TOTAL MAXIMUM DAILY LOAD (TMDL)

for

Pathogens

in the

Caney Fork Watershed (HUC 05130108)

Bledsoe, Cannon, Cumberland, DeKalb, Putnam, Sequatchie, Smith, Van Buren, Warren, White and Wilson Counties, Tennessee

FINAL

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TDEC
Environment & Conservation

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LIST OF ABBREVIATIONS

ADB	Assessment Database
AFO	Animal Feeding Operation
BMP	Best Management Practices
BST	Bacteria Source Tracking
CAFO	Concentrated Animal Feeding Operation
CFR	Code of Federal Regulations
CFS	Cubic Feet per Second
DEM	Digital Elevation Model
DWPC	Division of Water Pollution Control
E. coli	Escherichia coli
EPA	Environmental Protection Agency
GIS	Geographic Information System
HSPF	Hydrological Simulation Program - Fortran
HUC	Hydrologic Unit Code
LA	Load Allocation
LDC	Load Duration Curve
LSPC	Loading Simulation Program in C^{++}
MGD	Million Gallons per Day
MOS	Margin of Safety
MRLC	Multi-Resolution Land Characteristic
MS4	Municipal Separate Storm Sewer System
MST	Microbial Source Tracking
NHD	National Hydrography Dataset
NMP	Nutrient Management Plan
NPS	Nonpoint Source
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
PCR	Polymerase Chain Reaction
PDFE	Percent of Days Flow Exceeded
PFGE	Pulsed Field Gel Electrophoresis
Rf3	Reach File v.3
RM	River Mile
SSO	Sanitary Sewer Overflow
STP	Sewage Treatment Plant
SWMP	Storm Water Management Program
TDA	Tennessee Department of Agriculture
TDEC	Tennessee Department of Environment & Conservation
TDOT	Tennessee Department of Transportation
TMDL	Total Maximum Daily Load
TWRA	Tennessee Wildlife Resources Agency
USGS	United States Geological Survey
UCF	Unit Conversion Factor
WCS	Watershed Characterization System
WLA	Waste Load Allocation
WWTF	Wastewater Treatment Facility

SUMMARY SHEET

Total Maximum Daily Load for Pathogens in
Caney Fork Watershed (HUC 05130108)

Impaired Waterbody Information

State: Tennessee
Counties: Bledsoe, Cannon, Cumberland, DeKalb, Putnam, Sequatchie, Smith, Van Buren, Warren, White, and Wilson
Watershed: Caney Fork (HUC 05130108)
Constituents of Concern: Pathogens

Impaired Waterbodies Addressed in This Document:

Waterbody ID	Waterbody	Miles Impaired
TN05130108002 – 2000	HICKMAN CREEK	10.16
TN05130108045 – 0300	HUDGENS CREEK	6.7
TN05130108045 – 0400 & 0450	PIGEOND ROOST CREEK	5.6
TN05130108097 – 2000	MINE LICK CREEK	4.23
TN05130108684 – 1000	FALL CREEK	9.8

Designated Uses:

The designated use classifications for waterbodies in the Caney Fork watershed include fish and aquatic life, irrigation, livestock watering & wildlife, and recreation. A portion of Mine Lick Creek is also designated for domestic water supply.

Water Quality Goal:

Derived from *State of Tennessee Water Quality Standards, Chapter 1200-4-3, General Water Quality Criteria, January, 2004* for recreation use classification (most stringent):

The concentration of the E. coli group shall not exceed 126 colony forming units per 100 mL, as a geometric mean based on a minimum of 5 samples collected from a given sampling site over a period of not more than 30 consecutive days with individual samples being collected at intervals of not less than 12 hours. For the purposes of determining the geometric mean, individual samples having an E. coli concentration of less than 1 per 100 mL shall be considered as having a concentration of 1 per 100 mL. In addition, the concentration of the E. coli group in any individual sample taken from a lake, reservoir, State Scenic River, or Tier II or III stream (1200-4-3-.06) shall not exceed 487 colony forming units per 100 mL. The concentration of the E. coli group in any individual sample taken from any other waterbody shall not exceed 941 colony forming units per 100 mL.

Additionally, consistent with current TMDL methodology, standards from *State of Tennessee Water Quality Standards, Chapter 1200-4-3, General Water Quality Criteria, October 1999* for recreation use classification:

The concentration of a fecal coliform group shall not exceed 200 per 100 mL nor shall the concentration of the *E. coli* group exceed 126 per 100 mL, as a geometric mean based on a minimum of 10 samples collected from a given sampling site over a period of not more than 30 consecutive days with individual samples being collected at intervals of not less than 12 hours. For the purposes of determining the geometric mean, individual samples having a fecal coliform group or *E. coli* concentration of less than 1 per 100 mL shall be considered as having a concentration of 1 per 100 mL. In addition, the concentration of the fecal coliform group in any individual sample shall not exceed 1,000 per 100 mL.

TMDL Scope:

Waterbodies identified on the Final 2004 303(d) list as impaired due to E. coli coliform. TMDLs are generally developed for impaired waterbodies on a HUC-12 basis.

Analysis/Methodology:

The TMDLs for impaired waterbodies in the Caney Fork watershed were developed using the load duration curve methodology to assure compliance with the E. Coli 126 counts/100 mL geometric mean and 941 counts/100 mL maximum standards while also incorporating the fecal coliform 200 counts/100 mL geometric mean and 1,000 counts/100 mL maximum concentration as surrogates. A duration curve is a cumulative frequency graph that represents the percentage of time during which the value of a given parameter is equaled or exceeded. Load duration curves are developed from flow duration curves and can illustrate existing water quality conditions (as represented by loads calculated from monitoring data), how these conditions compare to desired targets, and the portion of the waterbody flow regime represented by these existing loads. Load duration curves were used to determine the load reductions required to meet the target maximum concentrations for E. coli and fecal coliform (standard - MOS). When sufficient data were available, load reductions were also determined based on geometric mean criteria.

Critical Conditions:

Water quality data collected over a period of 10 years for load duration curve analysis were used to assess the water quality standards representing a range of hydrologic and meteorological conditions.

Seasonal Variation:

The 10-year period used for LSPC model simulation period and for load duration curve analysis included all seasons and a full range of flow and meteorological conditions.

Margin of Safety (MOS):

Explicit – 10% of the water quality standard for each impaired subwatershed.

Summary of TMDLs, WLAs, & LAs for Impaired Waterbodies

HUC-12 Subwatershed (05130108__) or Drainage Area	Impaired Waterbody Name	Impaired Waterbody ID	TMDL	WLAs				LAs	
				WWTFs[a] (Monthly Avg.) E. Coli	Leaking Collection Systems[b]	CAFOs	MS4s[c]	Precipitation Induced Nonpoint Sources	Other Direct Sources[d]
			[% Red.]	[cts./day]	[cts./day]	[cts./day]	[% Red.]	[% Red.]	[cts./day]
0807	Hickman Creek	TN05130108002 – 2000	**88.3**	**1.431×10^9**	**0**	**NA**	**88.3**	**88.3**	**0**
0702	Hudgens Creek	TN05130108045 – 0300	**82.4**	**6.677×10^{10}**	**0**	**NA**	**82.4**	**82.4**	**0**
	Pigeon Roost Creek	TN05130108045 – 0400 & 0450							
0803	Mine Lick Creek	TN05130108097 – 2000	**45.1**	**2.385×10^9**	**0**	**NA**	**NA**	**45.1**	**0**
0406	Fall Creek	TN05130108684 – 1000	**43.8**	**1.030×10^{10}**	**0**	**NA**	**NA**	**43.8**	**0**

Note: NA = Not Applicable.

a. WLAs for WWTFs expressed as E. coli loads (counts/day).

b. The objective for leaking collection systems is a waste load allocation of zero. It is recognized, however, that a WLA of 0 counts/day may not be practical. For these sources, the WLA is interpreted to mean a reduction in coliform loading to the maximum extent practicable, consistent with the requirement that these sources not contribute to a violation of the water quality standard for E. coli.

c. Applies to any MS4 discharge loading in the subwatershed.

d. The objective for all "other direct sources" is a load allocation of zero. It is recognized, however, that for leaking septic systems a LA of 0 counts/day may not be practical. For these sources, the LA is interpreted to mean a reduction in coliform loading by the application of best management practices, consistent with the requirement that these sources not contribute to a violation of the water quality standard for E. coli.

PROPOSED PATHOGEN TOTAL MAXIMUM DAILY LOAD (TMDL) CANEY FORK WATERSHED (HUC 05130108)

1.0 INTRODUCTION

Section 303(d) of the Clean Water Act requires each state to list those waters within its boundaries for which technology based effluent limitations are not stringent enough to protect any water quality standard applicable to such waters. Listed waters are prioritized with respect to designated use classifications and the severity of pollution. In accordance with this prioritization, states are required to develop Total Maximum Daily Loads (TMDLs) for those waterbodies that are not attaining water quality standards. State water quality standards consist of designated uses for individual waterbodies, appropriate numeric and narrative water quality criteria protective of the designated uses, and an antidegradation statement. The TMDL process establishes the maximum allowable loadings of pollutants for a waterbody that will allow the waterbody to maintain water quality standards. The TMDL may then be used to develop controls for reducing pollution from both point and nonpoint sources in order to restore and maintain the quality of water resources (USEPA, 1991).

2.0 SCOPE OF DOCUMENT

This document presents details of TMDL development for waterbodies in the Caney Fork watershed, identified on the Final 2004 303(d) list as not supporting designated uses due to E. coli and/or fecal coliform. TMDL analyses are performed primarily on a 12-digit hydrologic unit area (HUC-12) basis. In some cases, where appropriate, TMDLs are developed for an impaired waterbody drainage area only.

3.0 WATERSHED DESCRIPTION

The Caney Fork watershed (HUC 05130108) is located in Middle and East Tennessee (Figure 1), primarily in DeKalb, Putnam, Van Buren, and White Counties. The Caney Fork watershed lies within two Level III ecoregions (Southwestern Appalachians, Interior Plateau) and contains four Level IV ecoregions as shown in Figure 2 (USEPA, 1997):

- **Cumberland Plateau (68a)** tablelands and open low mountains are about 1000 feet higher than the Eastern Highland Rim (71g) to the west, and receive slightly more precipitation with cooler annual temperatures than the surrounding lower-elevation ecoregions. The plateau surface is less dissected with lower relief compared to the Cumberland Mountains (69d) or the Plateau Escarpment (68c). Elevations are generally 1200-2000 feet, with the Crab Orchard Mountains reaching over 3000 feet. Pennsylvanian-age conglomerate, sandstone, siltstone, and shale is covered by well-drained, acid soils of low fertility. Bituminous coal that has been extensively surface and underground mined underlies the region. Acidification of first and second order streams is common. Stream siltation and mine spoil bedload deposits continue as long-term problems in these headwater systems. Pockets of severe acid mine drainage persist.

- **Plateau Escarpment (68c)** is characterized by steep, forested slopes and high velocity, high gradient streams. Local relief is often 1000 feet or more. The geologic strata include

Mississippian-age limestone, sandstone, shale, and siltstone, and Pennsylvanian-age shale, siltstone, sandstone, and conglomerate. Streams have cut down into the limestone, but the gorge talus slopes are composed of colluvium with huge angular, slabby blocks of sandstone. Vegetation community types in the ravines and gorges include mixed oak and chestnut oak on the upper slopes, mesic forests on the middle and lower slopes (beech-tulip poplar, sugar maple-basswood-ash-buckeye), with hemlock along rocky streamsides and river birch along floodplain terraces.

- **Eastern Highland Rim (71g)** has level terrain, with landforms characterized as tablelands of moderate relief and irregular plains. Mississippian-age limestone, chert, shale and dolomite predominate, and karst terrain sinkholes and depressions are especially noticeable between Sparta and McMinnville. Numerous springs and spring-associated fish fauna also typify the region. Natural vegetation for the region is transitional between the oak-hickory type to the west and the mixed mesophytic forests of the Appalachian ecoregions to the east. Bottomland hardwoods forests were once abundant in some areas, although much of the original bottomland forest has been inundated by several large impoundments. Barrens and former prairie areas are now mostly oak thickets or pasture and cropland.

- **Outer Nashville Basin (71h)** is a heterogeneous region, with rolling and hilly topography and slightly higher elevations. The region encompasses most all of the outer areas of the generally no-cherty Mississippian-age formations, and some Devonian-age Chattanooga shale, remnants of the Highland Rim. The region's limestone rocks and soils are high in phosphorus, and commercial phosphate is mined. Deciduous forest with pasture and cropland are the dominant land covers. Streams are low to moderate gradient, with productive, nutrient-rich waters, resulting in algae, rooted vegetation and occasionally high densities of fish. The Nashville Basin as a whole has a distinctive fish fauna, notable for fish that avoid the region, as well as those that are present.

The Caney Fork watershed, located in Bledsoe, Cannon, Cumberland, DeKalb, Putnam, Sequatchie, Smith, Van Buren, Warren, White, and Wilson Counties, Tennessee, has a drainage area of approximately 1,790 square miles (mi^2). Watershed land use distribution is based on the Multi-Resolution Land Characteristic (MRLC) databases derived from Landsat Thematic Mapper digital images from the period 1990-1993. Although changes in the land use of the Caney Fork watershed have occurred since 1993 as a result of development, this is the most current land use data available. Land use for the Caney Fork watershed is summarized in Table 1 and shown in Figure 3. Predominant land use in the Caney Fork watershed is forest (74.7%) followed by agriculture (21.1%). Urban areas represent approximately 1.2% of the total drainage area of the watershed. Details of land use distribution of impaired subwatersheds in the Caney Fork watershed are presented in Appendix A.

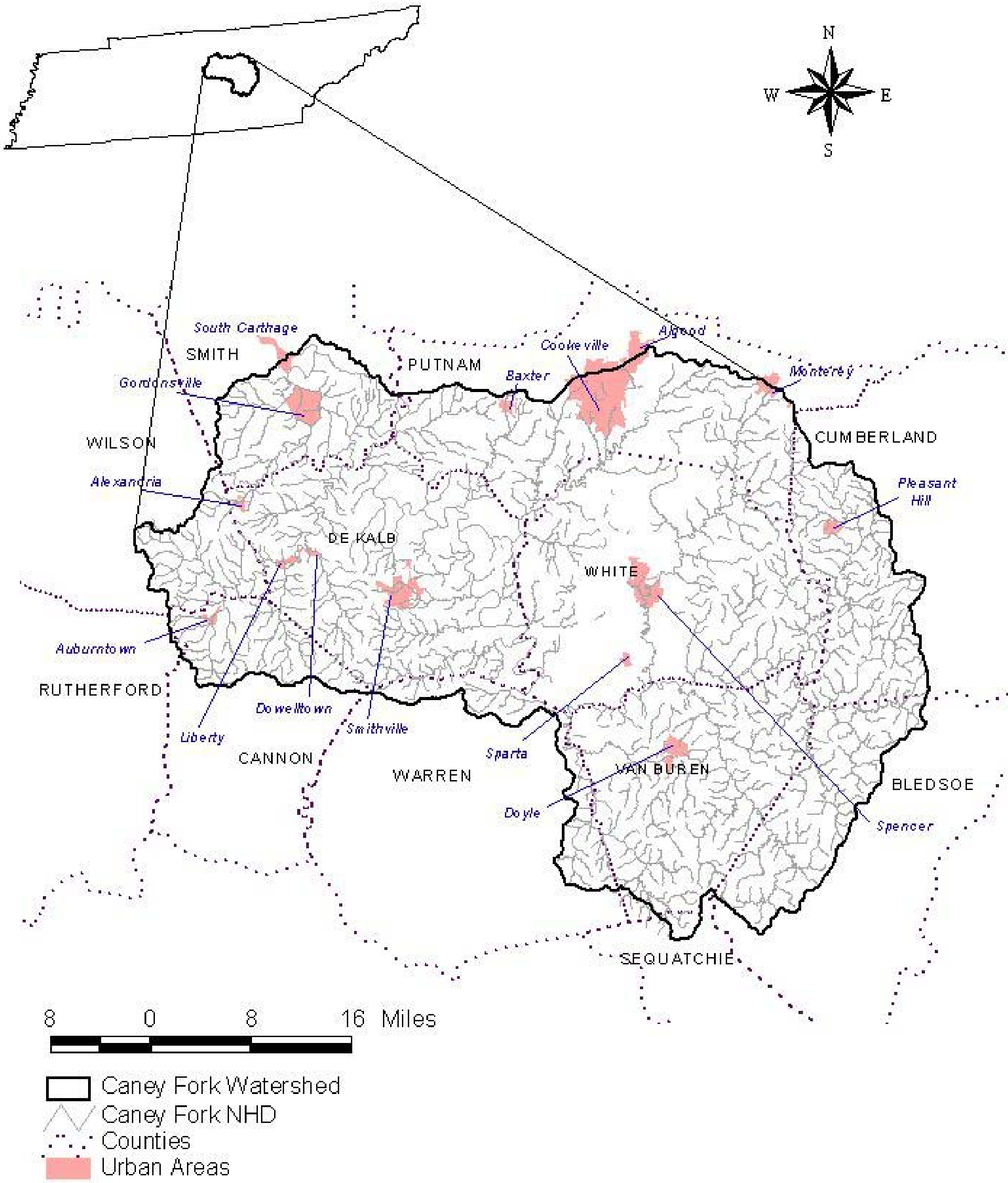

Figure 1. Location of the Caney Fork Watershed.

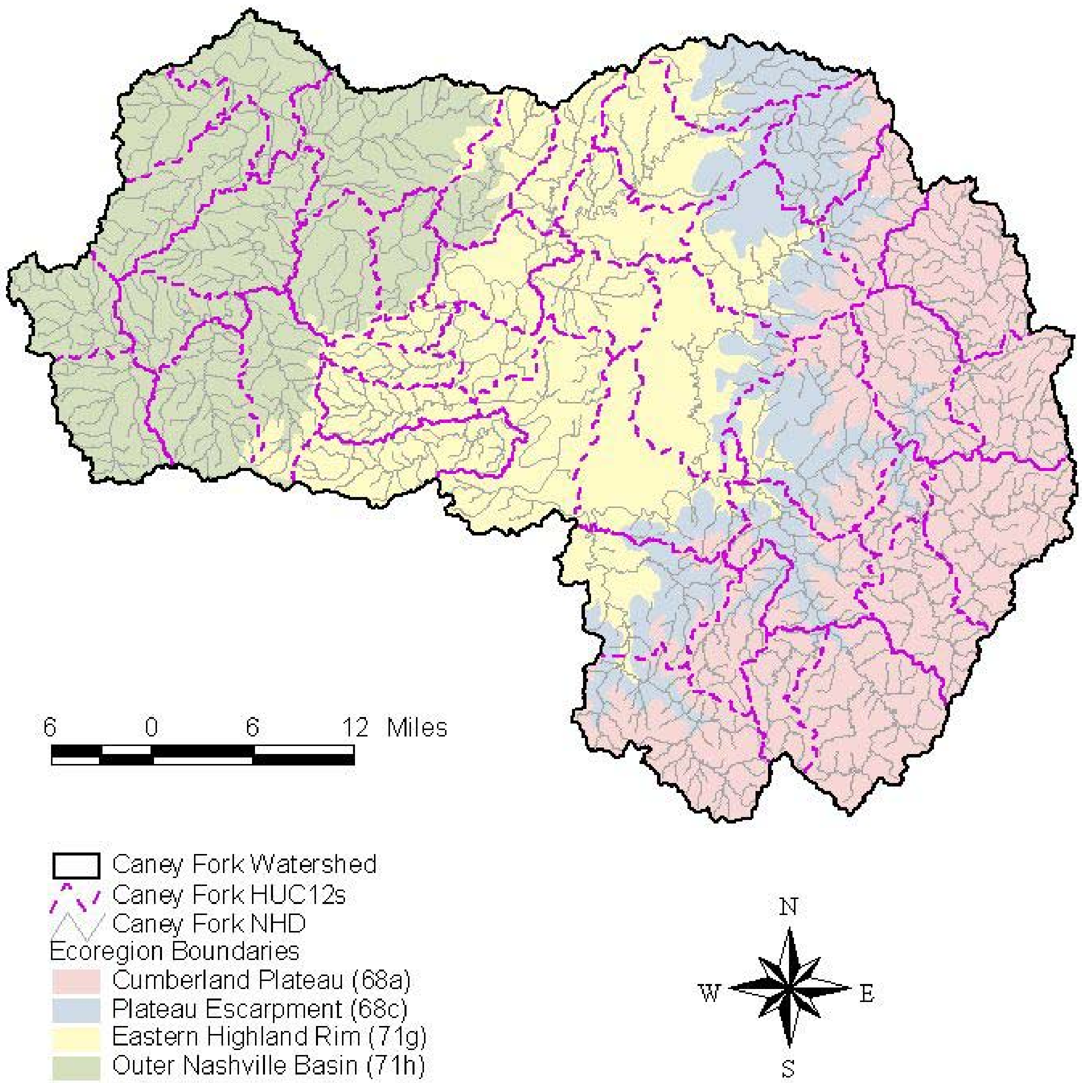

Figure 2. Level IV Ecoregions in the Caney Fork Watershed.

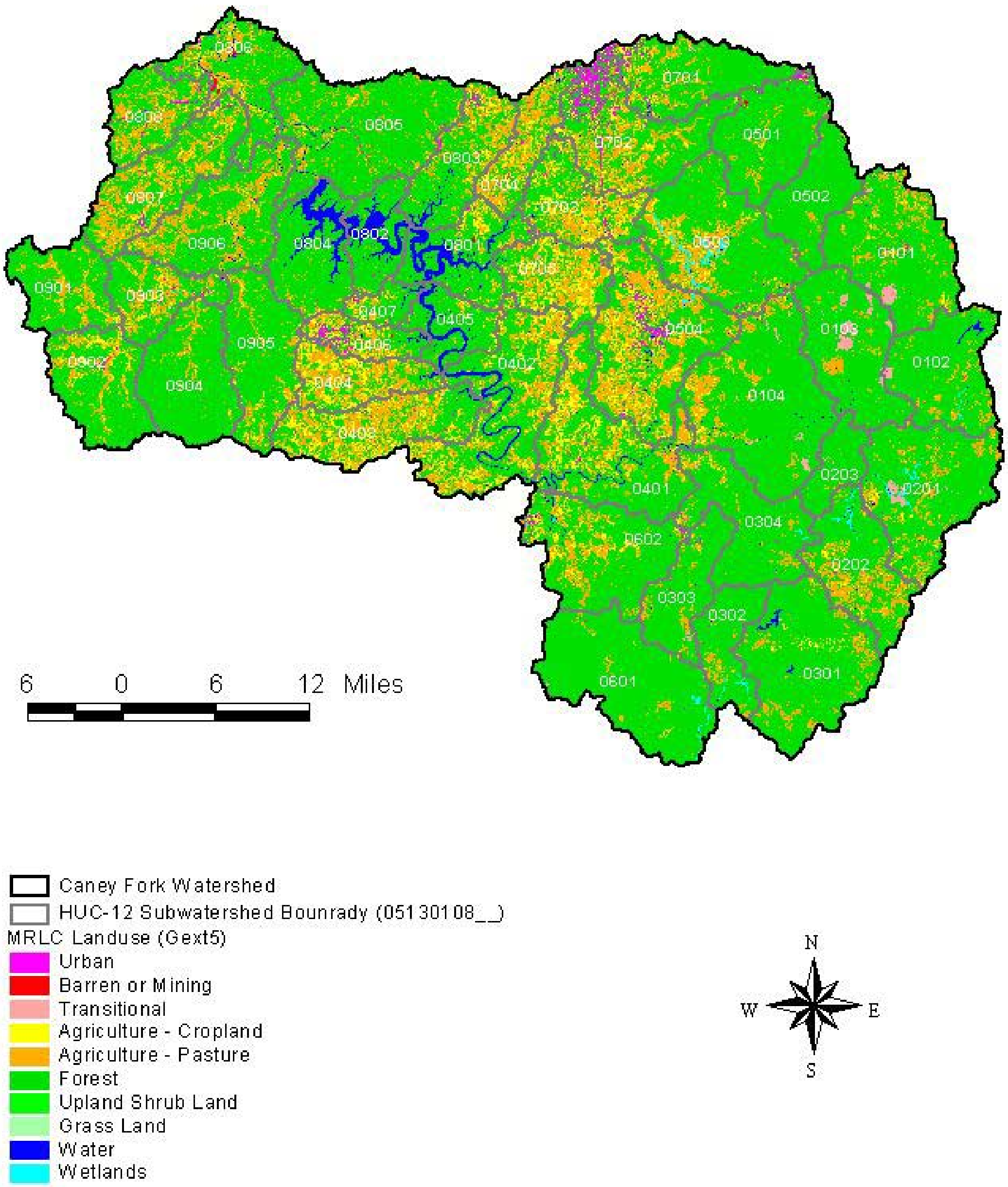

Figure 3. Land Use Characteristics of the Caney Fork Watershed.

Table 1. MRLC Land Use Distribution – Caney Fork Watershed

Land Use	Area	
	[acres]	[%]
Bare Rock/Sand/Clay	7	0.0
Deciduous Forest	619,711	53.9
Emergent Herbaceous Wetlands	42	0.0
Evergreen Forest	88,323	7.7
High Intensity Commercial/Industrial/ Transportation	5,210	0.5
High Intensity Residential	1,021	0.1
Low Intensity Residential	7,362	0.6
Mixed Forest	150,871	13.1
Open Water	18,663	1.6
Other Grasses (Urban/recreational)	7,775	0.7
Pasture/Hay	185,405	16.1
Quarries/Strip Mines/ Gravel Pits	532	0.1
Row Crops	57,498	5.0
Transitional	4,742	0.4
Woody Wetlands	2,806	0.2
Total	**1,149,968**	**100.0**

4.0 PROBLEM DEFINITION

The State of Tennessee's final 2004 303(d) list (TDEC, 2004a) was approved by the U.S. Environmental Protection Agency (EPA), Region IV in August of 2005. This list identified portions of five waterbodies in the Caney Fork watershed as not supporting designated use classifications due, in part, to E. coli and/or fecal coliform (see Table 2). The designated use classifications for these waterbodies include fish and aquatic life, irrigation, livestock watering & wildlife, and recreation. A portion of Mine Lick Creek is also designated for domestic water supply.

When used in the context of waterbody assessments, the term pathogens is defined as disease-causing organisms such as bacteria or viruses that can pose an immediate and serious health threat if ingested or introduced into the body. The primary sources for pathogens are untreated or inadequately treated human or animal fecal matter. The E. coli and fecal coliform groups are indicators of the presence of pathogens in a stream.

