to more than 45 per square mile.

Five, or 21 percent, of the 24 water samples collected at this station from May 1998 through October 2000 exceeded the fecal coliform WQS of 400 cfu/100 ml. There is no active NPDES-permitted WWTP discharging fecal coliform in this watershed. There are an estimated 896 OSWD systems within this watershed. There are no MS4 urban areas within this watershed. The sources of fecal coliform contributing to nonsupport of primary contact recreation most probably include a combination of nonpoint sources such as land application fields, cattle in creeks, failing OSWD systems, and wildlife.

**WQM Station B-350, Little River**

This downstream segment of the Little River drains into the Broad River. Home Branch is a tributary. The watershed for WQM station B-350 contains 13,862 acres. Approximately 11 percent of the watershed is residential and commercial land use. Approximately 87 percent is covered by forest. Pastures and row crops occupy approximately 1 percent and 3 percent, respectively. It is estimated there are 105 cattle in this watershed. The deer population ranges from 30 to more than 45 per square mile. Seven, or 26 percent, of the 24 water samples collected at this station from January 2001 through December 2002 exceeded the fecal coliform WQS of 400 cfu/100 ml. There are no MS4 urban areas nor NPDES-permitted dischargers in this watershed. The number of OSWD systems is estimated to be 221. Sources of fecal coliform may include failing OSWD systems, pets, cattle, and wildlife. The high number of samples exceeding the geometric mean criteria suggests there are dry weather sources of fecal coliform, such as cattle watering in creeks.

### 3.3.6 Winnsboro Branch, Winnsboro Branch below Outfall, Jackson Creek, and Mill Creek

The watersheds discussed in this subsection are located in central Fairfield County, SC and are within HUC 03050106080.

**WQM Station B-123, Winnsboro Branch (upper)**

Winnsboro Branch is a tributary to Jackson Creek. The WQM station B-123 watershed is only 440 acres, and the estimated median flow is only 0.5 cfs. Approximately 65 percent of the watershed is residential and commercial land use (Town of Winnsboro). Approximately 26 percent is forest. Pastures and row crops are approximately 2 and 3 percent, respectively. The large urban area suggests a sizeable pet population within the watershed. The estimated number of cattle in this watershed is insignificant. The deer population surrounding the residential areas ranges from 30 to more than 45 per square mile.

Thirteen, or 72 percent, of the 18 water samples collected at this station from May 1998 through October 2000 exceeded the fecal coliform WQS of 400 cfu/100 ml. On September 6, 2000 the fecal coliform concentration was 20,000 cfu/100 ml which may have been associated with a sewage spill. High fecal coliform concentrations at B-123 generally correlate with high concentrations downstream at WQM station B-077. However, the high concentration recorded on September 6, 2000 did not result in WQS exceedances downstream at B-077. There are no MS4 urban areas in this watershed. The number of OSWD systems is estimated to be 32. Likely sources of fecal coliform are SSOs, leaking sewers, failing OSWD systems, pets, and wildlife.

**WQM Station B-077, Winnsboro Branch (lower)**

The water quality of the lower part of Winnsboro Branch is monitored at WQM station B-077. The watershed contains 2,114 acres. Approximately 27 percent of the watershed is residential and commercial land use (Town of Winnsboro). Approximately 55 percent is forest. Pastures and row crops are approximately 4 percent and 10 percent, respectively. The estimated number of cattle in this watershed is 55. The deer population ranges from 30 to more than 45 per square mile.

Eleven, or 58 percent, of the 19 water samples collected at B-077 from May 1998 through October 2000 exceeded the fecal coliform WQS of 400 cfu/100 ml. The Winnsboro Jackson Creek WWTP, which is upstream of this station, reported nine SSOs that reached a water body between September 2000 and December 2004. All quantity estimations were below 1,000 gallons. Six of these SSOs were reported to have entered Winnsboro Branch. One of the SSOs was reported on September 12, 2000; the actual date of the spill is unknown. The other SSOs occurred after the last water quality samples were collected October 2000 at B-123 and B-077.

There are no MS4 urban areas in this watershed. The number of OSWD systems is estimated to be 63 which equates to approximately 10 OSWD systems per 100 acres. The sources of fecal coliform contributing to nonsupport of primary contact recreation most probably include a combination of nonpoint sources upstream of B-123 but also from failing OSWD systems, SSOs, leaking sewer systems, pets, and wildlife within the watershed of B-077.

**WQM Station B-102, Jackson Creek**

Jackson Creek is a tributary to Little River. The watershed for WQM station B-102 contains 16,752 acres. Approximately 5 percent is occupied by houses and businesses. Approximately 83 percent is forest. Pastures and row crops are approximately 4 percent and 6 percent, respectively. It is estimated there are 550 cattle in this watershed. The deer population ranges from 30 to more than 45 per square mile.

Seven, or 19 percent, of the 37 water samples collected at B-102 from November 1998 through December 2002 exceeded the fecal coliform WQS of 400 cfu/100 ml. The Royal Hill subdivision WWTP (SC0031046) near the Town of Adger, approximately 5 miles upstream of B-102, had two SSOs on November 30, 2001, (quantity unknown) and July 2, 2003 (approximately 400 gallons). A water sample collected on December 5, 2001 at B-102 contained 650 cfu/100 ml and may have been associated with the SSO on November 30, 2001. The WWTP is believed to be a “no-discharge” facility that may use irrigation as the disposal method.

There are no MS4 urban areas in this watershed. The number of OSWD systems is estimated to be 283. The sources of fecal coliform contributing to nonsupport of primary contact recreation most probably include a combination of nonpoint sources upstream of B-077 but also from failing land application fields, OSWD systems, and wildlife in the Jackson Creek watershed.

**WQM Station B-338, Mill Creek**

Mill Creek is a tributary to Little River. The watershed for WQM station B-338 contains 12,675 acres. Only 2 percent of the watershed is occupied by residential and commercial land use. Approximately 75 percent is forest, with pastures and row crops covering approximately 8 percent each. It is estimated there are 715 cattle in this watershed. The deer population ranges from 30 to more than 45 per square mile.

Twenty, or 56 percent, of the 36 water samples collected from November 1998 through December 2002 exceeded the fecal coliform WQS of 400 cfu/100 ml. There are no MS4 urban areas or NPDES dischargers in this watershed. The number of OSWD systems is estimated to be 181. Sources of fecal coliform may include land application fields, failing OSWD systems, wildlife, and cattle watering in creeks.

# SECTION 4
# TECHNICAL APPROACH AND METHODOLOGY

A TMDL is defined as the total quantity of a pollutant that can be assimilated by a receiving water body while achieving the WQS. A TMDL is expressed as the sum of all WLAs (point source loads), LAs (nonpoint source loads), and an appropriate MOS, which attempts to account for uncertainty concerning the relationship between effluent limitations and water quality.

This definition can be expressed by the following equation:

**TMDL = Σ WLA + Σ LA + MOS**

The objective of the TMDL is to estimate allowable pollutant loads and to allocate these loads to the known pollutant sources in the watershed so the appropriate control measures can be implemented and the WQS achieved. 40 CFR § 130.2 (1) states that TMDLs can be expressed in terms of mass per time, toxicity, or other appropriate measures. For fecal coliform, TMDLs are expressed as cfu per day where possible or as percent reductions, and represent the maximum one-day load the stream can assimilate while still attaining the WQS.

## 4.1 Using Load Duration Curves to Develop TMDLs

LDCs are graphical analytical tools that illustrate the relationships between stream flow and water quality and assist in decision making regarding this relationship. Flow is an important factor affecting the loading and concentration of fecal coliform. Both point and nonpoint source loads of pollutants to streams may be affected by changes in flow regime. Given an understanding of the potential loading mechanisms of fecal coliform, and how those mechanisms relate to flow conditions, it is possible to infer and quantify the major contributing sources of pollutants to a stream by examining the relationship between flow and pollutant concentration or load. Of critical importance is that the incremental watershed LDC approach makes effective use of existing data. The lack of instream flow data at most water quality monitoring locations would typically be identified as a significant data gap for application of watershed and water quality models. However, since the incremental watershed LDC approach makes use of drainage area ratio-based flow estimates, the lack of flow information at these locations is not limiting. The incremental watershed approach also allows for assessment of land use, soil, and source contribution differences between observation points. The fecal coliform TMDLs presented in this report are designed to be protective of typical flow conditions. The following discussion provides an overview of the approach used to develop LDCs and TMDL calculations. Results and calculations are presented in Section 5.

## 4.2 Explanation of Steps used to Perform TMDL Calculations

The following discussion provides a summary of the steps involved in the calculation of the key components of the fecal coliform TMDLs presented in Section 5 of this report.

**Step 1: Develop Flow Percentiles for each WQM Station.** Direct flow measurements are not available for all of the WQM stations addressed in this report. This information, however, is vitally important to understanding the relationship between water quality and stream flow. Therefore, to characterize flow, in some cases flow data were derived from a flow estimation model for each relevant watershed. Flow data to support development of flow duration curves will be derived for each SCDHEC WQM station from USGS daily flow records (USGS 2005b) in the following priority:

i) In cases where a USGS flow gage coincides with, or occurs within one-half mile upstream or downstream of a SCDHEC WQM station and simultaneous daily flow data matching the water quality sample date are available, these flow measurements will be used.

ii) If flow measurements at the coincident gage are missing for some dates on which water quality samples were collected, gaps in the flow record will be filled, or the record extended, by estimating flow based on measured streamflows at a nearby gage. First, the most appropriate nearby stream gage is identified. All flow data are first log-transformed to linearize the data because flow data are highly skewed. Linear regressions are then developed between 1) daily streamflow at the gage to be filled/extended; and 2) streamflow at all gages within 93 miles (150 kilometers) that have at least 300 daily flow measurements on matching dates. The station with the strongest flow relationship, as indicated by the highest correlation coefficient (r-squared value), is selected as the index gage. R-squared indicates the fraction of the variance in flow explained by the regression. The regression is then used to estimate flow at the gage to be filled/extended from flow at the index station. Flows will not be estimated based on regressions with r-squared values less than 0.25, even if that is the best regression. This value was selected based on familiarity with using regression analysis in estimating flows. In some cases, it will be necessary to fill/extend flow records from two or more index gages. The flow record will be filled/extended to the extent possible based on the strongest index gage (highest r-squared value), and remaining gaps will be filled from successively weaker index gages (next highest r-squared value), and so forth.

iii) In the event no coincident flow data are available for a WQM station, but flow gage(s) are present upstream and/or downstream, flows will be estimated for the WQM station from an upstream or downstream gage using a watershed area ratio method derived by delineating subwatersheds, and relying on the Natural Resources Conservation Service runoff curve numbers and antecedent rainfall condition. Drainage subbasins will first be delineated for all impaired 303(d)-listed WQM stations, along with all USGS flow stations located in the 8-digit HUCs with impaired streams. All USGS gage stations upstream and downstream of the subwatersheds with 303(d)-listed WQM stations will be identified.

**Step 2: Develop Flow Duration Curves.** Flow duration curves serve as the foundation of LDC TMDLs. Flow duration curves are graphical representations of the flow regime of a stream at a given site. The flow duration curve is an important tool of hydrologists, utilizing the historical hydrologic record from stream gages to forecast future recurrence frequencies.

Flow duration curves are a type of cumulative distribution function. The flow duration curve represents the fraction of flow observations that exceed a given flow at the site of interest. The observed flow values are first ranked from highest to lowest, then, for each observation, the percentage of observations exceeding that flow is calculated. The flow rates for each 5$^{th}$ percentile for each WQM station are provided in Appendix D. The flow value is read from the ordinate (y-axis), which is typically on a logarithmic scale since the high flows would otherwise overwhelm the low flows. The flow exceedance frequency is read from the abscissa, which is numbered from 0 to 100 percent, and may or may not be logarithmic. The lowest measured flow occurs at an exceedance frequency of 100 percent, indicating that flow has equaled or exceeded this value 100 percent of the time, while the highest measured flow is found at an exceedance frequency of 0 percent. The median flow occurs at a flow exceedance frequency of 50 percent.

While the number of observations required to develop a flow duration curve is not rigorously specified, a flow duration curve is usually based on more than 1 year of observations, and encompasses inter-annual and seasonal variations. Ideally, the drought and flood of record are included in the observations. For this purpose, the long term flow gaging stations operated by the USGS are ideal.

A typical semi-log flow duration curve exhibits a sigmoidal shape, bending upward near a flow duration of 0 percent and downward at a frequency near 100 percent, often with a relatively constant slope in between. However, at extreme low and high flow values, flow duration curves may exhibit a "stair step" effect due to the USGS flow data rounding conventions near the limits of quantitation. The extreme high flow conditions (<10$^{th}$ percentile) and low flow conditions (>95 percentile) are not considered in development of these TMDLs. The overall slope of the flow duration curve is an indication of the flow variability of the stream.

Flow duration curves can be subjectively divided into several hydrologic condition classes. These hydrologic classes facilitate the diagnostic and analytical uses of flow and LDCs. The hydrologic classification scheme utilized in the development of these TMDLs is presented in Table 4-1.

**Table 4-1 Hydrologic Condition Classes**

| Flow Duration Interval | Hydrologic Condition Class* |
|---|---|
| 0-10% | High flows |
| 10-40% | Moist Conditions |
| 40-60% | Mid-Range Conditions |
| 60-90% | Dry Conditions |
| 90-100% | Low Flows |

Source: Cleland 2003.

**Step 3: Estimate Current Point Source Loading.** In SC, NPDES permittees that discharge treated sanitary wastewater must meet the state WQS for fecal coliform bacteria at the point of discharge (see discussion in Section 2). However, for TMDL analysis it is necessary to understand the relative contribution of WWTPs to the overall pollutant loading and their general compliance with required effluent limits. The fecal coliform load for continuous point source dischargers was estimated by multiplying the monthly average flow rates by the monthly geometric mean using a conversion factor. The data were extracted from each point source's DMR from 1998 through 2004. The $90^{th}$ percentile value of the monthly loads was used to express the estimated existing load in counts/day. The current pollutant loading from each permitted point source discharge as summarized in Section 3 was calculated using the equation below.

*Point Source Loading = monthly average flow rates (mgd) * geometric mean of corresponding fecal coliform concentration * unit conversion factor*

*Where:*
*unit conversion factor = 37,854,120 100-ml/million gallons (mg)*

**Step 4: Estimate Current Loading and Identify Critical Conditions.** It is difficult to estimate current nonpoint loading due to lack of specific water quality and flow information that would assist in estimating the relative proportion of non-specific sources within the watershed. Therefore, existing instream loads were used as a conservative surrogate for nonpoint loading. It was calculated by multiplying the concentration by the flow matched to the specific sampling date. Then using the hydrologic flow intervals shown in Table 4-1, the $90^{th}$ percentile nonpoint loading within each of the intervals would then represent the nonpoint loading estimate for that interval. Existing loads have been estimated using a regression-based relationship developed between observed fecal coliform loads and flow or flow exceedance percentile.

