TOTAL MAXIMUM DAILY LOAD (TMDL)

for

Pathogens

in the

Watts Bar Watershed (HUC 06010201)

Bledsoe, Cumberland, Loudon, McMinn, Meigs, Monroe, Rhea, and Roane 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
DMR	Discharge Monitoring Report
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
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 Watts Bar Watershed (HUC 06010201)

<u>Impaired Waterbody Information</u>

State: Tennessee
Counties: Bledsoe, Cumberland, Loudon, McMinn, Meigs, Monroe, Rhea, and Roane
Watershed: Watts Bar (HUC 06010201)
Constituents of Concern: Pathogens

Impaired Waterbodies Addressed in This Document:

Waterbody ID	Waterbody	Miles Impaired
TN06010201011 – 1000	PAINT ROCK CREEK	12.2
TN06010201013 – 0100	MUD CREEK	7.2
TN06010201013 – 0200	GREASY BRANCH	7.3
TN06010201013 – 1000 & 2000	POND CREEK	20.2
TN06010201015 – 0100	BACON CREEK	10.2
TN06010201015 – 1000	SWEETWATER CREEK	29.3
TN06010201040 – 0600	BLACK CREEK	16.7
TN06010201065 – 1000	STEEKEE CREEK	11.0
TN06010201087 – 1000	HINES CREEK	20.3
TN060102011149 – 1000	POLECAT CREEK	13.1
TN060102011621 – 1000	CANEY CREEK	13.2

Designated Uses:

The designated use classifications for waterbodies in the Watts Bar watershed include fish and aquatic life, irrigation, livestock watering & wildlife, and recreation. Portions of Sweetwater Creek are also designated for domestic and/or industrial 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. TMDLs are generally developed for impaired waterbodies on a HUC-12 basis.

Analysis/Methodology:

The TMDLs for impaired waterbodies in the Watts Bar 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 (06010201__) 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]
0306	PAINT ROCK CREEK	TN06010201011 – 1000	**89.0**	**NA***	**NA**	**NA**	**89.0**	**89.0**	**0**
0305	MUD CREEK	TN06010201013 – 0100	**99.1**	**NA***	**NA**	**0**	**99.1**	**99.1**	**0**
	GREASY BRANCH	TN06010201013 – 0200							
	POND CREEK	TN06010201013 – 1000 & 2000							
0304	BACON CREEK	TN06010201015 – 0100	**89.1**	**7.154×10^9**	**0**	**0**	**89.1**	**89.1**	**0**
	SWEETWATER CREEK	TN06010201015 – 1000							
0503	BLACK CREEK	TN06010201040 – 0600	**40.1**	**7.869×10^9**	**0**	**NA**	**NA**	**40.1**	**0**
0302	STEEKEE CREEK	TN06010201065 – 1000	**91.0**	**NA***	**NA**	**NA**	**91.0**	**91.0**	**0**
0303	HINES CREEK	TN06010201087 – 1000	**92.3**	**NA***	**NA**	**NA**	**92.3**	**92.3**	**0**
	POLECAT CREEK	TN060102011149 – 1000							
0402	CANEY CREEK	TN060102011621 – 1000	**>65.0**	**NA***	**NA**	**NA**	**NA**	**>65.0**	**0**

Note: NA = Not Applicable.

* Future WWTFs must meet instream water quality standards at the point of discharge as specified in their NPDES permit.

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.

PATHOGEN TOTAL MAXIMUM DAILY LOAD (TMDL)
WATTS BAR WATERSHED (HUC 06010201)

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 Watts Bar watershed, identified on the Final 2004 303(d) list as not supporting designated uses due to E. coli. 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.

3.0 WATERSHED DESCRIPTION

The Watts Bar watershed (HUC 06010201) is located in East Tennessee (Figure 1), primarily in Loudon, Rhea, and Roane Counties. The Watts Bar watershed lies within two Level III ecoregions (Ridge and Valley, Southwestern Appalachians) and contains five Level IV ecoregions as shown in Figure 2 (USEPA, 1997):

- **The Southern Limestone/Dolomite Valleys and Low Rolling Hills (67f)** form a heterogeneous region composed predominantly of limestone and cherty dolomite. Landforms are mostly low rolling ridges and valleys, and the solids vary in their productivity. Landcover includes intensive agriculture, urban and industrial, or areas of thick forest. White oak forests, bottomland oak forests, and sycamore-ash-elm riparian forests are the common forest types, and grassland barrens intermixed with cedar-pine glades also occur here.

- **The Southern Shale Valleys (67g)** consist of lowlands, rolling valleys, and slopes and hilly areas that are dominated by shale materials. The northern areas are associated with Ordovician-age calcareous shale, and the well-drained soils are often slightly acid to neutral. In the south, the shale valleys are associated with Cambrian-age shales that contain some narrow bands of limestone, but the soils tend to be strongly acid. Small farms and rural residences subdivide the land. The steeper slopes are used for pasture or have reverted to brush and forested land, while small fields of hay, corn , tobacco, and garden crops are grown on the foot slopes and bottomland.

- **The Southern Dissected Ridges and Knobs (67i)** contain more crenulated, broken, or hummocky ridges, compared to smoother, more sharply pointed sandstone ridges. Although shale is common, there is a mixture and interbedding of geologic materials. The ridges on the east side of Tennessee's Ridge and Valley tend to be associated with the Ordovician-age Sevier shale, Athens shale, and Holston and Lenoir limestones. These can include calcareous shale, limestone, siltstone, sandstone, and conglomerate. In the central and western part of the ecoregion, the shale ridges are associated with the Cambrian-age Rome Formation: shale and siltstone with beds of sandstone. Chestnut oak forests and pine forests are typical for the higher elevations of the ridges, with areas of white oak, mixed mesophytic forest, and tulip poplar on the lower slopes, knobs, and draws.

- **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.

The Watts Bar watershed, located in Bledsoe, Cumberland, Loudon, McMinn, Meigs, Monroe, Rhea, and Roane Counties, Tennessee, has a drainage area of approximately 684 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 Watts Bar watershed have occurred since 1993 as a result of development, this is the most current land use data available. Land use for the Watts Bar watershed is summarized in Table 1 and shown in Figure 3. Predominant land use in the Watts Bar watershed is forest (70.4%) followed by agriculture (18.7%). Urban areas represent approximately 1.9% of the total drainage area of the watershed. Details of land use distribution of impaired subwatersheds in the Watts Bar watershed are presented in Appendix A.

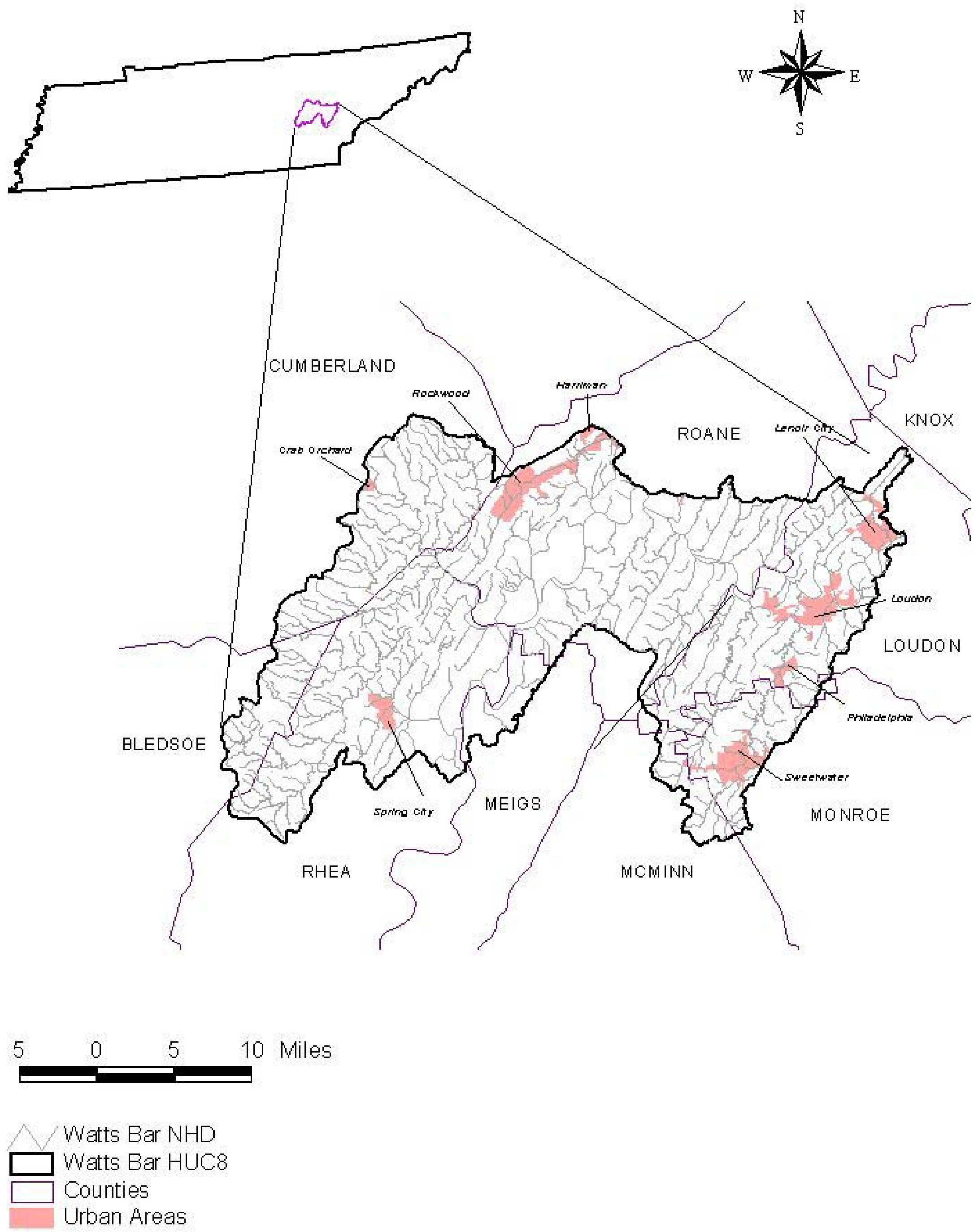

Figure 1. Location of the Watts Bar Watershed.

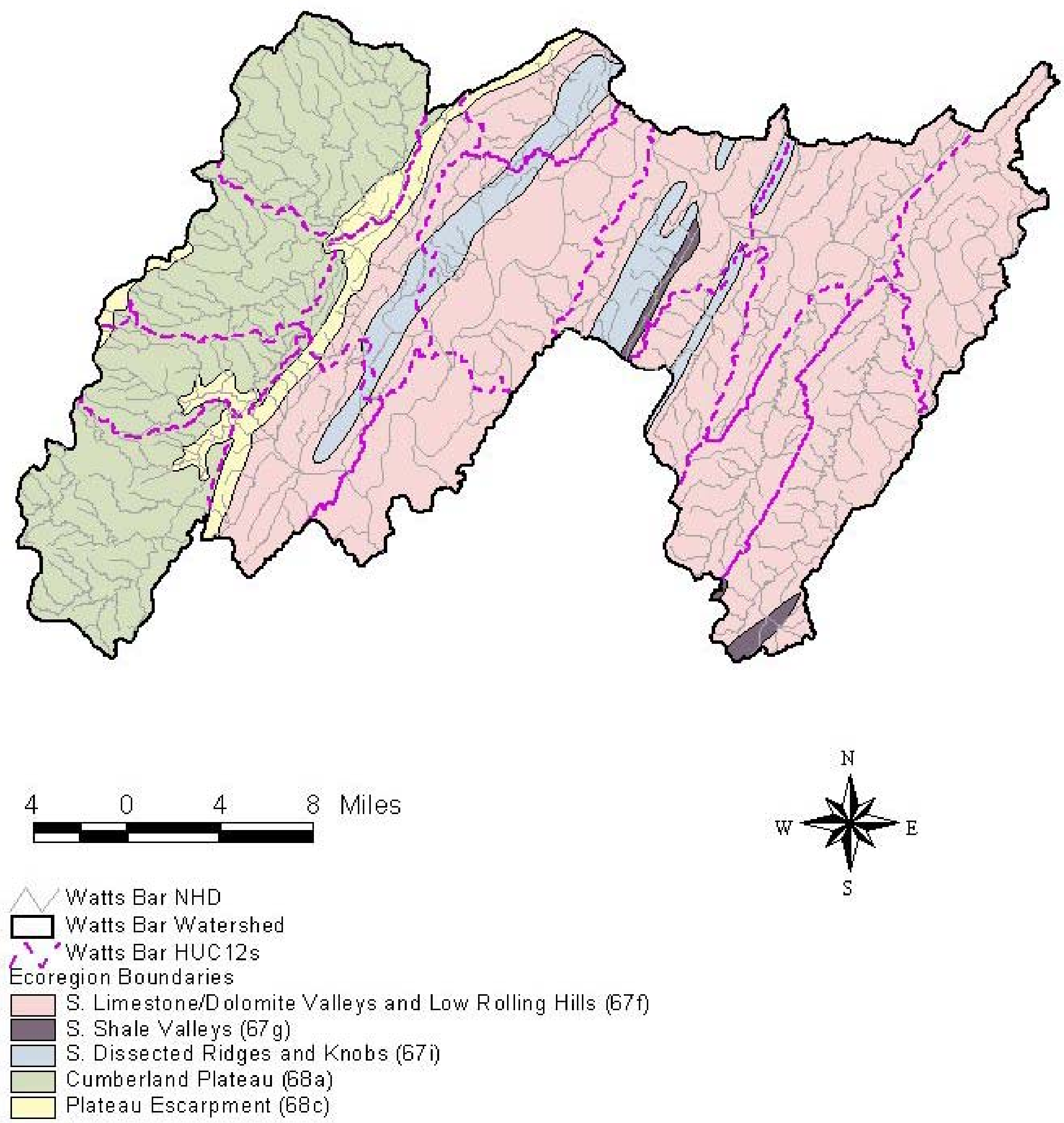

Figure 2. Level IV Ecoregions in the Watts Bar Watershed.

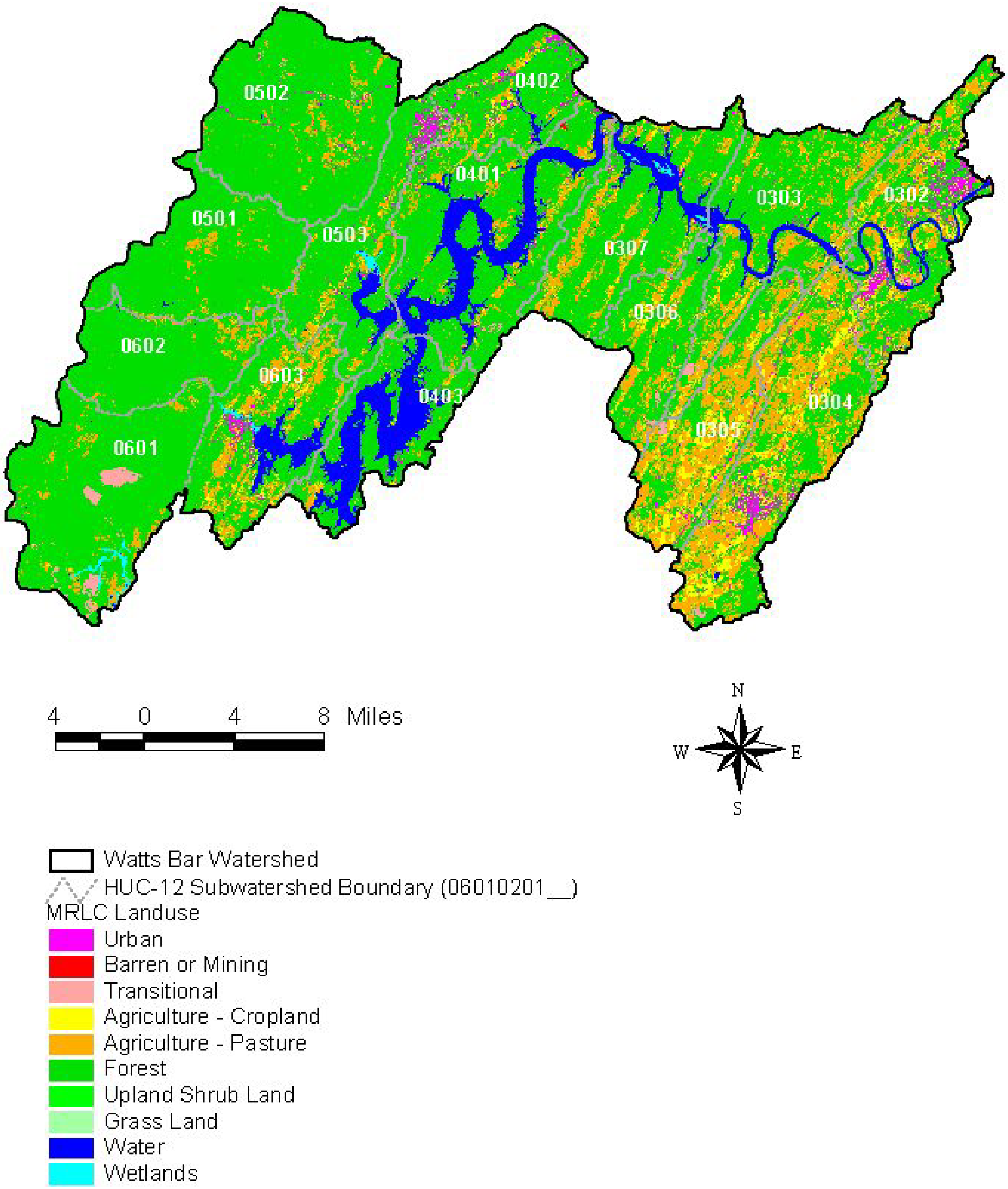

Figure 3. Land Use Characteristics of the Watts Bar Watershed.