The waterbody segments listed in Table 2 were assessed as impaired based on sampling data and/or biological surveys. The results of these assessment surveys are summarized in Table 3 and shown in Figure 4. The assessment information presented is excerpted from the EPA/TDEC Assessment Database (ADB) and is referenced to the waterbody ID in Table 2. ADB information may be accessed at:

http://gwidc.memphis.edu/website/wpc_arcmap

5.0 WATER QUALITY GOAL

As previously stated, the designated use classifications for the Caney Fork waterbodies include fish & aquatic life, recreation, irrigation, and livestock watering & wildlife. A portion of Mine Lick Creek is also designated for domestic water supply. Of the use classifications with numeric criteria for pathogens, the recreation use classification is the most stringent and will be used to establish target levels for TMDL development. The coliform water quality criteria, for protection of the recreation use classification, is established by *State of Tennessee Water Quality Standards, Chapter 1200-4-3, General Water Quality Criteria, January 2004* (TDEC, 2004b). Section 1200-4-3-.03 (4) (f) states:

> The concentration of the E. coli group shall not exceed 126 colony forming units per 100 mL, as a geometric mean based on a minimum of 5 samples collected from a given sampling site over a period of not more than 30 consecutive days with individual samples being collected at intervals of not less than 12 hours. For the purposes of determining the geometric mean, individual samples having an E. coli concentration of less than 1 per 100 mL shall be considered as having a concentration of 1 per 100 mL.
>
> Additionally, the concentration of the E. coli group in any individual sample taken from a lake, reservoir, State Scenic River, or Tier II or III stream (1200-4-3-.06) shall not exceed 487 colony forming units per 100 mL. The concentration of the E. coli group in any individual sample taken from any other waterbody shall not exceed 941 colony forming units per 100 mL.

Portions of Cane Creek, Calfkiller River, and Caney Fork River have been classified as Tier II streams. None of the impaired waterbodies in the Caney Fork watershed have been classified as either Tier II or Tier III streams.

Prior to January 2004, the coliform water quality criteria, for protection of the recreation use classification, established by *State of Tennessee Water Quality Standards, Chapter 1200-4-3, General Water Quality Criteria, October 1999* (TDEC, 1999), Section 1200-4-3-.03 (4) (f) states:

> The concentration of a fecal coliform group shall not exceed 200 per 100 mL, nor shall the concentration of the *E. coli* group exceed 126 per 100 mL, as a geometric mean based on a minimum of 10 samples collected from a given sampling site over a period of not more than 30 consecutive days with individual samples being collected at intervals of not less than 12 hours. For the purposes of determining the geometric mean, individual samples having a fecal coliform group or *E. coli* concentration of less than 1 per 100 mL shall be considered as having a concentration of 1 per 100 mL. In addition, the concentration of the fecal coliform group in any individual sample shall not exceed 1,000 per 100 mL.

In addition to utilizing the E. coli water quality standards (with MOS) as the target, this TMDL utilizes a fecal coliform target as a surrogate for determining the attainment of the E. coli standard because of the demonstrated high correlation between E. coli and fecal coliform in this watershed. In the state of Tennessee, E. coli and fecal coliform are well correlated (R = 0.902) when evaluating all available ecoregion data (623 observations).

Therefore, this TMDL employs both the E. coli water quality standard and the surrogate fecal coliform criteria by determining the amount of load reduction required to comply with each of four criteria: 1) the geometric mean standard for E. coli of 126 counts/100mL, 2) the E. coli sample maximum of 941 counts/100 mL, 3) the geometric mean for fecal coliform of 200 counts/100 mL, and 4) the fecal coliform sample maximum of 1,000 counts/100 mL. The fecal coliform surrogate is most frequently used when insufficient monitoring data is available for E. coli or when analysis of E. coli monitoring data suggests that a listed segment is not impaired. The most protective (or highest percent of load reduction) of the four criteria will determine the percent reduction(s) required for impaired waterbodies. The analysis of fecal coliform data is only part of the methodology and is not included to comply with current water quality standards.

Note: In this document, the water quality standards are the instream goals. The term "target concentration" reflects the application of an explicit Margin of Safety (MOS) to the water quality standard. See Section 8.4 for an explanation of MOS.

Table 2. Final 2004 303(d) List for E. coli Impaired Waterbodies – Caney Fork Watershed

Waterbody ID	Impacted Waterbody	Miles/Acres Impaired	Cause (Pollutant)	Pollutant Source
TN05130108002 – 2000	HICKMAN CREEK (Brush Ck. to headwaters)	10.16	Alterations of stream-side or littoral vegetative cover Low dissolved oxygen Nitrates Phosphates Escherichia coli	Municipal Point Source Grazing Related Sources
TN05130108045 – 0300	HUDGENS CREEK	6.7	Alterations of stream-side or littoral vegetative cover Siltation Escherichia coli	Discharges from MS4 Area Pasture Grazing
TN05130108045 – 0400	PIGEON ROOST CREEK (Falling Water River to Cookeville STP outfall)	2.4	Nitrates Phosphorus Physical substrate habitat alteration Escherichia coli	Municipal Point Source Discharges from MS4 Area Channelization
TN05130108045 – 0450	PIGEON ROOST CREEK (Cookeville STP outfall to cave at mile 5.6 where creek emerges from underground)	3.2	Nitrates Phosphorus Physical substrate habitat alteration Escherichia coli	Discharges from MS4 Area Channelization
TN05130108097 – 2000	MINE LICK CREEK (Upper Mine Lick Creek)	4.23	Eschierichia coli Nitrates	Collection System Failure
TN05130108684 – 1000	FALL CREEK (Lower Fall Creek from embayment to and including Calvert's Lake)	9.8	Siltation Organic Enrichment Low dissolved oxygen Escherichia coli Other anthropogenic subsrate alterations	Major Municipal Point Source Upstream Impoundment

Table 3. Water Quality Assessment of Waterbodies Impaired Due to E. coli – Caney Fork Watershed

Waterbody ID	Segment Name	Comments
TN05130108002 – 2000	HICKMAN CREEK (Brush Ck. to headwaters)	2002 TDEC biorecon at mile 12.8; 3 EPT, 0 intolerant, 19 total genera; BR score = 7; Habitat score = 121. 2002 TDEC chemical stations at mile 13.0 & 13.7; pathogens and nutrients elevated. 1998 TDEC biological survey at mile 12.8; 5 EPT genera
TN05130108045 – 0300	HUDGENS CREEK	2002 TDEC biorecon at mile 0.7; 7 EPT, 1 intolerant, 20 total genera; BR score = 9; Habitat score = 100. 2002 TDEC chemical station at mile 0.7. 1998 TDEC biological survey at mile 0.7; 4 EPT genera.
TN05130108045 – 0400	PIGEON ROOST CREEK (Falling Water River to Cookeville STP outfall)	2002 TDEC biorecon and chemical station at mile 1.3; 3 EPT, 1 intolerant, 15 total genera; BR score = 5; Habitat score = 115; benthic community dominated by taxa tolerant to excessive nutrients; nutrients and pathogens elevated. 2002 TDEC biorecon at mile 0.1; 5 EPT, 1 intolerant, 16 total genera; BR score = 7; Habitat score = 119. Tennessee Tech RBPIII surveys at mile 1.3; Index score = 24; failed biocriteria.
TN05130108045 – 0450	PIGEON ROOST CREEK (Cookeville STP outfall to cave at mile 5.6 where creek emerges from underground)	2002 TDEC biorecon and chemical station at mile 2.4; 4 EPT, 1 intolerant, 19 total genera; BR score = 7; Habitat score = 138; pathogens and nutrients elevated. Tennessee Tech RBPIII surveys at mile 2.4; Index score = 26; failed biocriteria. 1998 TDEC biological & chemical sampling above STP; fecal & nutrients elevated. 1999 & 2000 Tenn. Tech. Biorecon surveys just u/s of STP outfall at mile 2.5; 5 EPT, 16 total genera in 5/99; 4 EPT, 23 total genera in 6/00; 6 EPT, 13 total genera in 11/00.
TN05130108097 – 2000	MINE LICK CREEK (Upper Mine Lick Creek)	2002 TDEC biorecon at mile 15.5; 6 EPT, 4 intolerant, 22 total genera; BR score = 11; habitat score = 144. 2002 TDEC chemical stations at 15.5 & 15.5; fecals and nutrients elevated. 2000 COE RBPIII-like survey at mile 12.5; 8 EPT, 22 total genera; Index score = 28; failed biocriteria. 1998 TDEC biological survey at mile 14.7; 8 EPT. 1998 TDEC biological survey at mile 15.3; 4 EPT genera; water contact advisory. 1996 COE biological survey at mile 12.5; 34 EPT genera.
TN05130108684 – 1000	FALL CREEK (Lower Fall Creek from embayment to and including Calvert's Lake)	2002 TDEC biorecon at mile 4.6; 3 EPT, 0 intolerant, 11 total genera; BR score = 5; Habitat score = 160. 2003 consultant for City of Smithville biorecon at 2 stations. D/s of lake: 6 EPT, 21 total genera; Index score = 24. D/s of falls: 8 EPT, 34 total genera; Index score = 28. 1998 TDEC biological survey at mile 4.7; 2 EPT genera. 1996 COE biological survey at mile 5.4; 18 EPT genera.

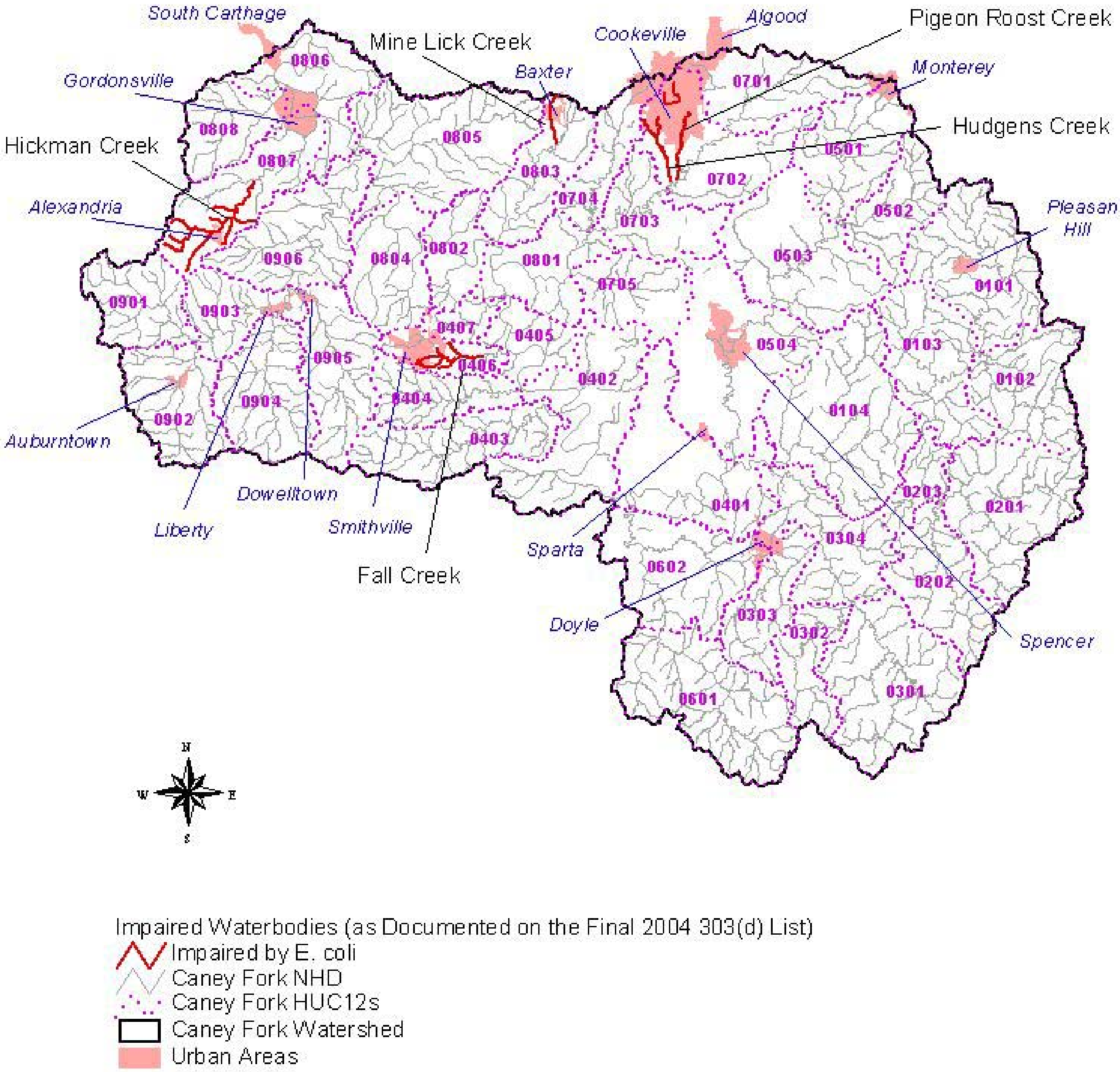

Figure 4. Waterbodies Impaired by Pathogens (as Documented on the Final 2004 303(d) List).

6.0 WATER QUALITY ASSESSMENT AND DEVIATION FROM GOAL

There are several water quality monitoring stations that provide data for waterbodies identified as impaired for pathogens in the Caney Fork watershed:

- Hickman Creek Subwatershed:
    - HICKM013.0SM – Hickman Creek, off Old Hwy 53, d/s Alexandria STP
    - HICKM013.7DB – Hickman Creek, at Hwy 53, u/s Alexandria STP
- Hudgens Creek Subwatershed:
    - HUDGE000.7PU – Hudgens Creek, at Keller Rd.
- Pigeon Roost Creek Subwatershed:
    - PROOS001.3PU – Pigeon Roost Creek, at South Ck Rd.
    - PROOS002.3PU – Pigeon Roost Creek, 80 ft d/s Cookeville STP
    - PROOS002.4PU – Pigeon Roost Creek, just u/s Cookeville STP
    - PROOS1T0.1PU – unnamed trib to Pigeon Roost Creek, at old Cookeville STP
- Mine Lick Creek Subwatershed
    - MLICK015.3PU – Mine Lick Creek, just d/s of Baxter STP
    - MLICK015.5PU – Mine Lick Creek, just u/s of Baxter STP
- Fall Creek Subwatershed:
    - FALL005.5DB – Fall Creek, 100 ft. u/s Smithville STP, near Macedonia Church (way d/s Monterey STP)

The location of these monitoring stations is shown in Figure 5. Water quality monitoring results for these stations are tabulated in Appendix B. Examination of the data shows violations of the 1,000 counts/100 mL maximum fecal coliform concentration and the 941 counts/100 mL maximum E. coli standard at many monitoring stations. Water quality monitoring results for those stations with 10% or more of samples in violation of water quality maximum criteria are summarized in Table 4.

There were not enough data to calculate the geometric mean at each monitoring station. Whenever a minimum of 5 samples was collected at a given monitoring station over a period of not more than 30 consecutive days, the geometric mean was calculated.

All waterbodies listed on the Final 2004 303(d) List are provided a TMDL for pathogen loading.

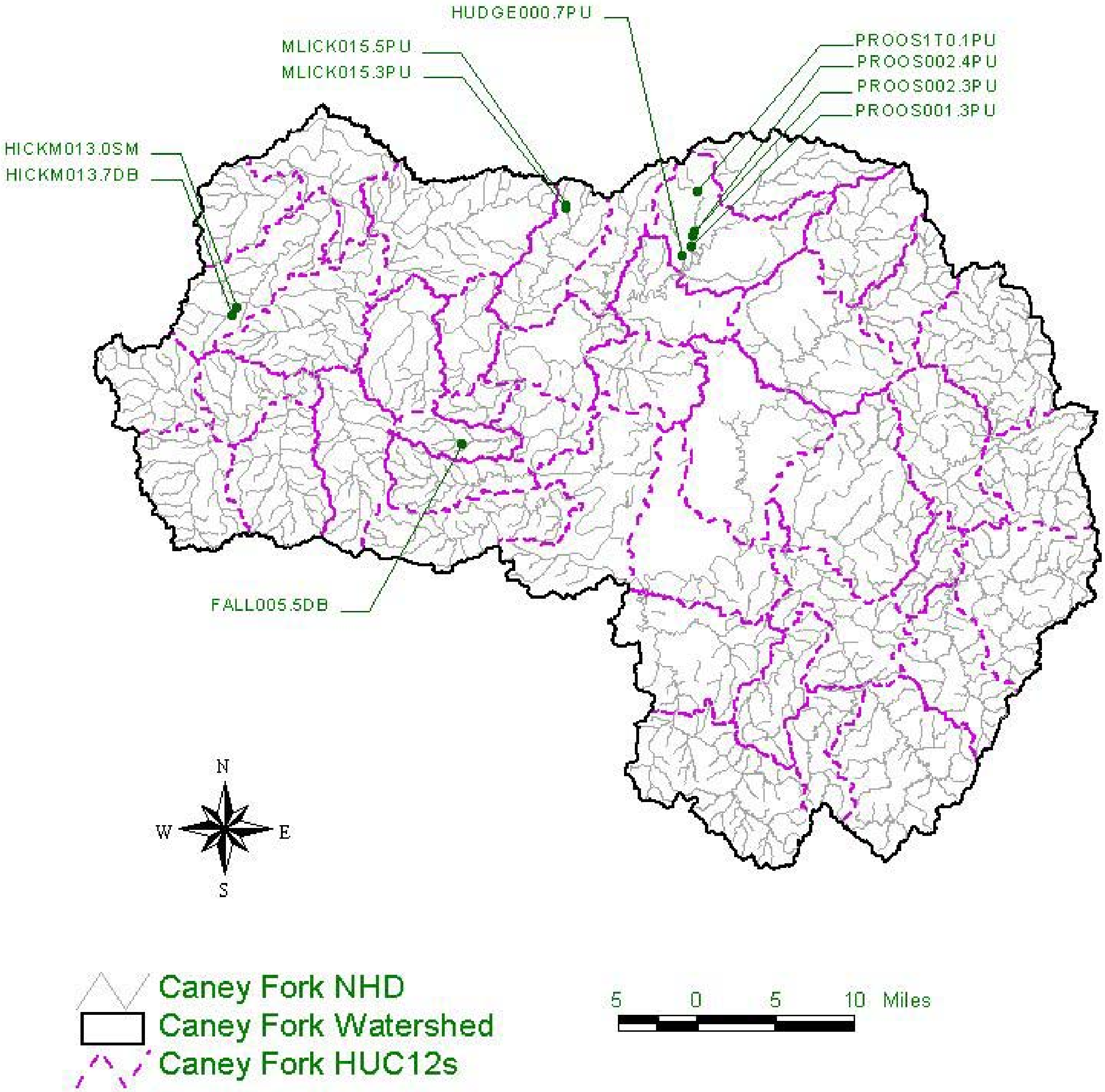

Figure 5. Water Quality Monitoring Stations in the Caney Fork Watershed

Table 4. Summary of TDEC Water Quality Monitoring Data

Monitoring Station	Monitoring Dates	E. Coli						Fecal Coliform					
		Data Pts.	[Counts/100 mL]			No. Viol. WQ Crit.	Percent Viol. WQ Crit.	Data Pts.	[Counts/100 mL]			No. Viol. WQ Crit.	Percent Viol. WQ Crit.
			Min.	Avg.	Max.				Min.	Avg.	Max.		
FALL005.5DB	2002 – 2003	11	28	254	1,100	1	9.1%	11	30	442	2,000	3	18.2%
HICKM013.0SM	2002 – 2003	10	45	879	>2,400	3	30.0%	10	14	2,074	9,200	3	30.0%
HICKM013.7DB	2002 – 2003	10	11	986	>2,400	4	40.0%	10	38	2,310	13,000	3	30.0%
HUDGE000.7PU	2002 – 2003	11	89	1,103	>2,400	5	45.5%	11	70	1,635	4,900	5	45.5%
MLICK015.3PU	2002 – 2003	10	46	496	1,600	2	20.0%	10	11	488	1,400	1	10.0%
MLICK015.5PU	2002 – 2003	10	84	491	2,000	1	10.0%	10	57	685	2,000	3	30.0%
PROOS001.3PU	1999 – 2003	12	100	889	2,400	5	41.7%	12	70	1,156	3,300	5	41.7%
PROOS002.4PU	2002 – 2003	11	25	1,082	>2,400	4	36.4%	11	20	1,764	5,400	5	45.5%

7.0 SOURCE ASSESSMENT

An important part of TMDL analysis is the identification of individual sources, or source categories of pollutants in the watershed that affect pathogen loading and the amount of loading contributed by each of these sources.

Under the Clean Water Act, sources are classified as either point or nonpoint sources. Under 40 CFR §122.2, a point source is defined as a discernable, confined, and discrete conveyance from which pollutants are or may be discharged to surface waters. The National Pollutant Discharge Elimination System (NPDES) program regulates point source discharges. Point sources can be described by three broad categories: 1) NPDES regulated municipal and industrial wastewater treatment facilities (WWTFs); 2) NPDES regulated industrial and municipal storm water discharges; and 3) NPDES regulated Concentrated Animal Feeding Operations (CAFOs). A TMDL must provide Waste Load Allocations (WLAs) for all NPDES regulated point sources. Nonpoint sources are diffuse sources that cannot be identified as entering a waterbody through a discrete conveyance at a single location. For the purposes of this TMDL, all sources of pollutant loading not regulated by NPDES permits are considered nonpoint sources. The TMDL must provide a Load Allocation (LA) for these sources.

7.1 Point Sources

7.1.1 NPDES Regulated Municipal and Industrial Wastewater Treatment Facilities

Both treated and untreated sanitary wastewater contain coliform bacteria. There are 17 NPDES permitted WWTFs that require monitoring of fecal coliform and/or E. coli within the Caney Fork watershed. The fecal coliform and E. coli permit limits for discharges from these WWTFs are in accordance with the criteria specified in the 1999 and 2004 State of Tennessee water quality standards (TDEC, 1999 and TDEC, 2004b, respectively) (ref.: Section 5.0).

Four of these facilities are located in impaired subwatersheds of the Caney Fork watershed. The Alexandria STP (TN0021539), with a design capacity of 0.3 MGD, discharges to Hickman Creek at mile 13.1. A new POTW started up in August 2002. Since that time, no overflows have been reported. The Baxter STP (TN0021121), with a design capacity of 0.5 MGD, discharges to Mine Lick Creek at mile 15.4. Baxter is under a collection system moratorium due to problems with infiltration and inflow. The Cookeville STP (TN0024198), with a design capacity of 14.0 MGD, discharges to Pigeon Roost Creek at mile 2.3. A collection system rehab is in progress as well as ongoing collection system maintenance. However, over 40 overflows/bypasses have been reported in both 2003 and 2004. The Smithville Sewage Treatment Plant (STP) (TN0065358), with a design capacity of 2.16 MGD, discharges to Fall Creek at mile 4.7. Only one overflow and three bypasses have been reported in the past two years. These problems can be a significant contributor to pathogen impairment in the watershed.

7.1.2 NPDES Regulated Municipal Separate Storm Sewer Systems (MS4s)

Municipal Separate Storm Sewer Systems (MS4s) are considered to be point sources of pathogens. Discharges from MS4s occur in response to storm events through road drainage systems, curb and gutter systems, ditches, and storm drains. Large and medium MS4s serving populations greater than 100,000 people are required to obtain NPDES storm water permits. At present, there are no

MS4s of this size in the Caney Fork watershed. As of March 2003, small MS4s serving urbanized areas, or having the potential to exceed instream water quality standards, are required to obtain a permit under the *NPDES General Permit for Discharges from Small Municipal Separate Storm Sewer Systems* (TDEC, 2002). An urbanized area is defined as an entity with a residential population of at least 50,000 people and an overall population density of at least 1,000 people per square mile. Under the General Permit, an annual report must be submitted to the Director of TDEC Water Pollution Control Division. Monitoring is not currently required.

Two permittees are covered under Phase II of the NPDES Storm Water Program (Figure 6). The two permitted MS4s in the Caney Fork watershed are as follows:

NPDES Permit Number	Phase	Permittee Name	Issuance Date	Effective Date	Expiration Date
TNS075256	II	City of Cookeville	7/3/03	7/7/03	2/26/08
TNS075809	II	Wilson County	7/3/03	7/7/03	2/26/08

The Tennessee Department of Transportation (TDOT) is also being issued MS4 permits for State roads in urban areas. Information regarding storm water permitting in Tennessee may be obtained from the TDEC website at http://www.state.tn.us/environment/wpc/stormh2o/.

7.1.3 NPDES Concentrated Animal Feeding Operations (CAFOs)

Animal feeding operations (AFOs) are agricultural enterprises where animals are kept and raised in confined situations. AFOs congregate animals, feed, manure and urine, dead animals, and production operations on a small land area. Feed is brought to the animals rather than the animals grazing or otherwise seeking feed in pastures, fields, or on rangeland (USEPA, 2002a). Concentrated Animal Feeding Operations (CAFOs) are AFOs that meet certain criteria with respect to animal type, number of animals, and type of manure management system. CAFOs are considered to be potential point sources of pathogen loading and are required to obtain an NPDES permit. Most CAFOs in Tennessee obtain coverage under TNA000000, *Class II Concentrated Animal Feeding Operation General Permit*, while larger, Class I CAFOs are required to obtain an individual NPDES permit.

As of May 5, 2005, there are no Class II CAFOs in the Caney Fork watershed with coverage under the general NPDES permit. There are also no Class I CAFOs with individual permits located in the watershed.