In many cases, inspection of the LDC will reveal a critical condition related to exceedances of WQSs. For example, criteria exceedances may occur more frequently in wet weather, low flow conditions, or after large rainfall events. The critical conditions are such that if WQSs were met under those conditions, WQSs would likely be met overall. Given that the instantaneous fecal coliform criterion indicates that no more than 10 percent of samples should exceed 400 cfy/100 ml, it is appropriate to evaluate existing loading as the $90^{th}$ percentile of observed fecal coliform concentrations. Together with the MOS, the reduction calculated in this way should ensure that no more than 10 percent of samples will exceed the criterion.

Existing loading is calculated as the $90^{th}$ percentile of measured fecal coliform concentrations under each hydrologic condition class multiplied by the flow at the middle of the flow exceedance percentile. For example, in calculating the existing loading under dry conditions (flow exceedance percentile = 60-90%), the $75^{th}$ percentile exceedance flow is multiplied by the $90^{th}$ percentile of fecal coliform concentrations measured under the $60\text{-}90^{th}$ percentile flows. The "high flow" or "low flow" hydrologic conditions will not be selected as critical conditions because these extreme flows are not representative of typical conditions, and few observations are typically available to reliably estimate loads under these conditions. This methodology results in multiple estimates of existing loading. However, TMDLs are typically expressed as a load or concentration under a single scenario. Therefore, these TMDLs will assume that if the highest percent reduction associated with the difference between the existing loading and the LDC (TMDL) is achieved, the WQS will be attained under all other flow conditions.

**Step 5: Develop Fecal Coliform Load Duration Curves (TMDL).** Load duration curves are based on flow duration curves, with the additional display of historical pollutant load observations at the same location, and the associated water quality criterion or criteria. In lieu of flow, the ordinate is expressed in terms of a fecal coliform load (cfu/day). The curve represents the single sample water quality criterion for fecal coliform (400 cfu/100 ml) expressed in terms of a load through multiplication by the continuum of flows historically observed at the site. The points represent individual paired historical observations of fecal coliform concentration and flow. Fecal coliform concentration data used for each WQM station are provided in Appendix A. The fecal coliform load (or the y-value of each point) is calculated by multiplying the fecal coliform WQS by the instantaneous flow (cfs) from the same site and time, with appropriate volumetric and time unit conversions.

***TMDL (cfu/day) = WQS * flow (cfs) * unit conversion factor***

*Where: WQS = 400 cfu/100ml*

*unit conversion factor = 24,465,525 ml*s /* $ft^3$**day*

The flow exceedance frequency (x-value of each point) is obtained by looking up the historical exceedance frequency of the measured flow, in other words, the percent of historical observations that equal or exceed the measured flow. It should be noted that the site daily average stream flow is often used if an instantaneous flow measurement is not available. Fecal coliform loads representing exceedance of water quality criteria fall above the water quality criterion line.

**Step 6: Develop LDCs with MOS.** An LDC depicting slightly lower estimates than the TMDL is developed to represent the TMDL with MOS. An explicit MOS is defined for each TMDL by establishing an LDC using 95 percent of the TMDL value (5 percent of the 400 cfu/100 ml instantaneous water quality criterion) to slightly reduce assimilative capacity in the watershed, thus providing a 5 percent MOS. The MOS at any given percent flow exceedance, therefore, is defined as the difference in loading between the TMDL and the TMDL with MOS.

**Step 7: Calculate WLA.** As previously stated, the pollutant load allocation for point sources is defined by the WLA. A point source can be either a wastewater (continuous) or stormwater (MS4) discharge. Stormwater point sources are typically associated with urban and industrialized areas, and recent USEPA guidance includes permitted stormwater discharges as point source discharges and, therefore, part of the WLA.

The LDC approach recognizes that the assimilative capacity of a water body depends on the flow, and that maximum allowable loading will vary with flow condition. TMDLs can be expressed in terms of maximum allowable concentrations, or as different maximum loads allowable under different flow conditions, rather than single maximum load values. This concentration-based approach meets the requirements of 40 CFR, 130.2(i) for expressing TMDLs "in terms of mass per time, toxicity, or other appropriate measures" and is consistent with USEPA's *Protocol for Developing Pathogen TMDLs* (USEPA 2001).

**WLA for WWTP.** Wasteload allocations may be set to zero in cases of watersheds with no existing or planned continuous permitted point sources. For watersheds with permitted point sources, wasteloads may be derived from NPDES permit limits. A WLA may be calculated for each active NPDES wastewater discharger using a mass balance approach as shown in the equation below. The permitted average flow rate used for each point source discharge and the water quality criterion concentration are used to estimate the WLA for each wastewater facility. All WLA values for each subwatershed are then summed to represent the total WLA for the watershed.

*WLA (cfu/day) = WQS * flow * unit conversion factor*
*Where: WQS = 400 cfu/100ml*
*flow (mgd) = permitted flow or design flow (if unavailable)*
*unit conversion factor = 37,854,120 100-ml/mg*

**WLA for MS4s.** Because a WLA for each MS4 cannot be calculated as an individual value, WLAs for MS4s are expressed as a percent reduction goal (PRG) derived from the LDC for nonpoint sources. The method for estimating the percent reduction of fecal coliform loading is described in Step 8.

**Step 8: Calculate LA.** Load allocations can be calculated under different flow conditions as the water quality target load minus the WLA. The LA is represented by the area under the LDC but above the WLA. The LA at any particular flow exceedance is calculated as shown in the equation below.

**LA = TMDL – MOS - ∑WLA**

However, to express the LA as an individual value, the LA is derived using the equation above but at the median point of the hydrologic condition class requiring the largest percent reduction as displayed in the LDCs provided in Appendix E. Thus, an alternate method for expressing the LA is to calculate a PRG for fecal coliform. Load allocations are calculated as percent reductions from current estimated loading levels required to meet water quality criteria.

**Step 9: Estimate WLA Load Reduction.** The WLA load reduction was not calculated because it was assumed that the continuous dischargers (NPDES permitted WWTPs) are adequately regulated under existing permits and, therefore, no WLA reduction would be required. For the MS4 permittees, the percent reduction was assumed to be the same as the nonpoint load reduction.

**Step 10: Estimate LA Load Reduction.** After existing loading estimates are computed for the three different hydrologic condition classes described in Step 2, nonpoint load reduction estimates for each WQM station are calculated by using the difference between estimated existing loading (Step 5) and the LDC (TMDL). This difference is expressed as a percent reduction, and the hydrologic condition class with the largest percent reduction is selected as the critical condition and the overall PRG for the LA.

Results of all these calculations are discussed in Section 5.

# SECTION 5
# TMDL CALCULATIONS

## 5.1 Results of TMDL Calculations

The calculations and results of the TMDLs for the 303(d)-listed WQM stations in the Saluda River basin are provided in this section. The methodology for deriving these results is specified in Section 4.

## 5.2 Critical Conditions and Estimated Loading

USEPA regulations at 40 CFR 130.7(c) (1) require TMDLs to take into account critical conditions for stream flow, loading, and water quality parameters. Available instream WQM data were evaluated with respect to flows and magnitude of water quality criteria exceedance using LDCs. Load duration curve analysis involves using measured or estimated flow data, instream criteria, and fecal coliform concentration data to assess flow conditions in which water quality exceedances are occurring (SCDHEC 2003). The goal of flow weighted concentration analysis is to compare instream observations with flow values to evaluate whether exceedances generally occur during low or high flow periods (SCDHEC 2003).

To calculate the fecal coliform load at the WQS, the instantaneous fecal coliform criterion of 400 cfu/100 ml is multiplied by the flow rate at each flow exceedance percentile, and a unit conversion factor ($24{,}465{,}525\ ml*s / ft^3*day$). This calculation produces the maximum fecal coliform load in the stream without exceeding the instantaneous standard over the range of flow conditions. The allowable fecal coliform loads at the WQS establish the TMDL and are plotted versus flow exceedance percentile as an LDC. The x-axis indicates the flow exceedance percentile, while the y-axis is expressed in terms of a fecal coliform load.

To estimate existing loading, the loads associated with individual fecal coliform observations are paired with the flows estimated at the same site on the same date. Fecal coliform loads are then calculated by multiplying the measured fecal coliform concentration by the estimated flow rate and a unit conversion factor of $24{,}465{,}525\ ml*s / ft^3*day$. The associated flow exceedance percentile is then matched with the measured flow from the tables provided in Appendix D. The observed fecal coliform loads are then added to the LDC plot as points. These points represent individual ambient water quality samples of fecal coliform. Points above the LDC indicate the fecal coliform instantaneous standard was exceeded at the time of sampling. Conversely, points under the LDC indicate the sample met the WQS.

The LDC approach recognizes that the assimilative capacity of a water body depends on the flow, and that maximum allowable loading varies with flow condition. Existing loading, and load reductions required to meet the TMDL water quality target, can also be calculated under different flow conditions. The difference between existing loading and the water quality target is used to calculate the loading reductions required. Given that the instantaneous fecal coliform criterion indicates that no more than 10 percent of samples should exceed 400 cfu/100 ml, it is appropriate to evaluate existing loading as the 90$^{th}$ percentile of observed fecal coliform concentrations. Together with the MOS, the reduction calculated in this way should ensure that no more than 10 percent of samples will exceed the criterion.

Existing loading is calculated as the 90th percentile of measured fecal coliform concentrations under each hydrologic condition class multiplied by the flow at the middle of the flow exceedance percentile. For example, in calculating the existing loading under dry conditions (flow exceedance percentile = 60-90 percent), the 75th percentile exceedance flow is multiplied by the 90th percentile of fecal coliform concentrations measured under 60-90th percentile flows.

After existing loading and percent reductions are calculated under each hydrologic condition class, the critical condition for each TMDL is identified as the flow condition requiring the largest percent reduction. However, the "high flow" (<10th percentile flow exceedance) or "low flow" (> 90th percentile flow exceedance) hydrologic conditions will not be selected as critical conditions because these extreme flows are not representative of typical conditions, and few observations are available to reliably estimate loads under these conditions. In the example shown in Table 5-1 for WQM station B-086, while similar load reductions are required under all the hydrologic condition classes, the critical condition occurs under "Dry Conditions," when a 97 percent loading reduction is required to meet the WQS.

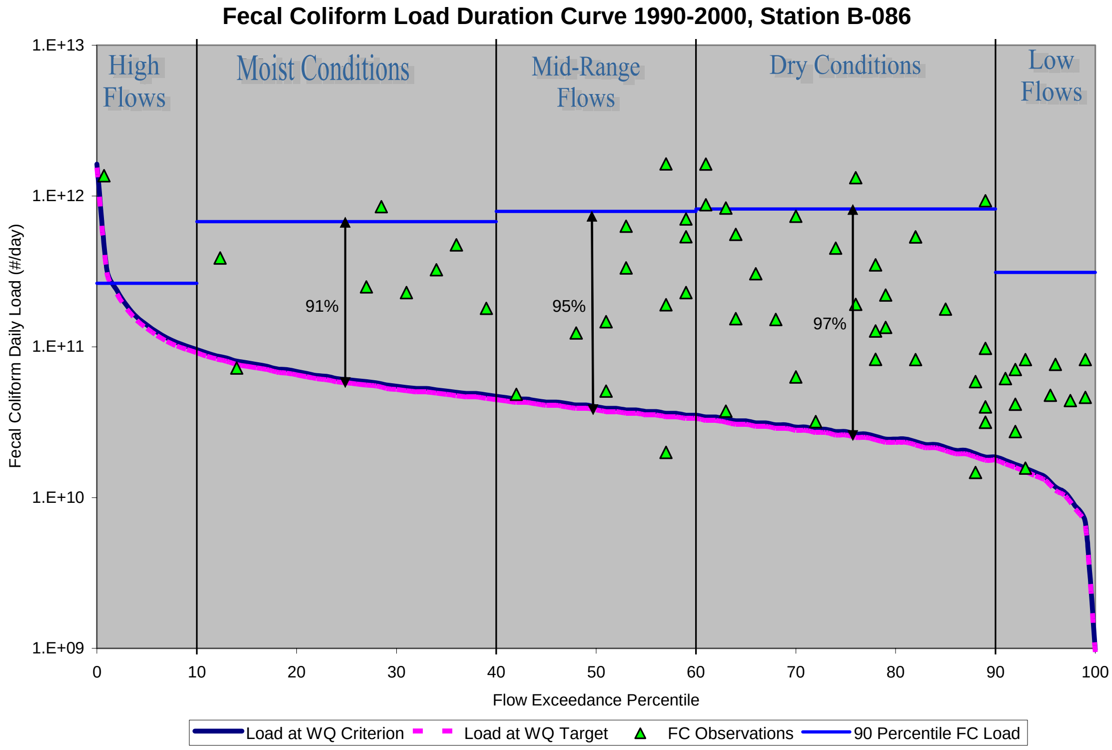
**Table 5-1 Estimated Existing Fecal Coliform Loading for Station B-086, with Critical Condition Highlighted**

| Hydrologic Condition Class* | Estimated Existing Loading (cfu/100 mL) | Percent Reduction Required |
|---|---|---|
| High Flows | 2.64E+11 | NA |
| Moist Conditions | 6.77E+11 | 91% |
| Mid-Range Conditions | 7.88E+11 | 95% |
| Dry Conditions | 8.19E+11 | 97% |
| Low Flows | 3.12E+11 | NA |

* Hydrologic Condition Classes are derived from Cleland 2003.

The LDC for WQM station B-086 shown in Figure 5-1 indicates actual fecal coliform loads are exceeding the instantaneous load of the WQS during all flow conditions. The LDCs similar to Figure 5-1 for all of the 303(d)-listed WQM stations in this report used to estimate existing loading and identify critical conditions are provided in Appendix E. The LDCs were developed for the time period from January 1990 through December 2002 if data were available.

**Figure 5-1 Estimated Fecal Coliform Load and Critical Conditions for Ross Branch, Station B-086**




The existing instream fecal coliform load (actual or estimated flow multiplied by observed fecal coliform concentration) is compared to the allowable load for that flow. Any existing loads above the allowable LDCs represent an exceedance of the WQS. For a low flow loading situation, there are typically observations in excess of criteria at the low flow side of the chart. For a high flow loading situation, observations in excess of criteria at the high flow side of the chart are typical. For water bodies impacted by both point and nonpoint sources, the “nonpoint source critical condition” would typically occur during high flows, when rainfall runoff would contribute the bulk of the pollutant load, while the “point source critical condition” would typically occur during low flows, when treatment plant effluents would dominate the base flow of the impaired water. Based on these characteristics, critical conditions for each WQM station are summarized in Table 5-2.

**Table 5-2 Summary of Critical Conditions for each WQM Station as derived from Load Duration Curves**

| SCDHEC WQM Station | Moist Conditions | Mid-Range Conditions | Dry Conditions |
|---|---|---|---|
| B-086 | | | ✱ |
| B-136 | | | ✱ |
| B-064 | ✱ | | |
| B-243 | ✱ | | |
| B-155 | | | ✱ |
| B-335 | | ✱ | |
| B-046 | | ✱ | |
| B-074 | ✱ | | |
| B-075 | | ✱ | |
| B-110 | ✱ | | |
| B-316 | ✱ | | |
| B-280 | | ✱ | |
| B-337 | | ✱ | |
| B-145 | ✱ | | |
| B-350 | | ✱ | |
| B-123 | | ✱ | |
| B-077 | | ✱ | |
| B-102 | | | ✱ |
| B-338 | | | ✱ |

The existing load for each WQM station was derived from the critical condition line depicted on the LDCs described above and provided in Appendix E. Estimated existing loading is derived from the 90$^{th}$ percentile of observed fecal coliform loads corresponding to the critical condition identified at each WQM station identified in Table 5-2. This estimated loading is indicative of loading from all sources including continuous point source dischargers, MS4s, SSOs, failing OSWD systems, wildlife, land application fields, domestic pets, and livestock. The total estimated existing load for each station is provided in Table 5-3.