Table 1. MRLC Land Use Distribution – Watts Bar Watershed

Land Use	Area	
	[acres]	[%]
Bare Rock/Sand/Clay	0	0.0
Deciduous Forest	159,474	37.3
Emergent Herbaceous Wetlands	253	0.1
Evergreen Forest	61,745	14.4
High Intensity Commercial/Industrial/ Transportation	3,144	0.7
High Intensity Residential	603	0.1
Low Intensity Residential	4,917	1.1
Mixed Forest	79,790	18.7
Open Water	31,050	7.3
Other Grasses (Urban/recreational)	2,930	0.7
Pasture/Hay	65,254	15.3
Quarries/Strip Mines/ Gravel Pits	44	0.0
Row Crops	14,490	3.4
Transitional	2,835	0.7
Woody Wetlands	1,031	0.2
Total	**427,560**	**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 eleven waterbodies in the Watts Bar watershed as not supporting designated use classifications due, in part, to E. coli (see Table 2). The designated use classifications for these waterbodies include fish and aquatic life, irrigation, livestock watering & wildlife, and recreation. Portions of Sweetwater Creek are also designated for domestic and/or industrial 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 fecal coliform and E. coli 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 Watts Bar waterbodies include fish & aquatic life, recreation, irrigation, and livestock watering & wildlife. Portions of Sweetwater Creek are also designated for domestic and/or industrial 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.

None of the impaired waterbodies in the Watts Bar 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 – Watts Bar Watershed

Waterbody ID	Impacted Waterbody	Miles/Acres Impaired	Cause (Pollutant)	Pollutant Source
TN06010201011-1000	PAINT ROCK CREEK	12.2	Escherichia coli	Pasture Grazing
TN06010201013 – 0100	MUD CREEK	7.2	Escherichia coli	Pasture Grazing
TN06010201013 – 0200	GREASY BRANCH	7.3	Escherichia coli	Pasture Grazing
TN06010201013 – 1000 & 2000	POND CREEK	21.1	Nitrates Physical Substrate Habitat Alterations Echerichi coli	Pasture Grazing Livestock in Stream Animal Feeding Operations (NPS)
TN06010201015-0100	BACON CREEK	10.0	Nitrates Escherichia coli	Pasture Grazing Animal Feeding Operations (NPS)
TN06010201015-1000	SWEETWATER CREEK	29.3	Nitrates Siltation Escherichia coli	Municipal Point Source Discharge Channelization Pasture Grazing Land Development Animal Feeding Operations (NPS)
TN06010201040-0600	BLACK CREEK	16.7	Polycyclic Aromatic Hydrocarbons (PAHs) Organic Enrichment Physical Substrate Habitat Alterations Escherichia coli	Municipal Point Source Discharge Collection System Failures RCRA Hazardous Waste Channelization
TN06010201065-1000	STEEKEE CREEK	11.0	Physical Substrate Habitat Alterations Siltation Escherichia coli	Pasture Grazing

Table 2 (cont'd). Final 2004 303(d) List for E. coli Impaired Waterbodies – Watts Bar Watershed

Waterbody ID	Impacted Waterbody	Miles/Acres Impaired	Cause (Pollutant)	Pollutant Source
TN06010201087-1000	HINES CREEK	20.3	Escherichia coli	Pasture Grazing
TN060102011149-1000	POLECAT CREEK	13.1	Escherichia coli	Pasture Grazing
TN060102011621-1000	CANEY CREEK	13.2	Physical Substrate Habitat Alteration Siltation Escherichia coli	Pasture Grazing Collection System Failure

Table 3. Water Quality Assessment of Waterbodies Impaired Due to E. coli – Watts Bar Watershed

Waterbody ID	Segment Name	Comments
TN06010201011-1000	PAINT ROCK CREEK	2002 biorecon and bacteria station at RM3.1; 19 EPT, 12 intolerant, 54 total genera. BR score = 15. Habitat score = 134. G.M. all pathogen samples = 686. Non-rain event G.M. = 578.
TN06010201013 – 0100	MUD CREEK	Monitored by UT Students. 6 out of 7 E.coli observations over 1000.
TN06010201013 – 0200	GREASY BRANCH	Monitored by UT Students. 5 out of 6 E.coli observations over 1000.
TN06010201013 – 1000 & 2000	POND CREEK	2001 TDEC RBPIII station at RM2.3; 13 EPT, 33 total genera. Index score = 42. Habitat score = 173. Passed biocriteria, but this site may not be representative of the rest of the stream. 2001 TDEC RBPIII station at RM8.2; 5 EPT, 21 total genera. Index score = 20. Habitat score = 100. Failed biocriteria. Monitored by UTK in 2001; 24 out of 33 E.coli observations over 1000.
TN06010201015-0100	BACON CREEK	2002 TDEC RBPIII, chemical and bacteria station at RM0.1; 6 EPT, 31 total genera. Index score = 32. Habitat score = 115. Passed biocriteria. 7 out of 12 pathogen samples exceeded 1000.
TN06010201015-1000	SWEETWATER CREEK	2002 TDEC RBPIII, chemical, & bacteria station at RM3.2; 7 EPT, 16 total genera. Index score core = 34. Habitat score = 133. Passed biocriteria. 3 out of 12 pathogen samples over 940. 2002 TDEC RBPIII, chemical, & bacteria station at RM9.3; 5 EPT, 17 total genera. Index score = 26. Habitat score = 92. Failed biocriteria. 7 out of 12 pathogen samples over 940. 2002 TDEC RBPIII, chemical, & bacteria station at RM17.3; 2 EPT, 21 total genera. Index score = 14. Habitat score = 123. Failed biocriteria. 9 out of 12 pathogen samples over 940. 2002 TDEC RBPIII, chemical, & bacteria station at RM19.4; 5 EPT, 26 total genera. Index score = 30. Habitat score = 98. Failed biocriteria. 5 out of 12 pathogen samples over 940. 2002 TDEC RBPIII, chemical, & bacteria station at RM23.3; 7 EPT, 25 total genera. Index score = 36. Habitat score = 90. Passed biocriteria. 2 out of 12 pathogen samples over 940.
TN06010201040-0600	BLACK CREEK	2002 TDEC RBPIII and bacteria station at RM3.2; 3 EPT, 18 total genera. Index score = 26. Habitat score = 131. Failed biocriteria. 3 out of 10 pathogen samples over 940. E.coli G.M. = 375.

Table 3 (cont'd). Water Quality Assessment of Waterbodies Impaired Due to E. coli – Watts Bar Watershed

Waterbody ID	Segment Name	Comments
TN06010201065-1000	STEEKEE CREEK	2002 TDEC RBPIII and bacteria station at mile 0.7; 6 EPT genera, 31 total genera. Index score = 24. Habitat score = 103. Failed biocriteria. 5 out of 10 pathogen samples over 940. E.coli G.M. = 637.
TN06010201087-1000	HINES CREEK	2002 TDEC biorecon and bacteria station at RM2.7; 11 EPT, 6 intolerant, 34 total genera. BR score = 11. Habitat score = 111. 2 out of 10 samples over 940. E.coli G.M. = 648.
TN060102011149-1000	POLECAT CREEK	2020 TDEC biorecon & bacteria station at Rm1.4; 14 EPT, 7 intolerant, 41 total genera. BR score = 11. Habitat score = 122. 6 out of 10 over 940. E.coli G.M. = 1108.
TN060102011621-1000	CANEY CREEK	2002 TDEC RBPIII biorecon & bacteria station at RM4.3; 4 EPT, 27 total genera. Index score = 24. Habitat score = 86. Failed biocriteria. 8 out of 10 pathogen samples over 940. E.coli G.M. = 1236.

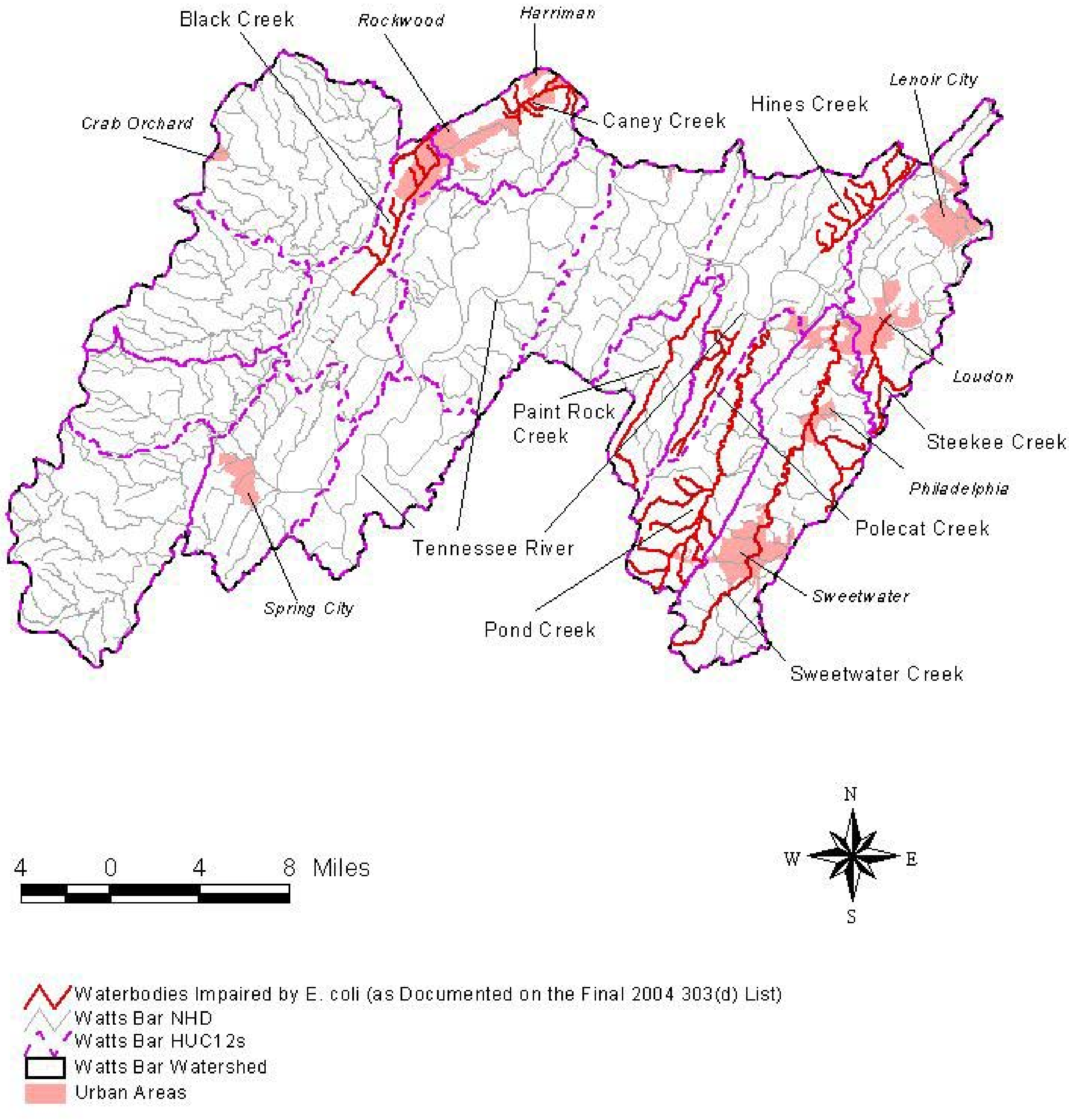

Figure 4. Waterbodies Impaired by E. Coli (as Documented on the Final 2004 303(d) List).

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 Watts Bar watershed:

- Bacon Creek Subwatershed:
  - BACON000.1LO – Bacon Creek, downstream of Spring St. bridge
- Black Creek Subwatershed:
  - BLACK002.2RO – Black Creek, 2nd bridge from mouth on Whites Creek
  - BLACK003.3RO – Black Creek, at Black Creek Rd.
- Caney Creek Subwatershed:
  - CANEY004.3RO – Caney Creek, d/s of Hwy 27 bridge, near embayment
- Greasy Branch Subwatershed:
  - GREAS000.5MO – Greasy Branch, on Bright farm
- Hines Creek Subwatershed:
  - HINES002.7LO – Hines Creek, at Hall Rd. bridge
- Mud Creek Subwatershed:
  - MUD001.9MO – Mud Creek, d/s of confluence of east and west tribs of Mud Crk
- Paint Rock Creek Subwatershed:
  - PAINT003.1RO – Paint Rock Creek at Tennessee Chapel Rd. bridge
- Polecat Creek Subwatershed:
  - POLEC001.4LO – Polecat Creek, at private br between Hwy 72 and embayment
- Pond Creek Subwatershed:
  - POND002.3LO – Pond Creek, at Bradshaw Rd.; dirt rd ends at ford
  - POND005.7LO – Pond Creek, at bridge on Jim Dyke Rd.
  - POND008.2LO – Pond Creek, at Bright Rd., d/s of PC-3
  - POND008.3LO – Pond Creek, at Pond Creek Rd. bridge; at junction with Bright Rd. & Barr farm
  - POND011.0LO – Pond Creek, along New Hope Church Rd.; A.J. Smith property
  - POND013.1MO – Pond Creek, New Hope Church Rd. bridge
  - POND013.9MO – Pond Creek, at private wooden bridge; Bright farm by spring
- Steekee Creek Subwatershed:
  - STEEK000.7LO – Steekee Creek, at Blairland Baptist
  - STEEK002.0LO – Steekee Creek, u/s site xing

- Sweetwater Creek Subwatershed:
    - SWEET001.4LO – Sweetwater Creek, at River Rd. bridge
    - SWEET003.1LO – Sweetwater Creek, in Loudon City Park, at Roberson Springs Rd. bridge
    - SWEET003.2LO – Sweetwater Creek, at Robertson Spring Rd.
    - SWEET009.3LO – Sweetwater Creek, at Pond Creek Rd. bridge; d/s town of Philadelphia
    - SWEET010.4LO – Sweetwater Creek, at Washington Pike bridge, u/s of Philadelphia
    - SWEET013.7MO – Sweetwater Creek, at Jones Rd. bridge
    - SWEET017.3MO – Sweetwater Creek, at Hwy 11 bridge; d/s of Sweetwater
    - SWEET019.3MO – Sweetwater Creek, u/s of Sweetwater STP discharge; d/w of new Hwy 322 bridge
    - SWEET023.3MO – Sweetwater Creek, at Head-of-Creek Rd. bridge; near Monroe-McMinn county line

Additional monitoring was conducted by UTK at several of the same locations as listed above:

- Greasy Branch Subwatershed:
    - GS – same as GREAS000.5MO
- Mud Creek Subwatershed:
    - MC – same as MUD001.9MO
- Pond Creek Subwatershed:
    - PC1 – same as POND002.3LO
    - PC2 – same as POND005.7LO
    - PC3 – same as POND008.3LO
    - PC4 – same as POND0011.0LO
    - PC5 – same as POND013.1MO
    - PC6 – same as POND013.9MO

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 941 counts/100 mL maximum E. coli standard and the 1,000 counts/100 mL maximum fecal coliform criterion at many monitoring stations. Water quality monitoring results for those stations with 10% of samples in violation of water quality standards are summarized in Tables 4 (TDEC) and 5 (UTK).

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 calculated geometric means were in violation of the 200 counts/100 mL geometric mean for fecal coliform.