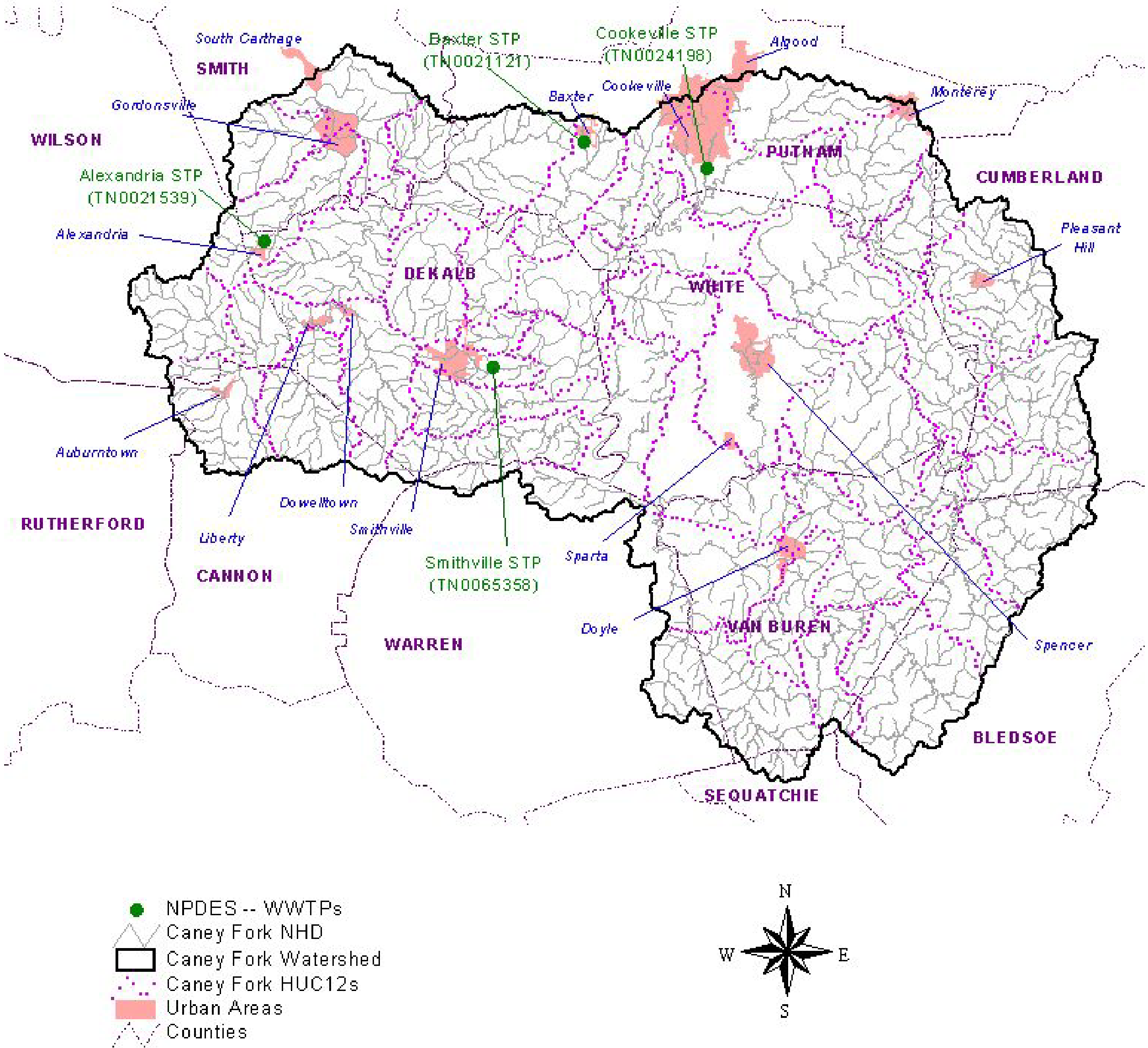

Figure 6. NPDES Regulated Point Sources in and near the Caney Fork Watershed.

7.2 Nonpoint Sources

Nonpoint sources of coliform bacteria are diffuse sources that cannot be identified as entering a waterbody through a discrete conveyance at a single location. These sources generally, but not always, involve accumulation of coliform bacteria on land surfaces and wash off as a result of storm events. Nonpoint sources of pathogen loading are primarily associated with agricultural and urban land uses. Many of the waterbodies identified on the Final 2004 303(d) list as impaired due to pathogens are attributed to nonpoint agricultural or urban sources.

7.2.1 Wildlife

Wildlife deposit coliform bacteria, with their feces, onto land surfaces where it can be transported during storm events to nearby streams. The overall deer density for Tennessee was estimated by the Tennessee Wildlife Resources Agency (TWRA) to be 23 animals per square mile. Fecal coliform loads due to deer are estimated by EPA to be 5.0×10^{8} counts/animal/day.

7.2.2 Agricultural Animals

Agricultural activities can be a significant source of coliform bacteria loading to surface waters. The activities of greatest concern are typically those associated with livestock operations:

- Agricultural livestock grazing in pastures deposit manure containing coliform bacteria onto land surfaces. This material accumulates during periods of dry weather and is available for washoff and transport to surface waters during storm events. The number of animals in pasture and the time spent grazing are important factors in determining the loading contribution.
- Processed agricultural manure from confined feeding operations is often applied to land surfaces and can provide a significant source of coliform bacteria loading. Guidance for issues relating to manure application is available through the University of Tennessee Agricultural Extension Service and the Natural Resources Conservation Service (NRCS).
- Agricultural livestock and other unconfined animals often have direct access to waterbodies and can provide a concentrated source of coliform bacteria loading directly to a stream.

Potential data sources related to livestock operations include the 2002 Census of Agriculture, which was compiled for the Caney Fork Watershed utilizing the Watershed Characterization System (WCS). WCS is an Arcview geographic information system (GIS) based program developed by USEPA Region IV to facilitate watershed characterization and TMDL development. Livestock information provided in WCS is based on the ratio of watershed pasture area to county pasture area applied to the livestock population within the county. Livestock data for E. coli-impaired watersheds are summarized in Table 5. Populations were rounded to the nearest 25 cows, 50 poultry, and 5 hogs, sheep, and horses.

Table 5. Livestock Distribution in the Caney Fork Watershed

Subwatershed	Livestock Population (WCS)					
	Beef Cow	Milk Cow	Poultry	Hogs	Sheep	Horse
Hickman Creek	2,225	100	0	185	40	420
Hudgens Creek	200	25	0	15	0	20
Pigeon Roost Creek	350	25	0	30	0	25
Mine Lick Creek	600	50	0	50	5	110
Fall Creek	450	25	0	0	5	135

7.2.3 Failing Septic Systems

Some coliform loading in the Caney Fork watershed can be attributed to failure of septic systems and illicit discharges of raw sewage. Estimates from 1997 county census data of people in the Caney Fork watershed utilizing septic systems were compiled using the WCS and are summarized in Table 6. In middle and eastern Tennessee, it is estimated that there are approximately 2.37 people per household on septic systems, some of which can be reasonably assumed to be failing. As with livestock in streams, discharges of raw sewage provide a concentrated source of coliform bacteria directly to waterbodies.

Table 6. Population on Septic Systems in the Caney Fork Watershed

Subwatershed	Population on Septic Systems	Subwatershed	Population on Septic Systems
Hickman Creek	1,561	Mine Lick Creek	1,504
Hudgens Creek	602	Fall Creek	440
Pigeon Roost Creek	1,276		

7.2.4 Urban Development

Nonpoint source loading of coliform bacteria from urban land use areas is attributable to multiple sources. These include: stormwater runoff, illicit discharges of sanitary waste, runoff from improper disposal of waste materials, leaking septic systems, and domestic animals. Impervious surfaces in urban areas allow runoff to be conveyed to streams quickly, without interaction with soils and groundwater. Pigeon Roost Creek has the highest percentage of urban land area for impaired waterbodies in the Caney Fork watershed, with 33.1%. Land use for the Caney Fork impaired drainage areas is summarized in Figures 7 and 8 and tabulated in Appendix A.

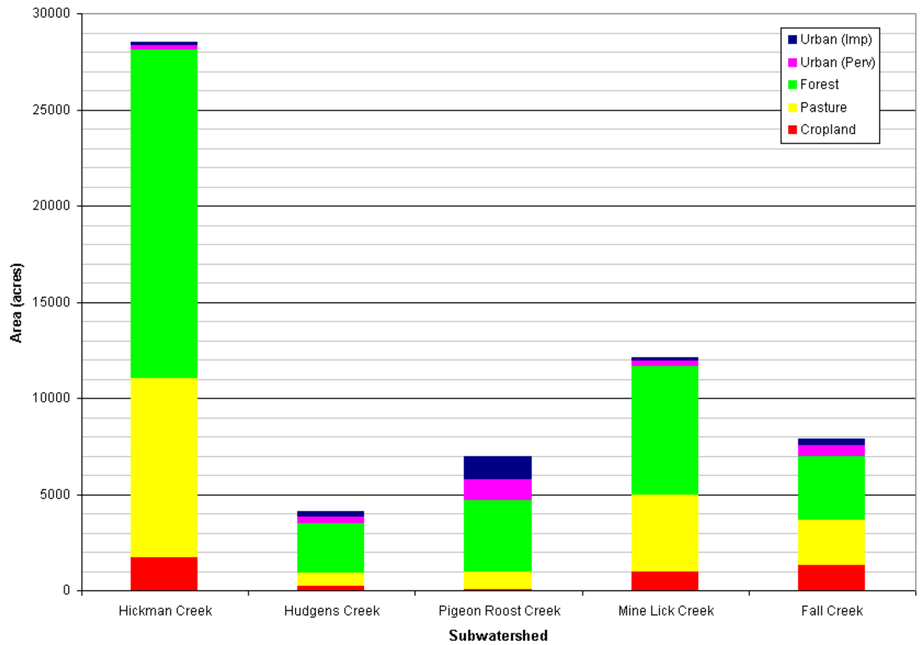

Figure 7. Land Use Area of Caney Fork Pathogen-Impaired Subwatersheds.

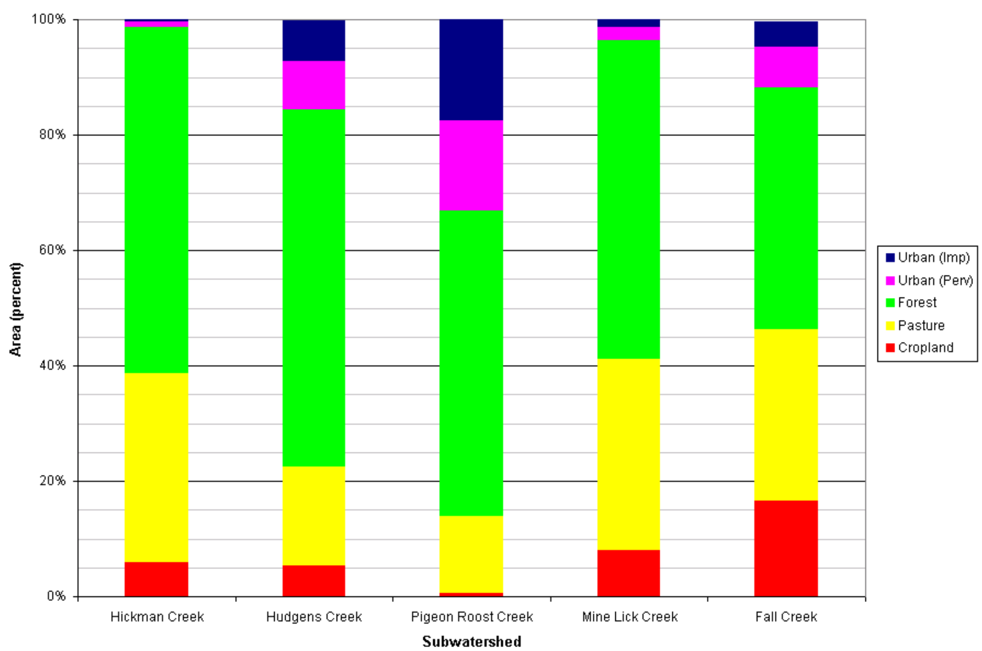

Figure 8. Land Use Percent of the Caney Fork Pathogen-Impaired Subwatersheds.

8.0 DEVELOPMENT OF TOTAL MAXIMUM DAILY LOAD

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

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

The objective of a TMDL is to allocate loads among all of the known pollutant sources throughout a watershed so that appropriate control measures can be implemented and water quality standards achieved. 40 CFR §130.2 (i) states that TMDLs can be expressed in terms of mass per time, toxicity, or <u>other appropriate measure</u>.

This document describes pathogen TMDL, Waste Load Allocation (WLA), and Load Allocation (LA) development for waterbodies identified as impaired due to E. coli on the Final 2004 303(d) list. TMDL analyses are performed primarily on a 12-digit hydrologic unit area (HUC-12) basis for subwatersheds containing waterbodies identified as impaired due to E. coli on the Final 2004 303(d) list.

8.1 Expression of TMDLs, WLAs, & LAs

In this document, the pathogen TMDL is expressed as the percent reduction in instream loading required to decrease existing E. coli or fecal coliform concentrations to desired target levels. Target concentrations are equal to the desired water quality goals (see Section 5.0) minus the appropriate MOS. WLAs & LAs for precipitation-induced loading sources are also expressed as required percent reductions in pathogen loading. Allocations for loading that is independent of precipitation (WLAs for WWTFs and LAs for “other direct sources”) are expressed as counts/day.

8.2 TMDL Analysis Methodology

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

TMDLs for the Caney Fork Watershed were developed using load duration curves for analysis of impaired waterbodies. A load duration curve (LDC) is a cumulative frequency graph that illustrates existing water quality conditions (as represented by loads calculated from monitoring data), how these conditions compare to desired targets, and the portion of the waterbody flow regime represented by these existing loads. Load duration curves were considered to be well suited for analysis of periodic monitoring data collected by grab sample. LDCs were developed at monitoring site locations in impaired waterbodies and an overall load reduction calculated to meet E. coli and fecal coliform targets according to the methods described in Appendix C.

8.3 Critical Conditions and Seasonal Variation

The critical condition for non-point source fecal coliform loading is an extended dry period followed by a rainfall runoff event. During the dry weather period, fecal coliform bacteria builds up on the land surface, and is washed off by rainfall. The critical condition for point source loading occurs during periods of low streamflow when dilution is minimized. Both conditions are represented in the TMDL analysis.

The ten-year period from October 1, 1994 to September 30, 2004 was used to simulate flow. This 10-year period contained a range of hydrologic conditions that included both low and high streamflows. Critical conditions are accounted for in the load duration curve analysis by using the entire period of flow and water quality data available for the impaired waterbodies. In all subwatersheds, water quality data have been collected during most flow ranges. Based on the location of the water quality exceedances on the load duration curves, no one delivery mode for pathogens appears to be dominant (see Section 9.3 and Table 10).

Seasonal variation was incorporated in the load duration curves by using the entire simulation period and all water quality data collected at the monitoring stations. The water quality data were collected during all seasons.

8.4 Margin of Safety

There are two methods for incorporating an MOS in the analysis: a) implicitly incorporate the MOS using conservative model assumptions; or b) explicitly specify a portion of the TMDL as the MOS and use the remainder for allocations.

An explicit MOS, equal to 10% of the E. coli and fecal coliform water quality goals (ref.: Section 5.0), was utilized for TMDL analysis. Explicit MOS and the resulting target concentrations are shown in Table 7.

Table 7. Explicit MOS and Target Concentrations

Pollutant	WQ Goal Type	WQ Goal [cts./100mL]	Explicit MOS [cts./100mL]	Target [cts./100mL]
E. coli	Maximum	941	94	847
	30-Day Geometric Mean	126	13	113
Fecal Coliform	Maximum	1,000	100	900
	30-Day Geometric Mean	200	20	180

8.5 Determination of TMDLs

E. coli and fecal coliform load reductions were calculated for impaired segments in the Caney Fork Watershed using Load Duration Curves to evaluate compliance with the maximum target concentrations (Appendix C). When sufficient data were available, load reductions were also developed to achieve compliance with the 30-day geometric mean target concentrations (Appendix C). All of the instream load reductions for a particular waterbody were compared and the largest required load reduction was selected as the TMDL. These TMDL load reductions for the impaired segments are shown in Table 8 and are applied to the entire HUC-12 subwatershed in which the impaired waterbodies are located. In cases where the geometric mean could not be developed, it is assumed that achieving the load reduction based on the maximum target concentrations should result in attainment of the geometric mean criteria.

8.6 Determination of WLAs & LAs

WLAs & LAs are developed in Appendix E for point sources and nonpoint sources respectively. TMDLs, WLAs, & LAs for Caney Fork Watershed impaired waterbodies are summarized in Table 9.

Table 8. Determination of TMDLs for Impaired Waterbodies, Caney Fork Watershed

HUC-12 SubWS	Impaired Waterbody Name	Impaired Waterbody ID	Required Load Reduction		
			Fecal Coliform	E. Coli	TMDL [%]
0807	HICKMAN CREEK	TN05130108002 – 2000	**88.3**	**64.7**	**88.3**
0702	HUDGENS CREEK	TN05130108045 – 0300	**80.9**	**>64.7**	**82.4**
	PIGEON ROOST CREEK	TN05130108045 – 0400	**68.2**	**63.7**	
	PIGEON ROOST CREEK	TN05130108045 – 0450	**82.4**	**64.7**	
0803	MINE LICK CREEK	TN05130108097 – 2000	**45.1**	**13.8**	**45.1**
0406	FALL CREEK	TN05130108684 – 1000	**43.8**	**NR**	**43.8**

Table 9. WLAs & LAs for Caney Fork Watershed, Tennessee

HUC-12 Subwatershed (05130108__) or Drainage Area	Impaired Waterbody Name	Impaired Waterbody ID	TMDL	WLAs				LAs	
				WWTFs[a] (Monthly Avg.) E. Coli	Leaking Collection Systems[b]	CAFOs	MS4s[c]	Precipitation Induced Nonpoint Sources	Other Direct Sources[d]
			[% Red.]	[cts./day]	[cts./day]	[cts./day]	[% Red.]	[% Red.]	[cts./day]
0807	Hickman Creek	TN05130108002 – 2000	**88.3**	**1.431×10^{9}**	**0**	**NA**	**88.3**	**88.3**	**0**
0702	Hudgens Creek	TN05130108045 – 0300	**82.4**	**6.677×10^{10}**	**0**	**NA**	**82.4**	**82.4**	**0**
	Pigeon Roost Creek	TN05130108045 – 0400 & 0450							
0803	Mine Lick Creek	TN05130108097 – 2000	**45.1**	**2.385×10^{9}**	**0**	**NA**	**NA**	**45.1**	**0**
0406	Fall Creek	TN05130108684 – 1000	**43.8**	**1.030×10^{10}**	**0**	**NA**	**NA**	**43.8**	**0**

Note: NA = Not Applicable.

a. WLAs for WWTFs expressed as E. coli loads (counts/day).

b. The objective for leaking collection systems is a waste load allocation of zero. It is recognized, however, that a WLA of 0 counts/day may not be practical. For these sources, the WLA is interpreted to mean a reduction in coliform loading to the maximum extent practicable, consistent with the requirement that these sources not contribute to a violation of the water quality standard for E. coli.

c. Applies to any MS4 discharge loading in the subwatershed.

d. The objective for all “other direct sources” is a load allocation of zero. It is recognized, however, that for leaking septic systems a LA of 0 counts/day may not be practical. For these sources, the LA is interpreted to mean a reduction in coliform loading by the application of best management practices, consistent with the requirement that these sources not contribute to a violation of the water quality standard for E. coli.

9.0 IMPLEMENTATION PLAN

The TMDLs, WLAs, and LAs developed in Section 8 are intended to be the first phase of a long-term effort to restore the water quality of impaired waterbodies in the Caney Fork watershed through reduction of excessive pathogen loading. Adaptive management methods, within the context of the State's rotating watershed management approach, will be used to modify TMDLs, WLAs, and LAs as required to meet water quality goals.

9.1 Point Sources

9.1.1 NPDES Regulated Municipal and Industrial Wastewater Treatment Facilities

All present and future discharges from industrial and municipal wastewater treatment facilities are required to be in compliance with the conditions of their NPDES permits at all times. In Tennessee, permit limits for treated sanitary wastewater require compliance with coliform water quality standards (ref: Section 5.0) prior to discharge. No additional reduction is required. WLAs for WWTFs are expressed as average loads in counts per day. WLAs are derived from facility design flows and permitted fecal coliform and E. coli limits.

In order to meet water quality criteria for the Caney Fork Watershed, all STPs must meet the provisions of their NPDES permits, including elimination of bypasses and overflows.

9.1.2 NPDES Regulated Municipal Separate Storm Sewer Systems (MS4s)

For regulated discharges from municipal separate storm sewer systems, WLAs will be implemented through Phase I & II MS4 permits. These permits will require the development and implementation of a Storm Water Management Program (SWMP) that will reduce the discharge of pollutants to the "maximum extent practicable" and not cause or contribute to violations of State water quality standards. The *NPDES General Permit for Discharges from Small Municipal Separate Storm Sewer Systems* (TDEC, 2002) was issued on February 27, 2003 and requires SWMPs to include six minimum control measures:

- Public education and outreach on storm water impacts
- Public involvement/participation
- Illicit discharge detection and elimination
- Construction site storm water runoff control
- Post-construction storm water management in new development and re-development
- Pollution prevention/good housekeeping for municipal operations

For discharges into impaired waters, the proposed Small MS4 General Permit (ref: http://www.state.tn.us/environment/wpc/stormh2o/MS4II.php) requires that SWMPs include a section describing how discharges of pollutants of concern will be controlled to ensure that they do not cause or contribute to instream exceedances of water quality standards. Specific measures and

BMPs to control pollutants of concern must also be identified. In addition, MS4s must implement the WLA provisions of an applicable TMDL and describe methods to evaluate whether storm water controls are adequate to meet the WLA.

Implementation of the coliform WLAs for MS4s in this TMDL document will require effluent or instream monitoring to evaluate SWMP effectiveness with respect to reduction of pathogen loading.

9.1.3 NPDES Regulated Concentrated Animal Feeding Operations (CAFOs)

WLAs provided to CAFOs will be implemented through NPDES Permit No. TNA000000, General NPDES Permit for *Class II Concentrated Animal Feeding Operation* or the facility's individual permit. Among the provisions of the general permit are:

- Development and implementation of a site-specific Nutrient Management Plan (NMP) that:
    - Includes best management practices (BMPs) and procedures necessary to implement applicable limitations and standards;
    - Ensures adequate storage of manure, litter, and process wastewater including provisions to ensure proper operation and maintenance of the storage facilities.
    - Ensures proper management of mortalities (dead animals);
    - Ensures diversion of clean water, where appropriate, from production areas;
    - Identifies protocols for manure, litter, wastewater and soil testing;
    - Establishes protocols for land application of manure, litter, and wastewater;
    - Identifies required records and record maintenance procedures.

  The NMP must submitted to the State for approval and a copy kept on-site.

- Requirements regarding manure, litter, and wastewater land application BMPs.

- Requirements for the design, construction, operation, and maintenance of CAFO liquid waste management systems that are constructed, modified, repaired, or placed into operation after April 13, 2006. The final design plans and specifications for these systems must meet or exceed standards in the NRCS Field Office Technical Guide and other guidelines as accepted by the Departments of Environment and Conservation, or Agriculture.

Provisions of individual CAFO permits are similar. NPDES Permit No. TNA000000, *Class II Concentrated Animal Feeding Operation General Permit* is available on the TDEC website at http://www.state.tn.us/environment/wpc/programs/cafo/.

9.2 Nonpoint Sources

The Tennessee Department of Environment & Conservation (TDEC) has no direct regulatory authority over most nonpoint source discharges. Reductions of pathogen loading from nonpoint sources (NPS) will be achieved using a phased approach. Voluntary, incentive-based mechanisms will be used to implement NPS management measures in order to assure that measurable reductions in pollutant loadings can be achieved for the targeted impaired waters. Cooperation and active participation by the general public and various industry, business, and environmental groups is critical to successful implementation of TMDLs. Local citizen-led and implemented management measures offer the most efficient and comprehensive avenue for reduction of loading rates from nonpoint sources. There are links to a number of publications and information resources on EPA's Nonpoint Source Pollution web page (http://www.epa.gov/owow/nps/pubs.html) relating to the implementation and evaluation of nonpoint source pollution control measures.

TMDL implementation activities will be accomplished within the framework of Tennessee's Watershed Approach (ref: http://www.state.tn.us/environment/wpc/watershed/). The Watershed Approach is based on a five-year cycle and encompasses planning, monitoring, assessment, TMDLs, WLAs/LAs, and permit issuance. It relies on participation at the federal, state, local and nongovernmental levels to be successful.

BMPs have been utilized in the Caney Fork watershed to reduce the amount of coliform bacteria transported to surface waters from agricultural sources. These BMPs (e.g., animal waste management systems, waste utilization, stream stabilization, fencing, heavy use area treatment, livestock exclusion, etc.) may have contributed to reductions in in-stream concentrations of coliform bacteria in the Caney Fork watershed during the TMDL evaluation period. The TDA keeps a database of BMPs implemented in Tennessee. Those listed in the Caney Fork watershed are shown in Figure 9. It is recommended that additional information (e.g., livestock access to streams, manure application practices, etc.) be provided and evaluated to better identify and quantify agricultural sources of coliform bacteria loading in order to minimize uncertainty in future modeling efforts.

It is further recommended that BMPs be utilized to reduce the amount of coliform bacteria transported to surface waters from agricultural sources. Demonstration sites for various types of BMPs should be established, maintained, and evaluated (performance in source reduction) over a period of at least two years prior to recommendations for utilization for subsequent implementation. E. coli sampling and monitoring are recommended during low-flow (baseflow) and storm periods at sites with and without BMPs and/or before and after implementation of BMPs.

9.3 Application of Load Duration Curves for Implementation Planning

The Load Duration Curve methodology (Appendix C) is a form of water quality analysis and presentation of data that aids in guiding implementation by targeting strategies to appropriate flow conditions. One of the strengths of this method is that it can be used to interpret possible delivery mechanisms of pathogens by differentiating between point and non-point problems. The E. coli load duration analysis was utilized for implementation planning. The E. coli load duration curve for each pathogen-impaired subwatershed (Figures 10 thru 17) was analyzed to determine the frequency with which water quality monitoring data exceed the E. coli target maximum concentration of 847 counts/100 mL (standard – MOS) under five flow conditions (low, dry, mid-range, moist, and high).

Table 10 presents Load Duration analysis statistics for E. coli in the Caney Fork Watershed and targeted implementation strategies for each source category covering the entire range of flow

(Stiles, 2003). Each implementation strategy addresses a range of flow conditions and targets point sources, non-point sources, or a combination of each. Results indicate the implementation strategy for all subwatersheds will require BMPs targeting a variety of sources. The implementation strategies listed in Table 10 are a subset of the categories of BMPs and implementation strategies available for application to the pathogen-impaired Caney Fork watersheds for reduction of pathogen loading and mitigation of water quality impairment.

See Appendix C for a detailed discussion of the Load Duration Curve Methodology applied to the Caney Fork Watershed.