**Table 5-3 Estimated Existing Loading at each WQM Station**

| SCDHEC WQM Station | 90th Percentile Load Estimation (counts/day) | Flow Exceedance Percentile |
|---|---|---|
| B-086 | 8.19E+11 | 75 |
| B-136 | 1.48E+12 | 75 |
| B-064 | 1.30E+12 | 25 |
| B-243 | 3.18E+11 | 25 |
| B-155 | 3.03E+11 | 75 |
| B-335 | 1.46E+11 | 50 |
| B-046 | 7.64E+13 | 50 |
| B-074 | 9.16E+11 | 25 |
| B-075 | 4.30E+12 | 50 |
| B-110 | 4.56E+11 | 25 |
| B-316 | 8.74E+12 | 25 |
| B-280 | 4.09E+12 | 50 |
| B-337 | 3.02E+13 | 50 |
| B-145 | 5.94E+12 | 25 |
| B-350 | 1.40E+13 | 50 |
| B-123 | 1.30E+12 | 50 |
| B-077 | 3.33E+11 | 50 |
| B-102 | 1.01E+12 | 75 |
| B-338 | 3.24E+11 | 75 |

## 5.3 Waste Load Allocation

Table 5-4 summarizes the WLA of the NPDES-permitted facilities within the watershed of each WQM station. The WLA for each facility is derived from the following equation:

***WLA = WQS * flow * unit conversion factor (#/day)***
*Where: WQS = 400 cfu/100ml*
*flow (cfs) = permitted flow*
*unit conversion factor = 37,854,120 100-ml/mg*

**Table 5-4 Wasteload Allocations (WLA) for NPDES Permitted Facilities**

| Water Quality Monitoring Station / Permittee | NPDES Permit Number | Flow (mgd) | Load (cfu/day) |
|---|---|---|---|
| HUC 03050106030 | | | |
| **B-335 Gregorys Creek at S-44-86, 8 mi E of Union** | | | |
| UNION/MENG CREEK (NEW) | SC0047236 | 1.0 | 1.51E+10 |
| HUC 03050106010 | | | |
| **B-046 Broad River at SC 72/215/121 3 mi E of Carlisle** | | | |
| LOCKHART TREATMENT FACILITY | SC0003051 | 0.17 | 2.56E+09 |
| CHEMTRADE PERF CHEMICALS/LEEDS | SC0022756 | 0.058* | 8.78E+08 |
| CONE MILLS CORP/CARLISLE PLANT | SC0001368 | 2.13* | 3.23E+10 |
| HUC 03050106040 | | | |
| **B-075 Sandy River at SC 215 2.5 mi AB Jct with Broad River** | | | |
| CHESTER/SANDY RIVER WWTF | SC0036081 | 2.133 | 3.23E+10 |
| HUC 03050106060 | | | |
| **B-337 Broad River at US 176 (Broad River Rd) in Columbia** | | | |
| CHAPIN, TOWN OF | SC0040631 | 1.2 | 1.82E+10 |
| RICHLAND CO/BROAD RIVER WWTF | SC0046621 | 2.5 | 3.79E+10 |
| RAINTREE ACRES SD/MIDLANDS UTL | SC0039055 | 0.14 | 2.12E+09 |
| RICHTEX CORPORATION | SC0031640 | 0.007* | 1.06E+08 |
| SCE&G V C SUMMER NUCLEAR STATION | SC0030856 | 0.0037 | 5.60E+07 |
| SCE&G/SUMMER NUCLEAR TRAINING | SC0038407 | 0.0006* | 9.08E+06 |
| FOREST HILLS SD/ELBO INC | SC0024571 | 0.02 | 3.03E+08 |
| NCW&SA/BROAD RV. WWTF PHASE 1A | SC0048020 | 0.05 | 7.57E+08 |
| NCW&SA/CANNONS CREEK WWTP | SC0048313 | 0.95 | 1.44E+10 |
| HUC 03050106080 | | | |
| **B-077 Winnsboro Branch below Plan Outfall** | | | |
| WINNSBORO/JACKSON CREEK PLANT | SC0020125 | 1.6 | 2.42E+10 |

* Maximum of reported monthly average flow rates

When multiple NPDES facilities occur within a watershed, individual WLAs are summed and the total WLA for continuous point sources is included in the TMDL calculation for the corresponding WQM station. When there are no NPDES WWTPs discharging into the contributing watershed of a WQM station, then the WLA for continuous point sources is zero. See Section 5.7 for an explanation of how the WLA for NPDES dischargers is depicted in a LDC.

The city of Columbia and Richland County are the only MS4s within the watersheds of this report. Because of insufficient data, it is not possible to express a WLA for MS4s as a load or concentration; therefore, the WLA is expressed as a PRG. Each MS4 was assigned a PRG equal to the PRG identified in the LA for each WQM station. The PRGs that will serve as a component of the WLA are provided in Table 5-5. When multiple WQM stations fall under one MS4 jurisdiction, multiple PRGs can occur. In these cases the highest PRG is selected as the overall reduction requirement incorporated into the TMDL of each station. For example, by reviewing the LDCs in Appendix E, Stations B-110, B-316, B-280, and B-337 have PRGs of 48, 92, 99, and 62 percent, respectively.

Therefore, using a conservative approach, the highest reduction goal of 99 percent is selected and incorporated into the TMDLs (see Table 5-5) for WQM stations B-110, B-316, B-280, and B-337. The PRGs in this TMDL report apply also to the fecal coliform WLAs attributable to those areas of the watershed which are covered or will be covered under NPDES MS4 permits. Compliance by those municipalities within the terms of their individual MS4 permits will fulfill any obligations they have toward implementing TMDLs for fecal coliform.

**Table 5-5 WLA for MS4 Entities in Lake Elizabeth at Spillway, Crane Creek, Smith Branch, and Broad River**

| MS4 Entity | WQM Stations | Percent Reduction Goal |
|---|---|---|
| City of Columbia, Richland County | B-110, B-316, B-280, B-337 | 99 |

## 5.4 Load Allocation

As discussed in Section 3, nonpoint source fecal coliform loading to the receiving streams of each WQM station emanate from a number of different sources. For a select group of WQM stations (Table 3-3) nonpoint sources of fecal coliform loading is the sole reason the primary contact recreation use is not supported. As discussed in Section 4, nonpoint source loading was estimated and depicted for all flow conditions using LDCs (See Figure 5-1 example and Appendix E). Figure 5-1, the LDC for B-086, displays the relationships between the TMDL water quality target, the MOS, and the PRG that can serve as an alternative for expressing the LA. The data analysis and the LDCs demonstrate that exceedances at many of the WQM stations are the result of nonpoint source loading such as failing OSWD systems, cattle in streams, and fecal loading from wildlife and domestic pets transported by runoff events. The LAs, calculated as the difference between the TMDL, MOS, and WLA, for each WQM station are presented in Table 5-6. Where MS4s are present then the LA is not calculated and is expressed as a PRG.

## 5.5 Seasonal Variability

Federal regulations (40 CFR §130.7(c)(1)) require that TMDLs take into consideration seasonal variation in watershed conditions and pollutant loading. Seasonal variation was accounted for in these TMDLs by using more than 5 years of water quality data (1990-2002) whenever possible and by using the longest period of USGS flow records when estimating flows to develop flow exceedance percentiles.

## 5.6 Margin of Safety

Federal regulations (40 CFR §130.7(c)(1)) require that TMDLs include an MOS. The MOS is a conservative measure incorporated into the TMDL equation that accounts for the uncertainty associated with calculating the allowable fecal coliform pollutant loading to ensure WQSs are attained. USEPA guidance allows for use of implicit or explicit expressions of the MOS, or both. When conservative assumptions are used in development of the TMDL, or conservative factors are used in the calculations, the MOS is implicit. When a specific percentage of the TMDL is set aside to account for uncertainty, then the MOS is considered explicit.

For the explicit MOS the water quality target was set at 380 cfu/100 ml for the instantaneous criterion, which is 5 percent lower than the water quality criterion of 400 cfu/100 ml. The net effect of the TMDL with MOS is that the assimilative capacity of the watershed is slightly reduced. These TMDLs incorporates an explicit MOS by using a curve representing 95 percent of the TMDL as the average MOS. The MOS at any given percent flow exceedance, therefore, can be defined as the difference in loading between the TMDL and the TMDL with MOS. For consistency, the explicit MOS at each WQM station will be expressed as a numerical value derived from the same critical condition as the largest load reduction goal at the respective 25$^{th}$, 50$^{th}$, or 75$^{th}$ flow exceedance percentile (see Table 5-6).

There are other conservative elements utilized in these TMDLs that can be recognized as an implicit MOS such as:

- The use of instream fecal coliform concentrations to estimate existing loading; and
- The highest PRG for nonpoint sources, based on the LDC used.

This conservative approach to establishing the MOS will ensure that both the 30-day geometric mean and instantaneous fecal coliform bacteria standards can be achieved and maintained.

## 5.7 TMDL Calculations

The fecal coliform TMDLs for the 303(d)-listed WQM stations covered in this report were derived using LDCs. A TMDL is expressed as the sum of all WLAs (point source loads), LAs (nonpoint source loads), and an appropriate MOS, which attempts to account for uncertainty concerning the relationship between effluent limitations and water quality. This definition can be expressed by the following equation:

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

For each WQM station the TMDLs presented in this report are expressed in cfus per day or as a percent reduction. The TMDLs are presented in fecal coliform counts to be protective of both the instantaneous, per day, and geometric mean, per 30-day, criteria. To express a TMDL as an individual value, the LDC is used to derive the LA, the MOS, and the TMDL based on the median percentile of the critical condition (*i.e.*, the median percentile of the hydrologic condition class requiring the greatest percent reduction to meet the instantaneous criterion which is the water quality target). The WLA component of each TMDL is the sum of all WLAs within the contributing watershed of each WQM station which is derived from each NPDES facilities' maximum design flow and the permitted 1-day maximum concentration of 400 cfu/100 ml. When MS4s do not exist in the contributing watershed, the LDC and the simple equation of:

***Average LA = average TMDL – MOS - ∑WLA***

can provide an individual value for the LA in counts per day which represents the area under the TMDL target line and above the WLA line. Percent reductions necessary to achieve the water quality target are also provided for all WQM stations as another acceptable representation of the TMDL. Like the LA, the percent reduction is derived from the median percentile of the critical condition (*i.e.*, the median percentile of the hydrologic condition class requiring the greatest percent reduction to meet the instantaneous criterion which is the water quality target). Table 5-6 summarizes the TMDLs for each WQM station, and Figures 5-2 through 5-20 present the LDCs for each station depicting the TMDL, MOS, and WLA (if applicable).

**Table 5-6 TMDL Summary for WQM Stations in Lower Broad River basin (HUC03050106)**

| SCDHEC WQM Station | WLAs cfu/ day) | MS4 WLA (Percent reduction) | LA (cfu/day or % reduction) | MOS | TMDL (cfu/day or % reduction) | Percent reduction |
|---|---|---|---|---|---|---|
| Turkey Creek HUC 3050106020 | | | | | | |
| B-086 | 0 | NA | 2.60E+10 | 1.37E+09 | 2.74E+10 | 97 |
| B-136 | 0 | NA | 8.99E+11 | 4.73E+10 | 9.46E+11 | 39 |
| Browns CreekHUC 3050106030 | | | | | | |
| B-064 | 0 | NA | 1.13E+11 | 5.97E+09 | 1.19E+11 | 91 |
| B-243 | 0 | NA | 2.05E+10 | 1.08E+09 | 2.15E+10 | 94 |
| B-155 | 0 | NA | 2.75E+11 | 1.45E+10 | 2.90E+11 | 9 |
| B-335 | 1.51E+10 | NA | 7.41E+10 | 4.70E+09 | 9.39E+10 | 39 |
| Broad River HUC 3050106010 | | | | | | |
| B-046 | 3.57E+10 | NA | 2.90E+13 | 1.53E+12 | 3.06E+13 | 62 |
| Sandy River HUC 3050106040 | | | | | | |
| B-074 | 0 | NA | 8.93E+10 | 4.70E+09 | 9.39E+10 | 90 |
| B-075 | 3.23E+10 | NA | 1.11E+12 | 6.02E+10 | 1.20E+12 | 73 |
| Broad River HUC 3050106060 | | | | | | |
| B-110 | 0 | 99 | 48 | 1.24E+10 | 2.49E+11 | 48 |
| B-316 | 0 | 99 | 92 | 3.89E+10 | 7.77E+11 | 92 |
| B-280 | 0 | 99 | 99 | 2.15E+09 | 4.31E+10 | 99 |
| B-337 | 7.38E+10 | 99 | 62 | 5.97E+11 | 1.19E+13 | 62 |
| Little River HUC 3050106070 | | | | | | |
| B-145 | 0 | NA | 2.37E+12 | 1.25E+11 | 2.50E+12 | 60 |
| B-350 | 0 | NA | 1.71E+12 | 9.01E+10 | 1.80E+12 | 88 |
| Jackson Creek / Mill Creek HUC 3050106080 | | | | | | |
| B-123 | 0 | NA | 4.65E+09 | 2.45E+08 | 4.89E+09 | 99 |
| B-077 | 0 | NA | 2.32E+10 | 1.22E+09 | 2.45E+10 | 93 |
| B-102 | 2.42E+10 | NA | 1.19E+11 | 7.54E+09 | 1.51E+11 | 86 |
| B-338 | 0 | NA | 9.48E+10 | 4.99E+09 | 9.98E+10 | 71 |