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

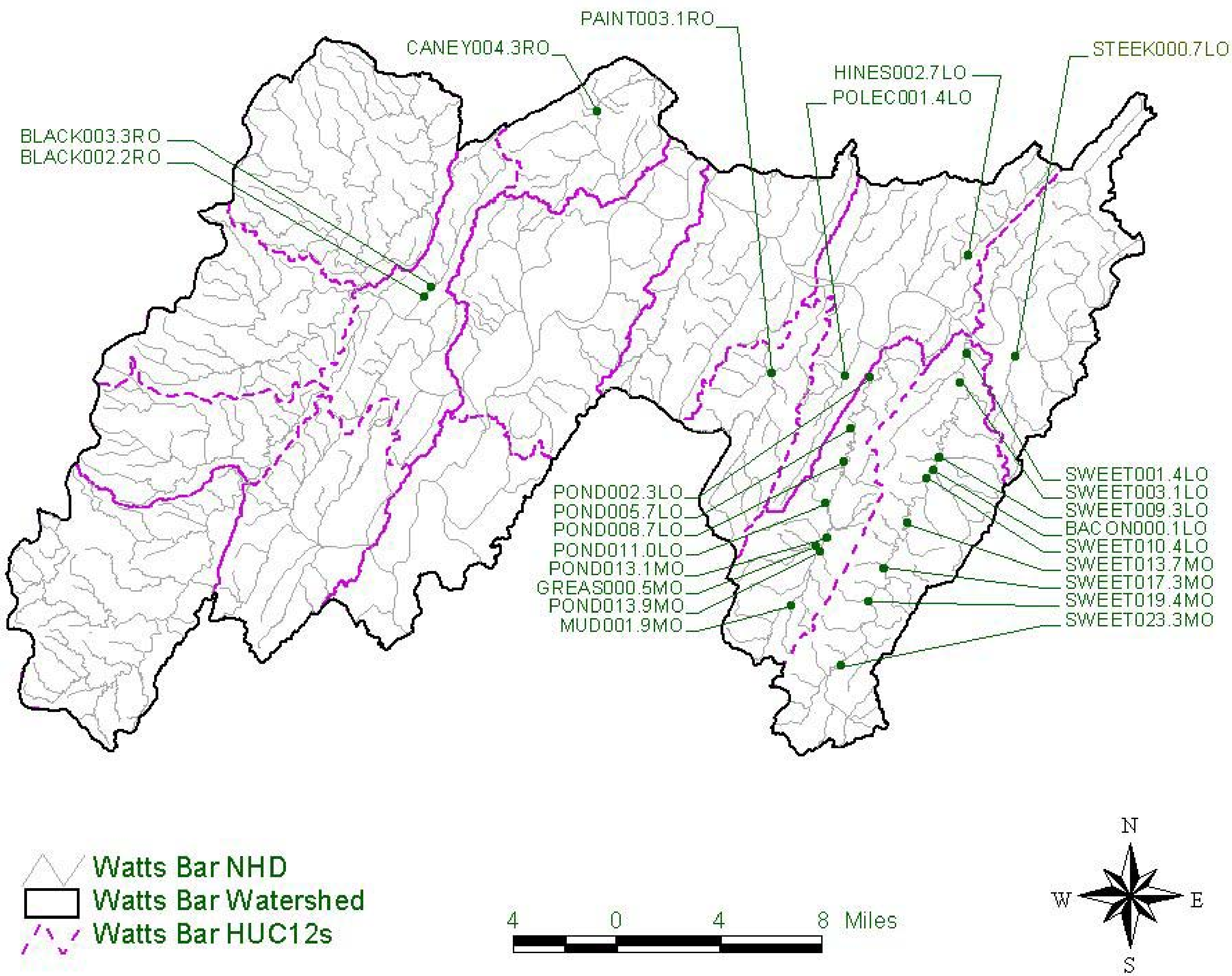

Figure 5. Water Quality Monitoring Stations in the Watts Bar Watershed

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.		
BACON000.1LO	2003	8	84	1,341	3,590	6	75.0%	8	180	1,720	5,000	5	62.5%
BLACK003.3RO	2002	7	161	717	1,733	2	28.6%	0					
CANEY004.3RO	2002	7	1,120	>2,089	>2,419	7	100.0%	0					
GREAS000.5MO	2002	1	1,300	1,300	1,300	1	100.0%	1	1,900	1,900	1,900	1	100.0%
HINES002.7LO	2002	9	276	683	1,733	1	11.1%	0					
MUD001.9MO	2002	1	1,046	1,046	1,046	1	100.0%	1	1,100	1,100	1,100	1	100.0%
PAINT003.1RO	2002	9	228	1,001	>2,419	4	44.4%	0					
POLEC001.4LO	2002	9	378	>1,349	>2,419	6	66.7%	0					
POND002.3LO	2002	1	1,414	1,414	1,414	1	100.0%	1	1,900	1,900	1,900	1	100.0%
POND005.7LO	2002	1	3,310	3,310	3,310	1	100.0%	1	2,600	2,600	2,600	1	100.0%
POND008.3LO	2002	1	>2,419	>2,419	>2,419	1	100.0%	1	2,200	2,200	2,200	1	100.0%
POND011.0LO	2002	1	1,986	1,986	1,986	1	100.0%	1	1,000	1,000	1,000	0	0.0%
POND013.1	2002	1	3,180	3,180	3,180	1	100.0%	1	2,000	2,000	2,000	1	100.0%
POND013.9	2002	1	1,986	1,986	1,986	1	100.0%	1	1,100	1,100	1,100	1	100.0%
STEEK000.7LO	2000 – 2002	10	326	>1,373	>2,419	6	60.0%	1	1,060	1,060	1,060	1	100.0%
SWEET001.4LO	2003	9	83	1,466	8,840	2	22.2%	9	76	1,736	8,900	4	44.4%
SWEET003.1LO	2003	9	60	1,233	5,560	2	22.2%	9	104	1,384	6,200	4	44.4%
SWEET009.3LO	2003	9	397	1,701	4,430	5	55.5%	9	400	1,733	3,400	5	55.5%
SWEET010.4LO	2003	9	517	3,853	9.840	7	77.8%	9	220	2,979	7,300	6	66.7%

Table 4 (cont'd). 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.		
SWEET013.7MO	2003	9	517	1,070	3,230	2	22.2%	9	122	1,072	2,000	5	55.5%
SWEET017.3MO	2003	9	205	2,160	6,830	6	66.7%	9	168	2,131	4,800	6	66.7%
SWEET019.4MO	2003	9	260	>999	>2,419	3	33.3%	9	260	1,018	2,500	3	33.3%
SWEET023.3MO	2003	9	22	410	1,414	1	11.1%	9	92	566	2,300	2	22.2%

Table 5. Summary of UTK Water Quality Monitoring Data

Monitoring Station (UTK/TDEC)	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.		
GS/GREAS000.5MO	2001 – 2002	11	300	32,888	241,920	9	81.8%	11	770	7,685	50,000	10	90.9%
MC/MUD001.9MO	2001 – 2002	12	<1	10,717	43,520	9	75.0%	12	<1	5,702	23,000	10	83.3%
PC-1/POND002.3LO	2001 – 2002	12	33.2	10,721	82,979	5	41.7%	12	600	3,182	13,000	8	66.7%
PC-2/POND005.7LO	2001 – 2002	12	410.6	6,839	32,550	10	83.3%	12	1,275	4,406	18,000	12	100.0%
PC-3/POND008.3LO	2001 – 2002	12	520	12,140	86,640	11	91.7%	12	1,200	6,550	33,000	12	100.0%
PC-4/POND011.0LO	2001 – 2002	12	517	30,625	173,290	10	83.3%	12	1,000	10,783	65,000	11	91.7%
PC-5/POND013.1MO	2001 – 2002	12	980	13,383	72,700	12	100.0%	12	1,700	6,996	22,000	12	100.0%
PC-6/POND013.9MO	2001 – 2002	11	160	6,868	41,060	8	72.7%	11	400	3,136	10,500	8	72.7%

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 9 NPDES permitted WWTFs that require monitoring of fecal coliform and/or E. coli within the Watts Bar 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).

Two of these facilities are located in impaired subwatersheds of the Watts Bar watershed. The Sweetwater Sewage Treatment Plant (STP) (TN0020052), with a design capacity of 1.5 MGD, discharges to Sweetwater Creek at mile 19.4. Seven of the nine permit violations recorded in 2003 were for overflows. A collection system rehab is in progress. The Rockwood STP (TN0026158), with a design capacity of 1.65 MGD, discharges to Black Creek at mile 5.3. A compliance evaluation inspection conducted in December 2004 reported numerous violations, including increased flow due to infiltration and inflow in collection systems and peak flows (greater than 5 MGD) in excess of the design capacity. Also, no bypasses or overflows were reported on Discharge Monitoring Reports (DMRs) between October 1, 2003 and September 30, 2004, although overflows had occured. 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 Watts Bar 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.

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

NPDES Permit Number	Phase	Permittee Name	Issuance Date	Effective Date	Expiration Date
TNS077798	II	City of Lenoir City	3/8/04	9/22/03	2/26/08
TNS075591	II	Loudon County	3/8/04	10/15/03	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 I CAFOs with individual permits located in the watershed. There are four Class II CAFOs in the Watts Bar watershed with coverage under the general NPDES permit (see Figure 6). The four CAFOS in the Watts Bar watershed are as follows:

NPDES Permit Number	Permittee Name	Watershed	Issuance Date	Effective Date	Expiration Date
TNA000021	Watson Dairy	Pond	8/30/99	8/30/99	4/30/04
TNA000023	Holt Dairy Farm	Pond	8/30/99	8/30/99	4/30/04
TNA000025	Springbrook Farm	Pond	8/30/99	8/30/99	4/30/04
TNA000033	Sweetwater Valley Farms	Sweetwater	8/30/99	8/30/99	4/30/04

All of these CAFOs submitted incomplete applications and have been operating in violation of the Tennessee Water Quality Control Act. All previous permits have expired and new applications had not been received by March 1, 2005. All applicants were notifed on February 11, 2005 of the need to submit applications within 30 days.

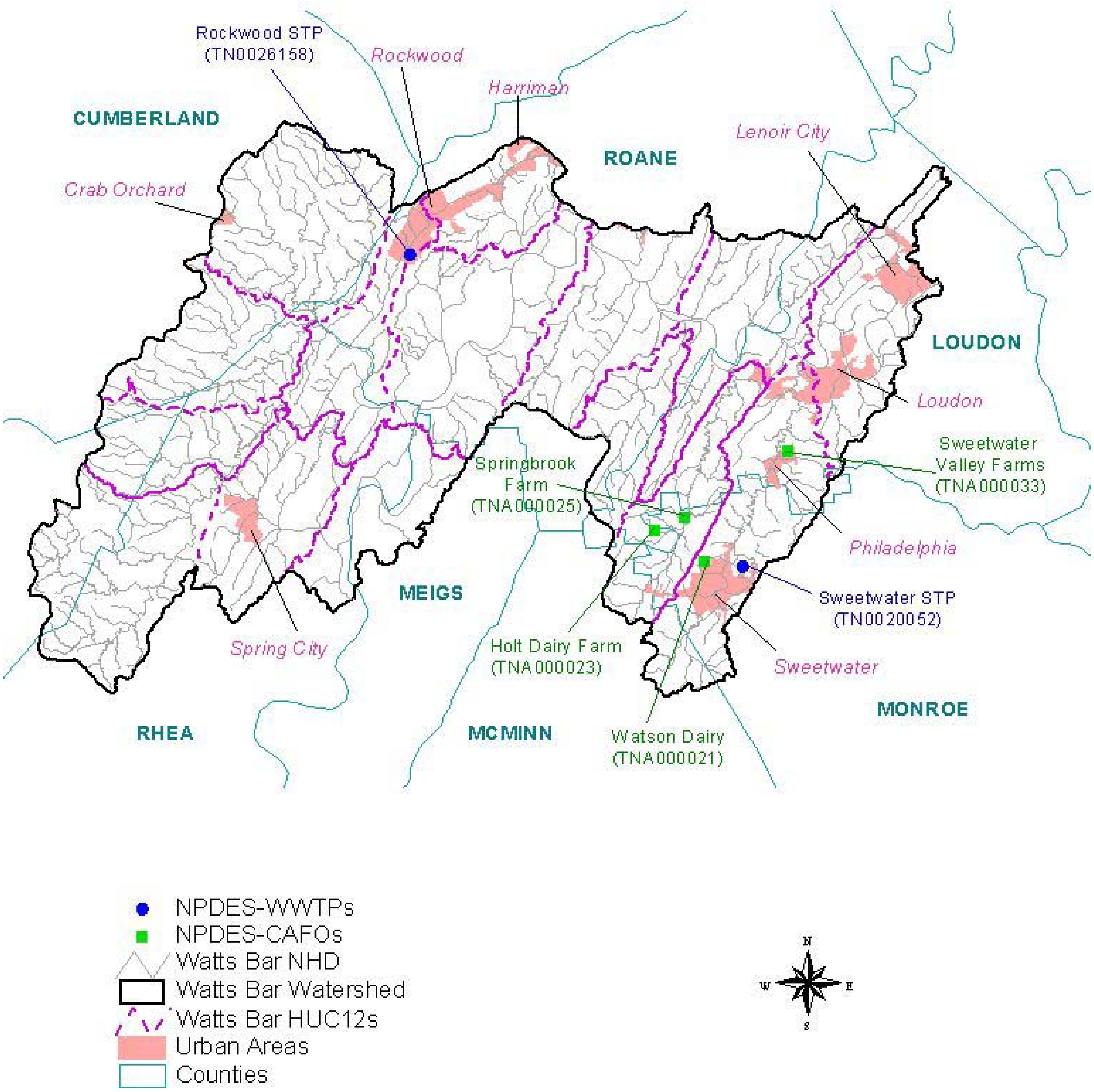

Figure 6. NPDES Regulated Point Sources in and near the Watts Bar Watershed.

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. The vast majority of 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 Watts Bar 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 is summarized in Table 6. Populations were rounded to the nearest 25 cows, 50 poultry, and 5 hogs, sheep, and horses.

Table 6. Livestock Distribution in the Watts Bar Watershed

Subwatershed	Livestock Population (WCS)					
	Beef Cow	Milk Cow	Poultry	Hogs	Sheep	Horse
Paint Rock Creek	600	100	1,050	10	15	90
Mud Creek	224	100	57,800	5	0	120
Greasy Branch	150	50	14,400	0	0	60
Pond Creek	1,175	425	84,200	15	20	420
Bacon Creek	200	75	0	0	5	85
Sweetwater Creek	1,825	675	110,500	25	30	720
Black Creek	175	0	0	5	5	30
Steekee Creek	300	100	0	0	10	30
Hines Creek	450	150	0	0	10	45
Polecat Creek	325	100	0	0	10	55
Caney Creek	125	0	0	0	0	25

7.2.3 Failing Septic Systems

Some coliform loading in the Watts Bar 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 Watts Bar watershed utilizing septic systems were compiled using the WCS and are summarized in Table 7. 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 7. Population on Septic Systems in the Watts Bar Watershed

Subwatershed	Population on Septic Systems	Subwatershed	Population on Septic Systems
Paint Rock Creek	2,203	Black Creek	1,248
Mud Creek	627	Steekee Creek	450
Greasy Branch	339	Hines Creek	771
Pond Creek	2,416	Polecat Creek	610
Bacon Creek	398	Caney Creek	698
Sweetwater Creek	3,640		

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. Black Creek has the highest percentage of urban land area for impaired waterbodies in the Watts Bar watershed, with 11.4%. Land use for the Watts Bar impaired drainage areas is summarized in Figures 7 thru 10 and tabulated in Appendix A.

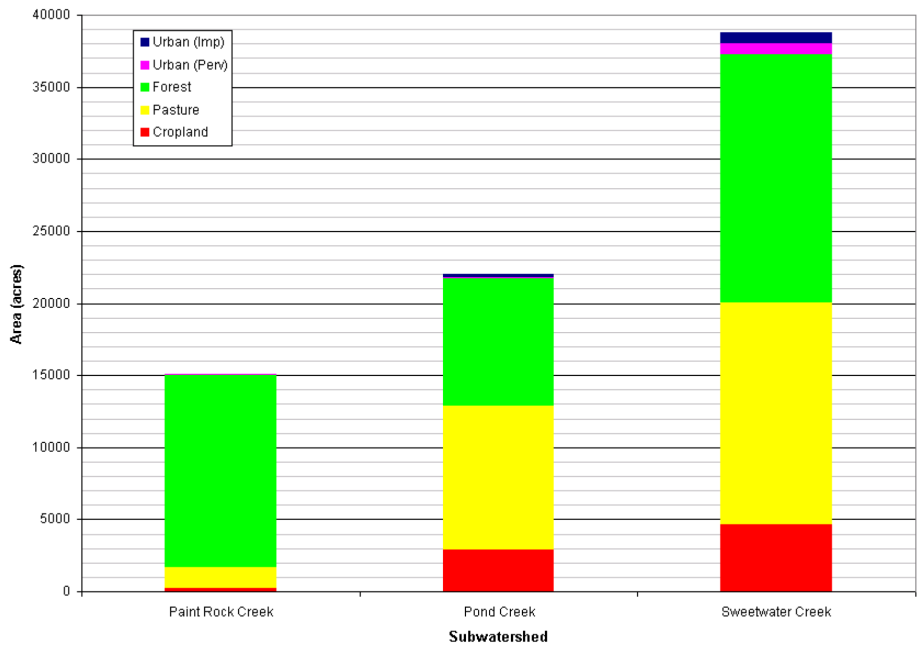

Figure 7. **Land Use Area of Watts Bar Pathogen-Impaired Subwatersheds – Drainage Areas Greater Than 10,000 Acres.**

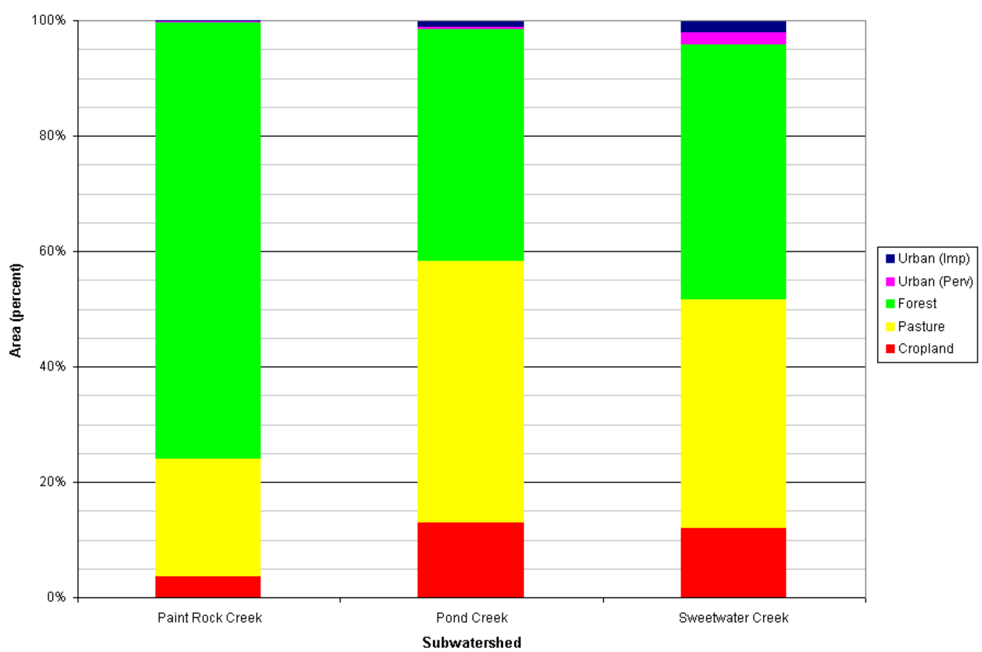

Figure 8. **Land Use Percent of the Watts Bar Pathogen-Impaired Subwatersheds – Drainage Areas Greater Than 10,000 Acres.**

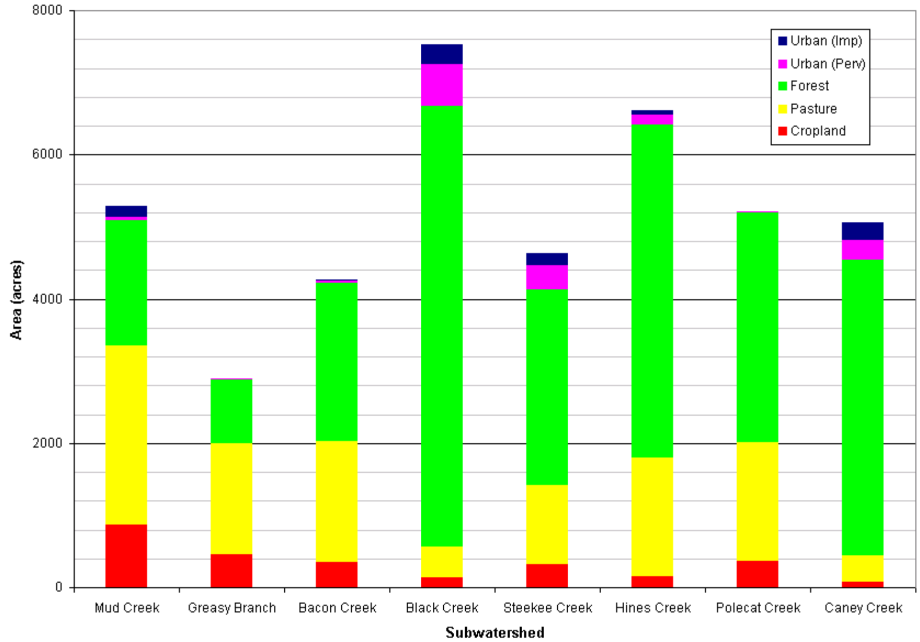

Figure 9. Land Use Area of Watts Bar Pathogen-Impaired Subwatersheds – Drainage Areas Less Than 10,000 Acres.