9.4 Additional Monitoring

Documenting progress in reducing the quantity of pathogens entering the Caney Fork watershed is an essential element of the TMDL Implementation Plan. Additional monitoring and assessment activities are recommended to determine whether implementation of TMDLs, WLAs, & LAs in tributaries and upstream reaches will result in achievement of instream water quality targets for fecal coliform and/or E. coli. Future monitoring activities should be representative of all seasons and a full range of flow and meteorological conditions. Monitoring activities should also be adequate to assess water quality using the 30-day geometric mean standard.

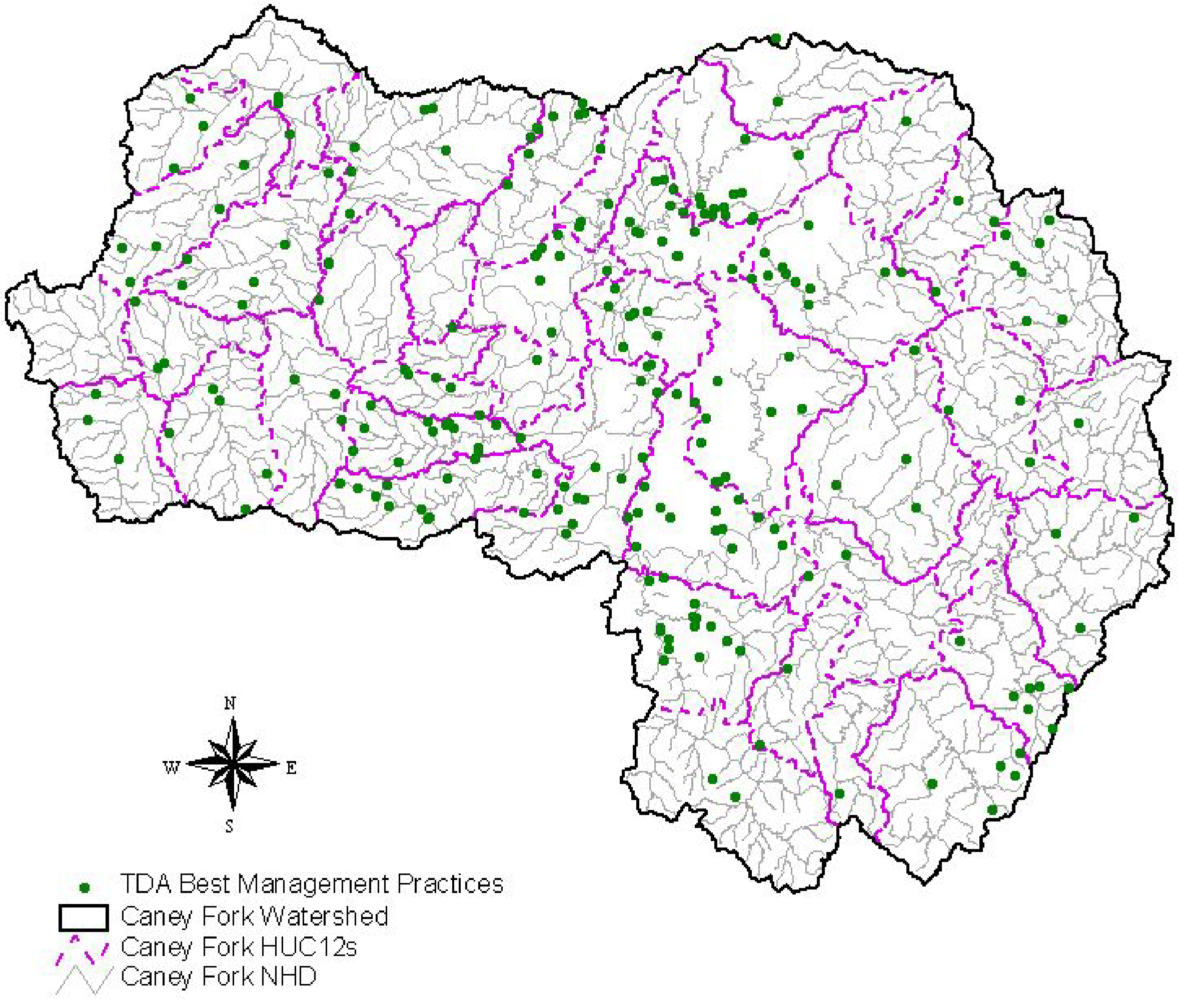

Figure 9. Tennessee Department of Agriculture Best Management Practices located in the Caney Fork Watershed.

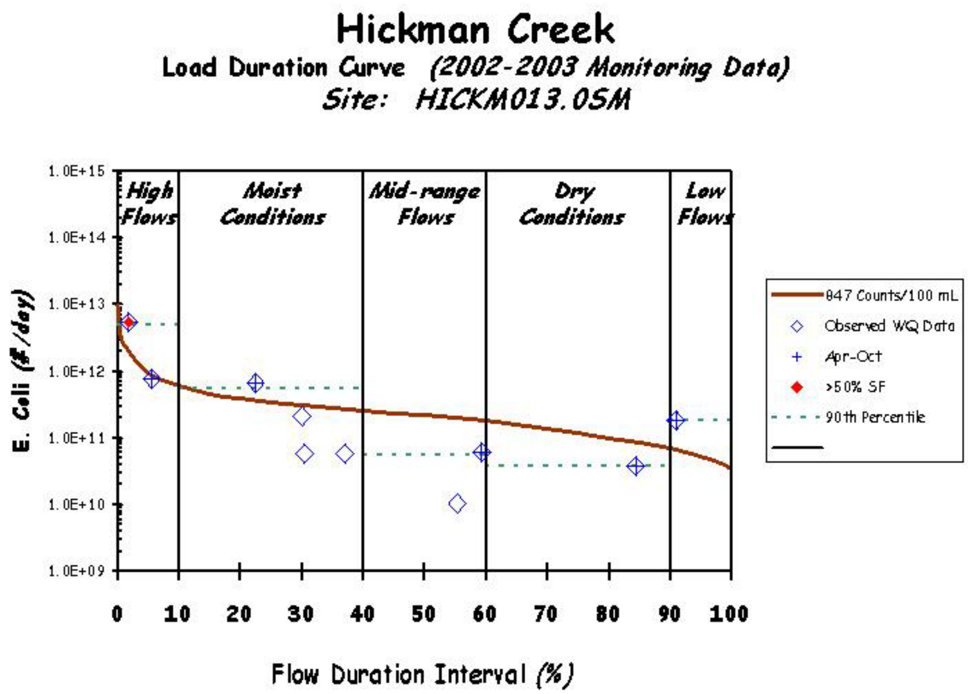

Figure 10. Load Duration Curve for Hickman Creek (Mile 13.0)

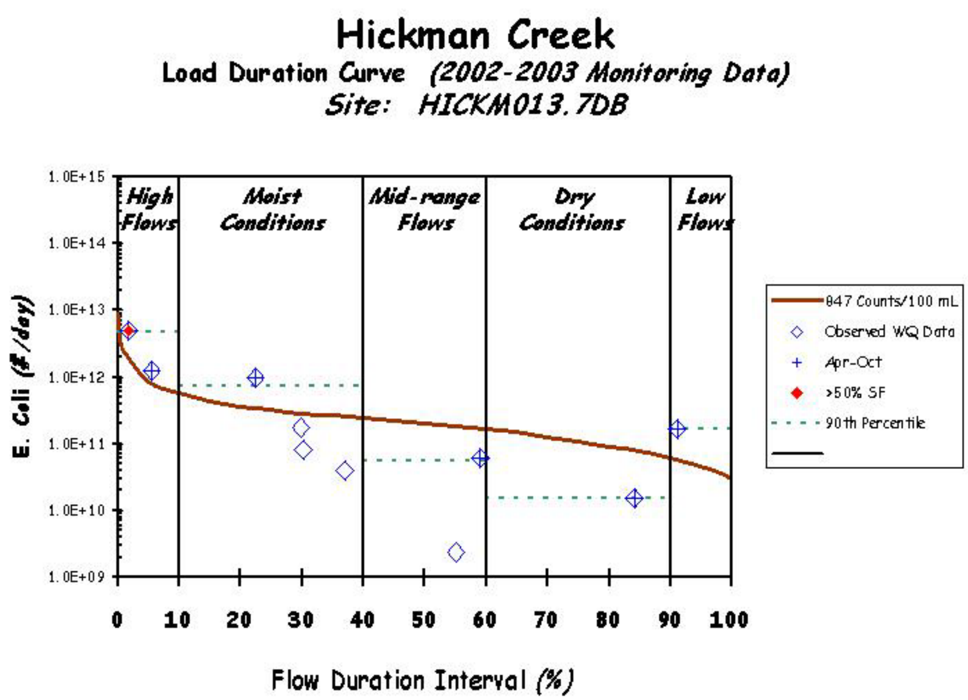

Figure 11. Load Duration Curve for Hickman Creek (Mile 13.7)

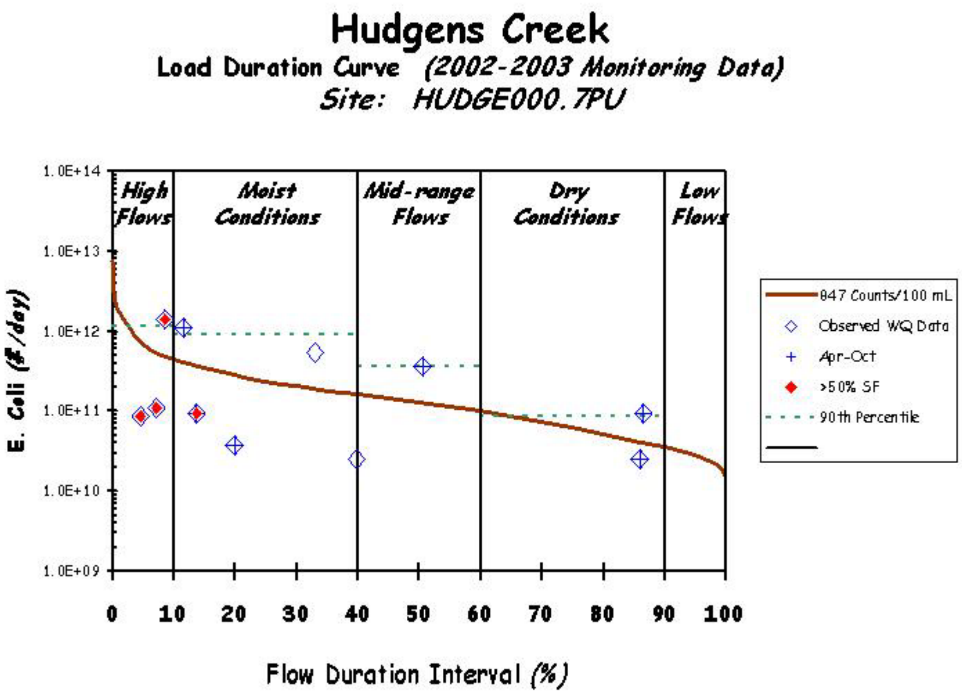

Figure 12. Load Duration Curve for Hudgens Creek

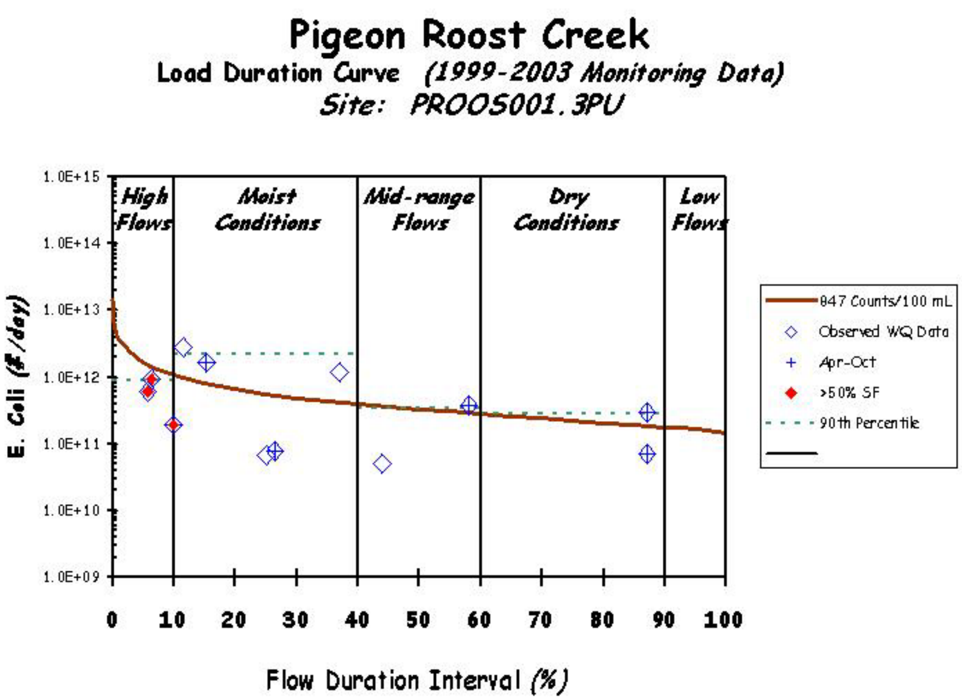

Figure 13. Load Duration Curve for Pigeon Roost Creek (Mile 1.3)

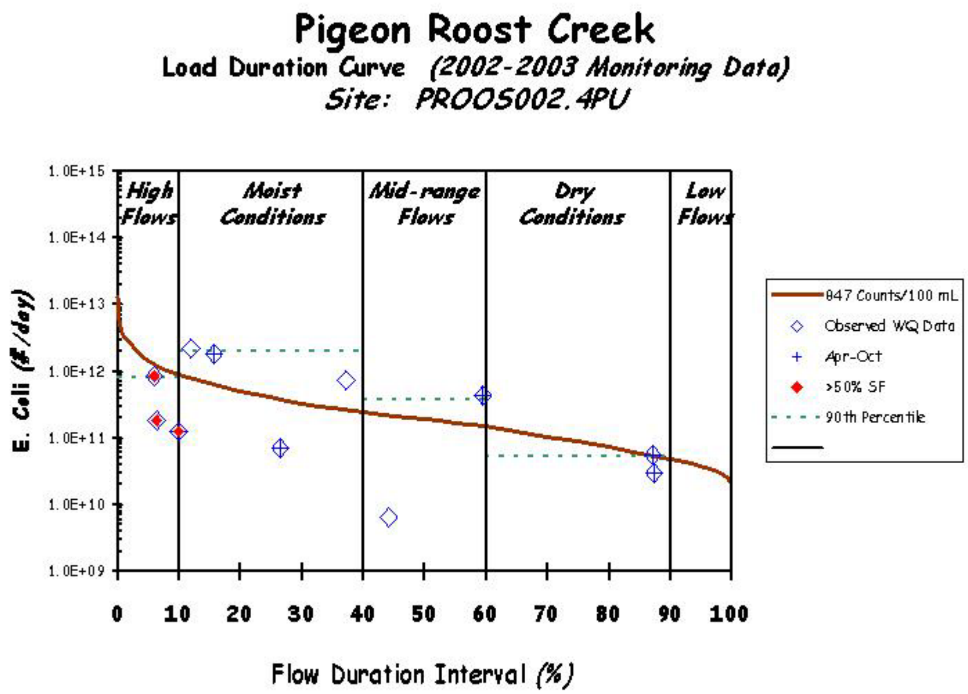

Figure 14. Load Duration Curve for Pigeon Roost Creek (Mile 2.4)

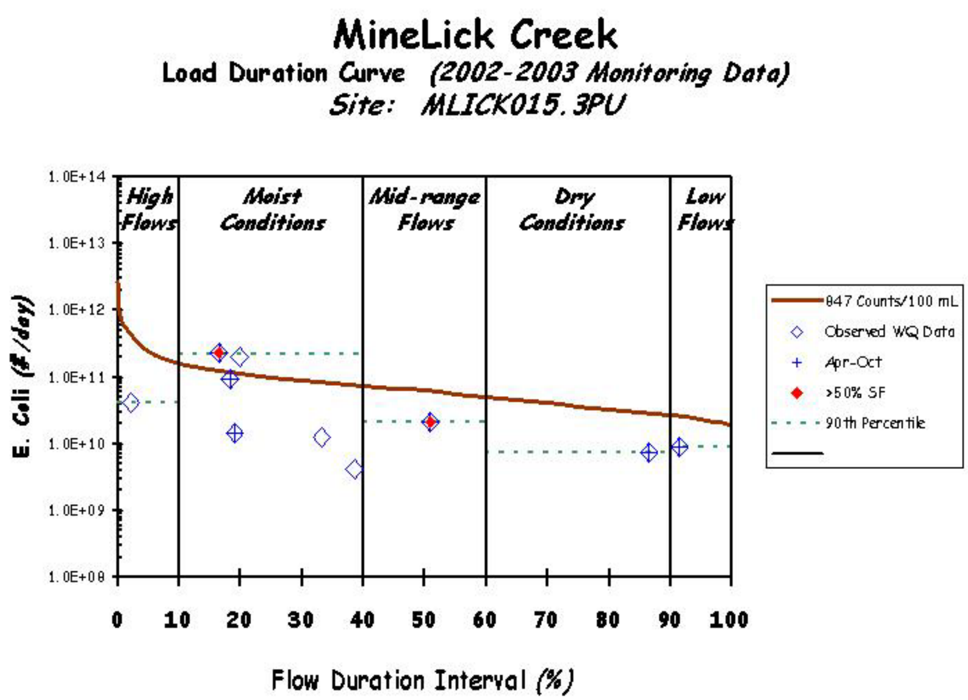

Figure 15. Load Duration Curve for Mine Lick Creek (Mile 15.3)

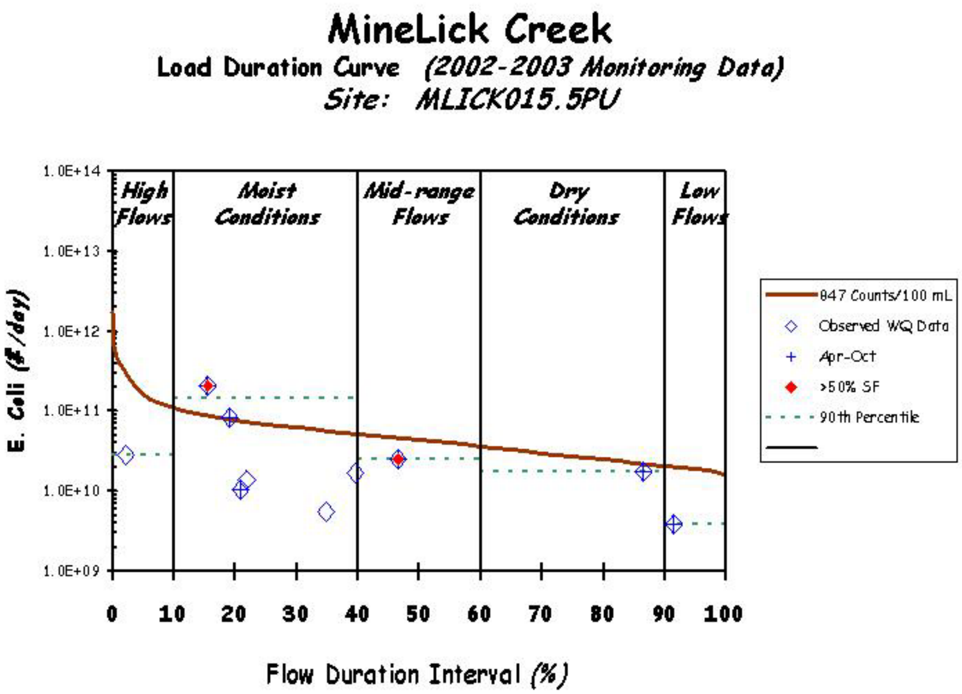

Figure 16. Load Duration Curve for Mine Lick Creek (Mile 15.5)

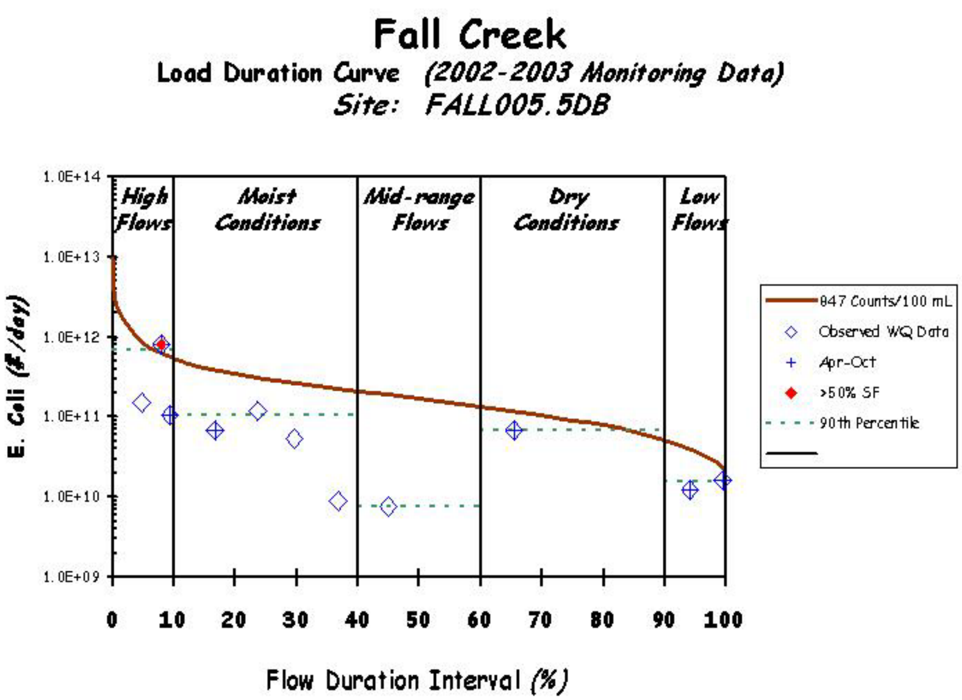

Figure 17. Load Duration Curve for Fall Creek

Tennessee's watershed management approach specifies a five-year cycle for planning and assessment. Each watershed will be examined (or re-examined) on a rotating basis. Generally, in years two and three of the five-year cycle, water quality data are collected in support of water quality assessment (including TMDL development) and planning activities. Therefore, a watershed TMDL is developed one to two years prior to commencement of the next cycle's monitoring period.

Additional sampling for both fecal coliform and E. coli is recommended to aid in a better understanding of the relationship between fecal coliform concentration and E. coli concentration.

Additional monitoring and assessment activities are recommended for the Hudgens Creek and Pigeon Roost Creek subwatersheds. Examination of monitoring data indicates that no sampling events have occurred during periods of low flow. Once additional monitoring representing all seasons and a full range of flow and meteorological conditions has been obtained, the required load reductions may be revised.

9.5 Source Identification

An important aspect of pathogen load reduction activities is the accurate identification of the actual sources of pollution. In cases where the sources of pathogen impairment are not readily apparent, Microbial Source Tracking (MST) is one approach to determining the sources of fecal pollution and pathogens affecting a waterbody. Those methods that use bacteria as target organisms are also known as Bacterial Source Tracking (BST) methods. This technology is recommended for source identification in E. coli impaired waterbodies.

Bacterial Source Tracking is a collective term used for various emerging biochemical, chemical, and molecular methods that have been developed to distinguish sources of human and non-human fecal pollution in environmental samples (Shah, 2004). In general, these methods rely on genotypic (also known as "genetic fingerprinting"), or phenotypic (relating to the physical characteristics of an organism) distinctions between the bacteria of different sources. Three primary genotypic techniques are available for BST: ribotyping, pulsed field gel electrophoresis (PFGE), and polymerase chain reaction (PCR). Phenotypic techniques generally involve an antibiotic resistance analysis (Hyer, 2004).

The USEPA has published a fact sheet that discusses BST methods and presents examples of BST application to TMDL development and implementation (USEPA, 2002b). Various BST projects and descriptions of the application of BST techniques used to guide implementation of effective BMPs to remove or reduce fecal contamination are presented. The fact sheet can be found on the following EPA website: http://www.epa.gov/owm/mtb/bacsortk.pdf.

A multi-disciplinary group of researchers is developing and testing a series of different microbial assay methods based on real-time PCR to detect fecal bacterial concentrations and host sources in water samples (McKay, 2005). The assays have been used in a study of fecal contamination and have proven useful in identification of areas where cattle represent a significant fecal input and in development of BMPs. It is expected that these types of assays could have broad applications in monitoring fecal impacts from Animal Feeding Operations, as well as from wildlife and human sources. Other BST projects have been conducted or are currently in progress throughout the state of Tennessee, as presented in sessions of the Thirteenth Tennessee Water Resources Symposium (Lawrence, 2003) and the Fifteenth Tennessee Water Resources Symposium (Bailey, 2005;

Farmer, 2005; McKay, 2005).

9.6 Evaluation of TMDL Effectiveness

The effectiveness of the TMDL will be assessed within the context of the State's rotating watershed management approach. Watershed monitoring and assessment activities will provide information by which the effectiveness of pathogen loading reduction measures can be evaluated. Additional monitoring data, ground-truthing activities, and bacterial source identification actions are recommended to enable implementation of particular types of BMPs to be directed to specific areas in impaired subwatersheds. This will optimize utilization of resources to achieve maximum reductions in pathogen loading. These TMDLs will be re-evaluated during subsequent watershed cycles and revised as required to assure attainment of applicable water quality standards.

Table 10. Load Duration Curve Summary for E.Coli and/or Fecal Coliform Impaired Segments

Flow Condition		High	Moist	Mid-range	Dry	Low
% Time Flow Exceeded		0-10	10-40	40-60	60-90	90-100
Hickman Creek at Mile 13.7	% Samples > 941 Counts/100 mL[1]	100.0	25.0	0.0	0.0	100.0
Hudgens Creek	% Samples > 941 Counts/100 mL[1]	33.3	40.0	100.0	50.0	NA
Example Implementation Strategies						
Municipal NPDES			L	M	H	H
Stormwater Management			H	H	H	
SSO Mitigation		H	H	M	L	
Collection System Repair			L	M	H	H
Septic System Repair			L	M	H	M
Livestock Exclusion[2]				M	H	H
Pasture Management/Land Application of Manure[2]		H	H	M	L	
Riparian Buffers[2]			H	H	H	
		Potential for source area contribution under given hydrologic condition (H: High; M: Medium; L: Low)				

[1] Tennessee maximum daily water quality standard for E.coli (941 Counts/100 mL).
[2] Example Best Management Practices (BMPs) for Agricultural Source reduction. Actual BMPs applied may vary.