**Figure 5-2 TMDL for B-086 Ross Branch**

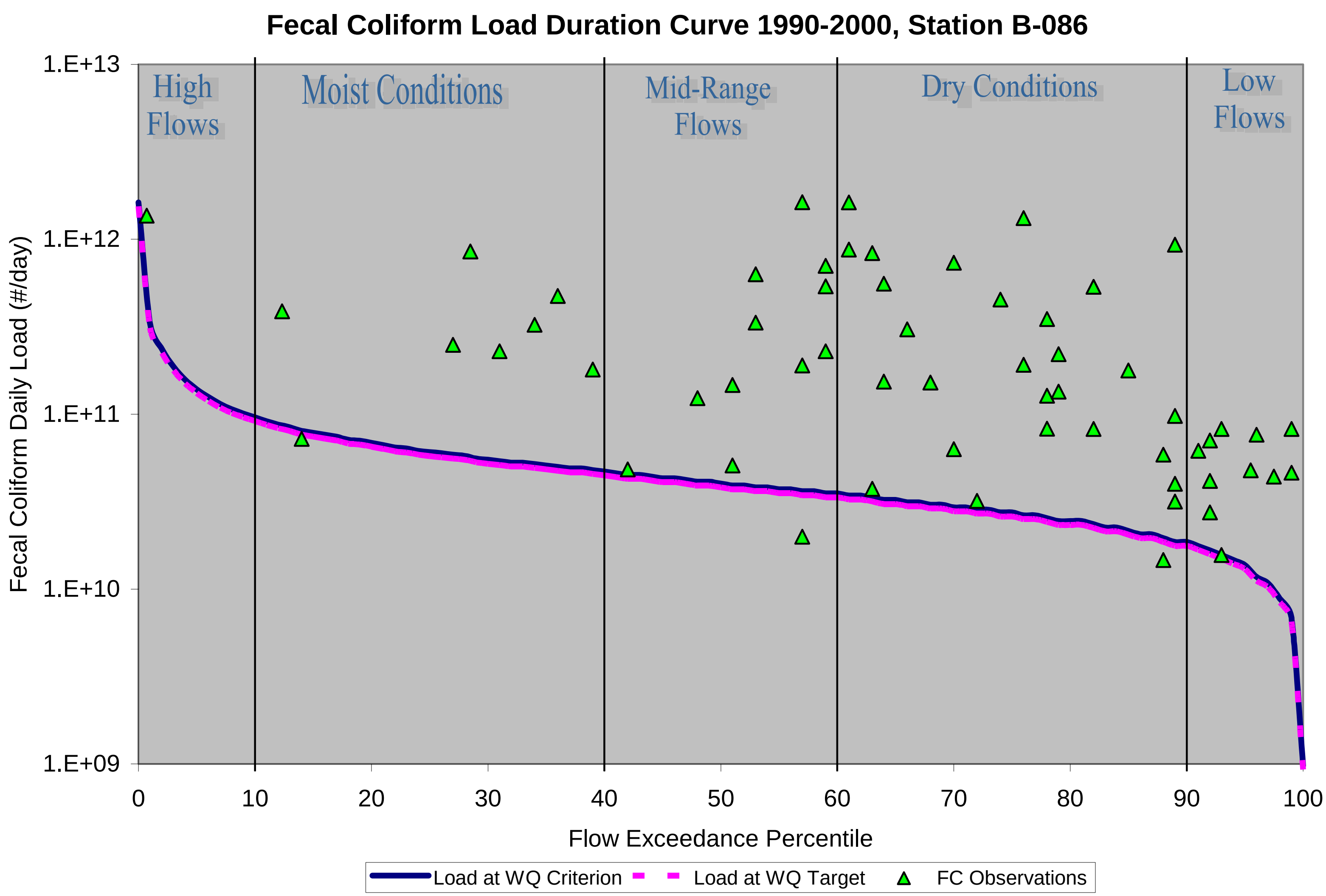


**Figure 5-3 TMDL for B-136 Turkey Creek**

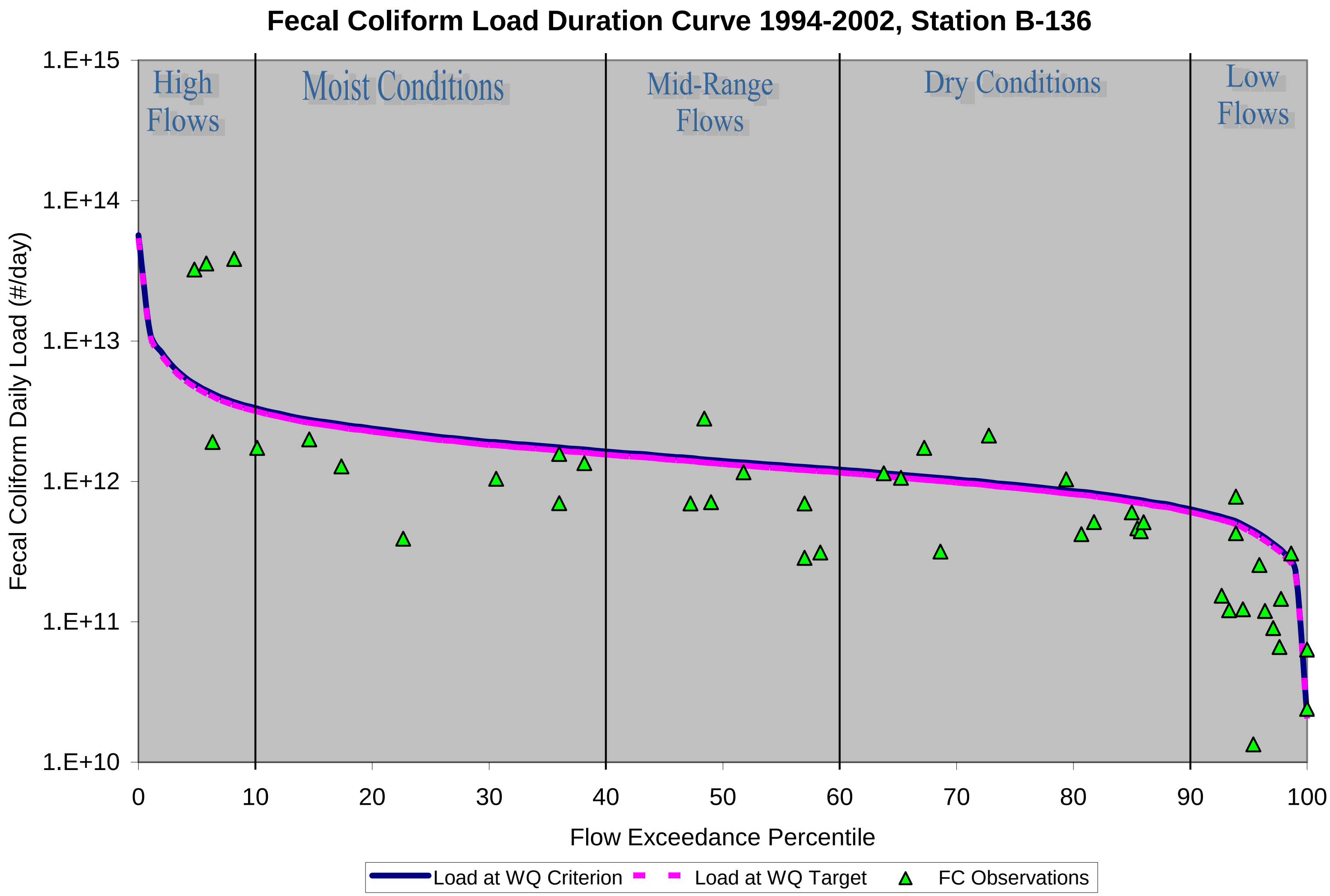


**Figure 5-4 TMDL for B-064 Meng Creek**

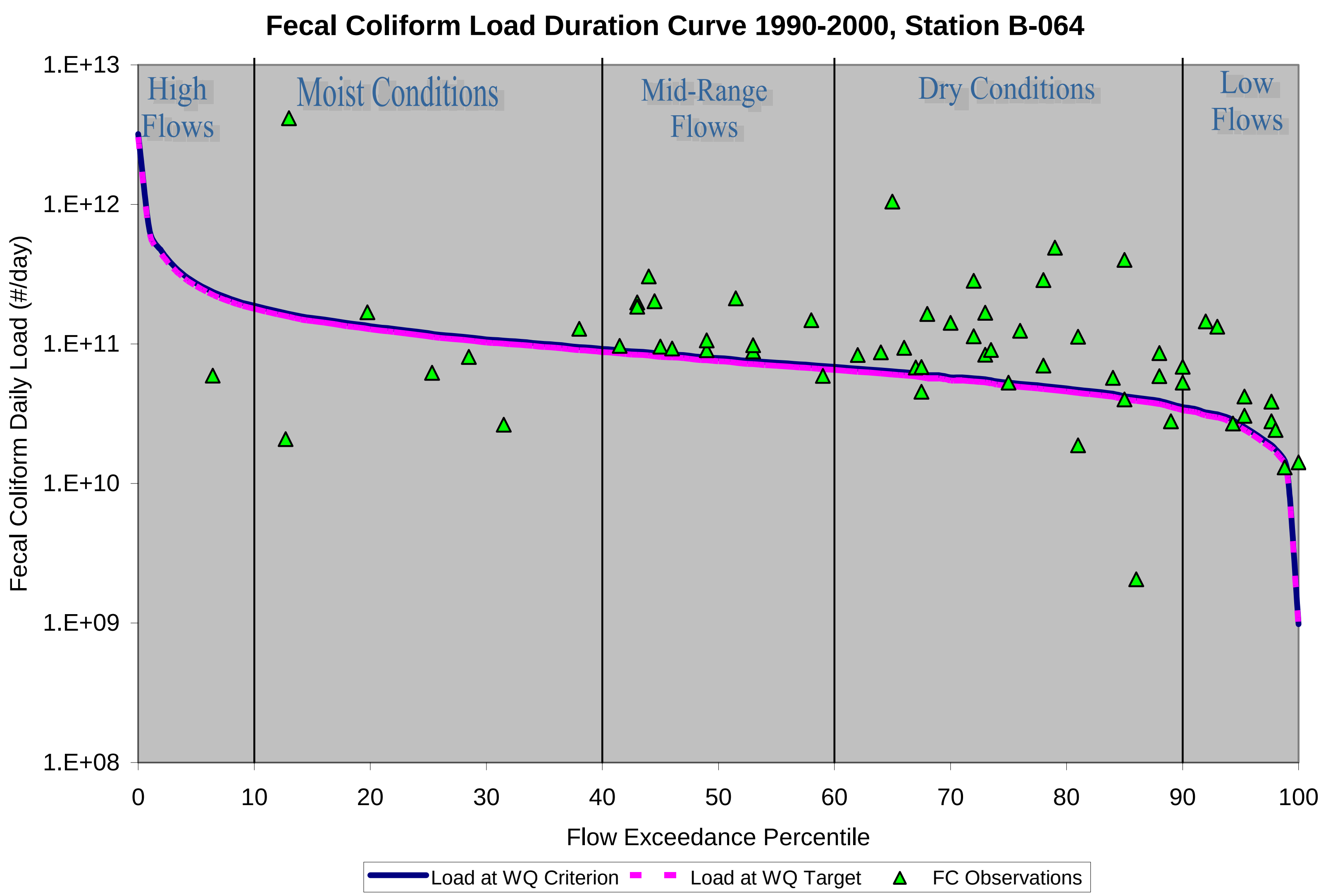


**Figure 5-5 TMDL for B-243 Tributary to Meng Creek**

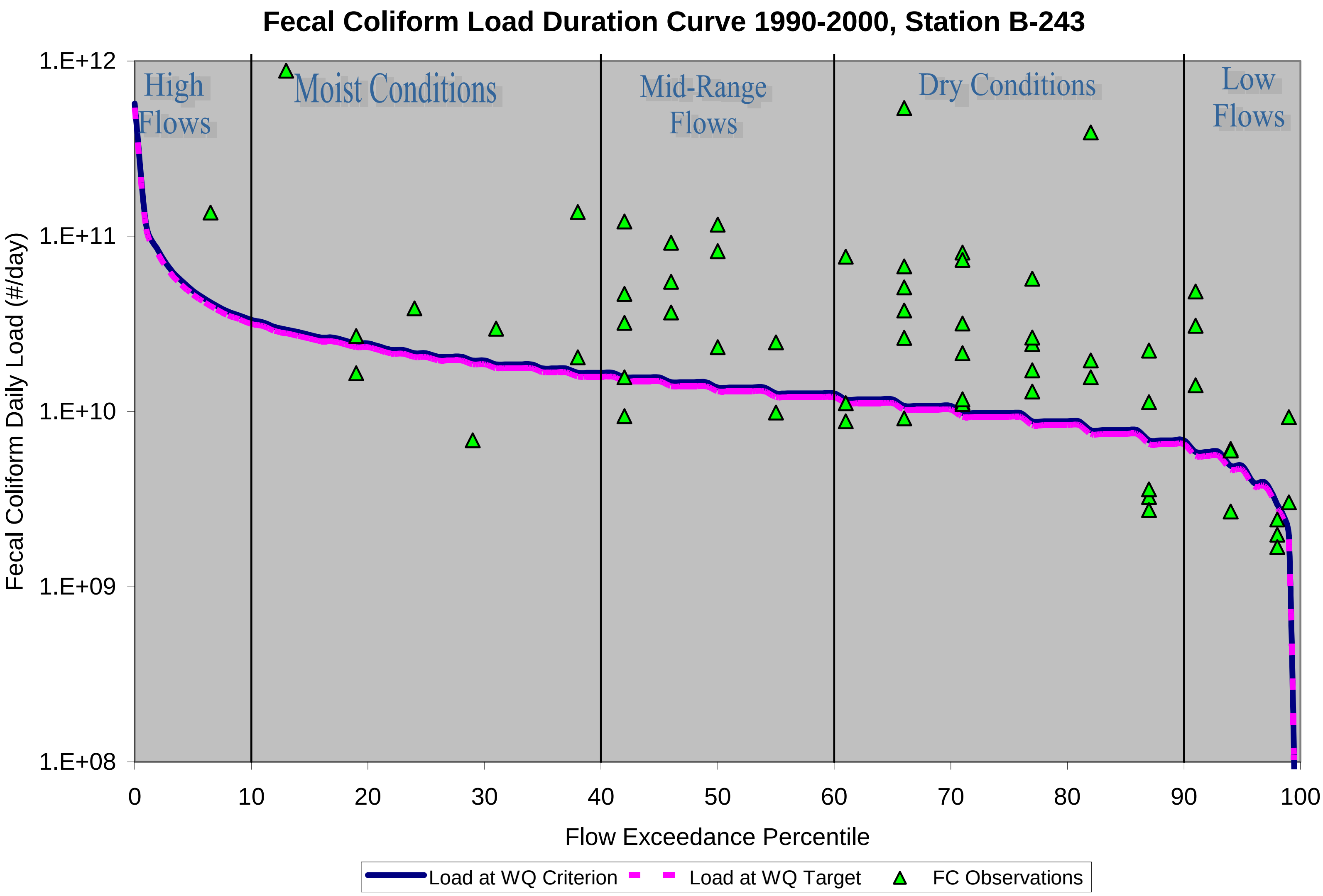


**Figure 5-6 TMDL for B-155 Browns Creek**

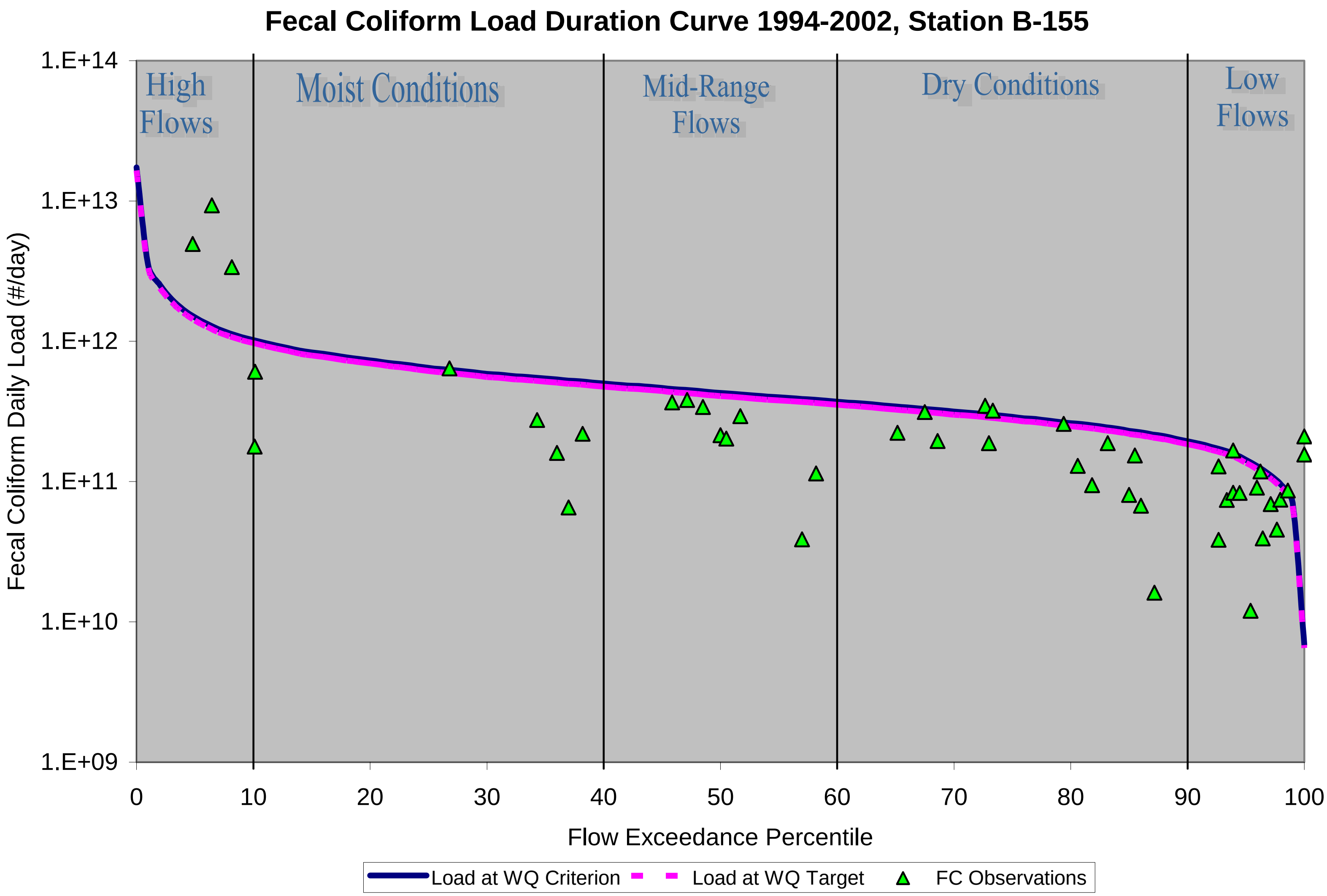


**Figure 5-7 TMDL for B-335 Gregorys Creek**

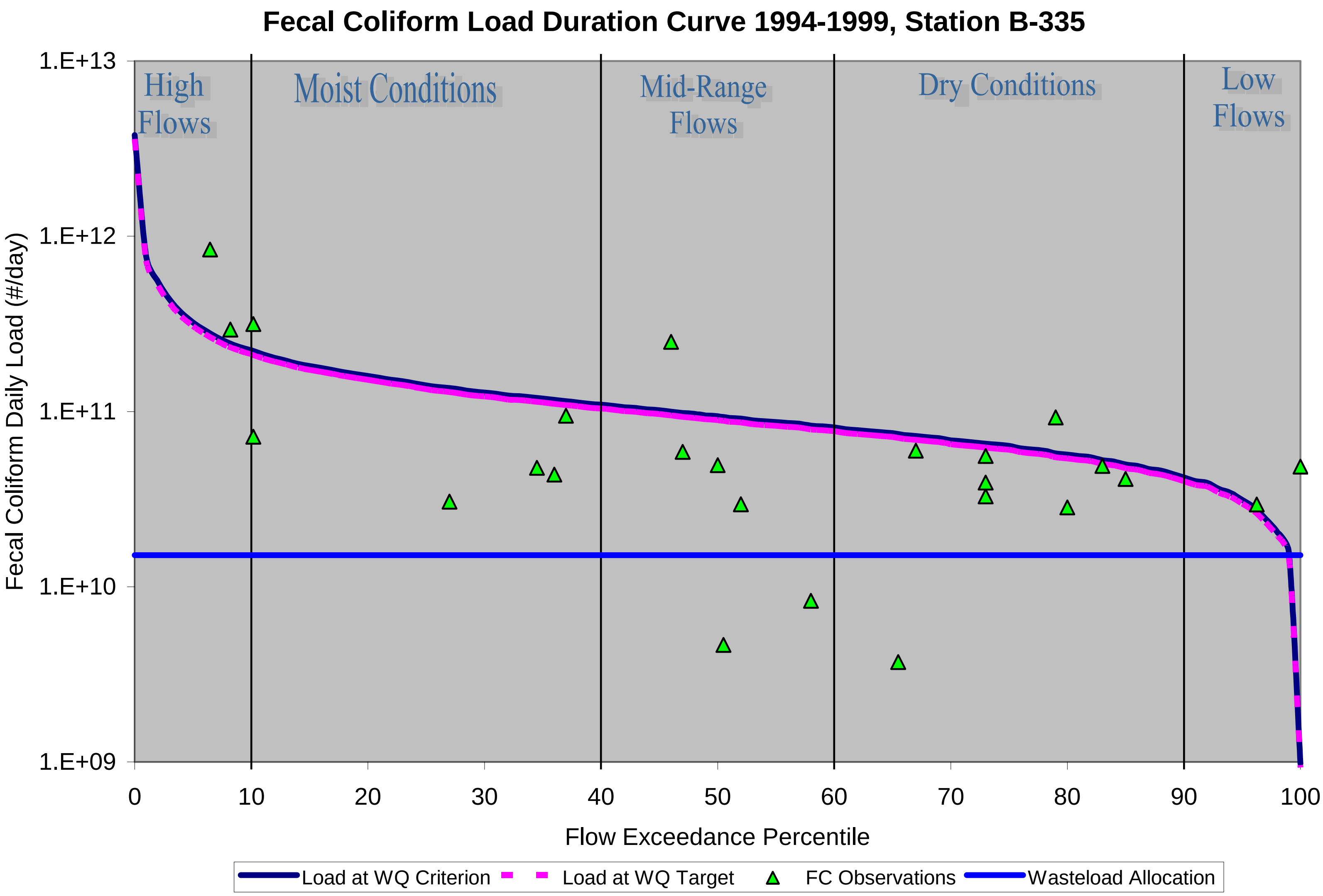


**Figure 5-8 TMDL for B-046 Broad River**

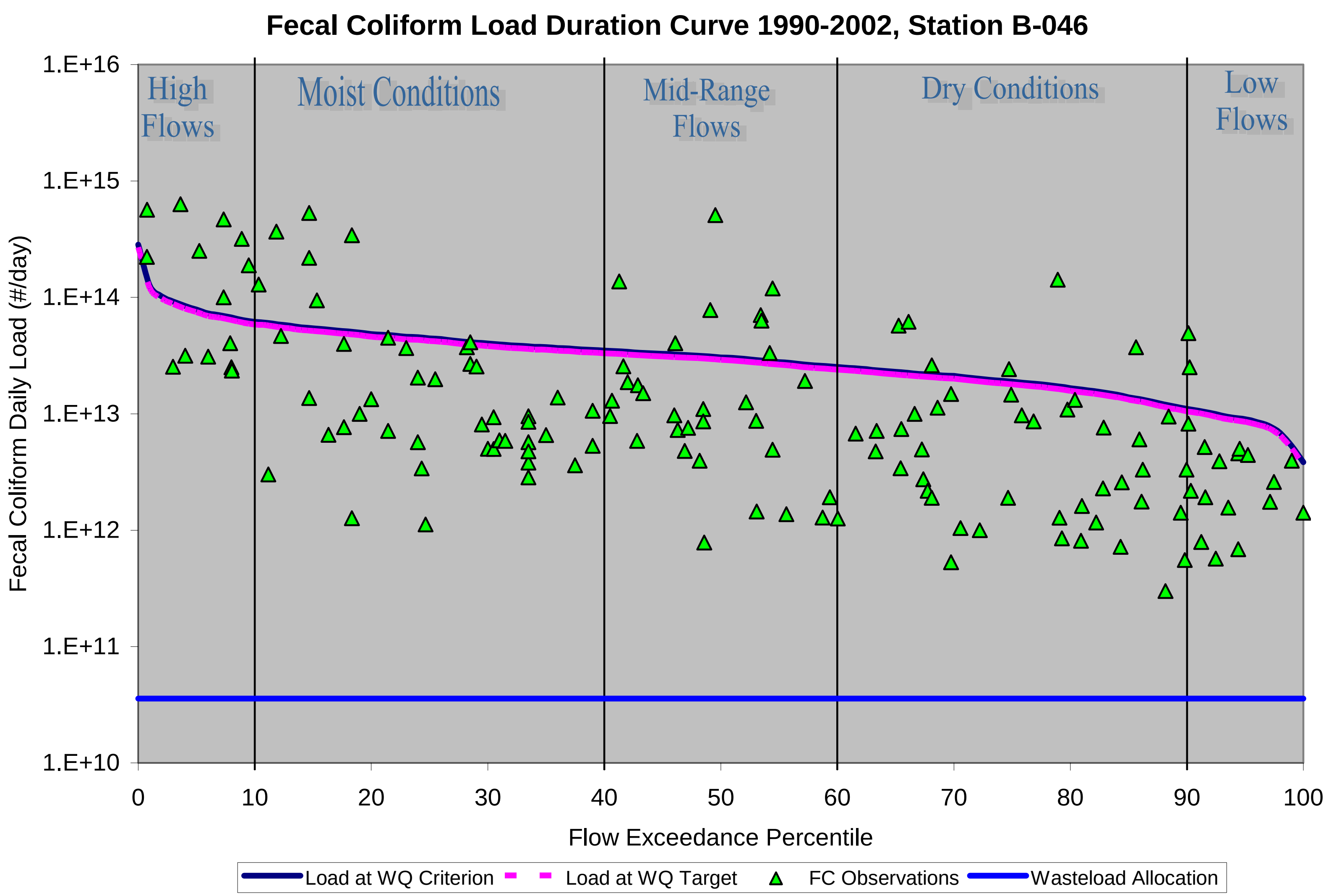


**Figure 5-9 TMDL for B-074 Dry Fork**

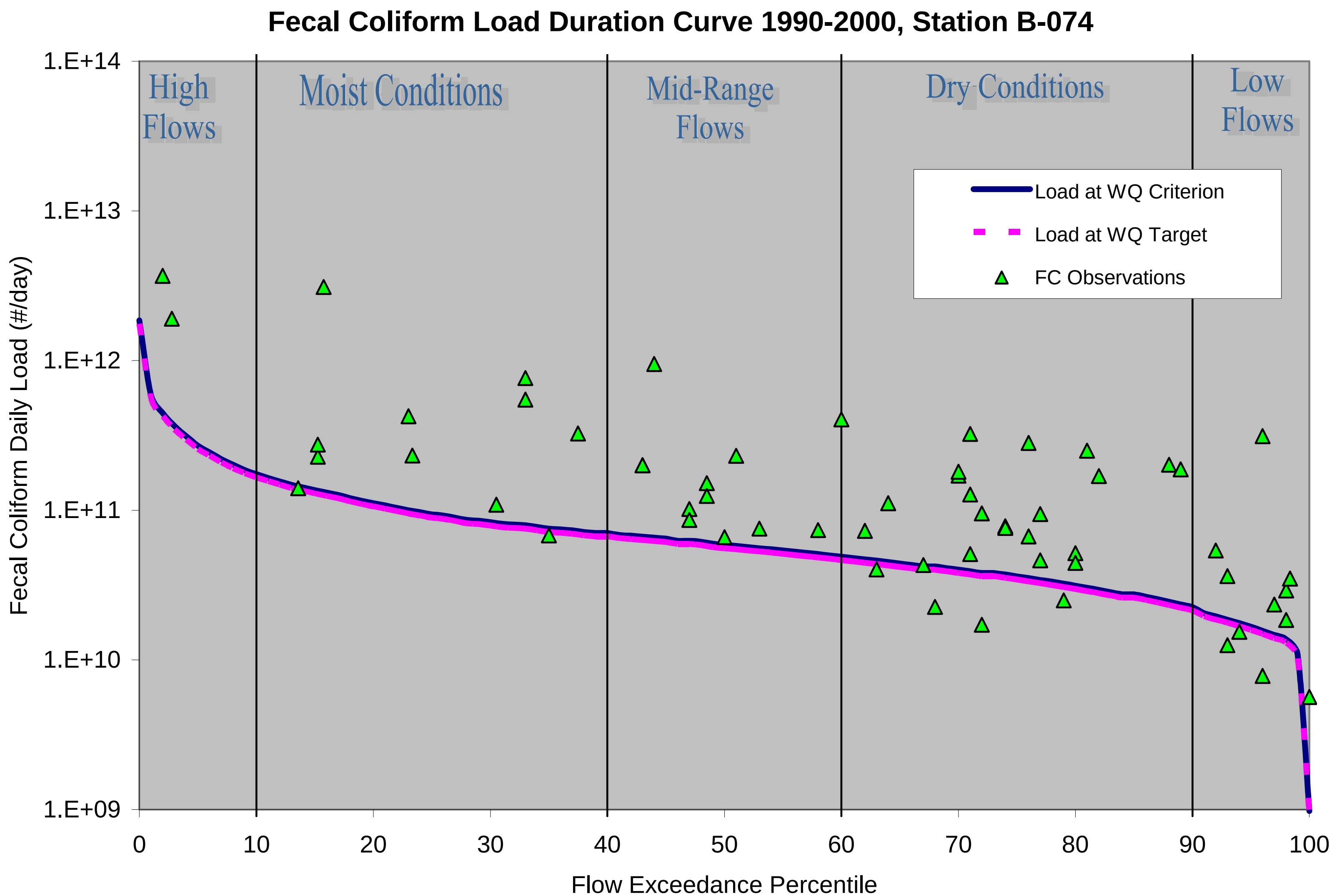


**Figure 5-10 TMDL for B-075 Sandy River**

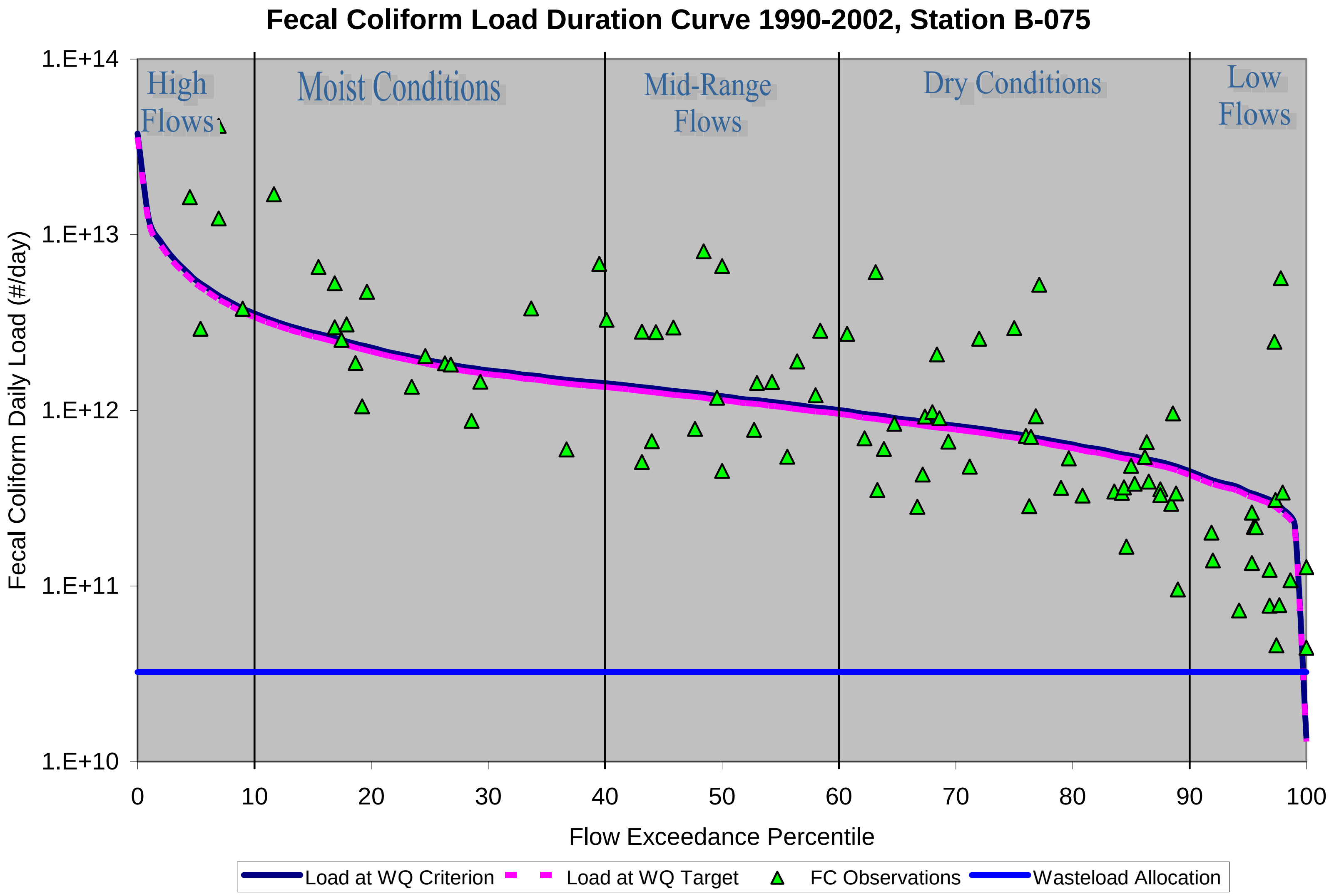


**Figure 5-11 TMDL for B-110 Elizabeth Lake**

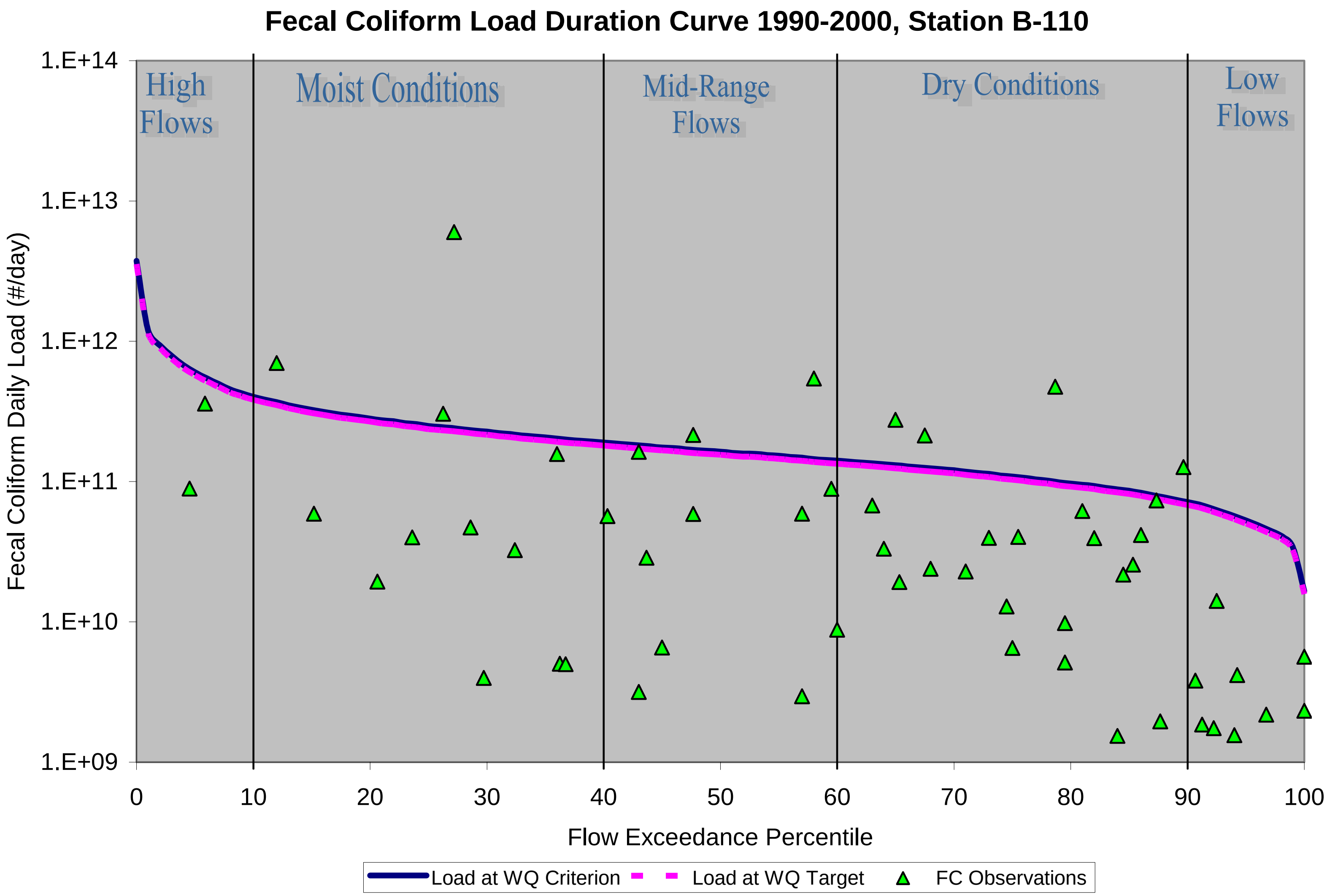


**Figure 5-12 TMDL for B-316 Crane Creek**

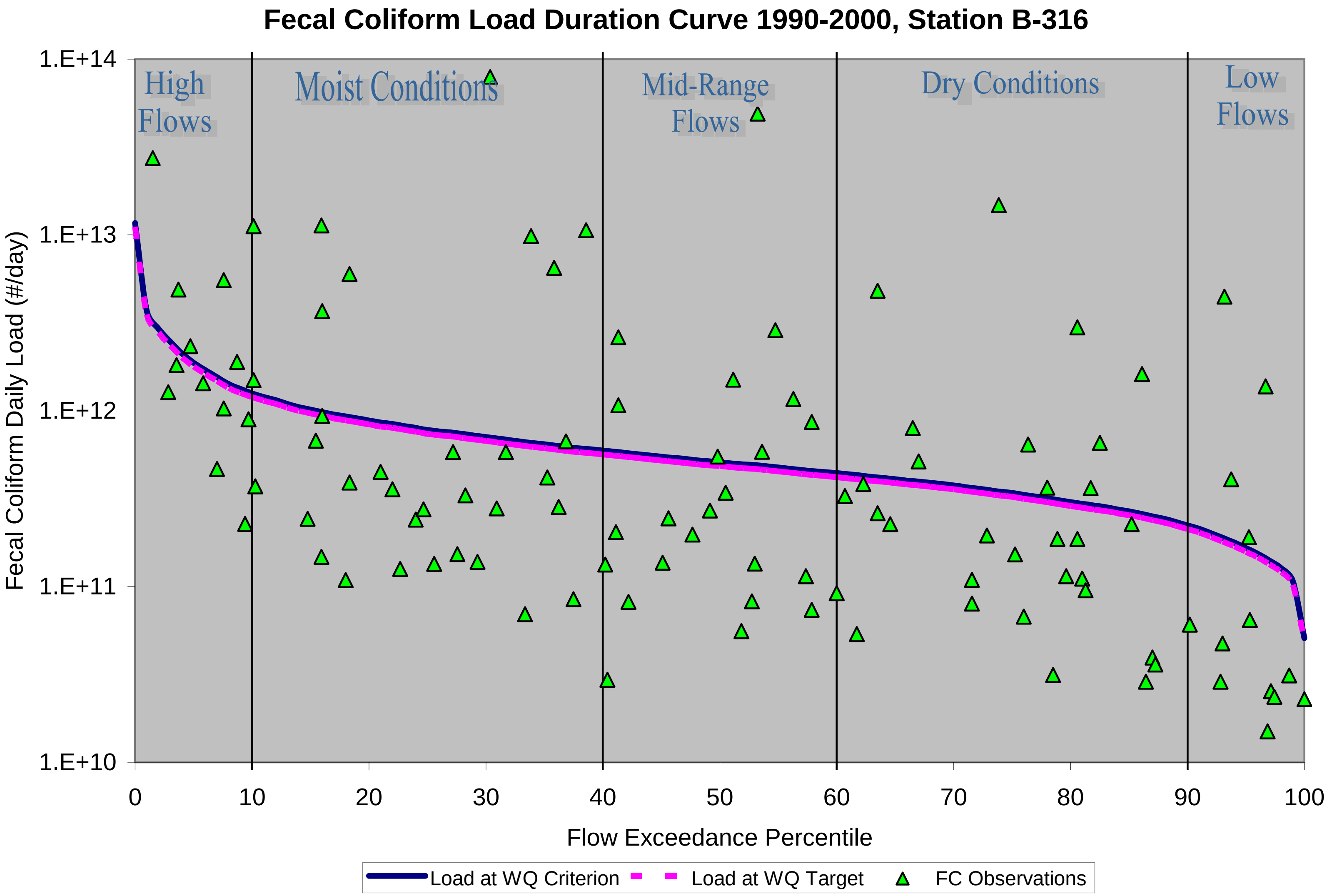


**Figure 5-13 TMDL for B-280 Smith Branch**

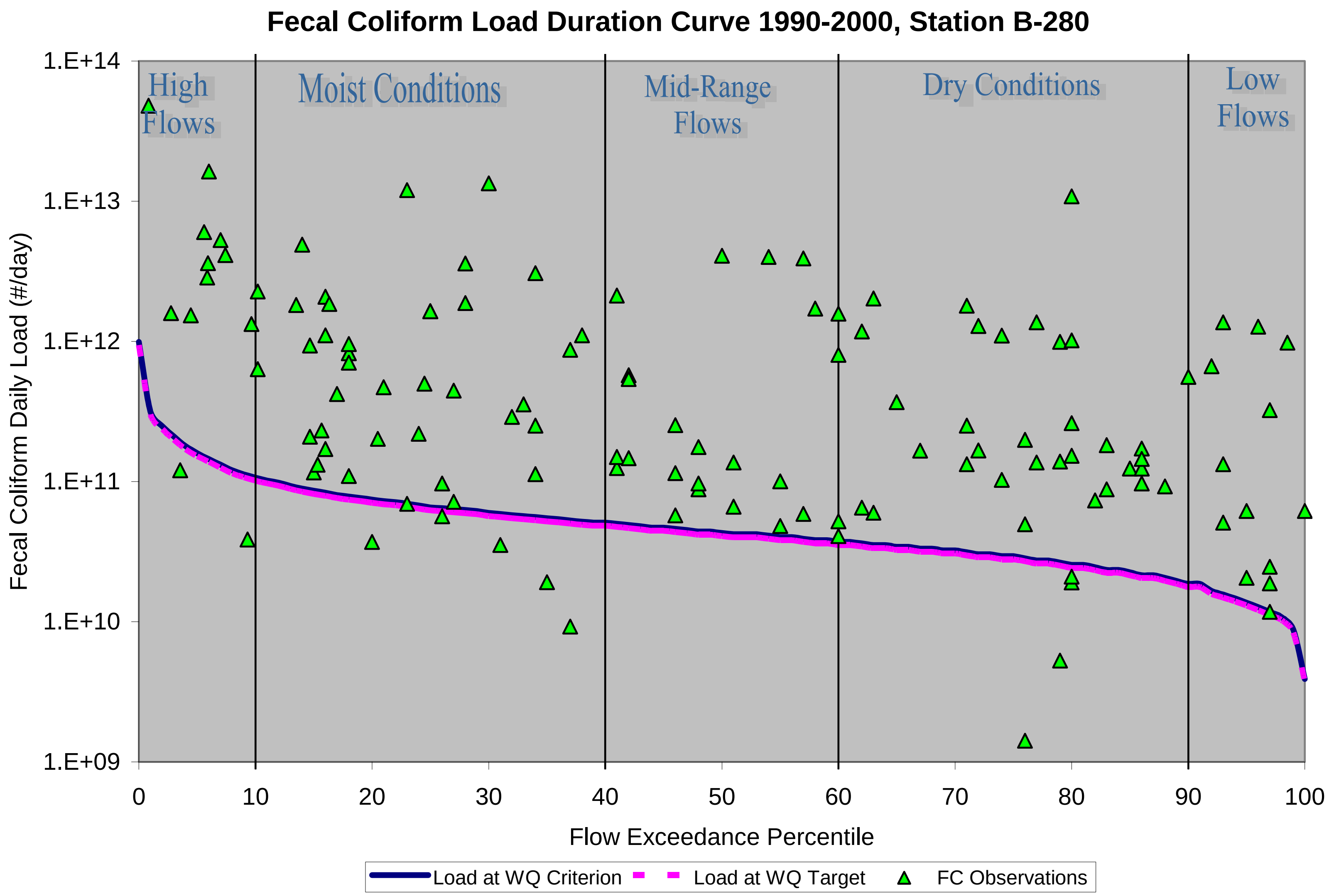


**Figure 5-14 TMDL for B-337 Broad River**

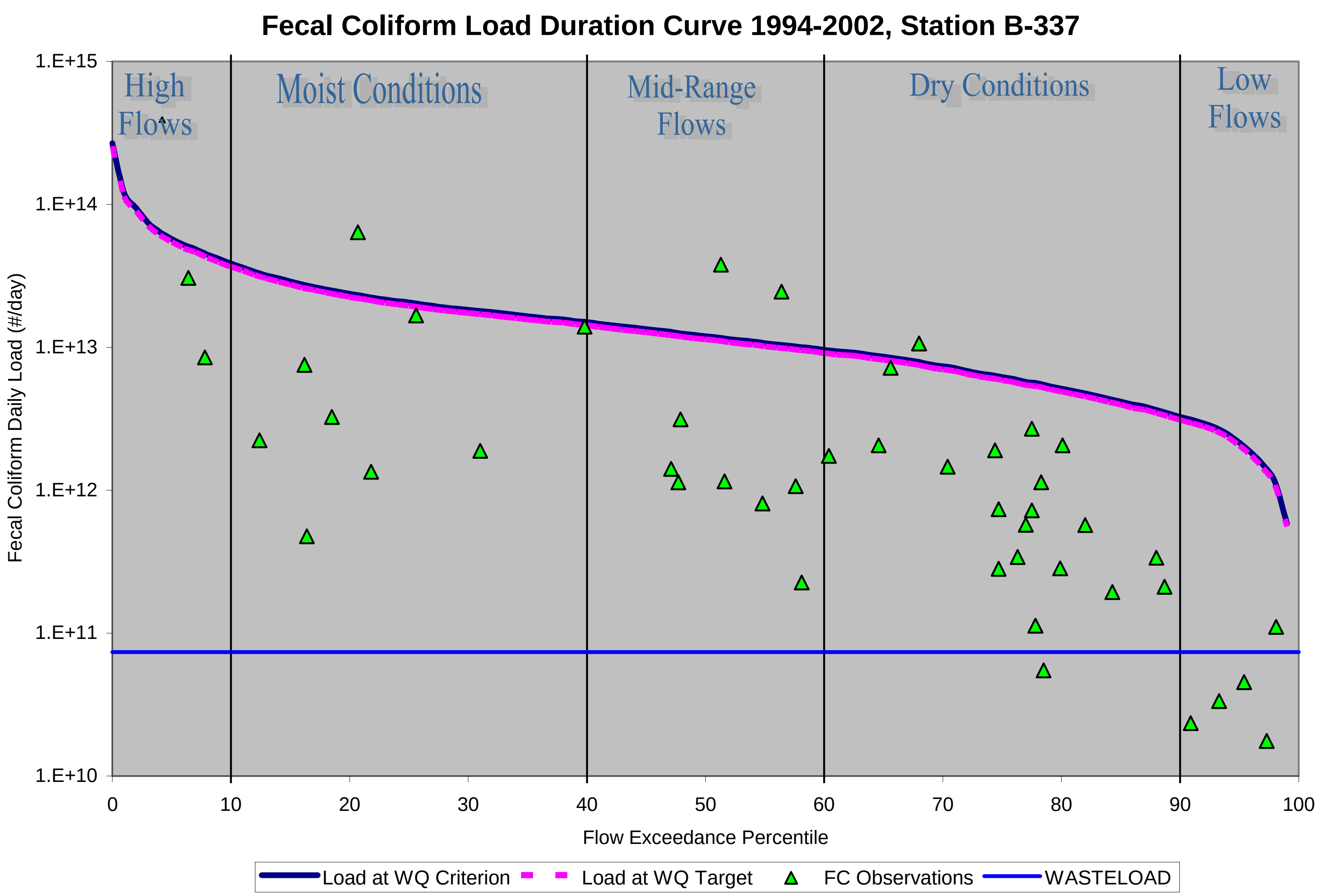