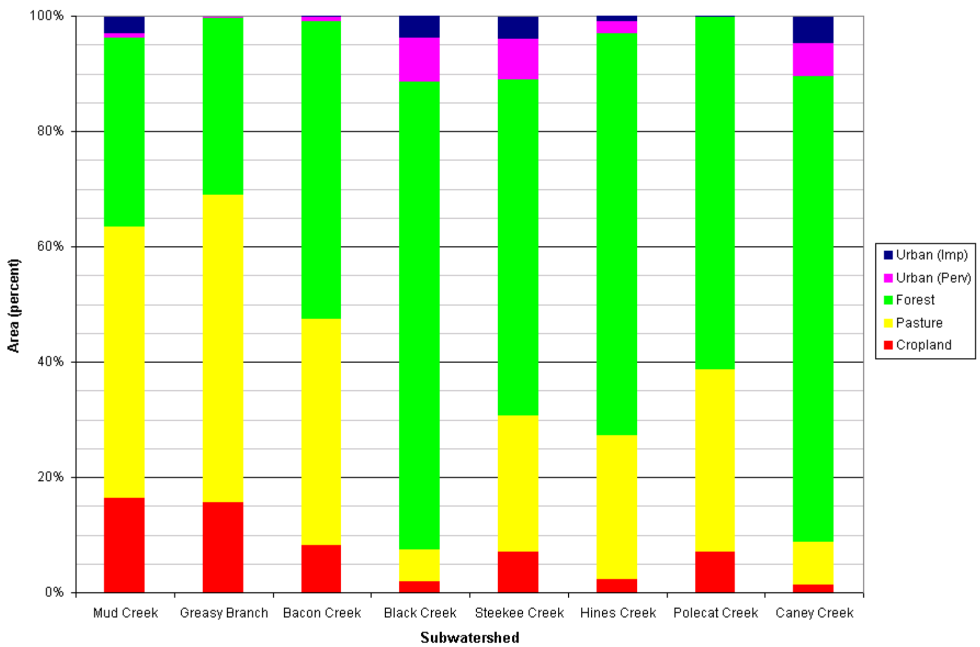

Figure 10. Land Use Percent of the Watts Bar Pathogen-Impaired Subwatersheds – Drainage Areas Less Than 10,000 Acres.

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:

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

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 Watts Bar 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 11).

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 not 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 8.

Table 8. 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 Watts Bar 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 9 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 Watts Bar Watershed impaired waterbodies are summarized in Table 10.

Table 9. Determination of TMDLs for Impaired Waterbodies, Watts Bar Watershed

HUC-12 Subwatershed (06010201__) or Drainage Area	Impaired Waterbody Name	Impaired Waterbody ID	Required Load Reduction [%]				
			Based on Target Maximum Concentration		Based on 30-day Geometric Mean Concentration		TMDL
			Fecal Coliform	E. Coli	Fecal Coliform	E. Coli	
0306	Paint Rock Creek	TN06010201011 – 1000	NA	>51.9		89.0	**89.0**
0305	Mud Creek	TN06010201013 – 0100	94.8	96.8			**99.1**
	Greasy Branch	TN06010201013 – 0200	86.7	98.5			
	Pond Creek	TN06010201013 – 1000 & 2000	95.4	99.1			
0304	Bacon Creek	TN06010201015 – 0100	72.9	59.0			**89.1**
	Sweetwater Creek	TN06010201015 – 1000	84.4	89.1			
0503	Black Creek	TN06010201040 – 0600		40.1			**40.1**
0302	Steekee Creek	TN06010201065 – 1000		>65.0		91.0	**91.0**
0303	Hines Creek	TN06010201087 – 1000		21.8		77.4	**92.3**
	Polecat Creek	TN060102011149 – 1000		>59.1		92.3	
0402	Caney Creek	TN060102011621 – 1000		>65.0			**>65.0**

Table 10. WLAs & LAs for Watts Bar Watershed, Tennessee

HUC-12 Subwatershed (06010201__) or Drainage Area	Impaired Waterbody Name	Impaired Waterbody ID	WLAs				LAs	
			WWTFs[a] (Monthly Avg.) E. Coli	Leaking Collection Systems[b]	CAFOs	MS4s[c]	Precipitation Induced Nonpoint Sources	Other Direct Sources[d]
			[cts./day]	[cts./day]	[cts./day]	[% Red.]	[% Red.]	[cts./day]
0306	PAINT ROCK CREEK	TN06010201011 – 1000	**NA***	**NA**	**NA**	**89.0**	**89.0**	**0**
0305	MUD CREEK	TN06010201013 – 0100	**NA***	**NA**	**0**	**99.1**	**99.1**	**0**
	GREASY BRANCH	TN06010201013 – 0200						
	POND CREEK	TN06010201013 – 1000 & 2000						
0304	BACON CREEK	TN06010201015 – 0100	**7.154 x 10^9**	**0**	**0**	**89.1**	**89.1**	**0**
	SWEETWATER CREEK	TN06010201015 – 1000						
0503	BLACK CREEK	TN06010201040 – 0600	**7.869 x 10^9**	**0**	**NA**	**NA**	**40.1**	**0**
0302	STEEKEE CREEK	TN06010201065 – 1000	**NA***	**NA**	**NA**	**91.0**	**91.0**	**0**
0303	HINES CREEK	TN06010201087 – 1000	**NA***	**NA**	**NA**	**92.3**	**92.3**	**0**
	POLECAT CREEK	TN060102011149 – 1000						
0402	CANEY CREEK	TN060102011621 – 1000	**NA***	**NA**	**NA**	**NA**	**>65.0**	**0**

Note: NA = Not Applicable.

* Future WWTFs must meet instream water quality standards at the point of discharge as specified in their NPDES permit.

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 Watts Bar 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 Watts Bar 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/ .

In order to meet water quality criteria for Pond Creek and Sweetwater Creek, all CAFOs must be permitted as required by the Tennessee Water Quality Control Act.

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 Watts Bar 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 Watts Bar watershed during the TMDL evaluation period. The TDA keeps a database of BMPs implemented in Tennessee. Those listed in the Watts Bar watershed are shown in Figure 11. 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.

Within the Watts Bar watershed, the UT Agricultural Extension Service is the lead organization for a project located in Pond Creek. The objective of the project is to identify nonpoint source impairments from agriculture, implement agricultural BMPs that will improve water quality, and restore the Pond Creek watershed to the condition of fully supporting its designated uses. Planned activities include installation of BMPs, formation of a stakeholder watershed management group, development of a watershed management plan, and monitoring of changes in water quality on a monthly basis. The project will be funded, in part, through a Tennessee Department of Agriculture (TDA) Nonpoint Source Program 319 grant. Additional information about this project is included in Appendix F.

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 12 thru 19) 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 11 presents Load Duration analysis statistics for E. coli in the Watts Bar 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 Black Creek and Caney Creek will require BMPs targeting primarily sources dominant during low-flow/dry conditions, while the implementation strategy for the remaining subwatersheds will require BMPS targeting non-point sources (dominant under high flow/runoff conditions). The implementation strategies listed in Table 11 are a subset of the categories of BMPs and implementation strategies available for application to the pathogen-impaired Watts Bar subwatersheds 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 Watts Bar Watershed.

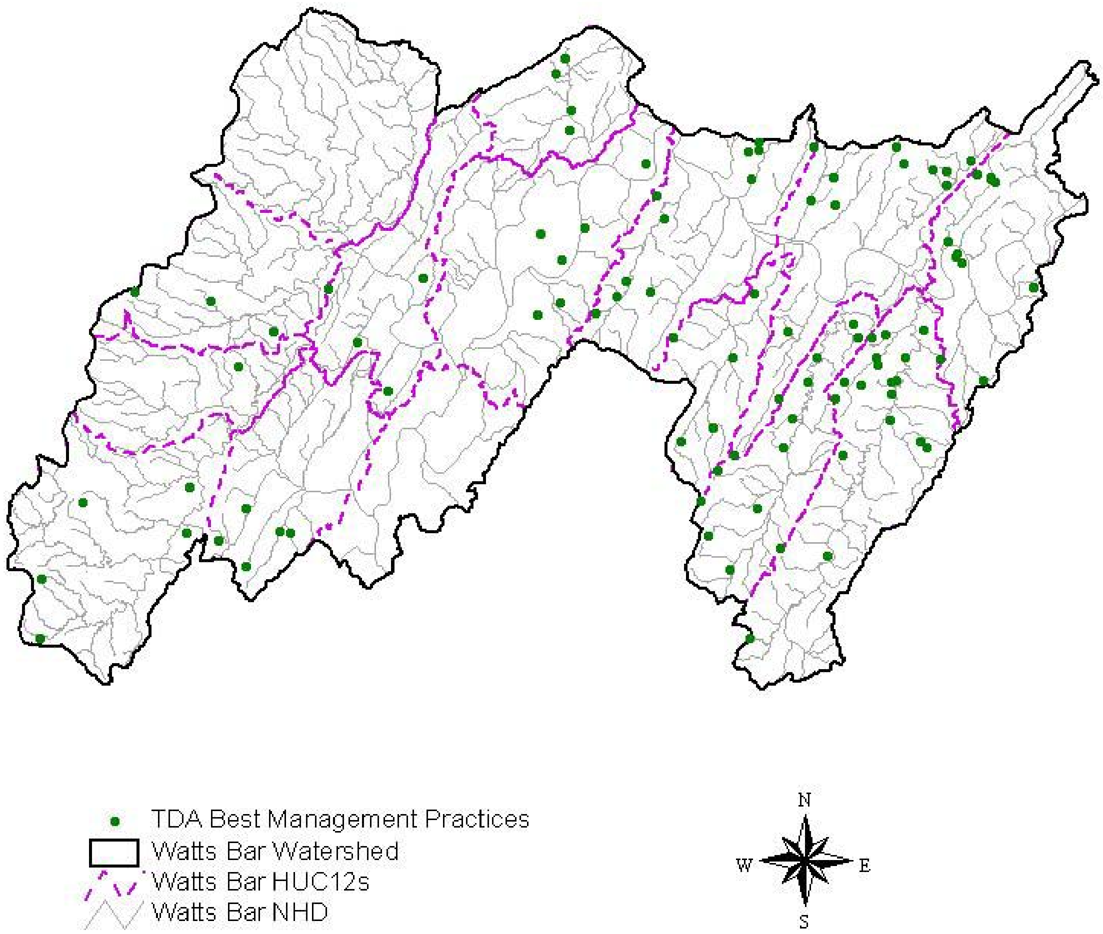

Figure 11. Tennessee Department of Agriculture Best Management Practices located in the Watts Bar Watershed.