10.0 PUBLIC PARTICIPATION

In accordance with 40 CFR §130.7, the proposed pathogen TMDLs for the Caney Fork Watershed were placed on Public Notice for a 35-day period and comments solicited. Steps that were taken in this regard include:

1) Notice of the proposed TMDLs was posted on the Tennessee Department of Environment and Conservation website. The announcement invited public and stakeholder comment and provided a link to a downloadable version of the TMDL document.

2) Notice of the availability of the proposed TMDLs (similar to the website announcement) was included in one of the NPDES permit Public Notice mailings which is sent to approximately 90 interested persons or groups who have requested this information.

3) Letters were sent to WWTFs located in or near pathogen-impaired subwatersheds in the Caney Fork watershed, permitted to discharge treated effluent containing pathogens, advising them of the proposed TMDLs and their availability on the TDEC website. The letters also stated that a copy of the draft TMDL document would be provided on request. A letter was sent to the following facilities:

   Baxter STP (TN0021121)
   Alexandria STP (TN0021539)
   Cookeville STP (TN0024198)
   Smithville STP (TN0065358)

4) A draft copy of the proposed TMDL was sent to those MS4s that are wholly or partially located in pathogen-impaired subwatersheds. A draft copy was sent to the following entities:

   City of Cookeville, Tennessee (TNS075256)
   Wilson County, Tennessee (TNS075809)
   Tennessee Dept. of Transportation (TNS077585)

5) A letter was sent to the local stakeholder group in the Caney Fork River Watershed advising them of the proposed pathogen TMDLs and their availability on the TDEC website. The letter also stated that a written copy of the draft TMDL document would be provided upon request. A letter was sent to the following local stakeholder group:

   Caney Fork Watershed Association

11.0 FURTHER INFORMATION

Further information concerning Tennessee's TMDL program can be found on the Internet at the Tennessee Department of Environment and Conservation website:

http://www.state.tn.us/environment/wpc/tmdl/

Technical questions regarding this TMDL should be directed to the following members of the Division of Water Pollution Control staff:

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APPENDIX A

Land Use Distribution in the Caney Fork Watershed

Table A-1. MRLC Land Use Distribution of Caney Fork Subwatersheds

Land Use	Caney Fork Subwatersheds					
	Hickman Creek		Hudgens Creek		Pigeon Roost Creek	
	[acres]	[%]	[acres]	[%]	[acres]	[%]
Deciduous Forest	8,477	29.8	1,163	28.2	1,799	25.8
Evergreen Forest	2,388	8.4	329	8.0	302	4.3
High Intensity Commercial/Industrial/Transp.	90	0.3	262	6.3	1,119	16.0
High Intensity Residential	28	0.1	57	1.4	247	3.5
Low Intensity Residential	289	1.0	319	7.7	947	13.6
Mixed Forest	5,896	20.7	732	17.7	1,036	14.9
Open Water	2	0.0	4	0.1	3	0.0
Other Grasses (Urban/recreation; e.g. parks)	301	1.1	338	8.2	557	8.0
Pasture/Hay	9,331	32.8	701	17.0	931	13.3
Quarries/Strip Mines/Gravel Pits	0	0.0	0	0.0	0	0.0
Row Crops	1,695	6.0	223	5.4	39	0.6
Transitional	0	0.0	0	0.0	0	0.0
Total	28,497	100.0	4,127	100.0	6,980	100.0

Table A-1 (Cont.). MRLC Land Use Distribution of Caney Fork Subwatersheds

Land Use	Caney Fork Subwatersheds			
	Mine Lick Creek		Fall Creek	
	[acres]	[%]	[acres]	[%]
Deciduous Forest	4,671	38.6	1,919	24.3
Evergreen Forest	258	2.1	205	2.6
High Intensity Commercial/Industrial/Transp.	118	1.0	216	2.7
High Intensity Residential	34	0.3	167	2.1
Low Intensity Residential	276	2.3	531	6.7
Mixed Forest	1,423	11.8	796	10.1
Open Water	1	0.0	22	0.3
Other Grasses (Urban/recreation; e.g. parks)	342	2.8	374	4.7
Pasture/Hay	4,026	33.3	2,341	29.6
Quarries/Strip Mines/Gravel Pits	0	0.0	19	0.2
Row Crops	961	7.9	1,315	16.6
Transitional	0	0.0	5	0.1
Total	12,111	100.0	7,909	100.0

APPENDIX B

Water Quality Monitoring Data

There are a number of water quality monitoring stations that provide data for waterbodies identified as impaired for pathogens in the Caney Fork watershed. The location of these monitoring stations is shown in Figure 5. Monitoring data recorded by TDEC at these stations are tabulated in Table B-1.

Table B-1. TDEC Water Quality Monitoring Data – Caney Fork Subwatersheds

Monitoring Station	Date	E. Coli	Fecal Coliform
		[cts./100 mL]	[cts./100 mL]
HICKM013.0SM	8/5/02	370	330
	9/25/02	2400	9200
	10/8/02	280	87
	11/19/02	580	360
	1/27/03	45	14
	2/11/03	180	97
	3/17/03	160	120
	4/7/03	2400	7500
	5/8/03	770	830
	6/12/03	1600	2200
HICKM013.7DB	8/5/02	160	390
	9/25/02	2400	13000
	10/8/02	300	230
	11/19/02	520	330
	1/27/03	11	38
	2/11/03	130	73
	3/17/03	240	170
	4/7/03	2400	5300
	5/8/03	1300	870
	6/12/03	2400	2700
HUDGE000.7PU	8/20/02	390	430
	8/20/02(dup)	520	470
	9/24/02	2000	560
	9/24/02(dup)	1400	2000
	10/30/02	2400	3600
	10/30/02(dup)	2400	4100
	11/21/02	170	120
	11/21/02(dup)	130	130
	12/11/02	2400	4900
	12/11/02(dup)	1900	4300
	1/13/03	130	90
	1/13/03(dup)	110	70

Monitoring Station	Date	E. Coli [cts./100 mL]	Fecal Coliform [cts./100 mL]
HUDGE000.7PU (cont'd)	2/27/03	93	130
	2/27/03(dup)	99	110
	3/20/03	2400	4300
	3/20/03(dup)	2400	4700
	4/16/03	110	140
	4/16/03(dup)	89	120
	5/15/03	110	240
	5/15/03(dup)	220	160
	6/12/03	2400	2900
	6/12/03(dup)	2400	2400
PROOS001.3PU	3/8/99	100	97
	8/20/02	330	1100
	9/24/02	1400	2200
	10/30/02	1700	2000
	11/21/02	520	700
	12/11/02	2400	2900
	1/13/03	120	90
	2/27/03	330	230
	3/20/03	2400	3300
	4/16/03	120	70
	5/15/03	150	190
	6/12/03	1100	1000
PROOS002.3PU	3/8/99	32	24
PROOS002.4PU	8/20/02	460	500
	9/24/02	870	2500
	10/30/02	2400	5100
	11/21/02	120	150
	12/11/02	2400	2900
	1/13/03	25	20
	2/27/03	550	280
	3/20/03	2400	5400
	4/16/03	160	300
	5/15/03	120	150
	6/12/03	2400	2100

Monitoring Station	Date	E. Coli [cts./100 mL]	Fecal Coliform [cts./100 mL]
PROOS1T0.1PU	8/20/02	200	530
	9/24/02	200	670
	10/30/02	440	350
	11/21/02	49	50
	12/11/02	190	280
	1/13/03	33	80
	2/27/03	410	280
	3/20/03	490	530
	4/16/03	38	42
	5/15/03	55	67
	6/12/03	770	550
MLICK015.3PU	8/22/02	290	280
	9/23/02	220	670
	10/30/02	690	870
	12/18/02	1500	1000
	1/15/03	46	11
	2/18/03	84	87
	3/31/03	130	100
	4/22/03	110	160
	5/21/03	1600	1400
	6/19/03	290	300
MLICK015.5PU	8/22/02	160	280
	9/23/02	690	2000
	10/30/02	870	1600
	11/20/02	160	240
	12/18/02	280	470
	1/15/03	88	57
	2/18/03	84	100
	4/22/03	120	190
	5/21/03	2000	1400
	6/19/03	460	510
FALL005.5DB	8/19/02	460	2000
	8/19/02(dup)	580	930
	9/23/02	180	180
	9/23/02(dup)	260	620
	10/30/02	490	520

Monitoring Station	Date	E. Coli	Fecal Coliform
		[cts./100 mL]	[cts./100 mL]
FALL005.5DB (cont'd)	10/30/02(dup)	340	590
	11/20/02	170	110
	11/20/02(dup)	160	130
	12/18/02	79	190
	12/18/02(dup)	330	230
	1/15/03	30	32
	1/15/03(dup)	34	30
	2/18/03	110	120
	2/18/03(dup)	140	110
	3/31/03	34	250
	3/31/03(dup)	28	220
	4/22/03	87	150
	4/22/03(dup)	150	140
	5/21/03	1100	1600
	5/21/03(dup)	580	1200
	6/19/03	160	190
	6/19/03(dup)	91	190

APPENDIX C

Load Duration Curve Development
and
Determination of Required Load Reductions

A flow duration curve is a cumulative frequency graph, constructed from historic flow data at a particular location, that represents the percentage of time a particular flow rate is equaled or exceeded. When a water quality target (or criteria) concentration is applied to the flow duration curve, the resulting load duration curve (LDC) represents the allowable pollutant loading in a waterbody over the entire range of flow. Pollutant monitoring data, plotted on the LDC, provides a visual depiction of stream water quality as well as the frequency and magnitude of any exceedances. Load duration curve intervals can be grouped into several broad categories or zones, in order to provide additional insight about conditions and patterns associated with the impairment. For example, the duration curve could be divided into five zones: high flows (exceeded 0-10% of the time), moist conditions (10-40%), median or mid-range flows (40-60%), dry conditions (60-90%), and low flows (90-100%). Impairments observed in the low flow zone typically indicate the influence of point sources, while those further left on the LDC (representing zones of higher flow) generally reflect potential nonpoint source contributions (Stiles, 2003).

C.1 Development of Flow Duration Curves

Flow duration curves are developed for a waterbody from daily discharges of flow over a period of record. In general, there is a higher level of confidence that curves derived from data over a long period of record correctly represent the entire range of flow. The preferred method of flow duration curve computation uses daily mean data from USGS continuous-record stations located on the waterbody of interest. For ungaged streams, alternative methods must be used to estimate daily mean flow. These include: 1) regression equations (using drainage area as the independent variable) developed from continuous record stations in the same ecoregion; 2) drainage area extrapolation of data from a nearby continuous-record station of similar size and topography; and 3) calculation of daily mean flow using a dynamic computer model, such as the Loading Simulation Program C++ (LSPC).

Flow duration curves for impaired waterbodies in the Caney Fork Watershed were derived from LSPC hydrologic simulations based on parameters derived from calibration at USGS Station No. 03426800, located on East Fork Stones River at Woodbury, in the Stones watershed (see Appendix D for details of calibration). For example, a flow-duration curve for Hudgens Creek at RM 0.7 was constructed using simulated daily mean flow for the period from 10/1/94 through 9/31/04 (RM 0.7 corresponds to the location of monitoring station HUDGE000.7PU). This flow duration curve is shown in Figure C-3 and represents the cumulative distribution of daily discharges arranged to show percentage of time specific flows were exceeded during the period of record (the highest daily mean flow during this period is exceeded 0% of the time and the lowest daily mean flow is equaled or exceeded 100% of the time). Flow duration curves for other impaired waterbodies were derived using a similar procedure and are shown in Figures C-1 thru C-8.

C.2 Development of Load Duration Curves and Determination of Required Load Reductions

E. coli and fecal coliform load duration curves for impaired waterbodies in the Caney Fork Watershed were developed from the flow duration curves developed in Section C.1 and available water quality monitoring data. Load duration curves were developed using the following procedure (Hudgens Creek is shown as an example):

1. A target load-duration curve was generated for Hudgens Creek by applying the fecal coliform target concentration of 900 cts./100 mL (1,000 cts./100mL - MOS) to each of the ranked flows used to generate the flow duration curve (ref.: Section D.1) and plotting the results. The fecal coliform target maximum load corresponding to each ranked daily mean flow is:

   $(\text{Target Load})_{\text{Hudgens Creek}}$ = (900 cts./100 mL) x (Q) x (UCF)

   where: Q = daily mean flow
   UCF = the required unit conversion factor

   For E. coli, the target concentration of 847 cts./100 mL was applied to generate load duration curves corresponding to the E. coli water quality standard (see Section 5.0).

2. Daily loads were calculated for each of the water quality samples collected at monitoring station HUDGE000.7PU (ref.: Table B-1) by multiplying the sample concentration by the daily mean flow for the sampling date and the required unit conversion factor. HUDGE000.7PU was selected for LDC analysis because it was the monitoring station on Hudgens Creek with the most exceedances of the target concentration.

   Note: *In order to be consistent for all analyses, the derived daily mean flow was used to compute sampling data loads, even if measured ("instantaneous") flow data was available for some sampling dates.*

3. Using the flow duration curves developed in C.1, the "percent of days the flow was exceeded" (PDFE) was determined for each sampling event. Each sample load was then plotted on the load duration curves developed in Step 1 according to the PDFE. The resulting fecal coliform and E. coli load duration curves for are shown in Figures C-13 and C-14.

4. For cases where the existing load exceeded the target maximum load at a particular PDFE, the reduction required to reduce the sample load to the target load was calculated.

5. The 90th percentile value for all of the fecal coliform sampling data at HUDGE000.7PU monitoring site was determined. If the 90th percentile value exceeded the target maximum fecal coliform concentration, the reduction required to reduce the 90th percentile value to the target maximum concentration was calculated.

6. Step 5 was repeated for E. coli data at HUDGE000.7PU.

7. For cases where five or more samples were collected over a period of not more than 30 consecutive days, the geometric mean fecal coliform concentration was determined and compared to the target geometric mean fecal coliform concentration of 180 cts/100 mL (200 cts/100mL – MOS). If the sample geometric mean exceeded the target geometric mean concentration, the reduction required to reduce the sample geometric mean value to the target geometric mean concentration was calculated.

8. Step 7 was repeated for the E. coli data at HUDGE000.7PU.

9. The load reductions required to meet the target maximum and target 30-day geometric mean concentrations of both fecal coliform and E. coli were compared and the load reduction of the greatest magnitude selected as the TMDL for Hudgens Creek. The determination of required load reductions for Hudgens Creek is shown in Tables C-5 and C-6.

Load reduction curves and required load reductions of other impaired waterbodies were derived in a similar manner and are shown in Figures C-9 through C-24 and Tables C-1 through C-16.