**Figure 5-15 TMDL for B-145 Little River**

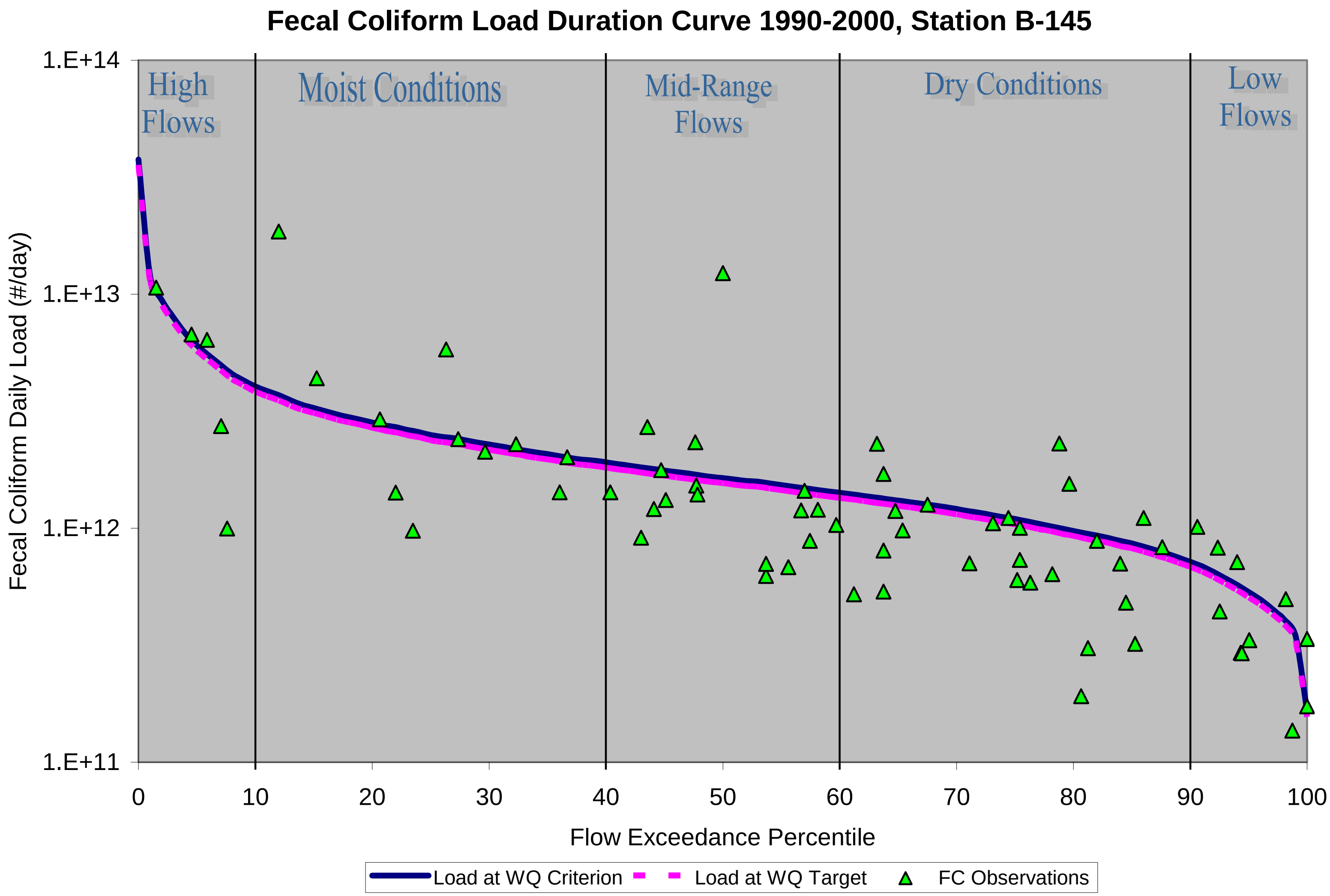


**Figure 5-16 TMDL for B-350 Little River**

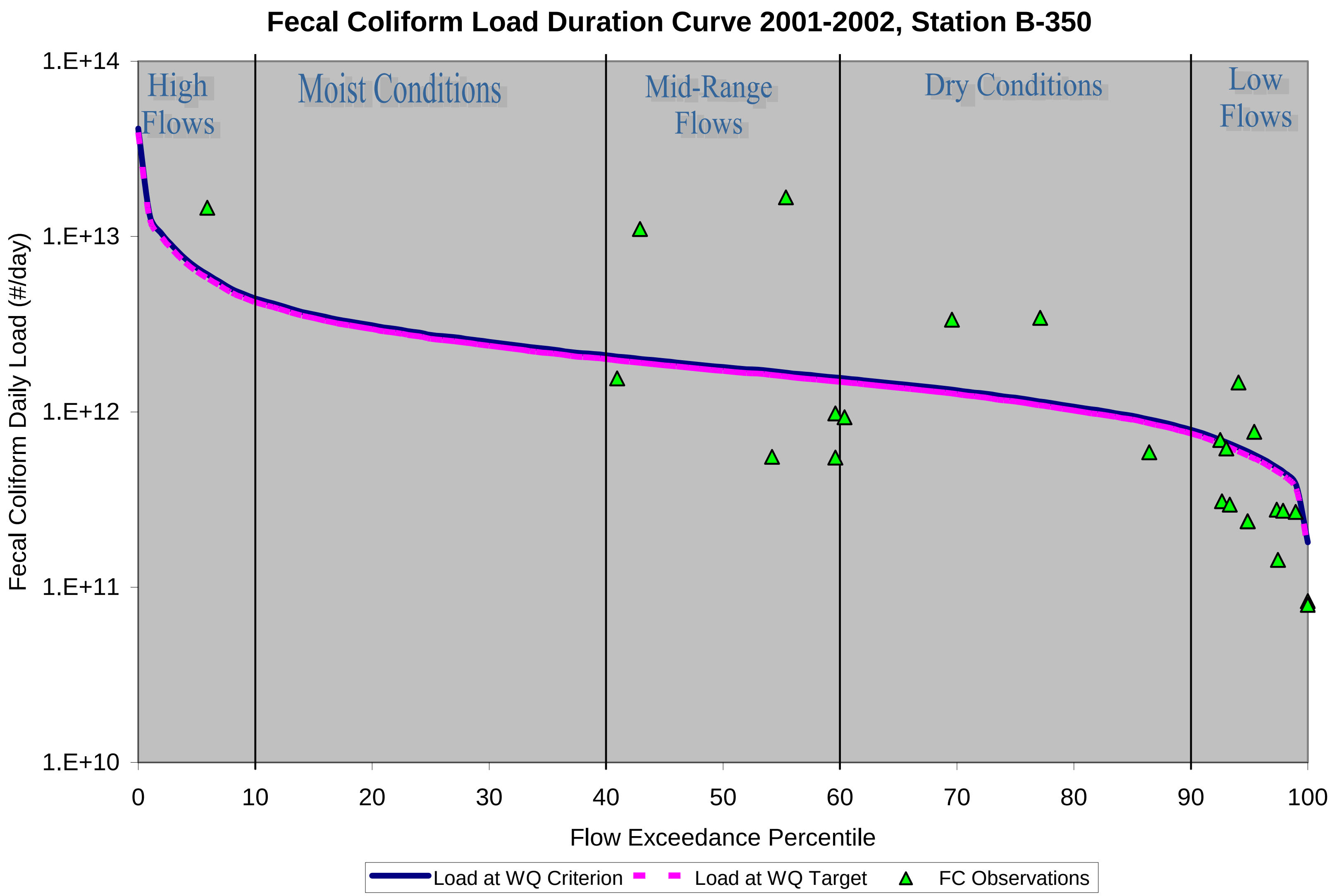


**Figure 5-17 TMDL for B-123 Winnsboro Branch**

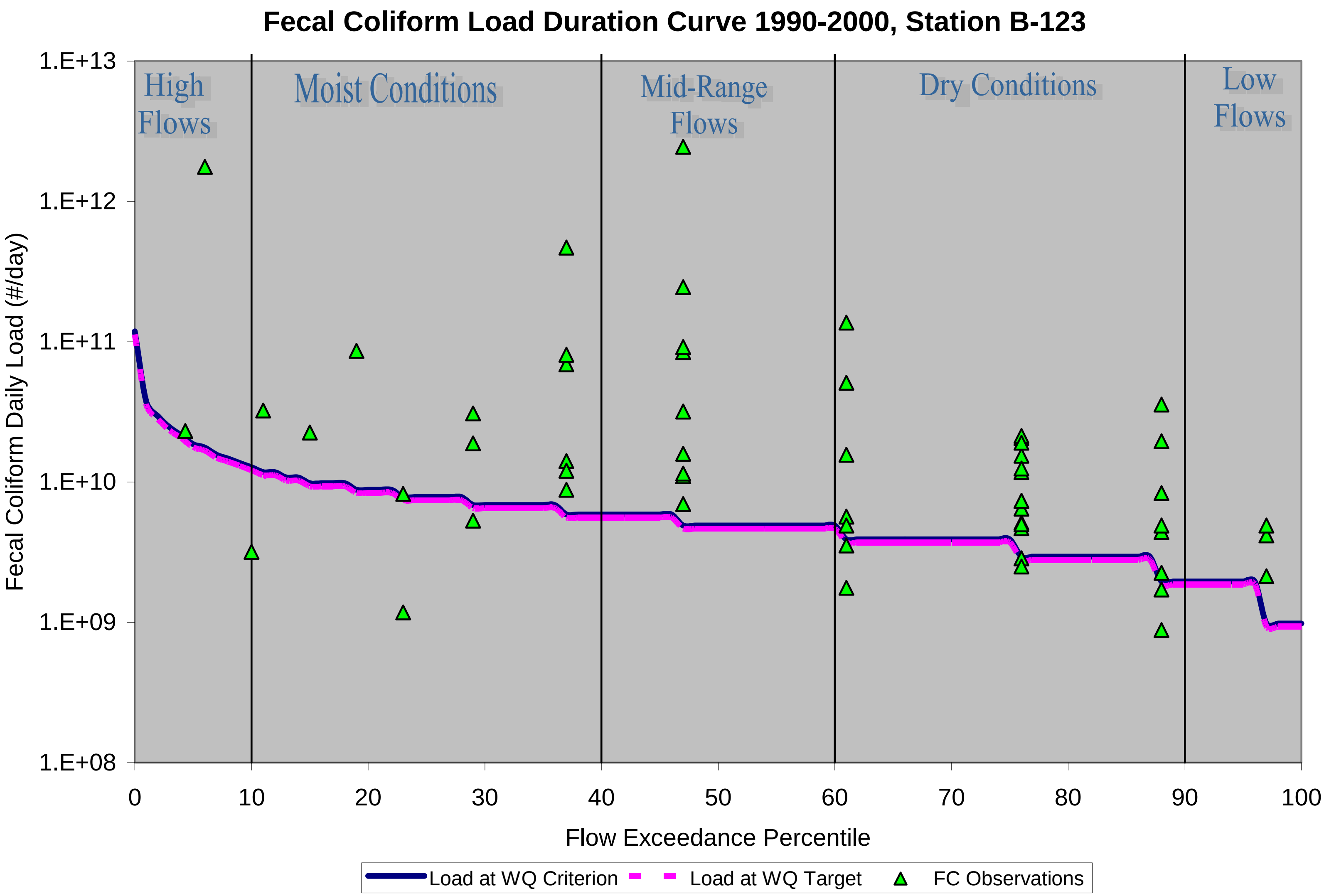


**Figure 5-18 TMDL for B-077 Winnsboro Branch**

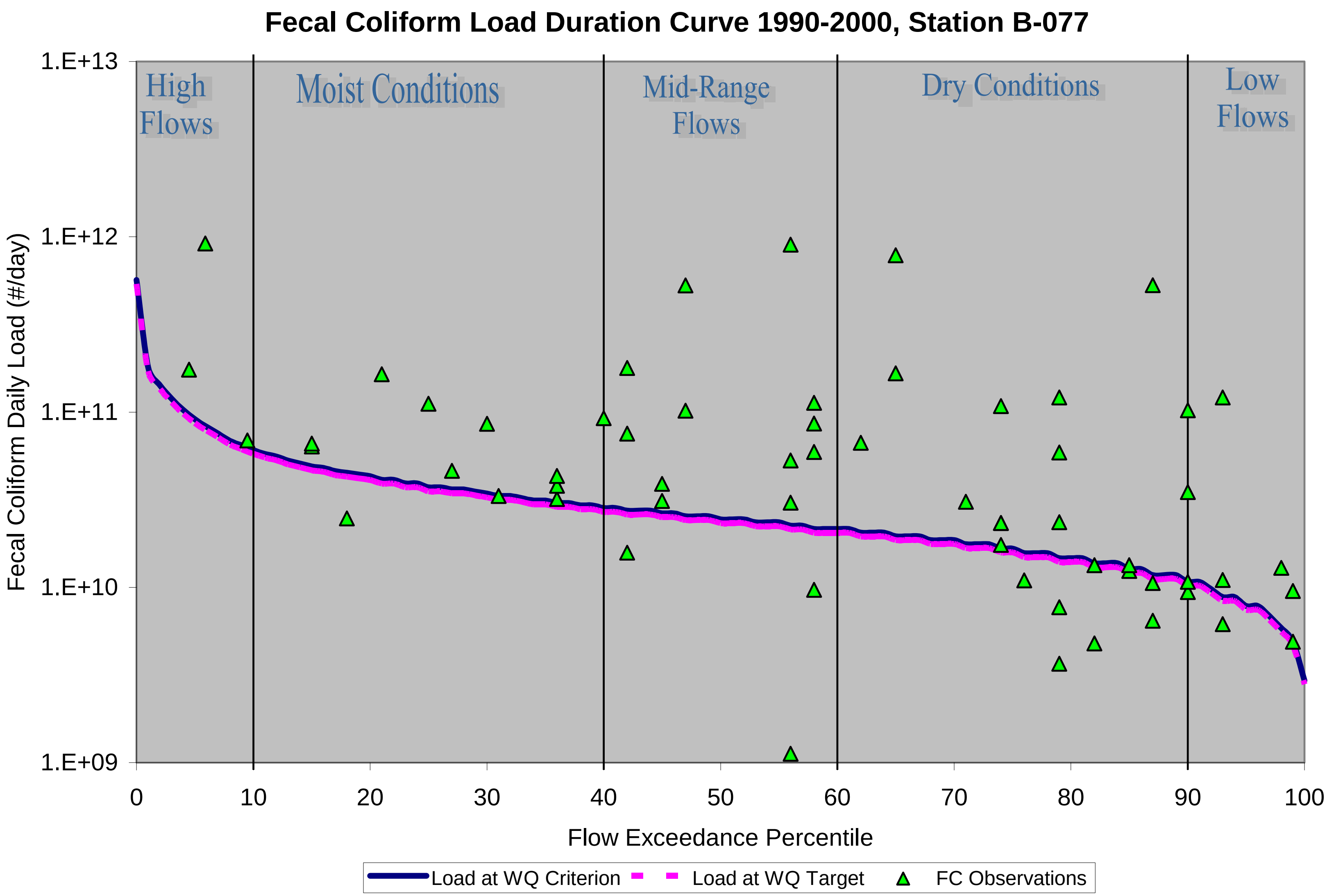


**Figure 5-19 TMDL for B-102 Jackson Creek**

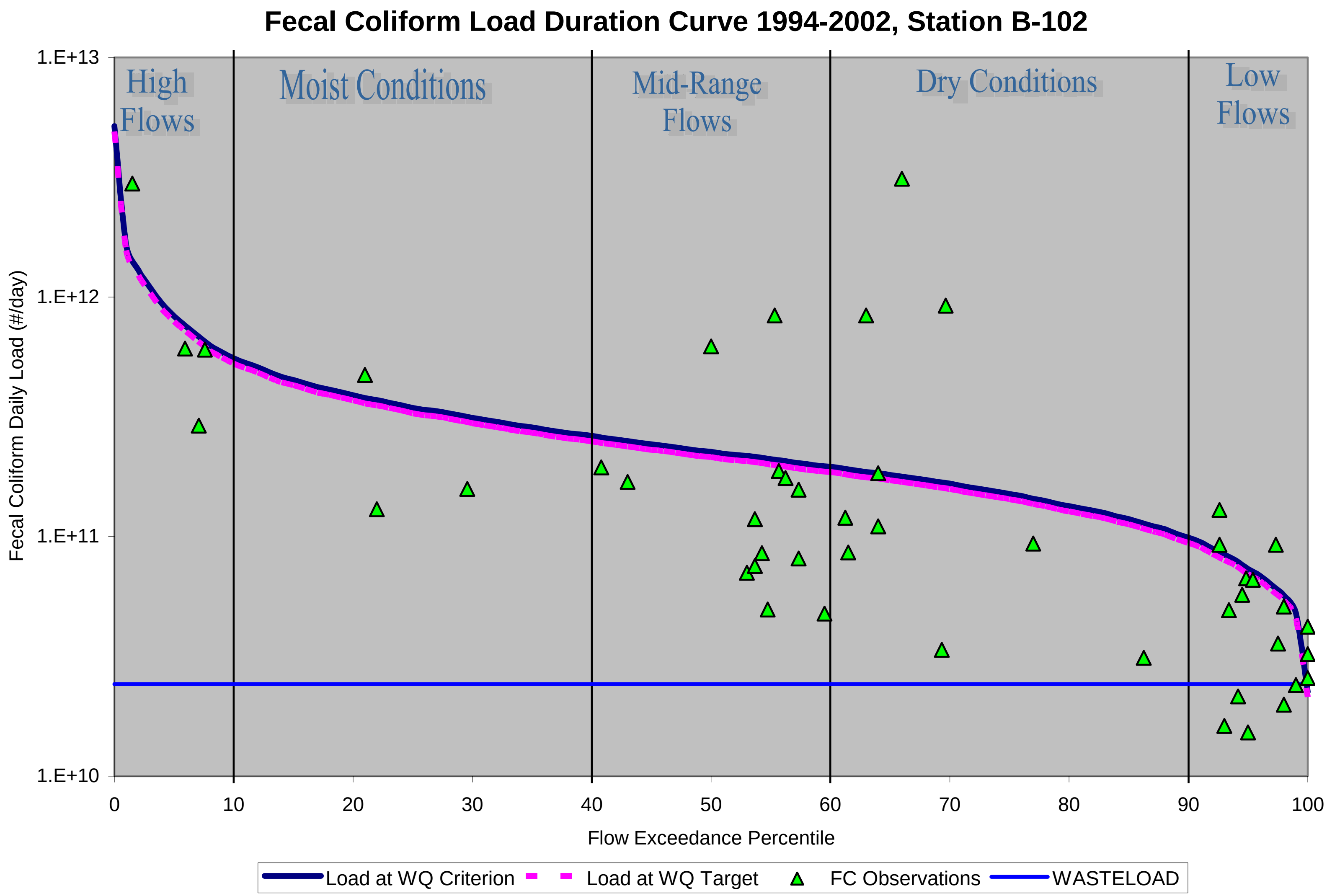
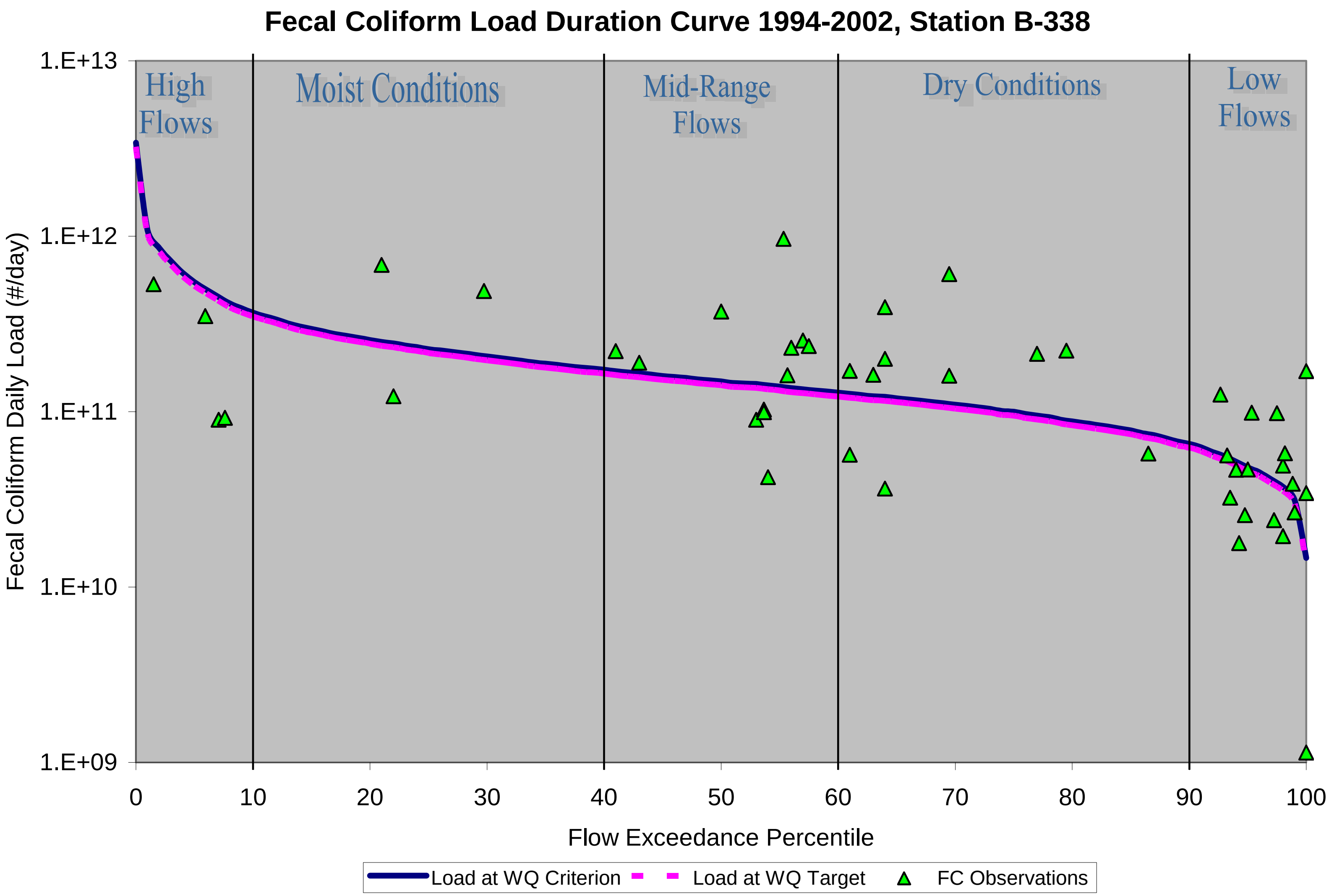


**Figure 5-20 TMDL for B-338 Mill Creek**



# SECTION 6
# PUBLIC PARTICIPATION

Section 303(d)(1) of the CWA, 33 United States Code [USC] §1313(d)(1)(C), and the implementing regulation of the USEPA (40 CFR §130.7(c)(1), require the establishment of total maximum daily loads (TMDL for waters identified by States as not meeting its WQSs under authority of §303(d)(1)(A) of the CWA. These TMDLs are established at levels necessary to implement applicable WQSs with seasonal variations and an MOS, accounting for lack of knowledge concerning the relationship between pollutant loading and water quality. When USEPA establishes a TMDL, 40 CFR §130.7(d)(2) requires USEPA to publish a Public Notice and seek comments concerning a TMDL.