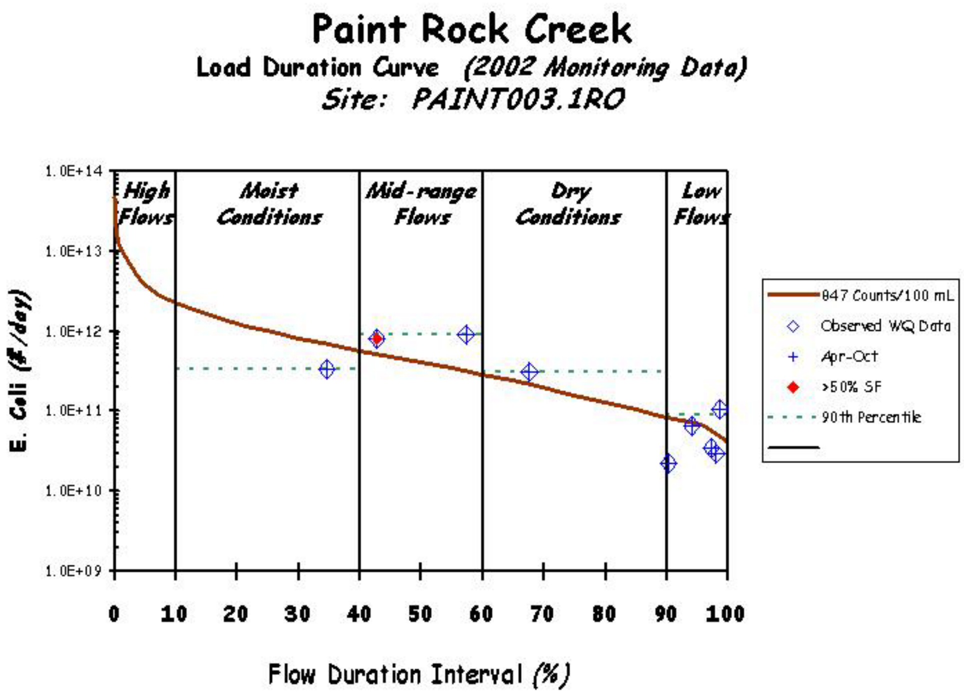

Figure 12. Load Duration Curve for Paint Rock Creek

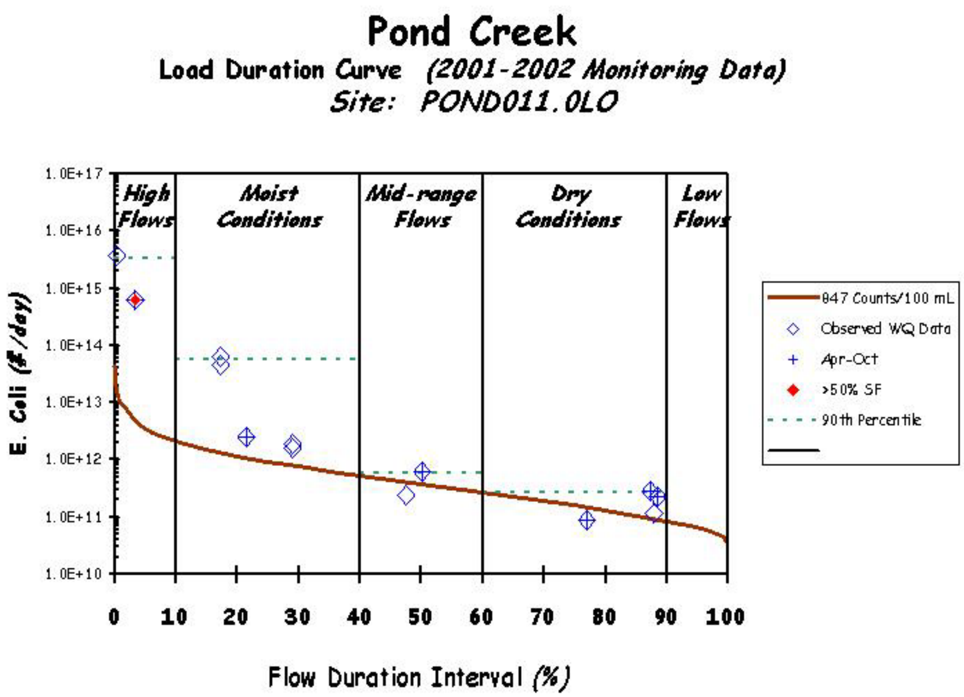

Figure 13. Load Duration Curve for Pond Creek

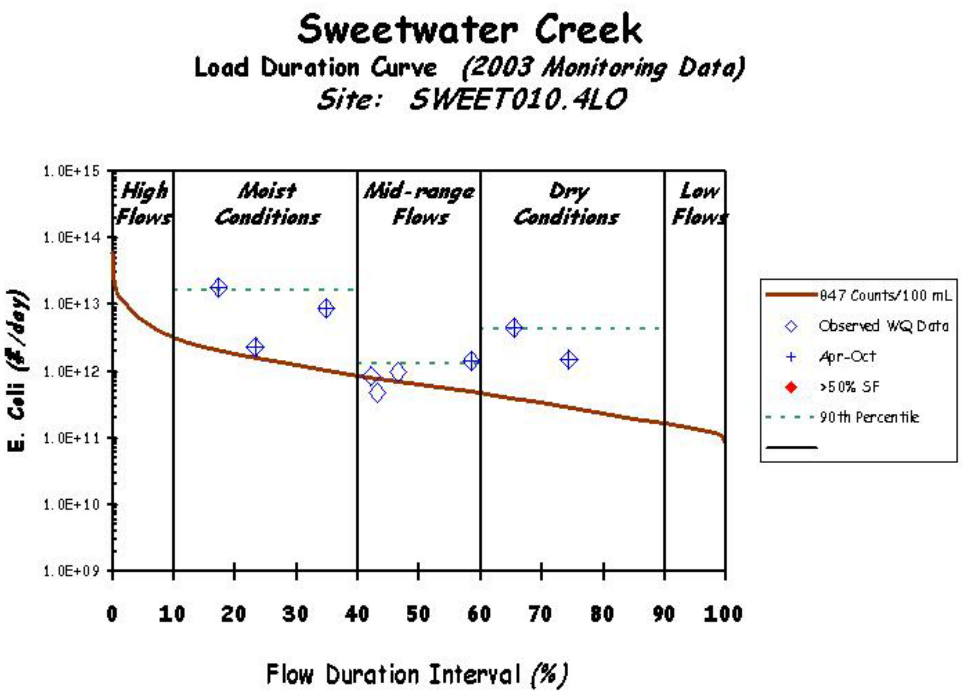

Figure 14. Load Duration Curve for Sweetwater Creek at Mile 10.4

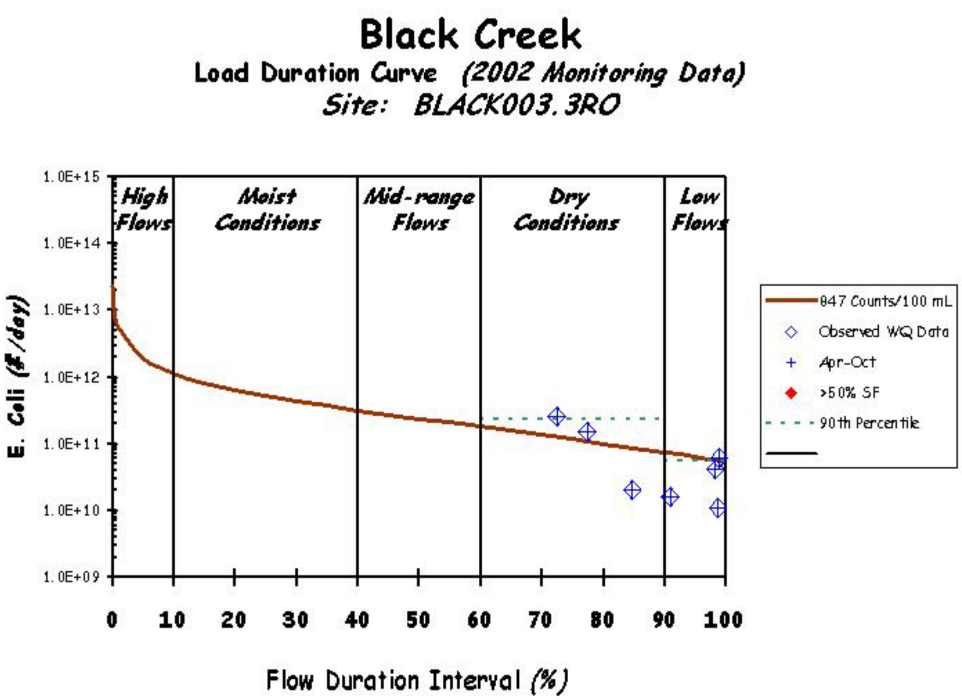

Figure 15. Load Duration Curve for Black Creek

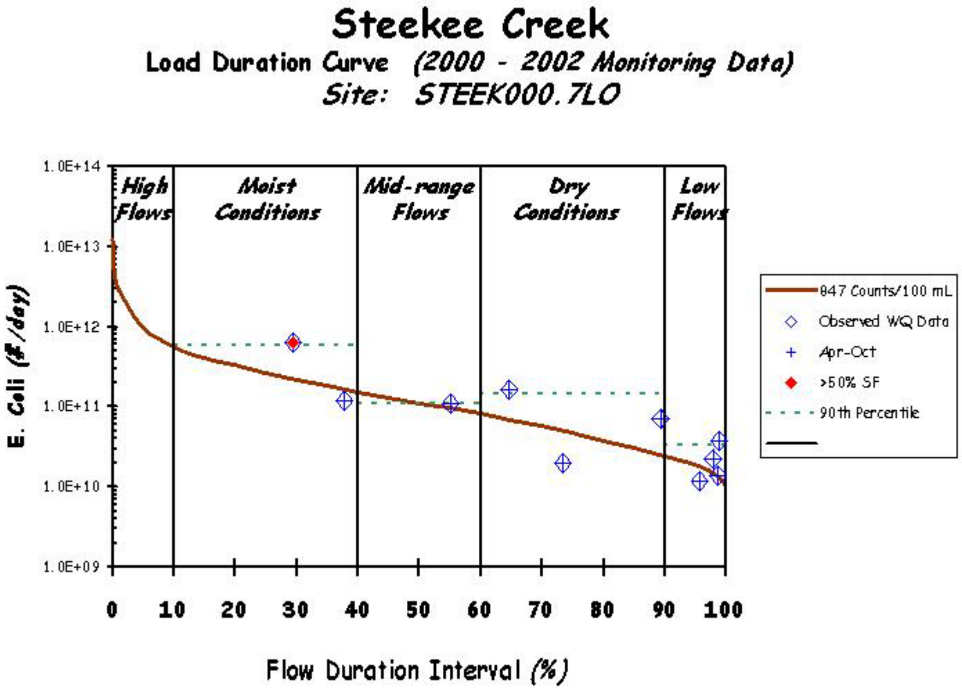

Figure 16. Load Duration Curve for Steekee Creek

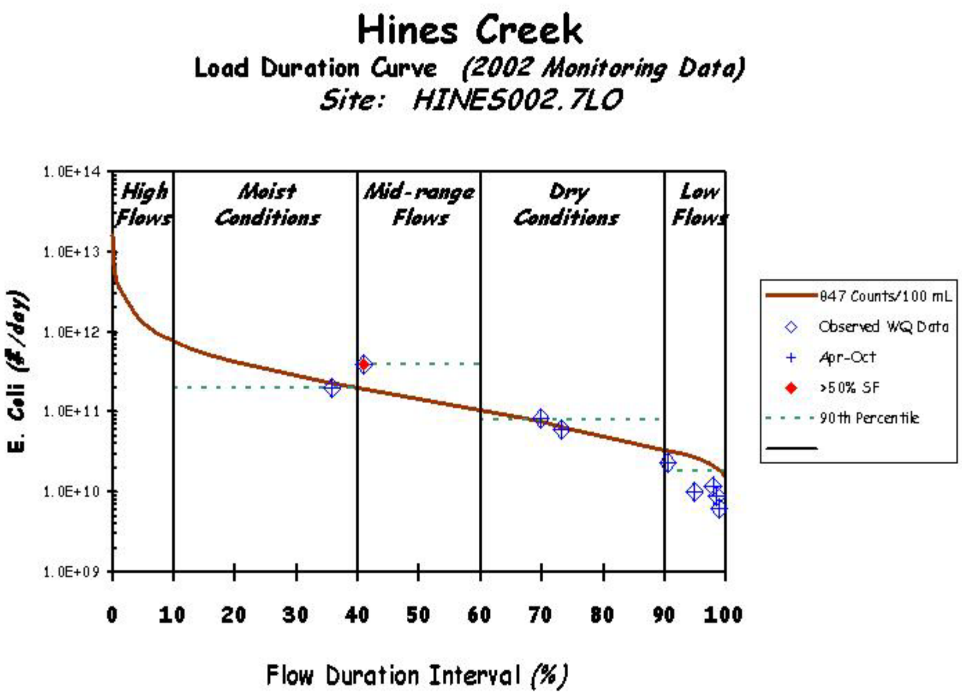

Figure 17. Load Duration Curve for Hines Creek

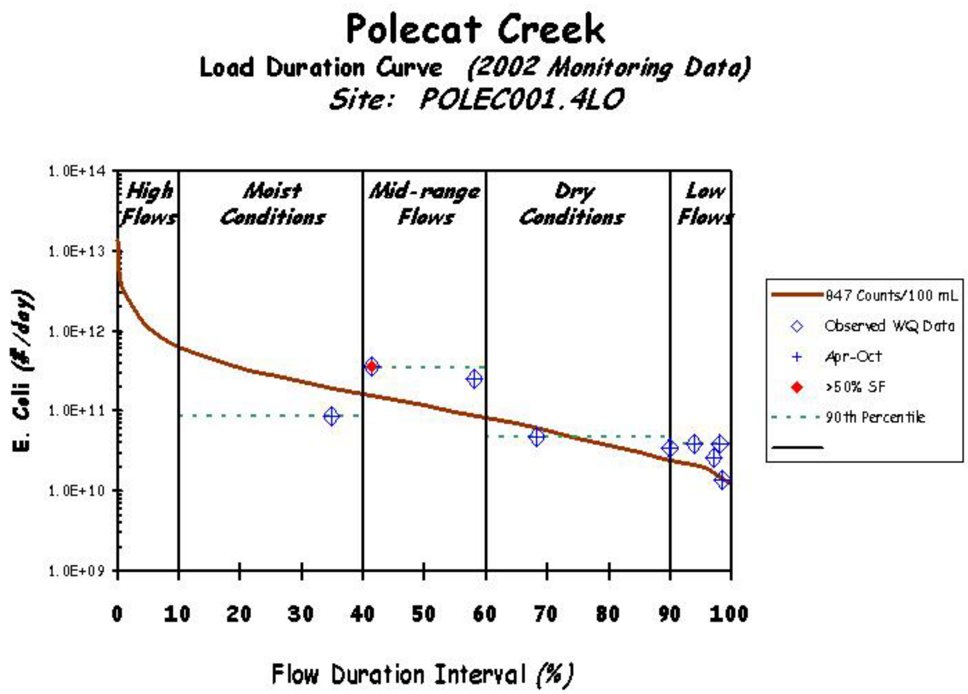

Figure 18. Load Duration Curve for Polecat Creek

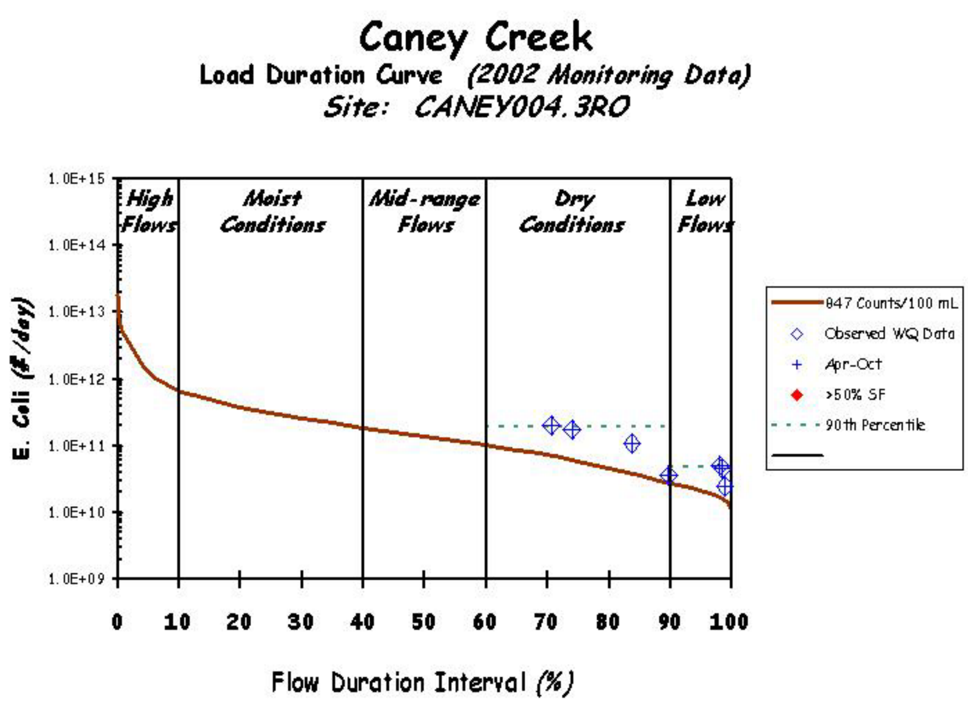

Figure 19. Load Duration Curve for Caney Creek

Table 11. 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
Sweetwater Creek at Mile 10.4	% Samples > 941 Counts/100 mL[1]	NA	100.0	50.0	100.0	NA
Caney Creek	% Samples > 941 Counts/100 mL[1]	NA	NA	NA	100.0	100.0
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.

9.4 Additional Monitoring

Documenting progress in reducing the quantity of pathogens entering the Watts Bar 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.

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.

Monitoring events for Pond Creek and its tributaries have occurred during all flow conditions. Additional monitoring and assessment activities are recommended only to verify reduction of pollutant loading as a result of implementation of appropriate BMPs within the subwatershed.

Examination of monitoring data for all subwatersheds except Pond Creek indicates that few sampling events have occurred during moist conditions or periods of high flow. Additional monitoring and assessment activities are recommended for these subwatersheds, especially the Black Creek and Caney Creek subwatersheds. 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; Baldwin, 2005; Farmer, 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.

10.0 PUBLIC PARTICIPATION

In accordance with 40 CFR §130.7, the proposed pathogen TMDLs for the Watts Bar Watershed was 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 invitedpublic 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) A letter was sent to Lena Beth Carmichael, Pond Creek Watershed Project Coordinator, advising her of the proposed TMDLs and their availability on the TDEC website. Ms. Carmichael is working with farmers in the Pond Creek watershed and other agencies to improve management and facilities of their farms.

4) Letters were sent to WWTFs located in or near pathogen-impaired subwatersheds in the Watts Bar 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:

   Rockwood STP (TN0026158)
   Sweetwater STP (TN0020052)

5) 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 Lenoir City (TNS077798)
   Loudon County, Tennessee (TNS075591)
   Tennessee Dept. of Transportation (TNS077585)

6) Notice of the availability of the Proposed TMDL was sent to the Oak Ridge Reservation (ORR) Local Oversight Committee (LOC). The ORR-LOC is a non-profit regional organization that represents the interests of local governments regarding Department of Energy's environmental management program and the operation of the Oak Ridge Reservation. The Watts Bar Reservoir Fish Advisory study was a special project of the CAP in conjunction with state and federal agencies to address concerns of the counties on Watts Bar Reservoir regarding the effects of PCB contamination on fishing and other recreational activities.

7) A draft copy of the proposed TMDL was sent to the Department of Biosystems Engineering and Environmental Science, University of Tennessee at Knoxville (UTK), Tennessee. Monitoring data for Pond Creek and its tributaries was provided as part of a contract between UTK and the Department of Agriculture. Also, UTK is working with one of the farmers (Holt Dairy Farms) in the Pond Creek watershed to develop the Nutrient Management Plan required for their CAFO permit.

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 Watts Bar Watershed

Table A-1. MRLC Land Use Distribution of Watts Bar Subwatersheds

Land Use	Watts Bar Subwatersheds					
	Paint Rock Creek		Mud Creek[a]		Greasy Branch[a]	
	[acres]	[%]	[acres]	[%]	[acres]	[%]
Deciduous Forest	6,269	35.6	469	8.9	237	8.2
Emergent Herbaceous Wetlands	0	0.0	0	0.0	0	0.0
Evergreen Forest	3,419	19.4	441	8.3	274	9.5
High Intensity Commercial/Industrial/Transp.	28	0.2	173	3.3	4	0.1
High Intensity Residential	0	0.0	1	0.0	0	0.0
Low Intensity Residential	46	0.3	21	0.4	4	0.1
Mixed Forest	3,460	19.6	762	14.4	373	12.9
Open Water	5	0.0	8	0.2	3	0.1
Other Grasses (Urban/recreation; e.g. parks)	14	0.2	60	1.1	0	0.0
Pasture/Hay	1,447	20.3	2,494	47.1	1,545	53.3
Quarries/Strip Mines/Gravel Pits	0	0.0	0	0.0	0	0.0
Row Crops	259	3.6	863	16.3	452	15.6
Transitional	154	0.9	0	0.0	7	0.2
Woody Wetlands	0	0.0	0	0.0	0	0.0
Total	15,102	100.0	5,293	100.0	2,898	100.0

Table A-1 (Cont.). MRLC Land Use Distribution of Watts Bar Subwatersheds

Land Use	Watts Bar Subwatersheds					
	Pond Creek		Bacon Creek[b]		Sweetwater Creek	
	[acres]	[%]	[acres]	[%]	[acres]	[%]
Deciduous Forest	2,716	12.3	588	13.8	5,313	13.7
Emergent Herbaceous Wetlands	0	0.0	0	0.0	0	0.0
Evergreen Forest	2,453	11.1	596	14.0	4,116	10.6
High Intensity Commercial/Industrial/Transp.	259	1.2	7	0.2	685	1.8
High Intensity Residential	1	0.0	2	0.0	78	0.2
Low Intensity Residential	45	0.2	36	0.8	773	2.0
Mixed Forest	3,459	15.7	993	23.3	7032	18.1
Open Water	25	0.1	0	0.0	62	0.2
Other Grasses (Urban/recreation; e.g. parks)	61	0.3	21	0.5	611	1.6
Pasture/Hay	9,989	45.3	1,672	39.2	15,415	39.7
Quarries/Strip Mines/Gravel Pits	0	0.0	0	0.0	0	0.0
Row Crops	2,859	13.0	347	8.2	4,628	11.9
Transitional	173	0.8	0	0.0	129	0.3
Woody Wetlands	0	0.0	0	0.0	0	0.0
Total	22,039	100.0	4,262	100.0	38,844	100.0

Table A-1 (Cont.). MRLC Land Use Distribution of Watts Bar Subwatersheds

Land Use	Watts Bar Subwatersheds					
	Black Creek		Steekee Creek		Hines Creek	
	[acres]	[%]	[acres]	[%]	[acres]	[%]
Deciduous Forest	4,036	53.6	691	15.0	1,558	23.5
Emergent Herbaceous Wetlands	0	0.0	0	0.0	0	0.0
Evergreen Forest	517	6.9	756	16.5	1,274	19.2
High Intensity Commercial/Industrial/Transp.	161	2.1	108	2.4	41	0.6
High Intensity Residential	111	1.5	62	1.4	12	0.2
Low Intensity Residential	582	7.7	328	7.2	147	2.2
Mixed Forest	1,421	18.9	,1000	21.8	1,681	25.4
Open Water	1	0.0	9	0.2	2	0.0
Other Grasses (Urban/recreation; e.g. parks)	121	1.6	278	5.0	105	1.6
Pasture/Hay	420	5.6	1,090	23.7	1,649	24.9
Quarries/Strip Mines/Gravel Pits	0	0.0	0	0.0	0	0.0
Row Crops	144	1.9	322	7.0	153	2.3
Transitional	12	0.2	0	0.0	0	0.0
Woody Wetlands	0	0.0	0	0.0	0	0.0
Total	7,523	100.0	4,643	100.0	6,623	100.0

Table A-1 (Cont.). MRLC Land Use Distribution of Watts Bar Subwatersheds

Land Use	Watts Bar Subwatersheds			
	Polecat Creek		Caney Creek	
	[acres]	[%]	[acres]	[%]
Deciduous Forest	1,213	23.3	2,704	53.4
Emergent Herbaceous Wetlands	0	0.0	0	0.0
Evergreen Forest	755	14.5	343	6.8
High Intensity Commercial/Industrial/Transp.	4	0.1	194	3.8
High Intensity Residential	0	0.0	51	1.0
Low Intensity Residential	7	0.1	273	5.4
Mixed Forest	1,025	19.7	962	19.0
Open Water	1	0.0	13	0.3
Other Grasses (Urban/recreation; e.g. parks)	30	0.6	76	1.5
Pasture/Hay	1,648	31.6	373	7.4
Quarries/Strip Mines/Gravel Pits	0	0.0	0	0.0
Row Crops	368	7.1	69	1.4
Transitional	160	3.1	8	0.2
Woody Wetlands	0	0.0	0	0.0
Total	5,211	100.0	5,066	100.0

[a] Mud Creek and Greasy Branch are tributaries of Pond Creek
[b] Bacon Creek is a tributary of Sweetwater Creek

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 Watts Bar 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. Monitoring data recorded by UTK are tabulated in Table B-2.