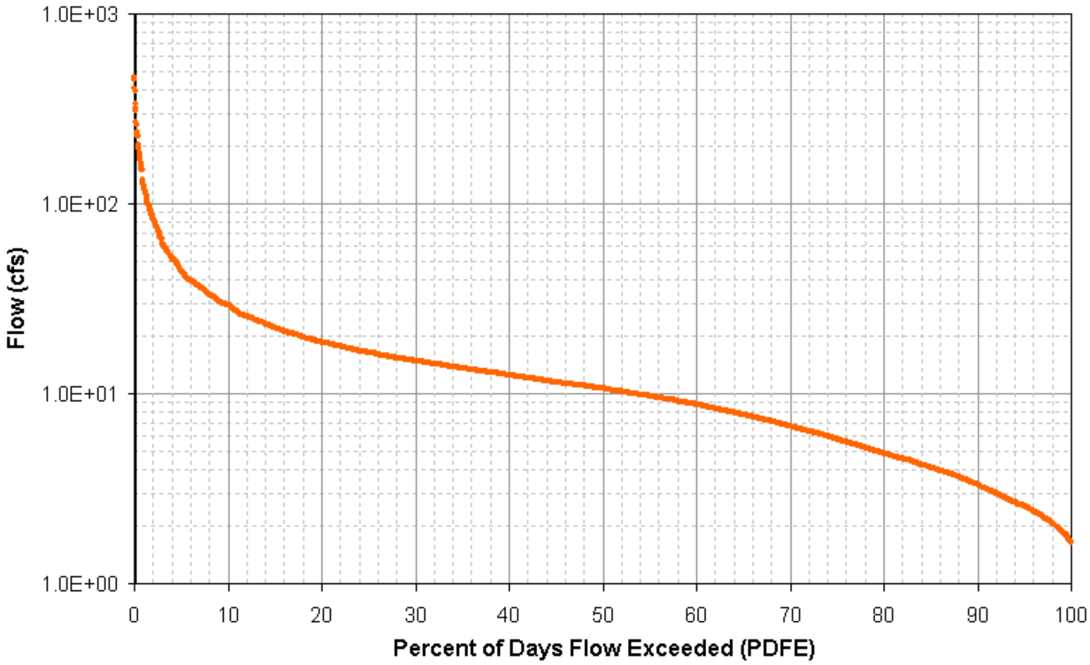

Figure C-1. Flow Duration Curve for Hickman Creek at Mile 13.0

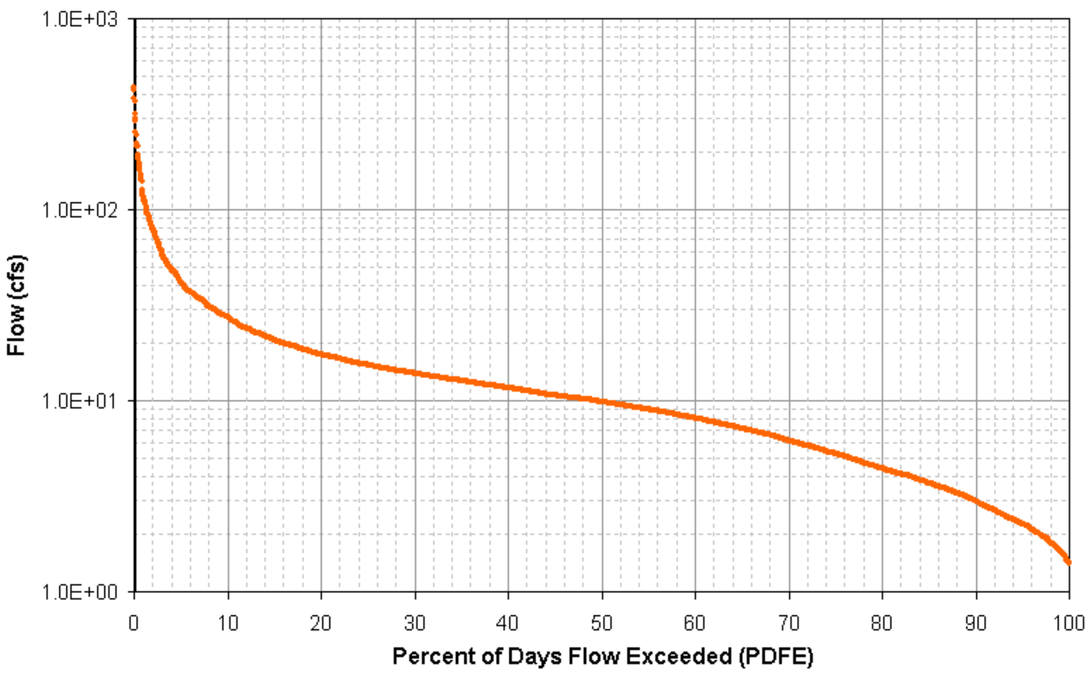

Figure C-2. Flow Duration Curve for Hickman Creek at Mile 13.7

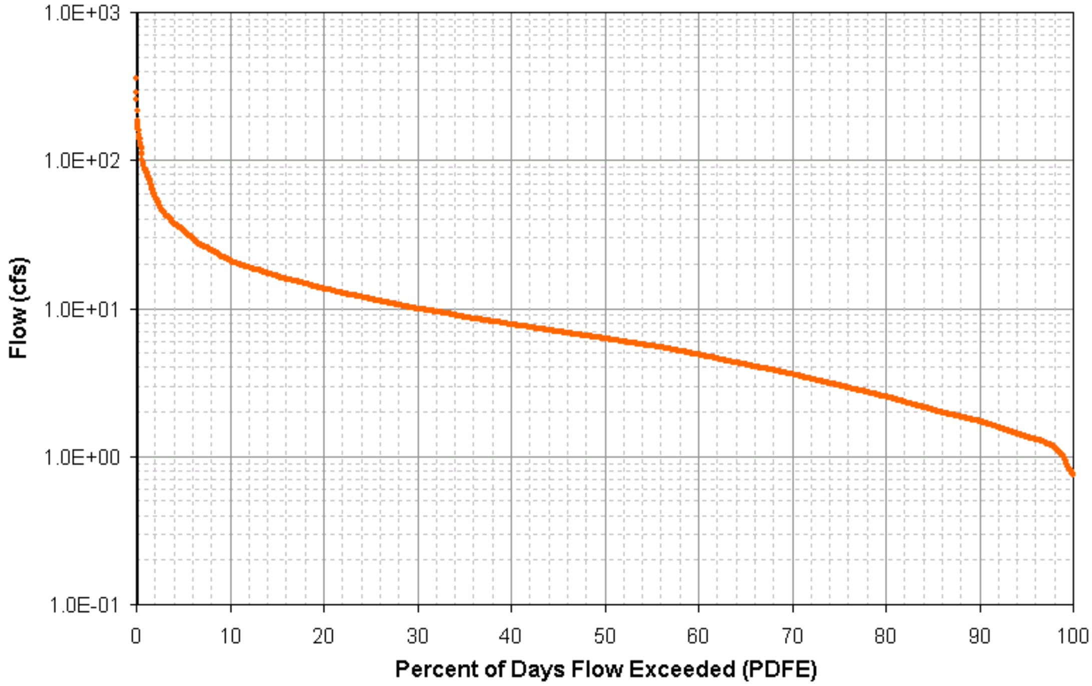

Figure C-3. Flow Duration Curve for Hudgens Creek

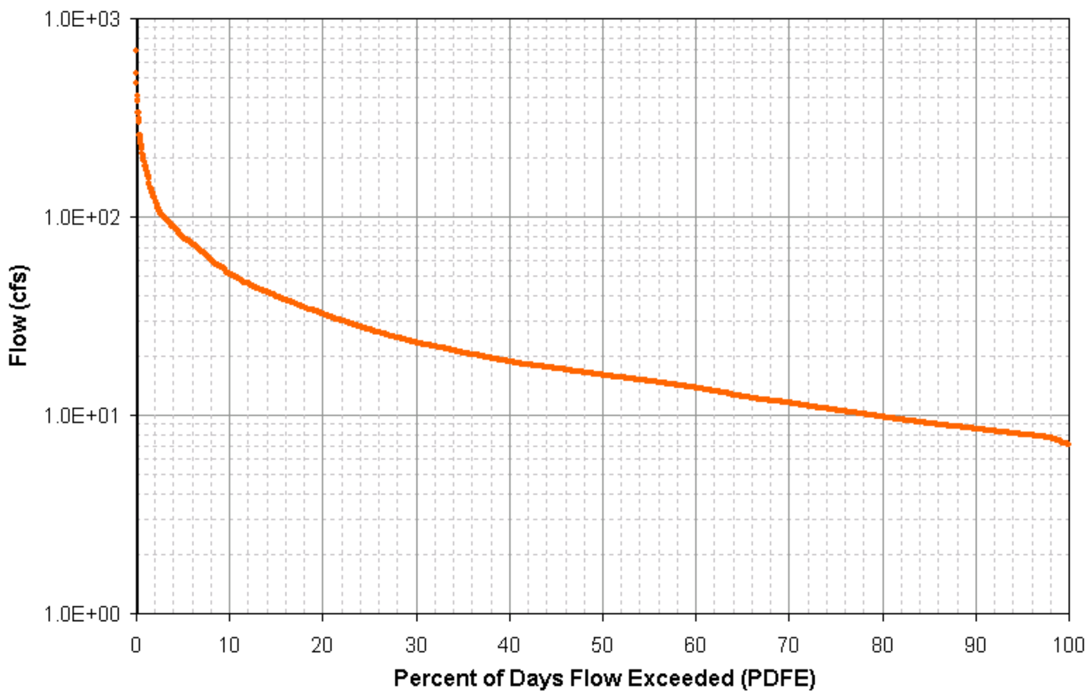

Figure C-4. Flow Duration Curve for Pigeon Roost Creek at Mile 1.3

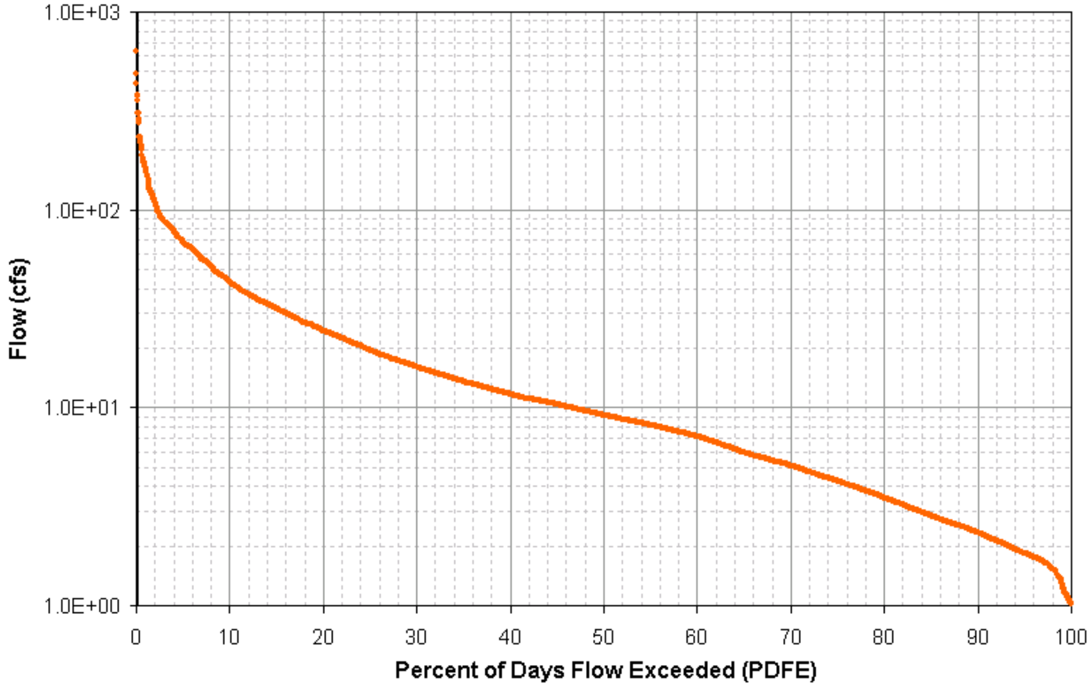

Figure C-5. Flow Duration Curve for Pigeon Roost Creek at Mile 2.4

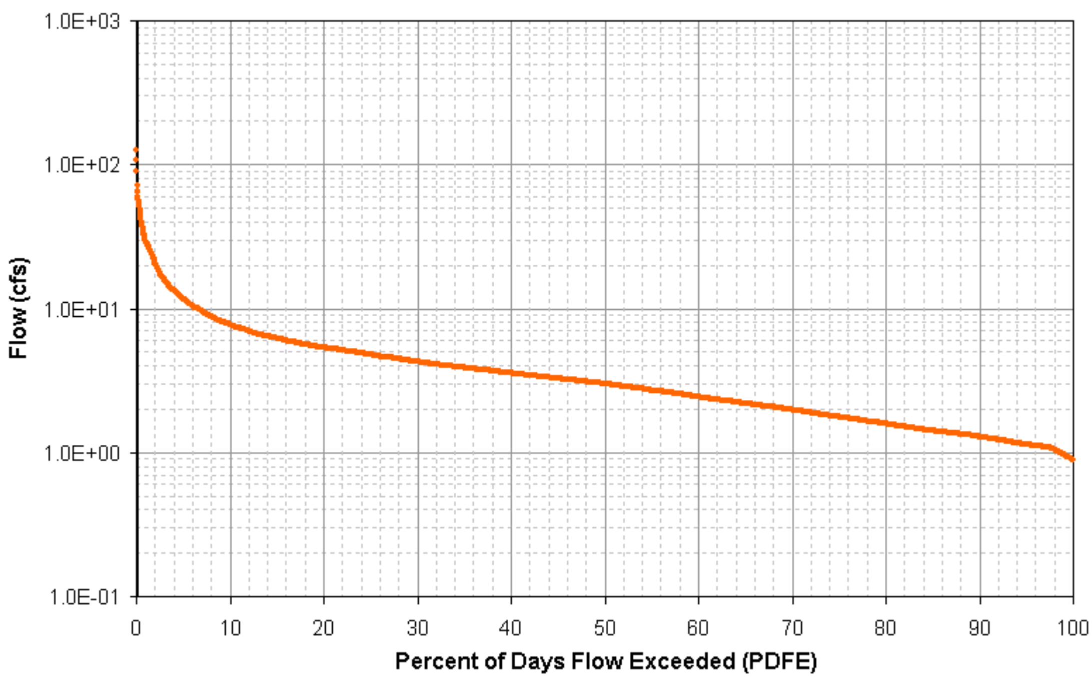

Figure C-6. Flow Duration Curve for Mine Lick Creek at Mile 15.3

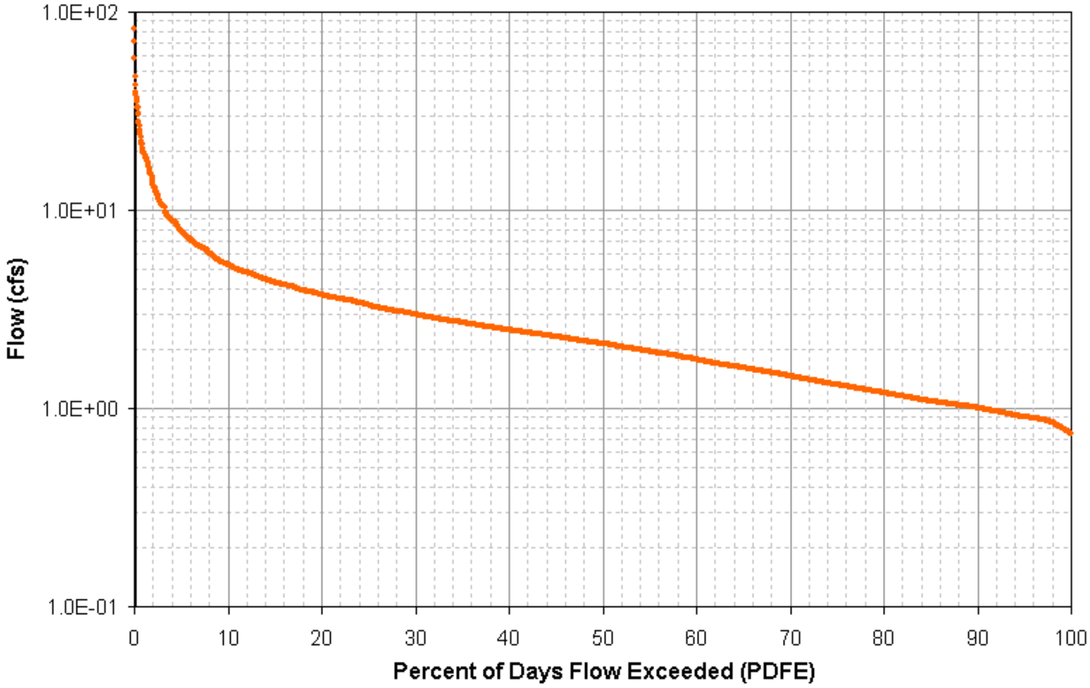

Figure C-7. Flow Duration Curve for Mine Lick Creek at Mile 15.5

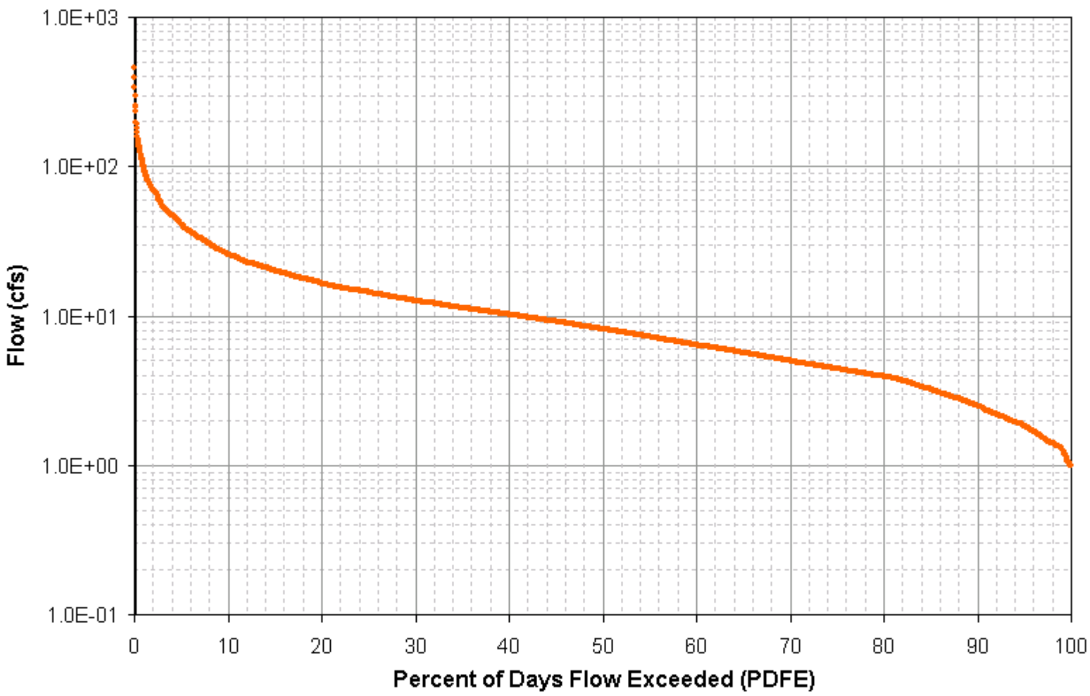

Figure C-8. Flow Duration Curve for Fall Creek

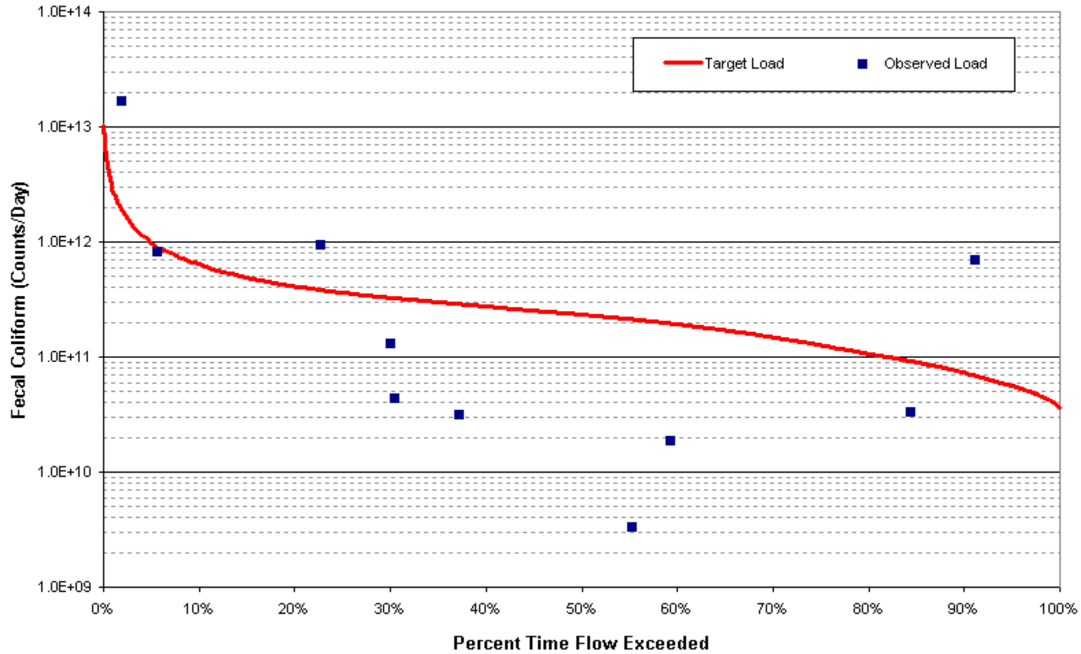

Figure C-9. Fecal Coliform Load Duration Curve for Hickman Creek at Mile 13.0

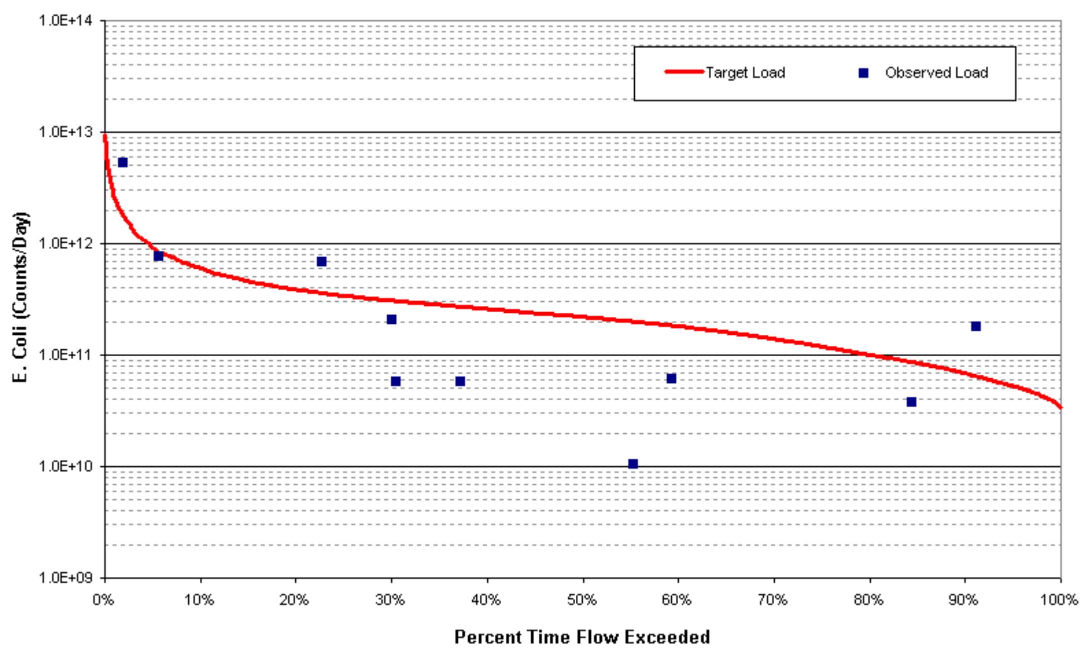

Figure C-10. E. Coli Load Duration Curve for Hickman Creek at Mile 13.0

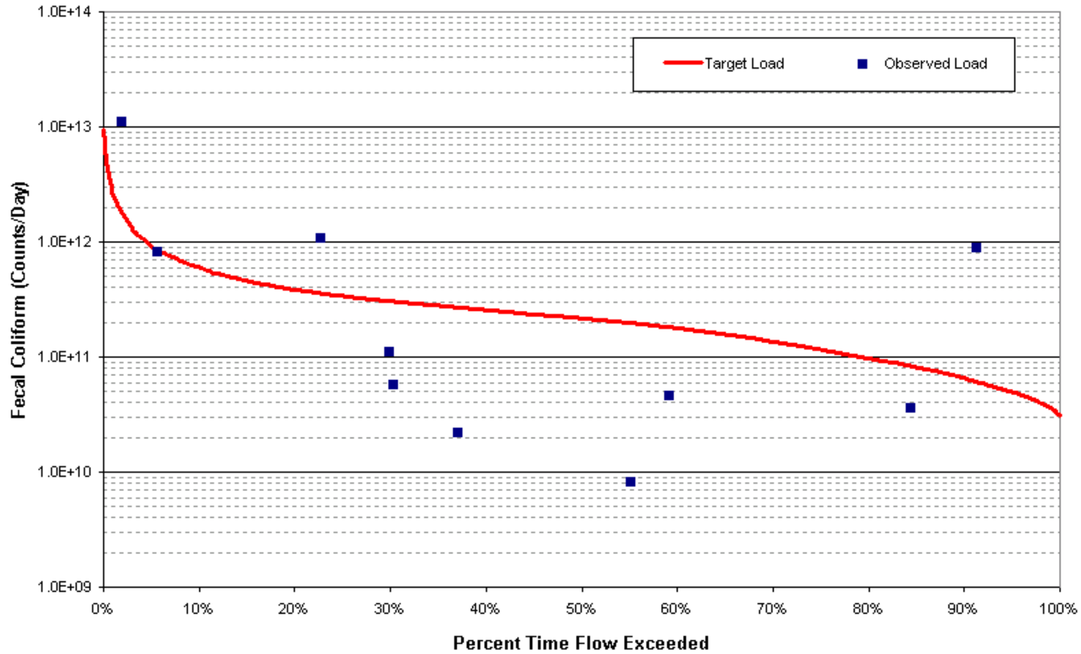

Figure C-11. Fecal Coliform Load Duration Curve for Hickman Creek at Mile 13.7

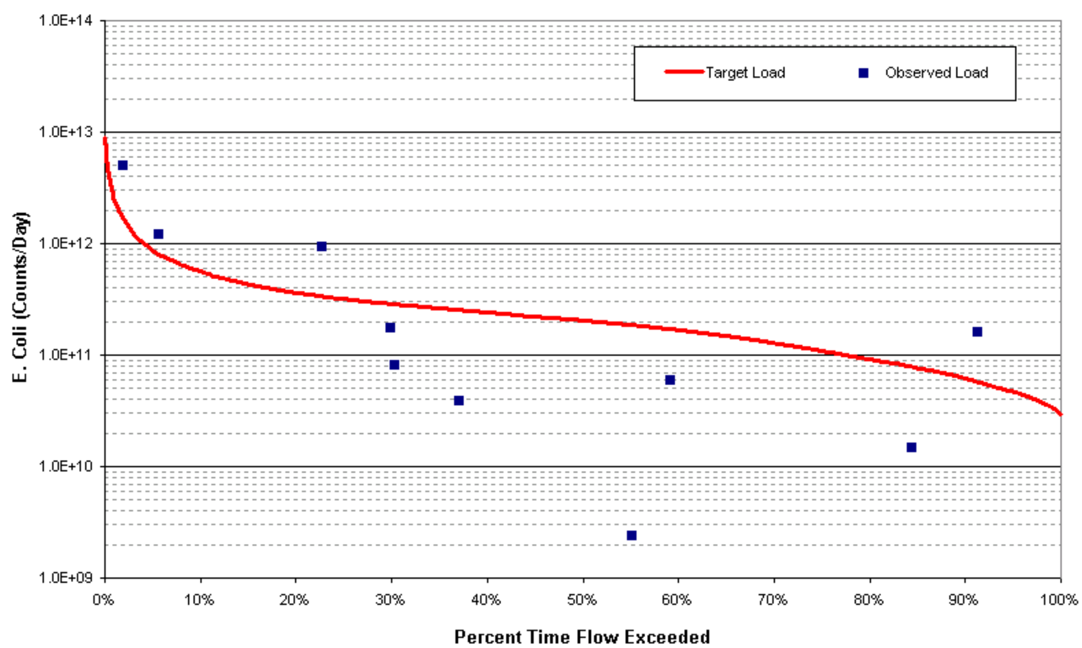

Figure C-12. E. Coli Load Duration Curve for Hickman Creek at Mile 13.7

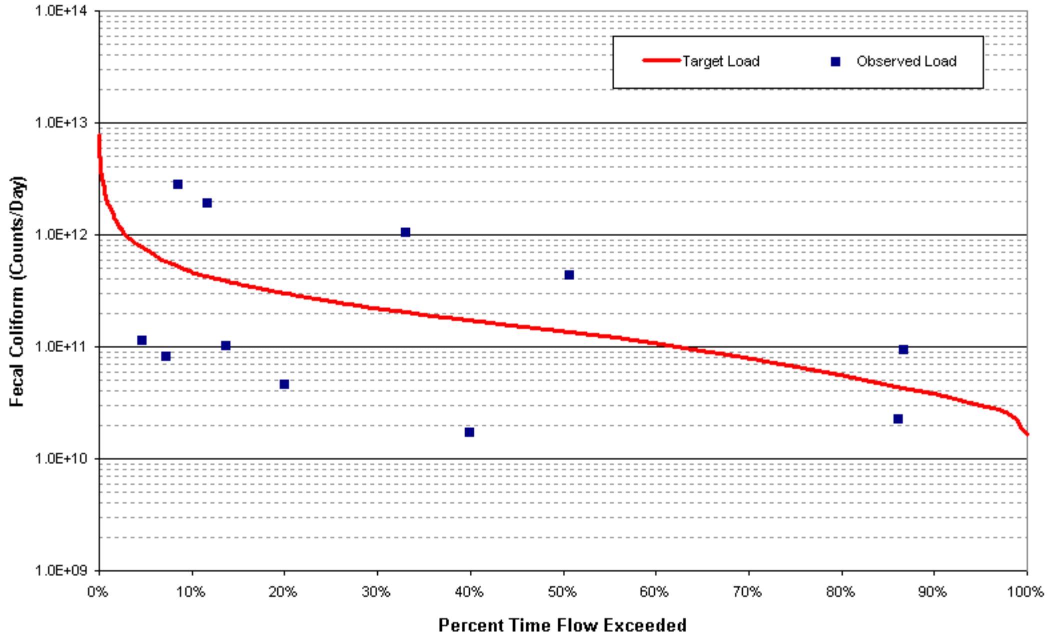

Figure C-13. Fecal Coliform Load Duration Curve for Hudgens Creek

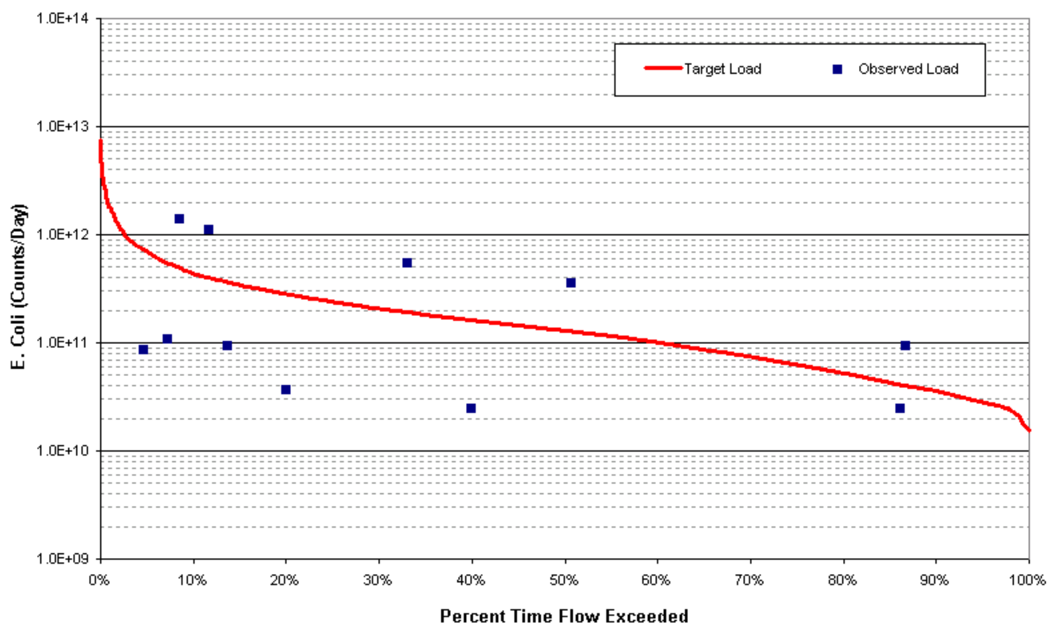

Figure C-14. E. Coli Load Duration Curve for Hudgens Creek

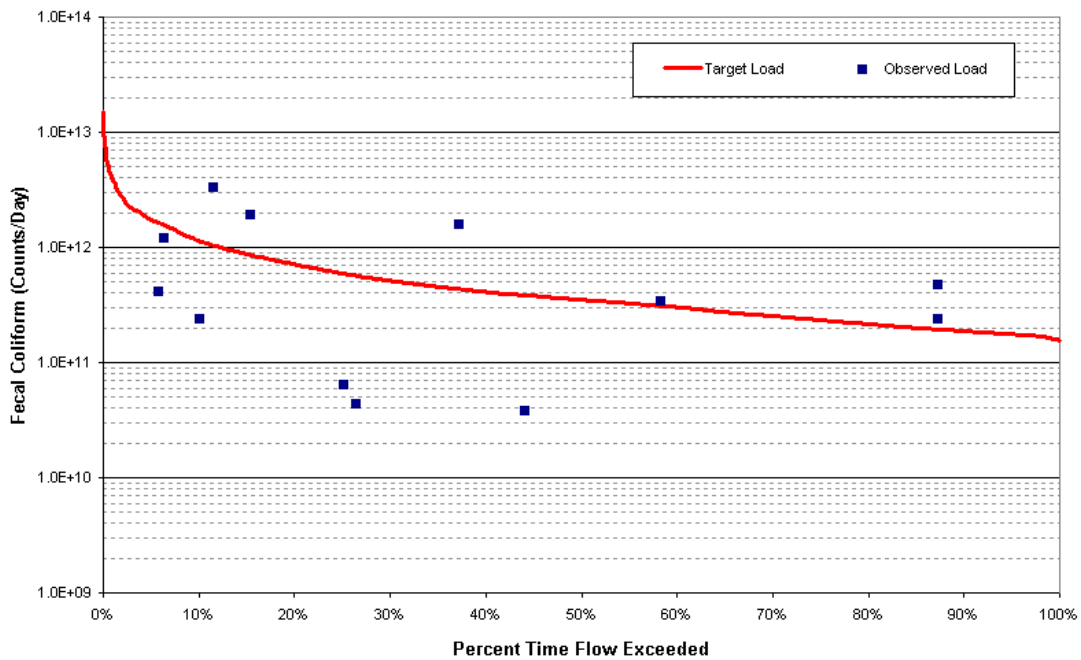

Figure C-15. Fecal Coliform Load Duration Curve for Pigeon Roost Creek at Mile 1.3

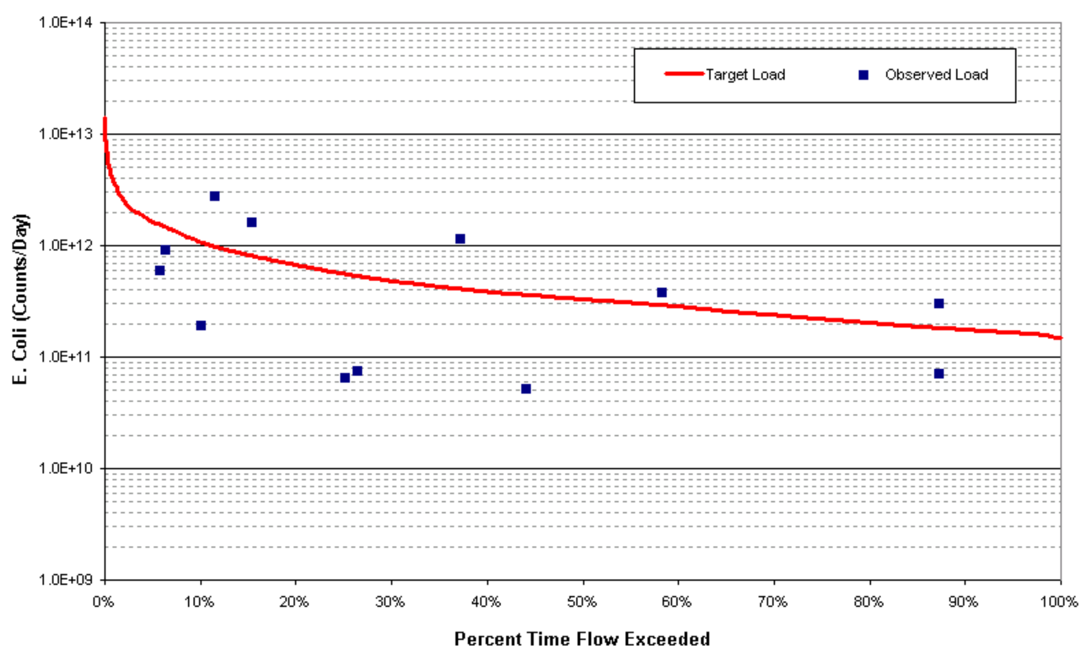

Figure C-16. E. Coli Load Duration Curve for Pigeon Roost Creek at Mile 1.3

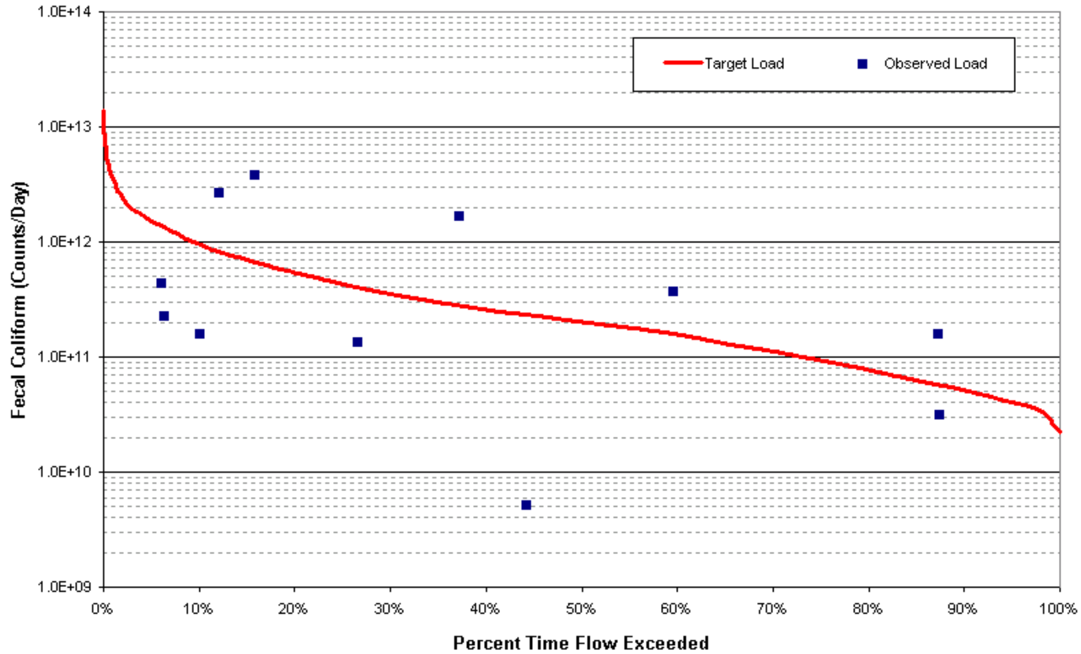

Figure C-17. Fecal Coliform Load Duration Curve for Pigeon Roost Creek at Mile 2.4