The USEPA developed fecal coliform bacteria TMDLs for the identified §303(d)(1)(A) waters listed in the Table 6-1 on the SC 2004 §303(d) List.

| Water Body Name | SCDHEC WQM Stations | WQM Station Locations |
|---|---|---|
| HUC 03050106020 | | |
| Ross Branch | B-086 | Ross Branch to Turkey Creek at SC 49 SW of York |
| Turkey Creek | B-136 | Turkey Creek AT SC 9, 14 mi NW of Chester |
| HUC 03050106030 | | |
| Meng Creek | B-064 | Meng Creek at SC 49 2.5 mi E of Union |
| Meng Creek | B-243 | Trib to Meng Ck at Clvrt on S-44-384 3 mi E of Union |
| Browns Creek | B-155 | Browns Creek at S-44-86, 8 mi E of Union |
| Gregorys Creek | B-335 | Gregorys Creek at S-44-86, 8 mi E of Union |
| HUC 03050106010 | | |
| Broad River | B-046 | Broad River at SC 72/215/121 3 mi E of Carlisle |
| HUC 03050106040 | | |
| Dry Fork | B-074 | Dry Fork at S-12-304 2 mi SW of Chester |
| Sandy River | B-075 | Sandy River at SC 215 2.5 mi AB Jct with Broad River |
| HUC 03050106060 | | |
| Elizabeth Lake Spillway | B-110 | Elizabeth Lake at Spillway on US 21 |
| Crane Creek | B-316 | Crane Creek at S-40-43 under I-20 - North Cola |