Table B-1. TDEC Water Quality Monitoring Data – Watts Bar Subwatersheds

Monitoring Station	Date	Fecal Coliform	E. Coli	Fecal Strep
		[cts./100 mL]	[cts./100 mL]	[cts./100 mL]
BACON000.1LO	1/28/03	180	84	72
	3/18/03	1160	1203	220
	4/16/03	1000	1120	148
	5/28/03	820	816	260
	6/18/03	5000	3590	650
	7/29/03	2600	1414	2200
	8/6/03	1500	1203	1800
	8/12/03	1500	1300	2500
BLACK003.3RO	8/6/02		199	
	8/14/02		192	
	9/5/02		613	
	9/9/02		161	
	9/19/02		921	
	10/3/02		1203	
	10/10/02		1733R	
CANEY004.3RO	8/6/02		2419	
	8/14/02		1120	
	9/5/02		2419	
	9/9/02		2419	
	9/19/02		1414	
	10/3/02		2419	
	10/10/02		2419R	
GREAS000.5MO	3/26/02	1900	1300	
HINES002.7LO	8/20/02		613	
	8/29/02		313	
	9/4/02		435	
	9/10/02		365	
	9/19/02		276	
	9/24/02		921R	
	10/1/02		770	
	10/24/02		727	
	10/28/02		1733R	

Monitoring Station	Date	Fecal Coliform	E. Coli	Fecal Strep
		[cts./100 mL]	[cts./100 mL]	[cts./100 mL]
MUD001.9MO	3/26/02	1100	1046	
PAINT003.1RO	8/20/02		228	
	8/29/02		770	
	9/4/02		488	
	9/10/02		461	
	9/19/02		1733	
	9/24/02		>2419R	
	10/1/02		1203R	
	10/24/02		411	
	10/28/02		1300R	
POLEC001.4LO	8/20/02		1203	
	8/29/02		1553	
	9/4/02		1203	
	9/10/02		1986	
	9/19/02		770	
	9/24/02		2419R	
	10/1/02		649	
	10/24/02		378	
	10/28/02		1986R	
POND002.3LO	3/26/02	1900	1414	
POND005.7LO	3/26/02	2600	3310	
POND008.3LO	3/26/02	2200	2419	
POND011.0LO	3/26/02	1000	1986	
POND013.1MO	3/26/02	2000	3180	
POND013.9MO	3/26/02	1100	1986	
STEEK000.7LO	5/17/00		980	
	8/20/02		>2419	
	8/29/02		549	
	9/4/02		1203	
	9/10/02		816	
	9/19/02		>2419	
	9/24/02		1986R	
	10/1/02		326	
	10/24/02		613	
	10/28/02		>2419	
STEEK002.0LO	5/17/00		770	

Monitoring Station	Date	Fecal Coliform [cts./100 mL]	E. Coli [cts./100 mL]	Fecal Strep [cts./100 mL]
SWEET001.4LO	1/14/03	156	96	42
	1/28/03	76	83	146
	3/18/03	490	313	220
	4/16/03	1600	921	210
	5/28/03	600	411	220
	6/18/03	1100	687	2000
	7/29/03	1800	980	1400
	8/6/03	900	866	1000
	8/12/03	8900	8840	4400
SWEET003.1LO	1/14/03	160	133	64
	1/28/03	104	60	54
	3/18/03	580	727	500
	4/16/03	1800	1733	470
	5/28/03	700	649	260
	6/18/03	1010	770	750
	7/29/03	1100	816	2600
	8/6/03	800	649	1100
	8/12/03	6200	5560	3300
SWEET009.3LO	1/14/03	400	435	64
	1/28/03	460	397	168
	3/18/03	740	436	440
	4/16/03	2000	1986	240
	5/28/03	800	727	290
	6/18/03	2700	1300	1200
	7/29/03	2800	2419	2100
	8/6/03	2300	4430	900
	8/12/03	3400	3180	1800
SWEET010.4LO	1/14/03	580	1203	280
	1/28/03	220	517	210
	3/18/03	810	921	400
	4/16/03	1400	1203	136
	5/28/03	2500	2419	600
	6/18/03	4200	4260	2400
	7/29/03	4400	9840	2500
	8/6/03	5400	7230	1700
	8/12/03	7300	7080	2200

Monitoring Station	Date	Fecal Coliform [cts./100 mL]	E. Coli [cts./100 mL]	Fecal Strep [cts./100 mL]
SWEET013.7MO	1/14/03	1400	866	100
	1/28/03	122	579	20
	3/18/03	2000	3230	236
	4/16/03	1200	921	164
	5/28/03	540	517	200
	6/18/03	850	770	750
	7/29/03	1400	1203	1800
	8/6/03	1300	688	1200
	8/12/03	840	860	800
SWEET017.3MO	1/14/03	1400	1300	98
	1/28/03	168	205	100
	3/18/03	2300	1986	340
	4/16/03	800	816	188
	5/28/03	510	613	250
	6/18/03	2700	1733	860
	7/29/03	3200	3180	2300
	8/6/03	4800	6830	1400
	8/12/03	3300	2780	1200
SWEET019.4MO	1/14/03	2500	2419	78
	1/28/03	380	344	30
	3/18/03	2400	2419	600
	4/16/03	340	345	190
	5/28/03	260	260	240
	6/18/03	1500	1300	950
	7/29/03	380	649	1000
	8/6/03	570	488	1200
	8/12/03	830	770	260
SWEET023.3MO	1/14/03	140	22	50
	1/28/03	260	365	44
	3/18/03	92	57	168
	4/16/03	360	126	98
	5/28/03	320	248	220
	6/18/03	2300	1414	2000
	7/29/03	1100	727	1400
	8/6/03	300	548	1100
	8/12/03	220	185	690

Table B-2. UTK Water Quality Monitoring Data – Watts Bar Subwatersheds

Monitoring Station	Date	Total Coliform [cts./100 mL]	Fecal Coliform [cts./100 mL]	E. Coli [cts./100 mL]	Entero [cts./100 mL]
GS (GREAS000.5MO)	7/25/01	198,630	1,640	17,820	50,120
	8/16/01	81,640	1,800	2,280	1,690
	9/26/01	173,290	2,000	34,480	3,140
	10/16/01	9,880	2,700	300	730
	11/14/01	7,480	6,800	1,580	81.6
	12/12/01	241,920	50,000	241,920	57,940
	2/26/02	5,650	5,420	1,733	148
	2/26/02 (dup)	5,940	6,300	1,553	190
	3/26/02	11,690	2,100	1,420	687
	5/3/02	241,920	5,000	57,940	92,080
	5/22/02	10,460	770	740	222
MC (MUD001.9MO)	7/25/01	241,920	1,700	27,550	98,040
	8/16/01	38,730	1,200	980	1,070
	9/26/01	57,940	2,500	2,419.2	100
	10/16/01	10,920	2,400	200	100
	11/14/01	104,620	10,900	8,260	1,990
	12/12/01	198,630	18,700	19,350	12,110
	1/24/02	241,920	23,000	43,520	1,810
	2/26/02	4,640	5,060	1,300	195
	3/26/02	15,760	1,400	1,203	435
	5/3/02	155,310	1,560	23,820	28,510
	5/22/02	nd	nd	nd	nd
	5/22/02 (dup)	nd	nd	nd	nd
PC1 (POND002.3LO)	7/25/01	8,360	700	98.5	960
	8/16/01	12,500	875	980	520
	8/16/01 (dup)	13,740	1,250	740	740
	9/26/01	6,570	1,000	816.4	26.6
	10/16/01	1,732.9	600	33.2	182.3
	11/14/01	1,203.3	2,600	34.1	79.4
	12/12/01	81,640	9,600	10,760	3,930
	1/24/02	241,920	13,000	20,350	11,120
	2/26/02	3,640	2,460	387	3
	3/26/02	31,510	2,100	1,553	387
	5/3/02	241,920	3,300	92,080	20,750
	5/22/02	8,330	700	816	250

Monitoring Station	Date	Total Coliform [cts./100 mL]	Fecal Coliform [cts./100 mL]	E. Coli [cts./100 mL]	Entero [cts./100 mL]
PC2 (POND005.7LO)	7/25/01	14,010	1,700	1,553.1	520
	8/16/01	23,100	1,600	2,780	840
	9/26/01	11,370	2,200	1,986.3	75.7
	9/26/01 (dup)	13,130	2,100	2,380	211.7
	10/16/01	3,410	2,000	410.6	686.7
	11/14/01	2,419.2	1,275	1,986.3	547.5
	12/12/01	155,310	18,000	32,550	9,850
	1/24/02	241,920	13,600	14,450	7,840
	2/26/02	4,640	2,400	435	20
	3/26/02	20,140	3,000	3,450	1,046
	5/3/02	198,630	3,500	19,040	17,270
	5/22/02	10,170	1,500	1,046	579
PC3 (POND008.3LO)	7/25/01	17,850	1,600	1,046.2	740
	8/16/01	57,940	2,100	2,500	1,210
	9/26/01	32,550	2,200	2,419.2	2,419.2
	10/16/01	6,010	1,850	1,090	410
	10/16/01(dup)	5,200	1,700	520	300
	11/14/01	6,200	1,250	1,986.3	344.8
	12/12/01	173,290	20,800	41,060	17,230
	1/24/02	241,920	33,000	2,595	15,700
	2/26/02	3,880	4,100	980	38
	3/26/02	13,540	2,500	2,419	548
	5/3/02	241,920	6,300	86,640	26380
	5/22/02	10,810	1200	2,419	272
PC4 (POND011.0LO)	7/25/01	18,500	3,400	2,160	2,060
	8/16/01	32,550	2,200	2,620	4,110
	9/26/01	1,560	1,100	1,986.3	410
	10/16/01	3,890	2,400	520	520
	11/14/01	6,440	5,700	1,119.9	268.2
	12/12/01	129,970	16,300	29,090	17,250
	12/12/01(dup)	241,920	20,600	41,060	27,550
	1/24/02	241,920	65,000	173,290	23,340
	2/26/02	3,840	3,600	517	75
	3/26/02	10,500	1,000	1,733	328
	5/3/02	241,920	7,000	111,990	10,350
	5/22/02	12,910	1,100	1,414	727

Monitoring Station	Date	Total Coliform [cts./100 mL]	Fecal Coliform [cts./100 mL]	E. Coli [cts./100 mL]	Entero [cts./100 mL]
PC5 (POND013.1RO)	7/25/01	111,990	3,650	12,230	8,650
	8/16/01	41,060	4,900	3,110	1,070
	9/26/01	1,530	9,600	1,413.6	620
	10/16/01	9,600	1,700	3,090	1,090
	11/14/01	1,553.1?	5,700	1,413.6	1
	11/14/01(dup)	12,500	8,100	1,986.3	24.9
	12/12/01	173,290	14,600	20,350	27,550
	1/24/02	241,920	22,000	38,730	2,740
	2/26/02	4,620	2,900	980	81
	3/26/02	19,680	2,500	3,130	436
	5/3/02	241,920	5,000	72,700	141,360
	5/22/02	14,830	3,300	1,460	517
PC6 (POND013.9RO)	7/25/01	68,670	1,180	11,870	5,440
	8/16/01	10,500	700	1,400	520
	9/26/01	2,110	500	727	1,299.7
	10/16/01	7,710	1,800	1,580	630
	11/14/01	5,860	9,640	1,986.3	343.6
	12/12/01	57,940	10,500	7,940	4,650
	1/24/02	241,920	5,000	6,690	1,350
	2/26/02	1,986	1,620	160	85
	3/26/02	33,250	1,300	1,553	154
	3/26/02	30,260	1,300	1,553	141
	5/3/02	241,920	1,860	41,060	86,640
	5/22/02	12,110	400	579	139

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 Watts Bar Watershed were derived from LSPC hydrologic simulations based on parameters derived from calibration at USGS Station No. 03535000, located on Bullrun Creek near Halls Crossroads, in the Lower Clinch watershed (see Appendix D for details of calibration). For example, a flow-duration curve for Bacon Creek at RM 0.1 was constructed using simulated daily mean flow for the period from 10/1/94 through 9/31/04 (RM 0.1 corresponds to the location of monitoring station BACON000.1LO). This flow duration curve is shown in Figure C-5 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-11.

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 Watts Bar 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 (Bacon Creek is shown as an example):

1. A target load-duration curve was generated for Bacon 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:

   $(\text{Target Load})_{\text{Bacon Creek}}$ = (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 BACON000.1LO (ref.: Table B-1) by multiplying the sample concentration by the daily mean flow for the sampling date and the required unit conversion factor. BACON000.1LO was selected for LDC analysis because it was the monitoring station on Bacon 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-19 and C-20.

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 90^{th} percentile value for all of the fecal coliform sampling data at BACON000.1LO monitoring site was determined. If the 90^{th} percentile value exceeded the target maximum fecal coliform concentration, the reduction required to reduce the 90^{th} percentile value to the target maximum concentration was calculated.

6. Step 5 was repeated for E. coli data at BACON000.1LO.

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 BACON000.1LO.

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 Bacon Creek. The determination of required load reductions for Bacon Creek is shown in Tables C-8 and C-9.

Load reduction curves and required load reductions of other impaired waterbodies were derived in a similar manner and are shown in Figures C-12 through C-27 and Tables C-1 through C-16.