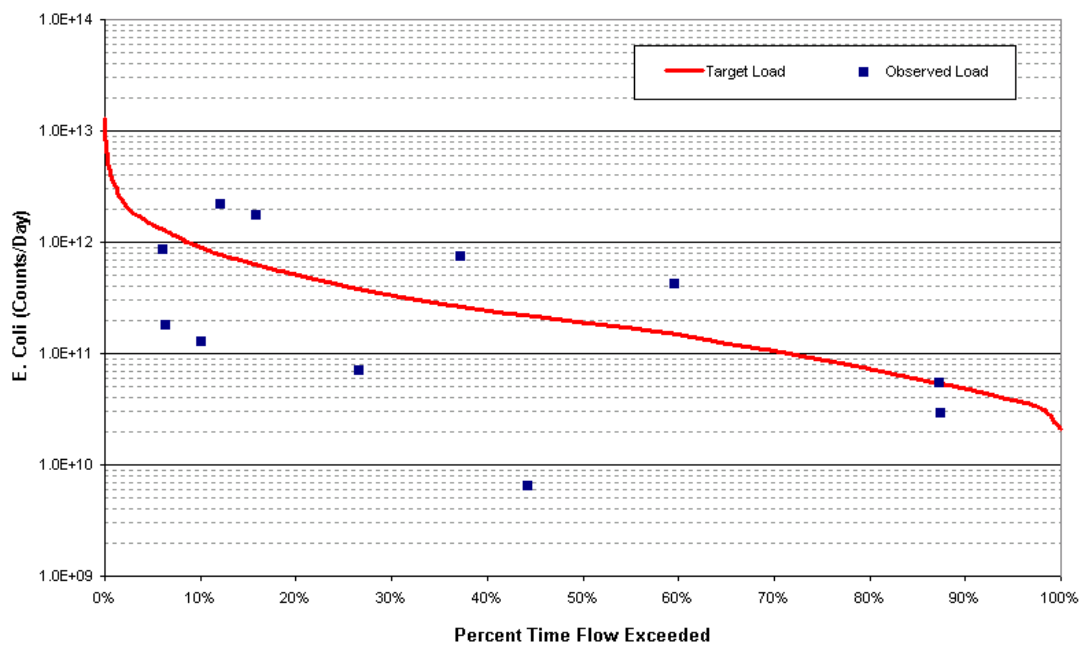

Figure C-18. E. Coli Load Duration Curve for Pigeon Roost Creek at Mile 2.4

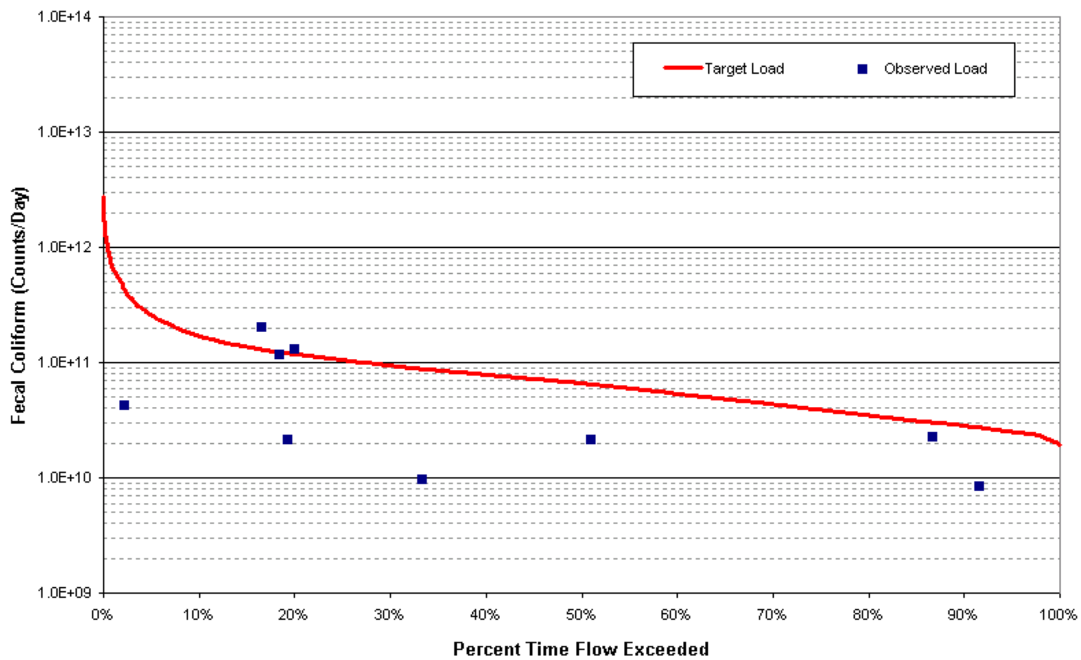

Figure C-19. Fecal Coliform Load Duration Curve for Mine Lick Creek at Mile 15.3

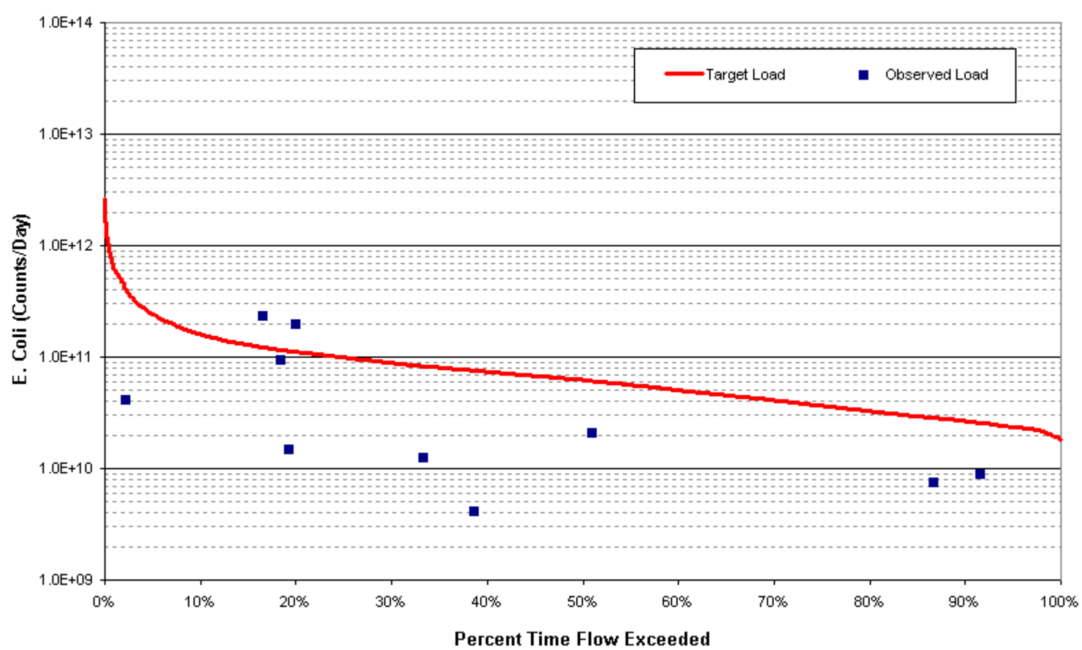

Figure C-20. E. Coli Load Duration Curve for Mine Lick Creek at Mile 15.3

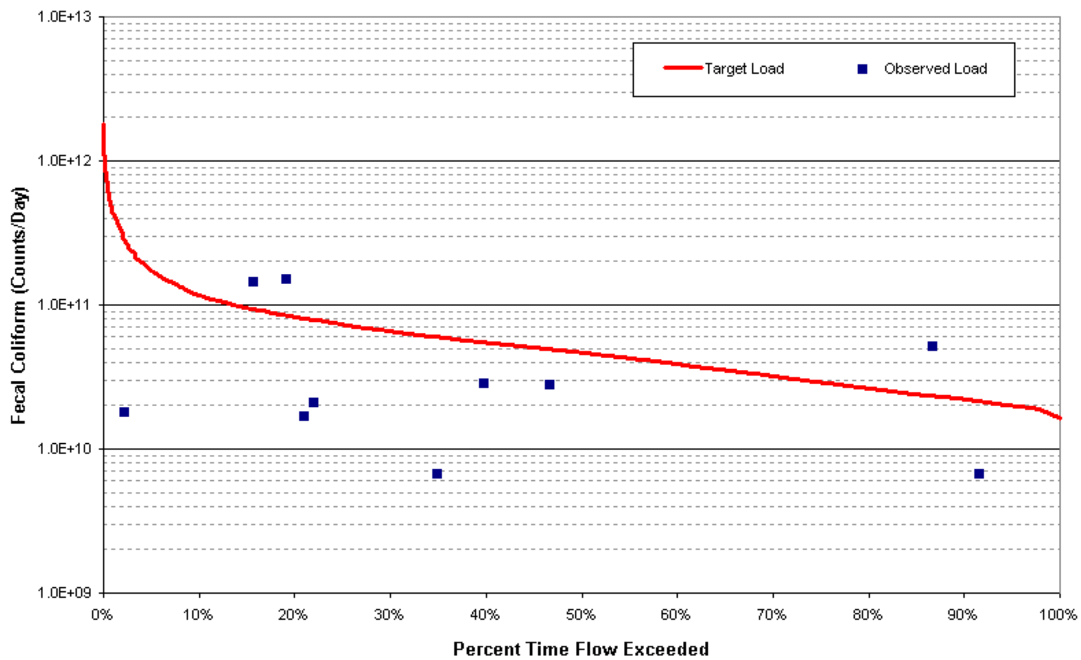

Figure C-21. Fecal Coliform Load Duration Curve for Mine Lick Creek at Mile 15.5

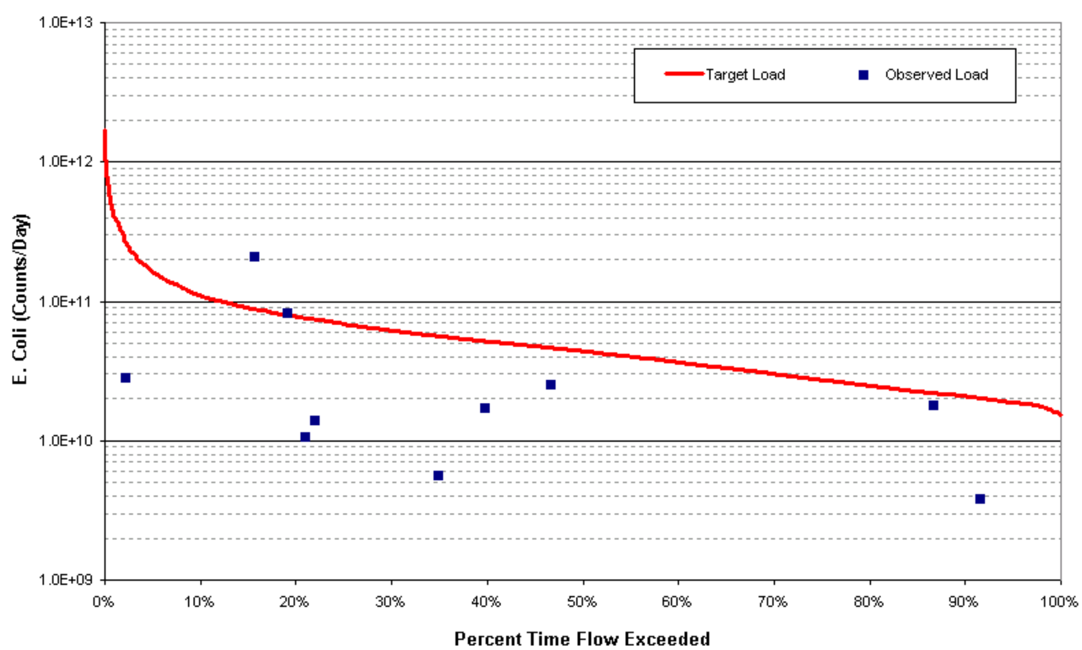

Figure C-22. E. Coli Load Duration Curve for Mine Lick Creek at Mile 15.5

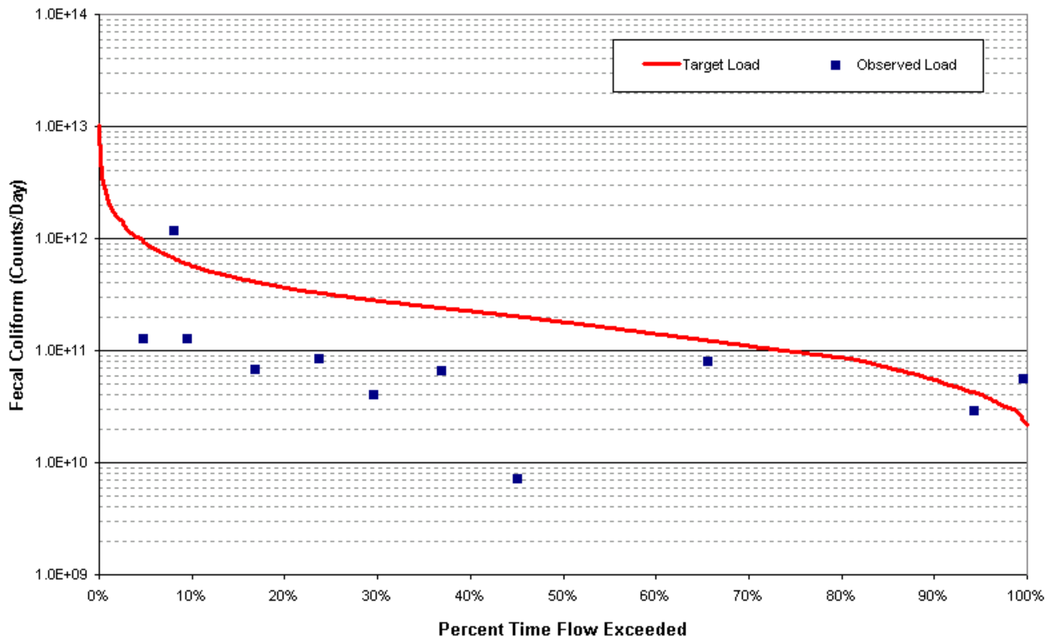

Figure C-23. Fecal Coliform Load Duration Curve for Fall Creek

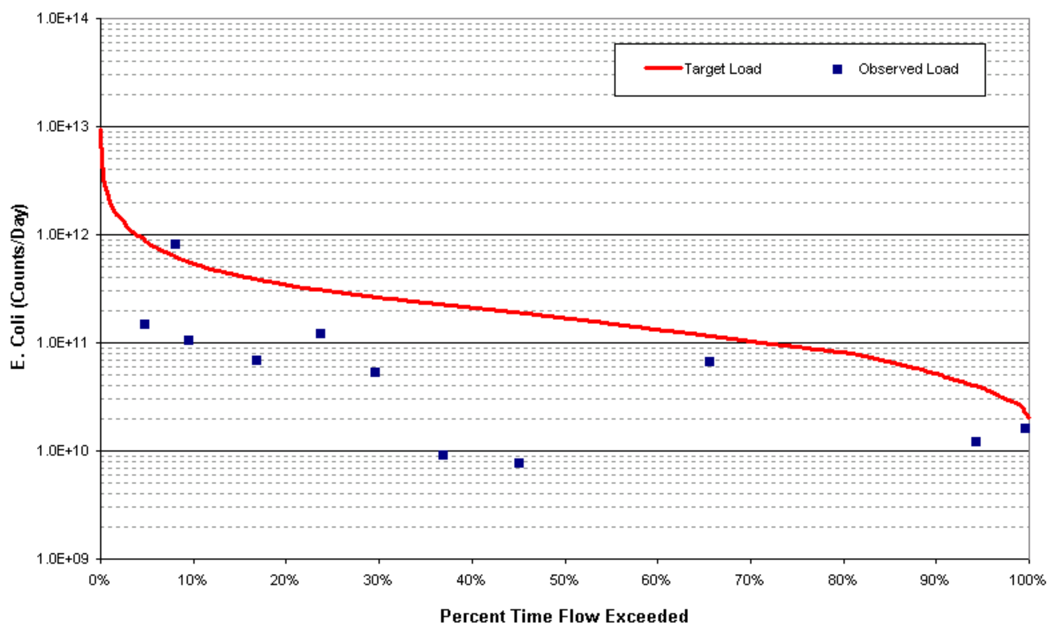

Figure C-24. E. Coli Load Duration Curve for Fall Creek

Table C-1. Required Load Reduction for Hickman Creek – Mile 13.0 – Fecal Coliform Analysis

Sample Date	Flow	PDFE	Fecal Coliform Sample Concentration	Fecal Coliform Required Reduction
	[cfs]	[%]	[cts/100 ml]	[%]
8/5/02	4.19	84.4%	330	**NR**
9/25/02	3.14	91.1%	9200	90.2
10/8/02	8.88	59.3%	87	**NR**
11/19/02	14.90	30.0%	360	**NR**
1/27/03	9.67	55.3%	14	**NR**
2/11/03	13.18	37.1%	97	**NR**
3/17/03	14.82	30.4%	120	**NR**
4/7/03	91.25	1.8%	7500	88.0
5/8/03	40.80	5.6%	830	**NR**
6/12/03	17.43	22.6%	2200	59.1
		90th Percentile	**7670**	**88.3**

Note: NR = Not Required
* 30-day Geometric Mean could not be calculated due to insufficient data.

Table C-2. Required Load Reduction for Hickman Creek – Mile 13.0 – E. Coli Analysis

Sample Date	Flow	PDFE	E. Coli Sample Concentration	E. Coli Required Reduction
	[cfs]	[%]	[cts/100 ml]	[%]
8/5/02	4.19	84.4%	370	**NR**
9/25/02	3.14	91.1%	2400	64.7
10/8/02	8.88	59.3%	280	**NR**
11/19/02	14.90	30.0%	580	**NR**
1/27/03	9.67	55.3%	45	**NR**
2/11/03	13.18	37.1%	180	**NR**
3/17/03	14.82	30.4%	160	**NR**
4/7/03	91.25	1.8%	2400	64.7
5/8/03	40.80	5.6%	770	**NR**
6/12/03	17.43	22.6%	1600	47.1
		90th Percentile	**2400**	**64.7**

Note: NR = Not Required
* 30-day Geometric Mean could not be calculated due to insufficient data.

Table C-3. Required Load Reduction for Hickman Creek – Mile 13.7 – Fecal Coliform Analysis

Sample Date	Flow	PDFE	Fecal Coliform Sample Concentration	Fecal Coliform Required Reduction
	[cfs]	[%]	[cts/100 ml]	[%]
8/5/02	3.81	84.3%	390	**NR**
9/25/02	2.78	91.2%	13000	93.1
10/8/02	8.28	59.1%	230	**NR**
11/19/02	13.94	29.8%	330	**NR**
1/27/03	8.98	55.1%	38	**NR**
2/11/03	12.30	37.0%	73	**NR**
3/17/03	13.82	30.3%	170	**NR**
4/7/03	85.99	1.8%	5300	83.0
5/8/03	38.31	5.6%	870	**NR**
6/12/03	16.31	22.6%	2700	66.7
		90th Percentile	**6070**	**85.2**

Note: NR = Not Required
* 30-day Geometric Mean could not be calculated due to insufficient data.

Table C-4. Required Load Reduction for Hickman Creek – Mile 13.7 – E. Coli Analysis

Sample Date	Flow	PDFE	E. Coli Sample Concentration	E. Coli Required Reduction
	[cfs]	[%]	[cts/100 ml]	[%]
8/5/02	3.81	84.3%	160	**NR**
9/25/02	2.78	91.2%	2400	64.7
10/8/02	8.28	59.1%	300	**NR**
11/19/02	13.94	29.8%	520	**NR**
1/27/03	8.98	55.1%	11	**NR**
2/11/03	12.30	37.0%	130	**NR**
3/17/03	13.82	30.3%	240	**NR**
4/7/03	85.99	1.8%	2400	64.7
5/8/03	38.31	5.6%	1300	34.8
6/12/03	16.31	22.6%	2400	64.7
		90th Percentile	**2400**	**64.7**

Note: NR = Not Required
* 30-day Geometric Mean could not be calculated due to insufficient data.

Table C-5. Required Load Reduction for Hudgens Creek – Fecal Coliform Analysis

Sample Date	Flow	PDFE	Fecal Coliform	
			Sample Concentration	Required Reduction
	[cfs]	[%]	[cts/100 ml]	[%]
8/20/02	1.98	86.1%	470	**NR**
9/24/02	1.95	86.6%	2000	55.0
10/30/02	19.30	11.6%	4100	78.0
11/21/02	26.21	7.2%	130	**NR**
12/11/02	23.91	8.5%	4900	81.6
1/13/03	7.82	39.9%	90	**NR**
2/27/03	35.60	4.6%	130	**NR**
3/20/03	9.30	33.0%	4700	80.9
4/16/03	13.70	20.0%	140	**NR**
5/15/03	17.55	13.7%	240	**NR**
6/12/03	6.18	50.6%	2900	69.0
		90th Percentile	**4700**	**80.9**

Note: NR = Not Required
* 30-day Geometric Mean could not be calculated due to insufficient data. However, duplicate samples were taken for each sample date. The sample concentrations listed above are the highest of the duplicate samples for each sample date.

Table C-6. Required Load Reduction for Hudgens Creek – E. Coli Analysis

Sample Date	Flow	PDFE	E. Coli	
			Sample Concentration	Required Reduction
	[cfs]	[%]	[cts/100 ml]	[%]
8/20/02	1.98	86.1%	520	**NR**
9/24/02	1.95	86.6%	2000	57.7
10/30/02	19.30	11.6%	>2400	>64.7
11/21/02	26.21	7.2%	170	**NR**
12/11/02	23.91	8.5%	>2400	60.3
1/13/03	7.82	39.9%	130	**NR**
2/27/03	35.60	4.6%	99	**NR**
3/20/03	9.30	33.0%	>2400	>64.7
4/16/03	13.70	20.0%	110	**NR**
5/15/03	17.55	13.7%	220	**NR**
6/12/03	6.18	50.6%	>2400	>64.7
		90th Percentile	**>2400**	**>64.7**

Note: NR = Not Required
* 30-day Geometric Mean could not be calculated due to insufficient data. However, duplicate samples were taken for each sample date. The sample concentrations listed above are the highest of the duplicate samples for each sample date.

Table C-7. Required Load Reduction for Pigeon Roost Creek – Mile 1.3 – Fecal Coliform Analysis

Sample Date	Flow	PDFE	Fecal Coliform Sample Concentration	Fecal Coliform Required Reduction
	[cfs]	[%]	[cts/100 ml]	[%]
3/8/99	27.01	25.1%	97	**NR**
8/20/02	8.82	87.2%	1100	18.2
9/24/02	8.82	87.3%	2200	59.1
10/30/02	39.17	15.4%	2000	55.0
11/21/02	71.69	6.3%	700	**NR**
12/11/02	47.31	11.5%	2900	69.0
1/13/03	17.49	44.1%	90	**NR**
2/27/03	74.72	5.8%	230	**NR**
3/20/03	19.85	37.1%	3300	72.7
4/16/03	25.90	26.4%	70	**NR**
5/15/03	51.93	10.0%	190	**NR**
6/12/03	14.15	58.2%	1000	**NR**
		90th Percentile	**2830**	**68.2**

Note: NR = Not Required
* 30-day Geometric Mean could not be calculated due to insufficient data.

Table C-8. Required Load Reduction for Pigeon Roost Creek – Mile 1.3 – E. Coli Analysis

Sample Date	Flow	PDFE	E. Coli Sample Concentration	E. Coli Required Reduction
	[cfs]	[%]	[cts/100 ml]	[%]
3/8/99	27.01	25.1%	100	**NR**
8/20/02	8.82	87.2%	330	**NR**
9/24/02	8.82	87.3%	1400	39.5
10/30/02	39.17	15.4%	1700	50.2
11/21/02	71.69	6.3%	520	**NR**
12/11/02	47.31	11.5%	2400	64.7
1/13/03	17.49	44.1%	120	**NR**
2/27/03	74.72	5.8%	330	**NR**
3/20/03	19.85	37.1%	2400	64.7
4/16/03	25.90	26.4%	120	**NR**
5/15/03	51.93	10.0%	150	**NR**
6/12/03	14.15	58.2%	1100	23.0
		90th Percentile	**2330**	**63.7**

Note: NR = Not Required
* 30-day Geometric Mean could not be calculated due to insufficient data.