| Smith Branch | B-280 | Smith Branch at N Main St (US 21) in Cola |
| Broad River | B-337 | Broad River at US 176 (Broad River Rd) in Columbia |
| HUC 03050106070 | | |
| Little River | B-145 | Little River at S-20-60 3.1 mi SW of Jenkinsville |
| Little River | B-350 | Little River at SC215, 1.5 mi NE of confl. w/ Broad River |
| HUC 03050106080 | | |
| Winnsboro Branch | B-123 | Winnsboro Branch at US 321-AB Winnsboro Mills Outfall |
| Winnsboro Branch | B-077 | Winnsboro Branch below Plant Outfall |
| Jackson Creek | B-102 | Jackson Creek at S-20-54, 5 mi W of Winnsboro |
| Mill Creek | B-338 | Mill Creek at S-20-48, 10 mi SW of Winnsboro |

Persons wishing to comment on the proposed TMDLs or to offer new data or information regarding the proposed TMDLs are invited to submit the same in writing no later than DATE, to the U.S. Environmental Protection Agency, Region 4, Water Management Division, 61 Forsyth Street, S.W., Atlanta, Georgia 30303: ATTENTION: Ms. Molly Davis, TMDL Modeling and Support Section. Ms. Cole's telephone number is (404) 562-9236. Ms. Davis may also be contacted via electronic mail at davis.molly@epa.gov. Please note that USEPA encourages the public to submit comments electronically.
The proposed TMDLs and the administrative records, including technical information, data and analyses, supporting the proposed TMDLs may be reviewed at 61 Forsyth Street, S.W., Atlanta, Georgia, between the hours of 8:00 a.m. and 3:00 p.m., Monday through Friday. Persons wishing to view this information should contact Ms. Davis to schedule a time for review. This notice and the proposed TMDLs can also be obtained through the Internet. The URL address for the proposed TMDLs is http://www.epa.gov/region4/water/tmdl/.
A final decision on the proposed TMDLs will be made soon after DATE. Please bring the foregoing to the attention of persons whom you believe will be interested in this matter.

# SECTION 7
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# APPENDIX A
# SCDHEC FECAL COLIFORM DATA – 1990 TO 2002

# APPENDIX B
# PLOTS COMPARING PRECIPITATION AND FECAL COLIFORM CONCENTRATIONS

# APPENDIX C
# NPDES PERMIT DISCHARGE MONITORING REPORT DATA

# APPENDIX D
# ESTIMATED FLOW EXCEEDANCE PERCENTILES

# APPENDIX E
# LOAD DURATION CURVES – ESTIMATED LOADING AND CRITICAL CONDITIONS