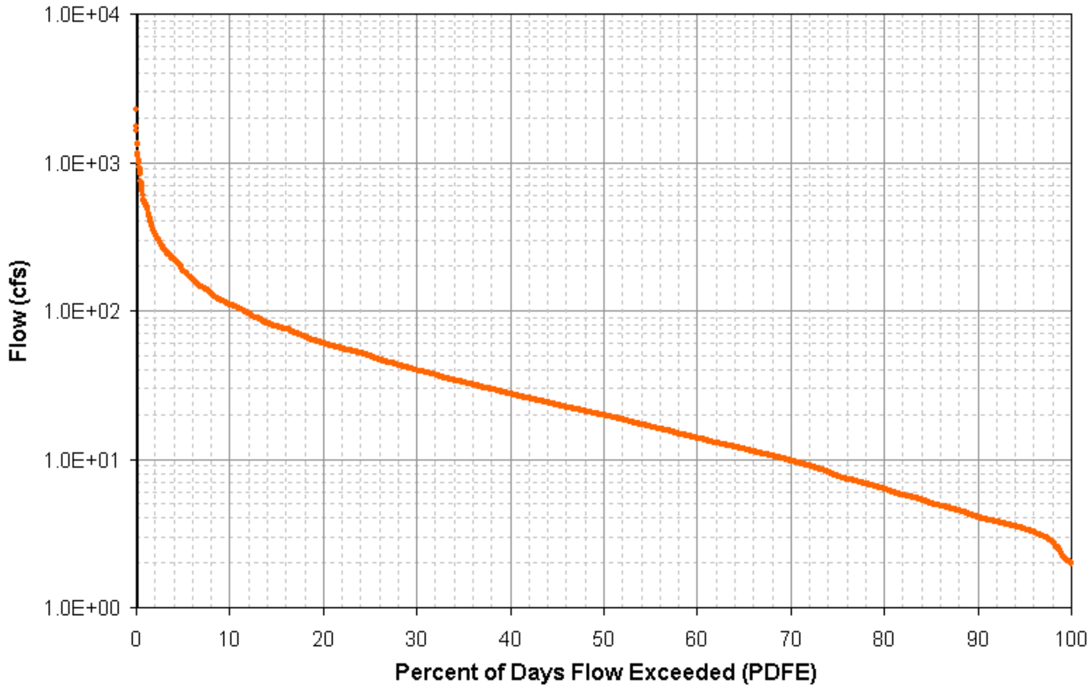


Figure C-1. Flow Duration Curve for Paint Rock Creek

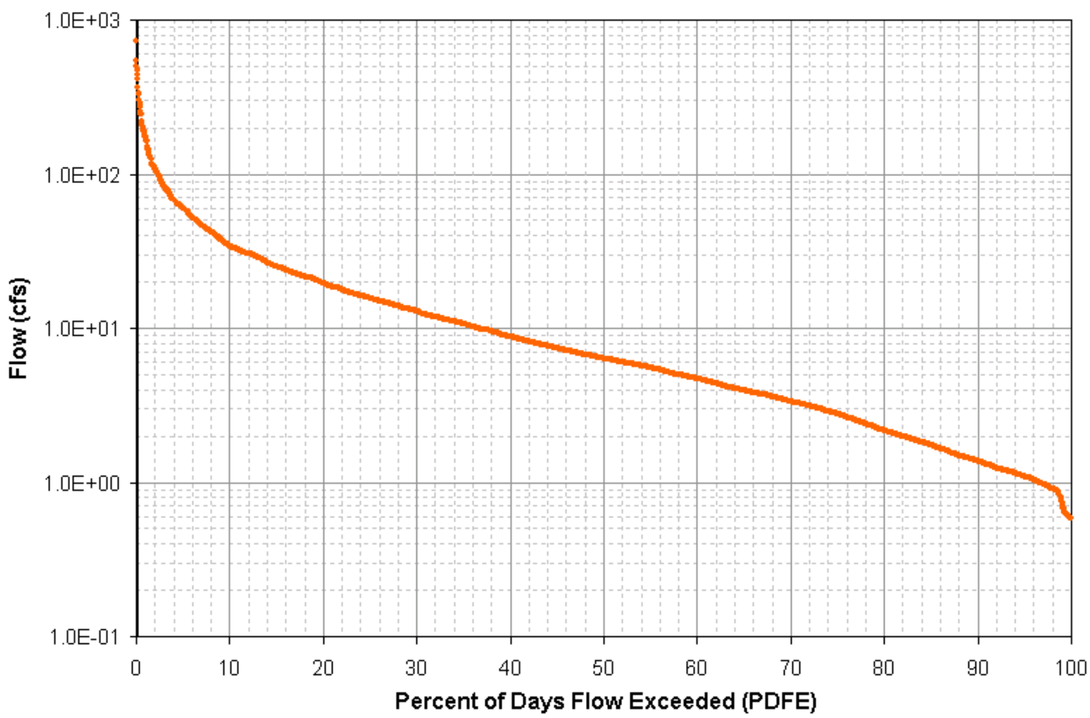


Figure C-2. Flow Duration Curve for Mud Creek

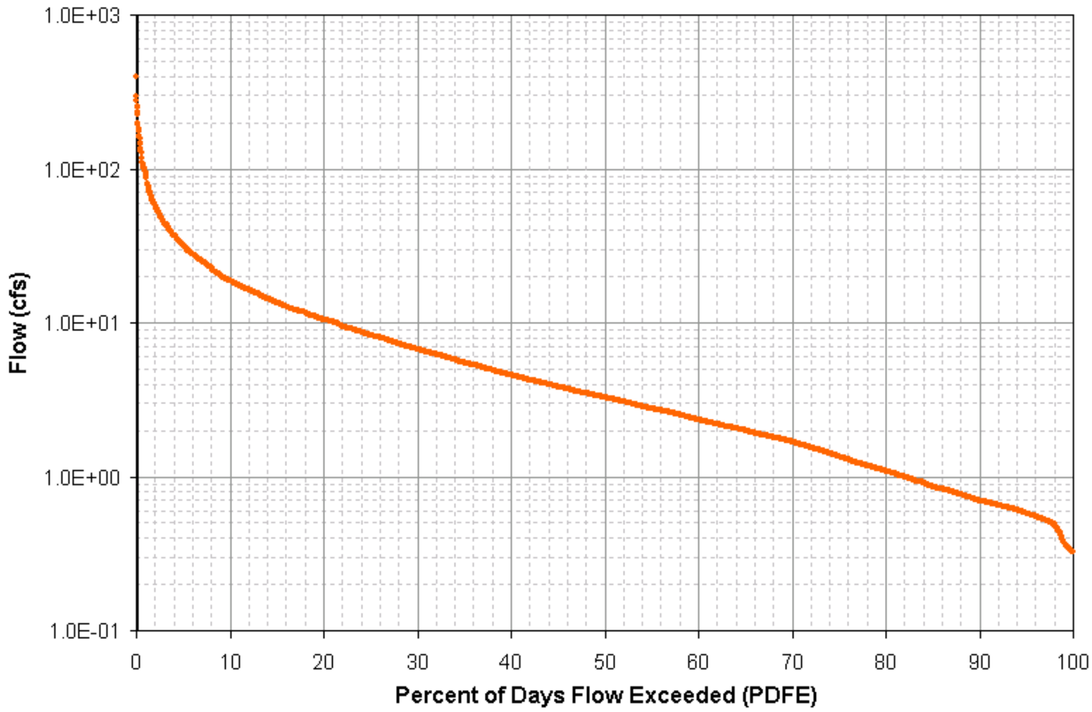


Figure C-3. Flow Duration Curve for Greasy Branch

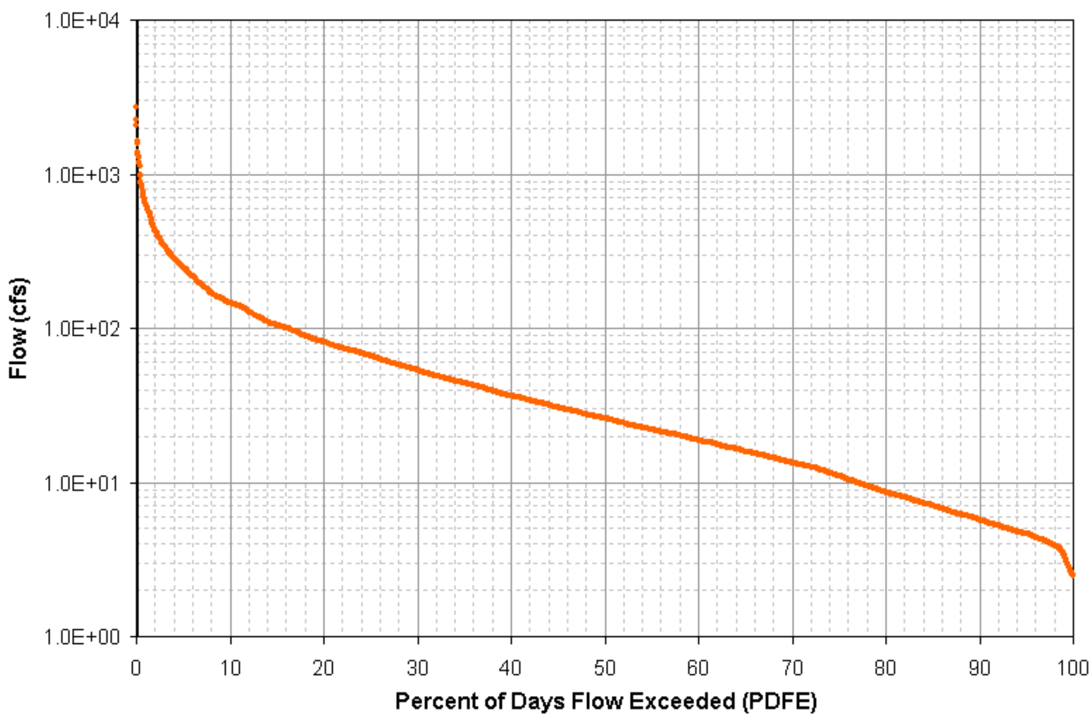


Figure C-4. Flow Duration Curve for Pond Creek

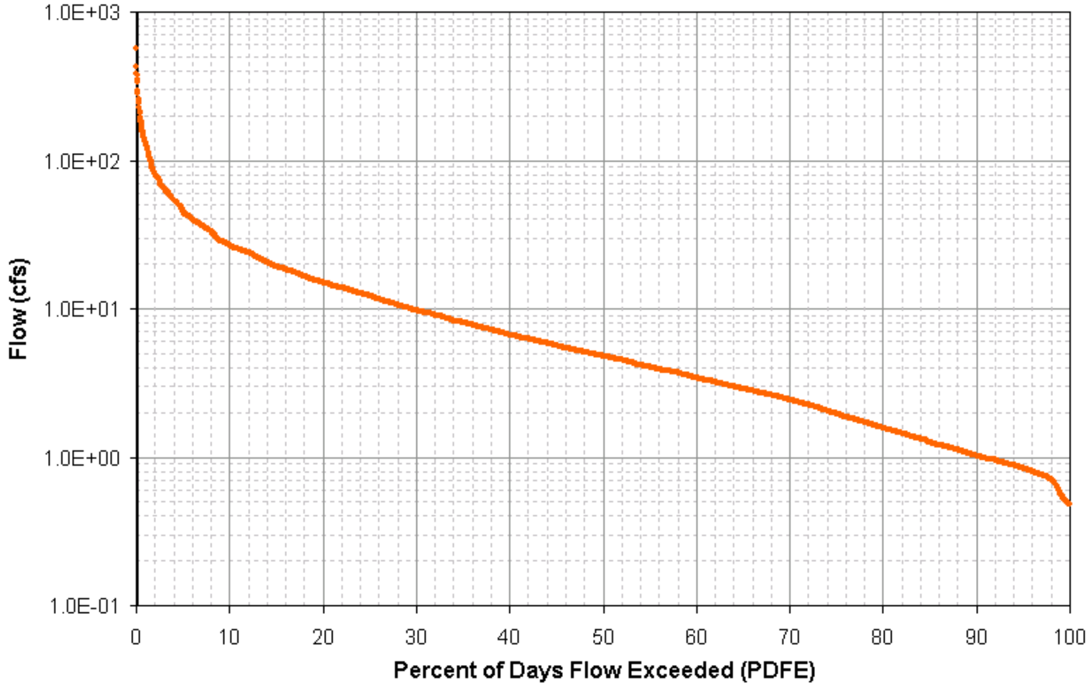


Figure C-5. Flow Duration Curve for Bacon Creek

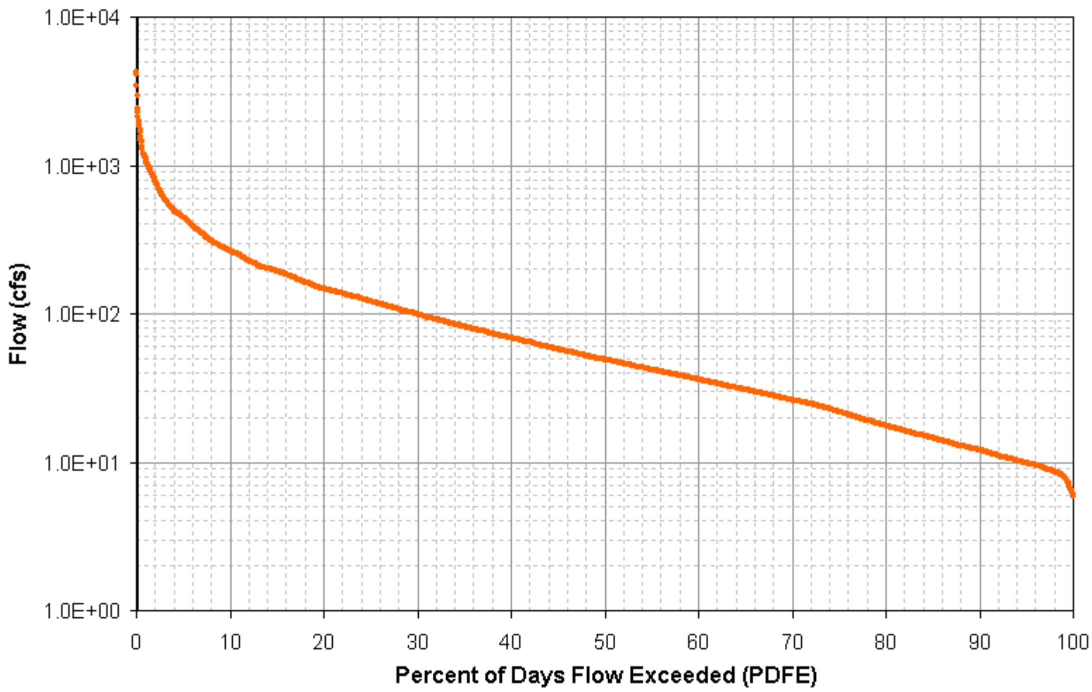


Figure C-6. Flow Duration Curve for Sweetwater Creek

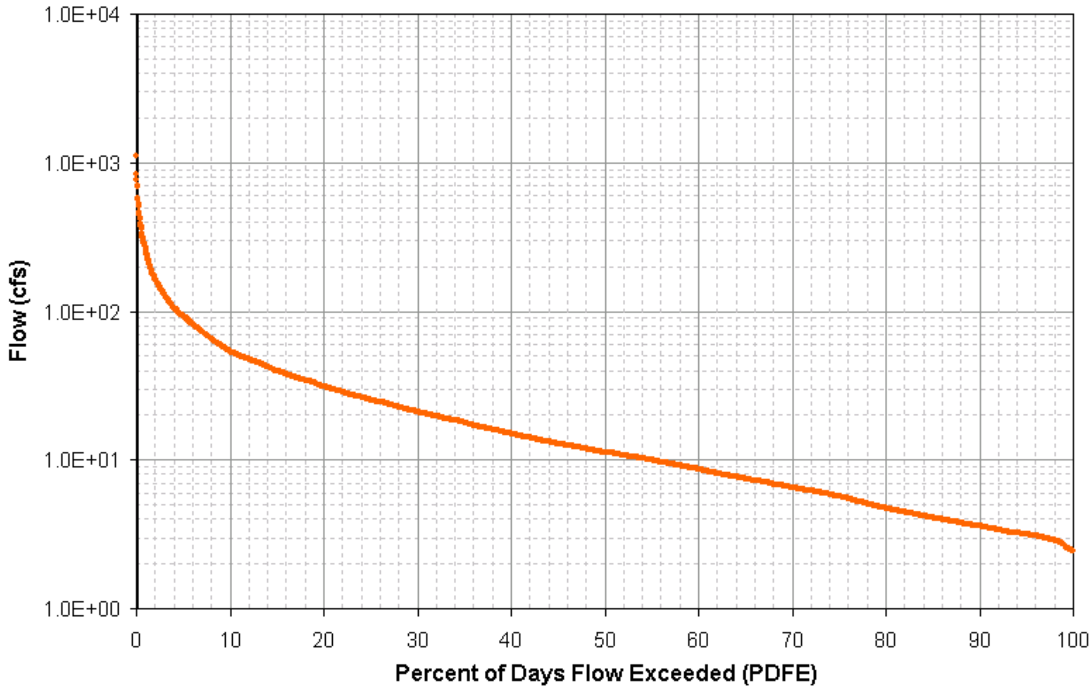


Figure C-7. Flow Duration Curve for Black Creek

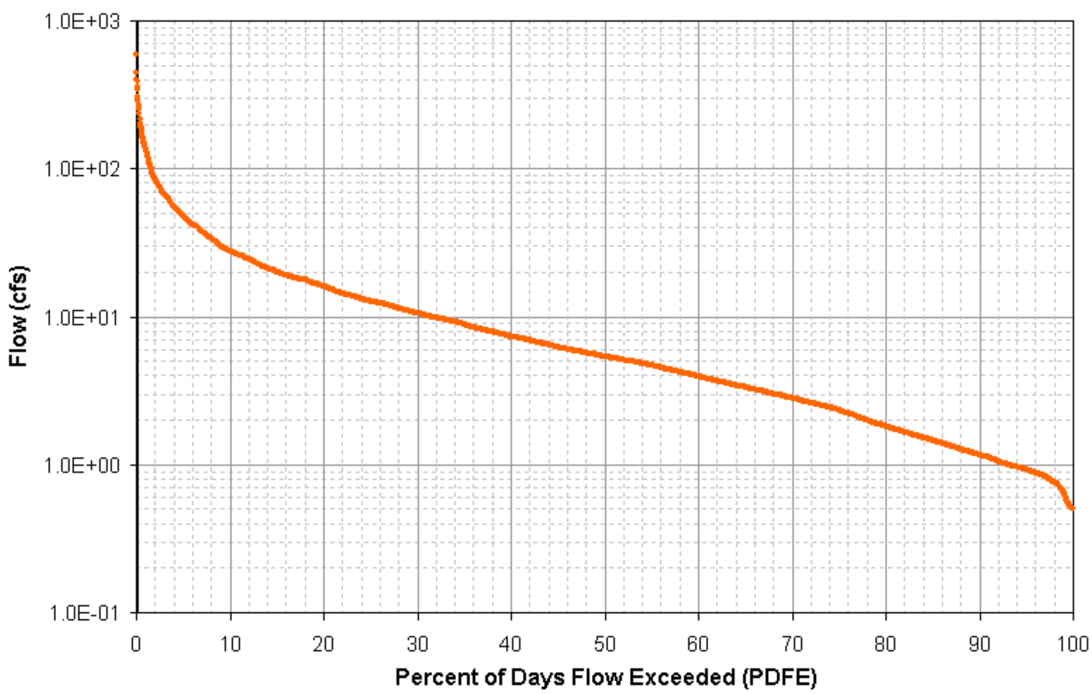


Figure C-8. Flow Duration Curve for Steekee Creek