Table C-9. Required Load Reduction for Pigeon Roost Creek – Mile 2.4 – Fecal Coliform Analysis

Sample Date	Flow	PDFE	Fecal Coliform Sample Concentration	Fecal Coliform Required Reduction
	[cfs]	[%]	[cts/100 ml]	[%]
8/20/02	2.59	87.4%	500	**NR**
9/24/02	2.60	87.3%	2500	64.0
10/30/02	30.39	15.8%	5100	82.4
11/21/02	61.83	6.3%	150	**NR**
12/11/02	37.64	12.0%	2900	69.0
1/13/03	10.60	44.2%	20	**NR**
2/27/03	64.15	6.0%	280	**NR**
3/20/03	12.72	37.2%	5400	83.3
4/16/03	18.34	26.5%	300	**NR**
5/15/03	43.68	10.0%	150	**NR**
6/12/03	7.23	59.6%	2100	57.1
		90th Percentile	**5100**	**82.4**

Note: NR = Not Required
* 30-day Geometric Mean could not be calculated due to insufficient data.

Table C-10. Required Load Reduction for Pigeon Roost Creek – Mile 2.4 – E. Coli Analysis

Sample Date	Flow	PDFE	E. Coli Sample Concentration	E. Coli Required Reduction
	[cfs]	[%]	[cts/100 ml]	[%]
8/20/02	2.59	87.4%	460	**NR**
9/24/02	2.60	87.3%	870	**NR**
10/30/02	30.39	15.8%	2400	64.7
11/21/02	61.83	6.3%	120	**NR**
12/11/02	37.64	12.0%	2400	64.7
1/13/03	10.60	44.2%	25	**NR**
2/27/03	64.15	6.0%	550	**NR**
3/20/03	12.72	37.2%	2400	64.7
4/16/03	18.34	26.5%	160	**NR**
5/15/03	43.68	10.0%	120	**NR**
6/12/03	7.23	59.6%	2400	64.7
		90th Percentile	**2400**	**64.7**

Note: NR = Not Required
* 30-day Geometric Mean could not be calculated due to insufficient data.

Table C-11. Required Load Reduction for Mine Lick Creek – Mile 15.3 – Fecal Coliform Analysis

Sample Date	Flow	PDFE	Fecal Coliform Sample Concentration	Fecal Coliform Required Reduction
	[cfs]	[%]	[cts/100 ml]	[%]
8/22/02	1.24	91.6%	280	**NR**
9/23/02	1.38	86.6%	670	**NR**
10/30/02	5.61	18.3%	870	**NR**
12/18/02	5.37	19.9%	1000	**NR**
1/15/03	3.65	38.6%	11	**NR**
2/18/03	20.22	2.1%	87	**NR**
3/31/03	4.00	33.3%	100	**NR**
4/22/03	5.46	19.2%	160	**NR**
5/21/03	5.93	16.5%	1400	35.7
6/19/03	2.95	51.0%	300	**NR**
		90th Percentile	**1040**	**13.5**

Note: NR = Not Required
* 30-day Geometric Mean could not be calculated due to insufficient data.

Table C-12. Required Load Reduction for Mine Lick Creek – Mile 15.3 – E. Coli Analysis

Sample Date	Flow	PDFE	E. Coli Sample Concentration	E. Coli Required Reduction
	[cfs]	[%]	[cts/100 ml]	[%]
8/22/02	1.24	91.6%	290	**NR**
9/23/02	1.38	86.6%	220	**NR**
10/30/02	5.61	18.3%	690	**NR**
12/18/02	5.37	19.9%	1500	43.5
1/15/03	3.65	38.6%	46	**NR**
2/18/03	20.22	2.1%	84	**NR**
3/31/03	4.00	33.3%	130	**NR**
4/22/03	5.46	19.2%	110	**NR**
5/21/03	5.93	16.5%	1600	47.1
6/19/03	2.95	51.0%	290	**NR**
		90th Percentile	**1510**	**43.9**

Note: NR = Not Required
* 30-day Geometric Mean could not be calculated due to insufficient data.

Table C-13. Required Load Reduction for Mine Lick Creek – Mile 15.5 – Fecal Coliform Analysis

Sample Date	Flow	PDFE	Fecal Coliform Sample Concentration	Fecal Coliform Required Reduction
	[cfs]	[%]	[cts/100 ml]	[%]
8/22/02	0.97	91.6%	280	**NR**
9/23/02	1.06	86.7%	2000	55.0
10/30/02	3.85	19.1%	1600	43.8
12/18/02	3.59	21.9%	240	**NR**
1/15/03	2.50	39.7%	470	**NR**
2/18/03	13.03	2.2%	57	**NR**
3/31/03	2.73	34.8%	100	**NR**
4/22/03	3.65	21.0%	190	**NR**
5/21/03	4.25	15.6%	1400	35.7
6/19/03	2.24	46.6%	510	**NR**
		90th Percentile	**1640**	**45.1**

Note: NR = Not Required
* 30-day Geometric Mean could not be calculated due to insufficient data.

Table C-14. Required Load Reduction for Mine Lick Creek – Mile 15.5 – E. Coli Analysis

Sample Date	Flow	PDFE	E. Coli Sample Concentration	E. Coli Required Reduction
	[cfs]	[%]	[cts/100 ml]	[%]
8/22/02	0.97	91.6%	160	**NR**
9/23/02	1.06	86.7%	690	**NR**
10/30/02	3.85	19.1%	870	**NR**
12/18/02	3.59	21.9%	160	**NR**
1/15/03	2.50	39.7%	280	**NR**
2/18/03	13.03	2.2%	88	**NR**
3/31/03	2.73	34.8%	84	**NR**
4/22/03	3.65	21.0%	120	**NR**
5/21/03	4.25	15.6%	2000	57.7
6/19/03	2.24	46.6%	460	**NR**
		90th Percentile	**983**	**13.8**

Note: NR = Not Required
* 30-day Geometric Mean could not be calculated due to insufficient data.

Table C-15. Required Load Reduction for Fall Creek – Fecal Coliform Analysis

Sample Date	Flow	PDFE	Fecal Coliform	
			Sample Concentration	Required Reduction
	[cfs]	[%]	[cts/100 ml]	[%]
8/19/02	1.14	99.6%	2000	55.0
9/23/02	1.93	94.2%	620	**NR**
10/30/02	5.59	65.6%	590	**NR**
11/20/02	12.80	29.6%	130	**NR**
12/18/02	14.91	23.7%	230	**NR**
1/15/03	9.18	45.0%	32	**NR**
2/18/03	43.88	4.7%	120	**NR**
3/31/03	10.89	36.9%	250	**NR**
4/22/03	18.77	16.8%	150	**NR**
5/21/03	30.44	8.0%	1600	43.8
6/19/03	27.21	9.4%	190	**NR**
		90th Percentile	**1600**	**43.8**

Note: NR = Not Required
* 30-day Geometric Mean could not be calculated due to insufficient data. However, duplicate samples were taken for each sample date. The sample concentrations listed above are the highest of the duplicate samples for each sample date.

Table C-16. Required Load Reduction for Fall Creek – E. Coli Analysis

Sample Date	Flow	PDFE	E. Coli	
			Sample Concentration	Required Reduction
	[cfs]	[%]	[cts/100 ml]	[%]
8/19/02	1.14	99.6%	580	**NR**
9/23/02	1.93	94.2%	260	**NR**
10/30/02	5.59	65.6%	490	**NR**
11/20/02	12.80	29.6%	170	**NR**
12/18/02	14.91	23.7%	330	**NR**
1/15/03	9.18	45.0%	34	**NR**
2/18/03	43.88	4.7%	140	**NR**
3/31/03	10.89	36.9%	34	**NR**
4/22/03	18.77	16.8%	150	**NR**
5/21/03	30.44	8.0%	1100	23.0
6/19/03	27.21	9.4%	160	**NR**
		90th Percentile	**580**	**NR**

Note: NR = Not Required
* 30-day Geometric Mean could not be calculated due to insufficient data. However, duplicate samples were taken for each sample date. The sample concentrations listed above are the highest of the duplicate samples for each sample date.

APPENDIX D

Hydrodynamic Modeling Methodology

HYDRODYNAMIC MODELING METHOD

D.1 Model Selection

The Loading Simulation Program C++ (LSPC) was selected for flow simulation of pathogen-impaired waters in the subwatersheds of the Caney Fork watershed. LSPC is a watershed model capable of performing flow routing through stream reaches. LSPC is a dynamic watershed model based on the Hydrologic Simulation Program - Fortran (HSPF)

D.2 Model Set Up

The Caney Fork watershed was delineated into subwatersheds in order to facilitate model hydrologic calibration. Boundaries were constructed so that subwatershed "pour points" coincided with HUC-12 delineations, 303(d)-listed waterbodies, and water quality monitoring stations. Watershed delineation was based on the NHD stream coverage and Digital Elevation Model (DEM) data. This discretization facilitates simulation of daily flows at water quality monitoring stations.

Several computer-based tools were utilized to generate input data for the LSPC model. The Watershed Characterization System (WCS), a geographic information system (GIS) tool, was used to display, analyze, and compile available information to support hydrology model simulations for selected subwatersheds. This information includes land use categories, point source dischargers, soil types and characteristics, population data (human and livestock), and stream characteristics.

An important factor influencing model results is the precipitation data contained in the meteorological data files used in these simulations. Weather data from multiple meteorological stations were available for the time period from January 1970 through August 2004. Meteorological data for a selected 11-year period were used for all simulations. The first year of this period was used for model stabilization with simulation data from the subsequent 10-year period (10/1/94 – 9/30/04) used for TMDL analysis.

D.3 Model Calibration

Hydrologic calibration of the watershed model involves comparison of simulated streamflow to historic streamflow data from U. S. Geological Survey (USGS) stream gaging stations for the same period of time. A USGS continuous record station located near the Caney Fork watershed with a sufficiently long and recent historical record was selected as the basis of the hydrology calibration. The USGS station was selected based on similarity of drainage area, Level IV ecoregion, land use, and topography. The calibration involved comparison of simulated and observed hydrographs until statistical stream volumes and flows were within acceptable ranges as reported in the literature (Lumb, et al., 1994).

Initial values for hydrologic variables were taken from an EPA developed default data set. During the calibration process, model parameters were adjusted within reasonable constraints until acceptable agreement was achieved between simulated and observed streamflow. Model parameters adjusted include: evapotranspiration, infiltration, upper and lower zone storage, groundwater storage, recession, losses to the deep groundwater system, and interflow discharge.

The results of the hydrologic calibration for East Stones Fork River at Woodbury, USGS Station 03426800, are shown in Table D-1 and Figures D-1 and D-2.

Table D-1. Hydrologic Calibration Summary: East Fork Stones River (USGS 03426800)

Simulation Name:	USGS03426800	**Simulation Period:**	
		Watershed Area (ac):	24843.69
Period for Flow Analysis			
Begin Date:	**10/01/80**	**Baseflow PERCENTILE:**	2.5
End Date:	**09/30/87**	*Usually 1%-5%*	
Total Simulated In-stream Flow:	**138.23**	Total Observed In-stream Flow:	**131.48**
Total of highest 10% flows:	**69.43**	Total of Observed highest 10% flows:	**70.61**
Total of lowest 50% flows:	**14.96**	Total of Observed Lowest 50% flows:	**14.93**
Simulated Summer Flow Volume (months 7-9):	**8.88**	Observed Summer Flow Volume (7-9):	**12.40**
Simulated Fall Flow Volume (months 10-12):	**29.04**	Observed Fall Flow Volume (10-12):	**34.87**
Simulated Winter Flow Volume (months 1-3):	**45.71**	Observed Winter Flow Volume (1-3):	**48.92**
Simulated Spring Flow Volume (months 4-6):	**54.60**	Observed Spring Flow Volume (4-6):	**35.28**
Total Simulated Storm Volume:	**126.64**	Total Observed Storm Volume:	**118.28**
Simulated Summer Storm Volume (7-9):	**5.97**	Observed Summer Storm Volume (7-9):	**9.10**
Errors (Simulated-Observed)		*Recommended Criteria*	Last run
Error in total volume:	**5.13**	10	
Error in 50% lowest flows:	**0.15**	10	
Error in 10% highest flows:	**-1.68**	15	
Seasonal volume error - Summer:	**-28.40**	30	
Seasonal volume error - Fall:	**-16.73**	30	
Seasonal volume error - Winter:	**-6.57**	30	
Seasonal volume error - Spring:	**54.76**	30	
Error in storm volumes:	**7.07**	20	
Error in summer storm volumes:	**-34.42**	50	

Criteria for Median Monthly Flow Comparisons	
Lower Bound (Percentile):	25
Upper Bound (Percentile):	75

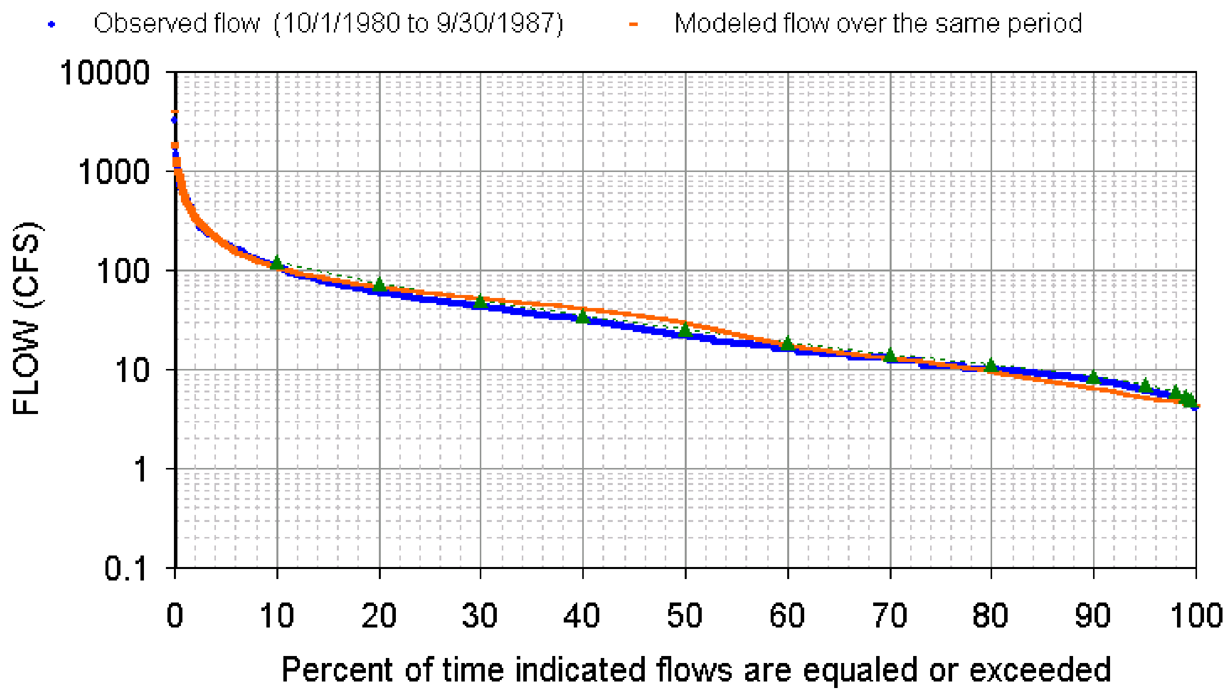

Figure D-1. Hydrologic Calibration: East Fork Stones River, USGS 03426800 (WYs1981-87)

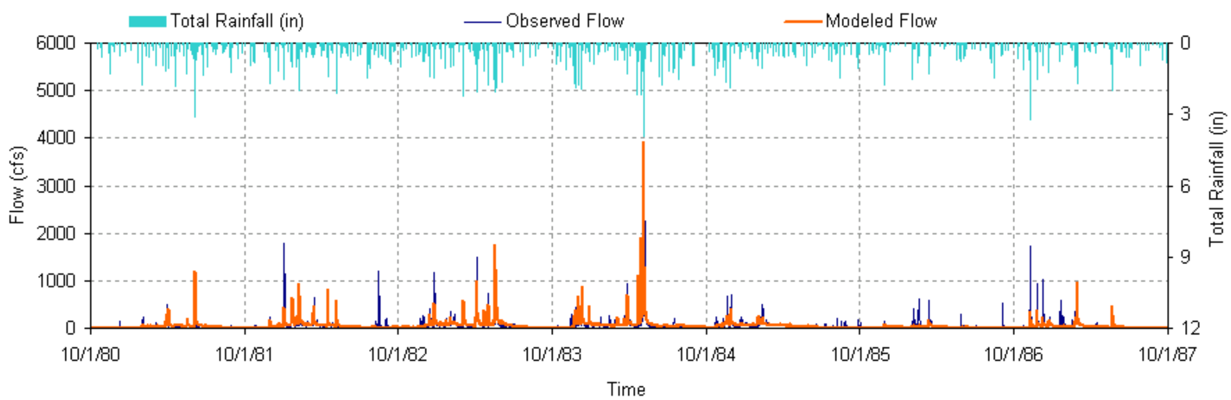

Figure D-2. 7-Year Hydrologic Comparison: East Fork Stones River, USGS 03426800

APPENDIX E

Determination of WLAs & LAs

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

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

The objective of a TMDL is to allocate loads among all of the known pollutant sources throughout a watershed so that appropriate control measures can be implemented and water quality standards achieved. 40 CFR §130.2 (i) states that TMDLs can be expressed in terms of mass per time, toxicity, or <u>other appropriate measure</u>.

For pathogen TMDLs in each impaired subwatershed, WLA terms include:

- $[\Sigma WLAs]_{WWTF}$ is the allowable load associated with discharges of NPDES permitted WWTFs located in impaired subwatersheds. Since NPDES permits for these facilities specify that treated wastewater must meet instream water quality standards at the point of discharge, no additional load reduction is required. WLAs for WWTFs are calculated from the facility design flow and the Monthly Average permit limit.
- $[\Sigma WLAs]_{CAFO}$ is the allowable load for all CAFOs in an impaired subwatershed. All wastewater discharges from a CAFO to waters of the state of Tennessee are prohibited, except when either chronic or catastrophic rainfall events cause an overflow of process wastewater from a facility properly designed, constructed, maintained, and operated to contain:
  - All process wastewater resulting from the operation of the CAFO (such as wash water, parlor water, watering system overflow, etc.); plus,
  - All runoff from a 25-year, 24-hour rainfall event for the existing CAFO or new dairy or cattle CAFOs; or all runoff from a 100-year, 24-hour rainfall event for a new swine or poultry CAFO.

  Therefore, a WLA of zero has been assigned to this class of facilities.
- $[\Sigma WLAs]_{MS4}$ is the required load reduction for discharges from MS4s. Fecal coliform and/or E. coli loading from MS4s is the result of buildup/wash-off processes associated with storm events. The percent load reductions for MS4s are considered to be equal to the load reductions developed for TMDLs.

LA terms include:

- $[\Sigma LAs]_{DS}$ is the allowable fecal coliform and/or E. coli load from "other direct sources". These sources include leaking septic systems, leaking collection systems, illicit discharges, and animals access to streams. The LA specified for all sources of this type is zero counts/day (or to the maximum extent practicable).
- $[\Sigma LAs]_{SW}$ represents the required reduction in fecal coliform and/or E. coli loading from nonpoint sources indirectly going to surface waters from all land use areas (except areas covered by a MS4 permit) as a result of the buildup/wash-off processes

associated with storm events. The percent load reductions for precipitation-induced nonpoint sources are considered to be equal to the load reductions developed for TMDLs (and specified for MS4s).

Explicit MOS has already been incorporated into TMDL development as stated in Appendix C. TMDLs, WLAs, & LAs are applied to the entire subwatershed. WLAs & LAs for Caney Fork waterbodies are summarized in Table E-1.

Table E-1. WLAs & LAs for Caney Fork, Tennessee

HUC-12 Subwatershed (05130108__) or Drainage Area	Impaired Waterbody Name	Impaired Waterbody ID	TMDL	WLAs				LAs	
				WWTFs[a] (Monthly Avg.) E. Coli	Leaking Collection Systems[b]	CAFOs	MS4s[c]	Precipitation Induced Nonpoint Sources	Other Direct Sources[d]
			[% Red.]	[cts./day]	[cts./day]	[cts./day]	[% Red.]	[% Red.]	[cts./day]
0807	Hickman Creek	TN05130108002 – 2000	**88.3**	**1.431×10^9**	**0**	**NA**	**88.3**	**88.3**	**0**
0702	Hudgens Creek	TN05130108045 – 0300	**82.4**	**6.677×10^{10}**	**0**	**NA**	**82.4**	**82.4**	**0**
	Pigeon Roost Creek	TN05130108045 – 0400 & 0450							
0803	Mine Lick Creek	TN05130108097 – 2000	**45.1**	**2.385×10^9**	**0**	**NA**	**NA**	**45.1**	**0**
0406	Fall Creek	TN05130108684 – 1000	**43.8**	**1.030×10^{10}**	**0**	**NA**	**NA**	**43.8**	**0**

Note: NA = Not Applicable.

a. *WLAs for WWTFs expressed as E. coli loads (counts/day).*

b. *The objective for leaking collection systems is a waste load allocation of zero. It is recognized, however, that a WLA of 0 counts/day may not be practical. For these sources, the WLA is interpreted to mean a reduction in coliform loading to the maximum extent practicable, consistent with the requirement that these sources not contribute to a violation of the water quality standard for E. coli.*

c. *Applies to any MS4 discharge loading in the subwatershed.*

d. *The objective for all "other direct sources" is a load allocation of zero. It is recognized, however, that for leaking septic systems a LA of 0 counts/day may not be practical. For these sources, the LA is interpreted to mean a reduction in coliform loading by the application of best management practices, consistent with the requirement that these sources not contribute to a violation of the water quality standard for E. coli.*

APPENDIX F

Public Notice Announcement

STATE OF TENNESSEE
DEPARTMENT OF ENVIRONMENT AND CONSERVATION
DIVISION OF WATER POLLUTION CONTROL

PUBLIC NOTICE OF AVAILABILITY OF PROPOSED TOTAL MAXIMUM DAILY LOAD (TMDL) FOR PATHOGENS IN CANEY FORK WATERSHED (HUC 05130108), TENNESSEE

Announcement is hereby given of the availability of Tennessee's proposed Total Maximum Daily Load (TMDL) for pathogens in the Caney Fork watershed, located in middle and eastern Tennessee. Section 303(d) of the Clean Water Act requires states to develop TMDLs for waters on their impaired waters list. TMDLs must determine the allowable pollutant load that the water can assimilate, allocate that load among the various point and nonpoint sources, include a margin of safety, and address seasonality.

A number of waterbodies in the Caney Fork watershed are listed on Tennessee's Proposed Final 2004 303(d) list as not supporting designated use classifications due, in part, to discharge of pathogens from MS4 areas and pasture land, livestock in stream, and collection system failure. The TMDL utilizes Tennessee's general water quality criteria, continuous flow data from a USGS discharge monitoring station located in proximity to the watershed, site specific water quality monitoring data, a calibrated hydrologic model, load duration curves, and an appropriate Margin of Safety (MOS) to establish allowable loadings of pathogens which will result in the reduced in-stream concentrations and attainment of water quality standards. The TMDL requires reductions of pathogen loading on the order of 43-88% in the listed waterbodies.

The proposed Caney Fork pathogen TMDL may be downloaded from the Department of Environment and Conservation website:

http://www.state.tn.us/environment/wpc/tmdl/

Technical questions regarding this TMDL should be directed to the following members of the Division of Water Pollution Control staff:

Vicki S. Steed, P.E., Watershed Management Section
Telephone: 615-532-0707

Sherry H. Wang, Ph.D., Watershed Management Section
Telephone: 615-532-0656

Persons wishing to comment on the proposed TMDLs are invited to submit their comments in writing no later than August 8, 2005 to:

Division of Water Pollution Control
Watershed Management Section
7th Floor, L & C Annex
401 Church Street
Nashville, TN 37243-1534

All comments received prior to that date will be considered when revising the TMDL for final submittal to the U.S. Environmental Protection Agency.

The TMDL and supporting information are on file at the Division of Water Pollution Control, 6th Floor, L & C Annex, 401 Church Street, Nashville, Tennessee. They may be inspected during normal office hours. Copies of the information on file are available on request.

APPENDIX G

Public Notice Comments Received

J. R. WAUFORD & COMPANY
Consulting Engineers
2835 LEBANON ROAD - P.O. BOX 140350 • (615) 883-3243 • FAX NO. (615) 391-3710
NASHVILLE, TENNESSEE 37214

July 14, 2005

RECEIVED
JUL 15 2005

Division of Water Pollution Control
Watershed Management Section
7th Floor, L & C Annex
401 Church Street
Nashville, TN 37243-1534

RE: Proposed TMDL for Pathogens, Caney Fork Watershed (HUC 05130108), TN

Dear Sir or Madam:

This letter will serve as a public comment on the subject proposed TMDL on behalf of the City of Smithville, Tennessee. As you know, the City of Smithville operates a wastewater treatment plant that discharges to Fall Creek, a waterbody listed as impaired. The comments are as enumerated hereinafter.

1. Part 6.0 Water Quality Assessment and Deviation from Goal, Page 13.

   Please correct the description of the Fall Creek Subwatershed monitoring station which contains the wording "(way d/s Monterey STP)".

2. Part 5.0 Water Quality Goal, Table 2, Page 9.

   The Smithville STP is referred to as a pollutant source in this table although the monitoring location on Page 13 is described as "100 ft. u/s Smithville STP". This document infers that the Smithville STP is to blame for the pathogen pollution in Fall Creek although the data was collected upstream. Please clarify.

Thank you for your attention to this matter.

Yours very truly,

J. R. WAUFORD & COMPANY,
CONSULTING ENGINEERS, INC.

J. Greg Davenport, P.E.
Vice President

JGD/psv

cc: Burnace Vandergriff, City Recorder
Bobby Pinegar, WWTP Operator

908 WEST BROADWAY, MARYVILLE, TENNESSEE 37801 • (865) 984-9638
50 VOLUNTEER BLVD. • JACKSON, TENNESSEE 38305 • (731) 668-1953

APPENDIX H

Response to Public Comments

Note: responses correspond to numbered comments (see Appendix G).

1. The description for the Fall Creek monitoring station has been corrected.

2. The Fall Creek monitoring station is indeed located upstream of the Smithville STP. However, Fall Creek is listed as impaired for E. coli on the 2004 Final 303(d) List based on biological data taken at 3 sampling locations, including one location downstream of the STP (mile 4.6) as indicated in Table 3, page 10. The absence of intolerant species is an indication of impairment. Although the Smithville STP is not mentioned by name, TDEC has determined the STP may be a contributing factor.