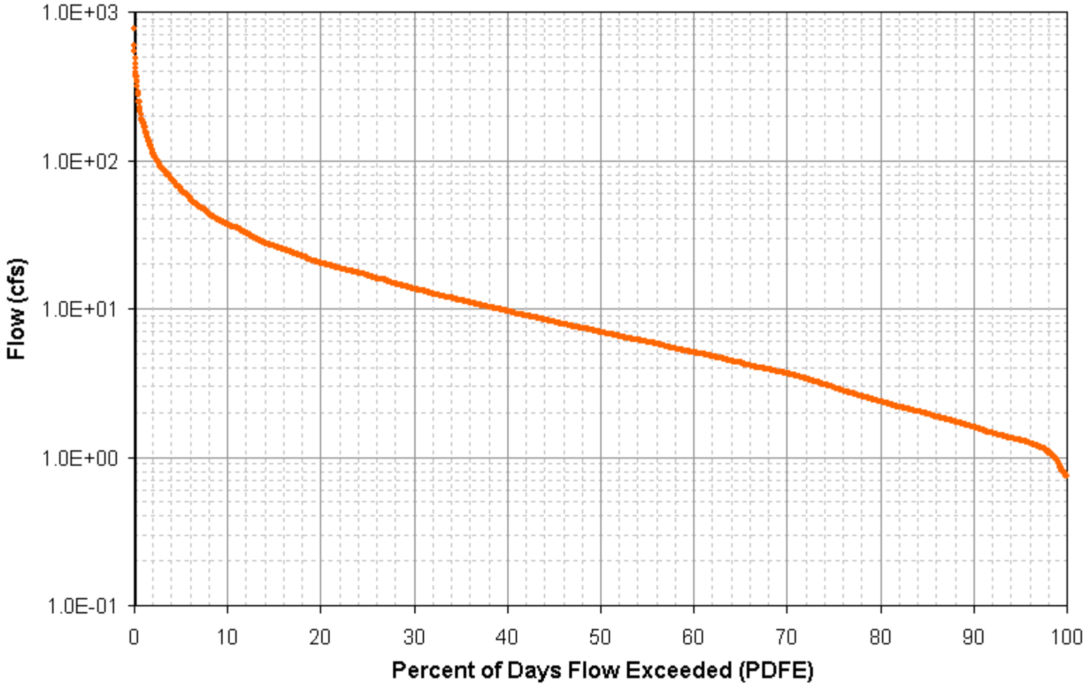


Figure C-9. Flow Duration Curve for Hines Creek

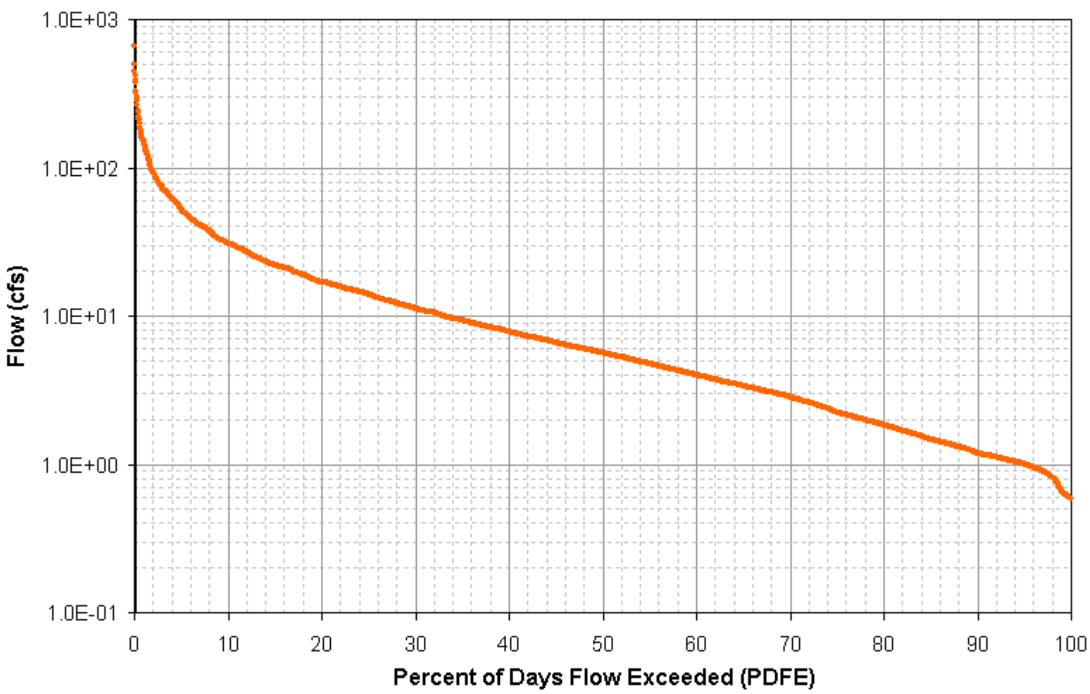


Figure C-10. Flow Duration Curve for Polecat Creek

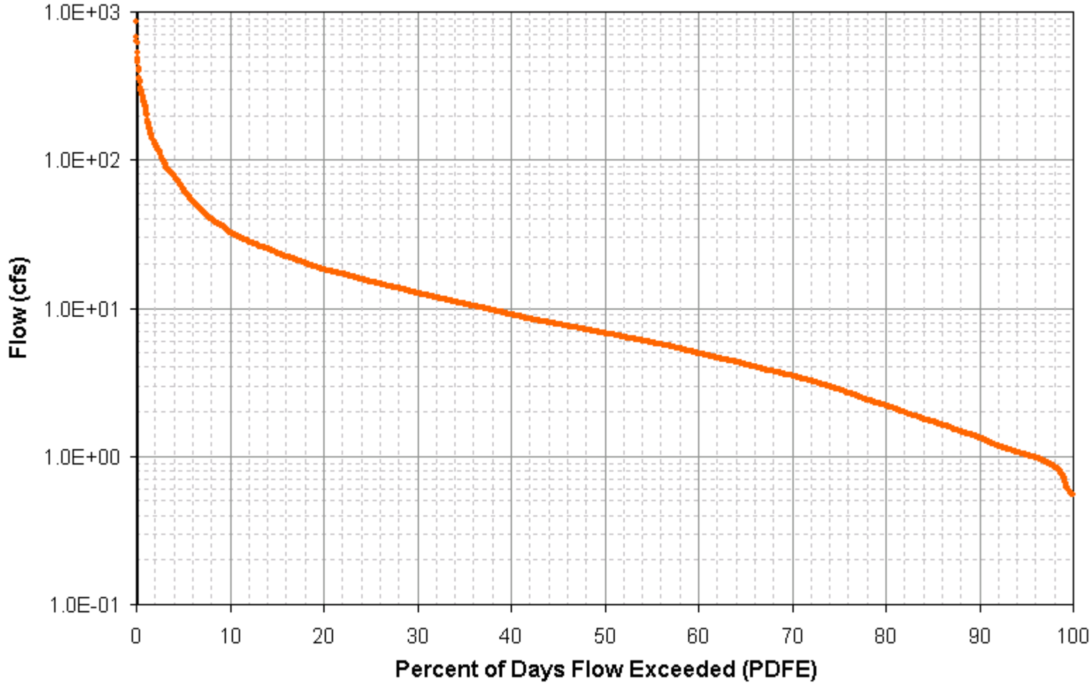


Figure C-11. Flow Duration Curve for Caney Creek

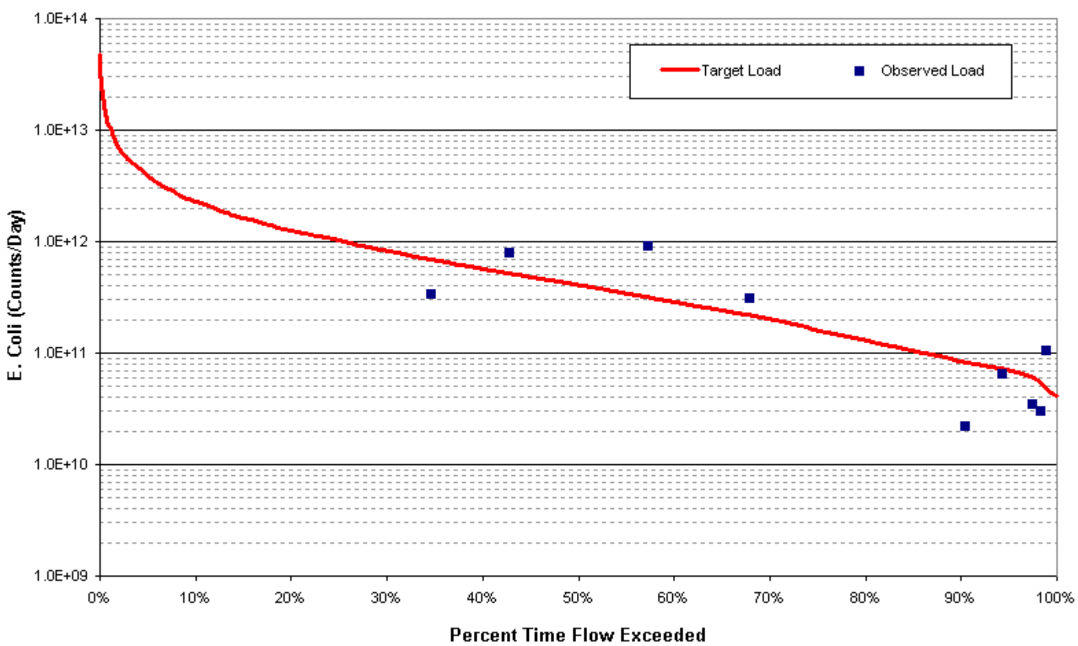


Figure C-12. E. Coli Load Duration Curve for Paint Rock Creek

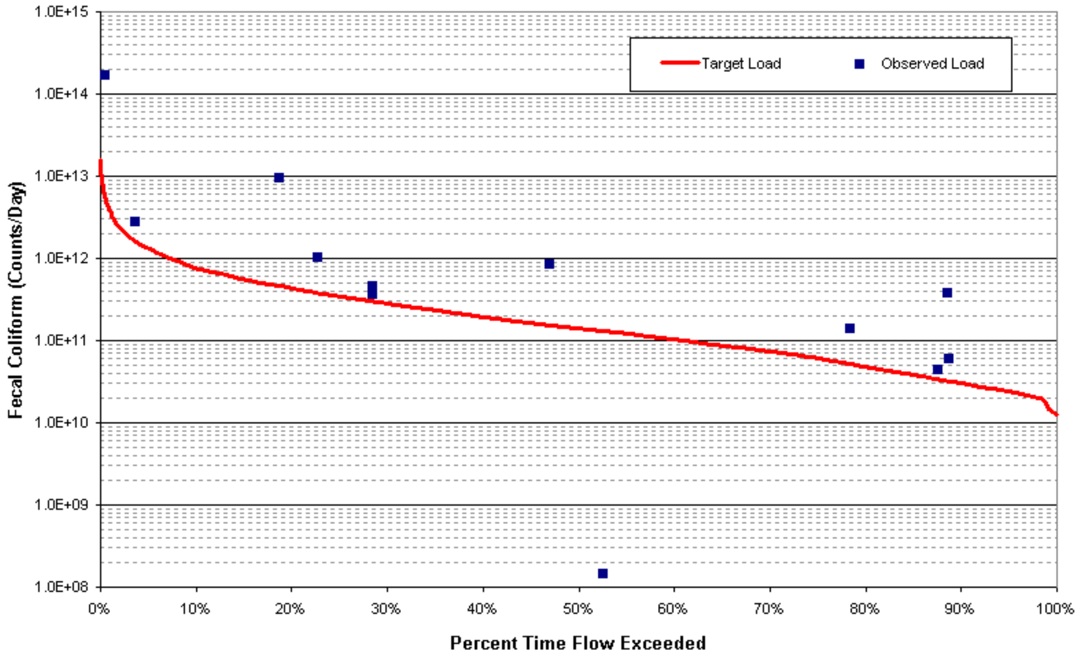


Figure C-13. Fecal Coliform Load Duration Curve for Mud Creek

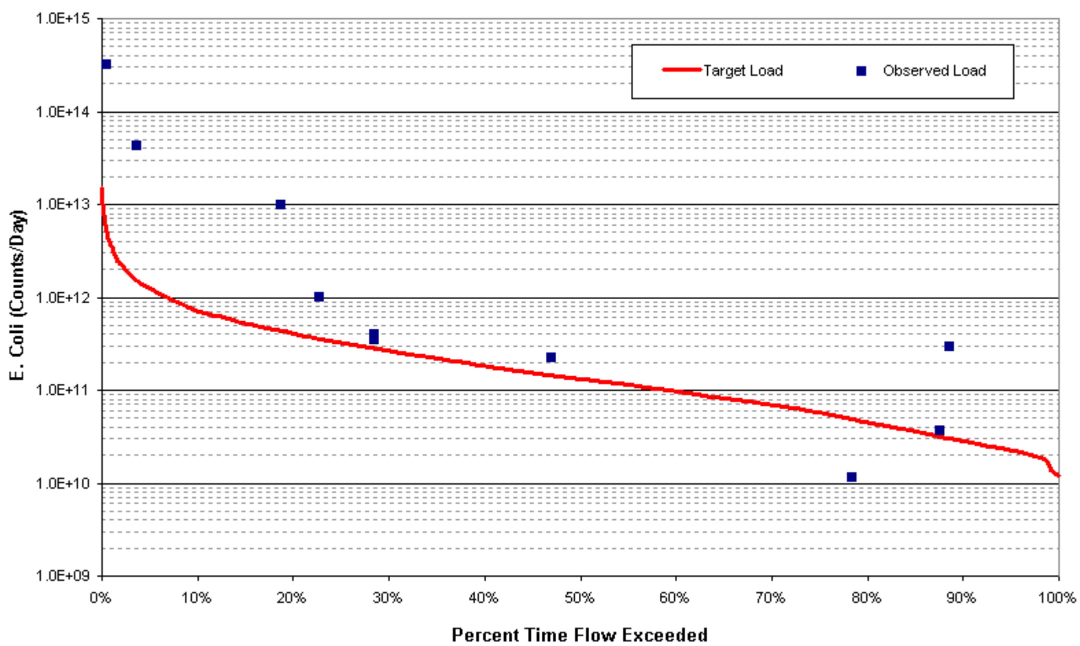


Figure C-14. E. Coli Load Duration Curve for Mud Creek

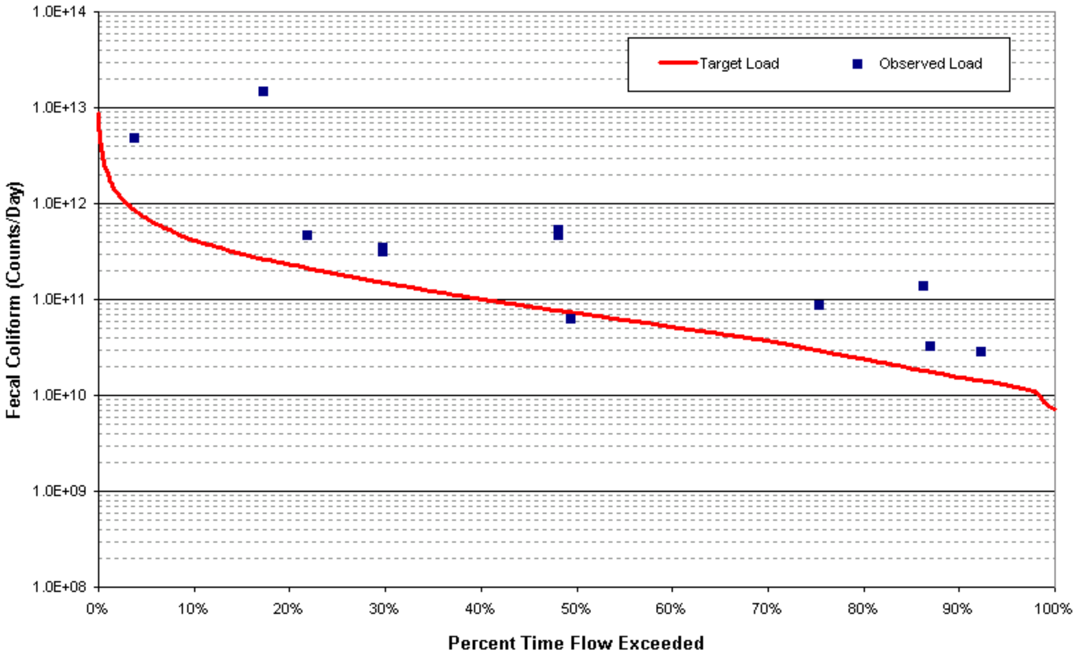


Figure C-15. Fecal Coliform Load Duration Curve for Greasy Branch

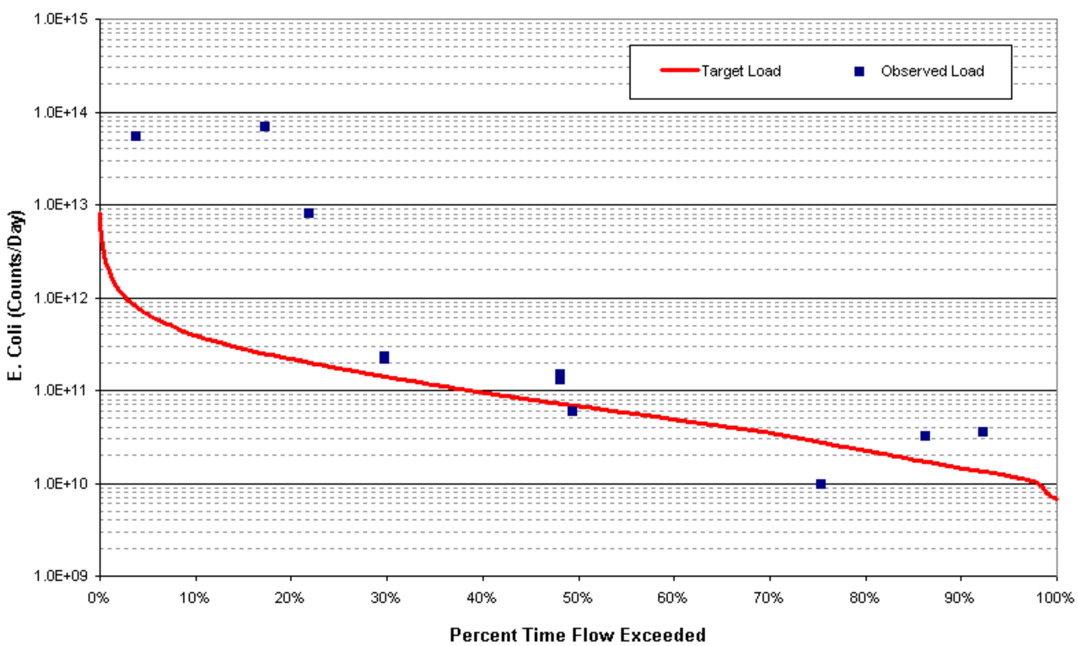


Figure C-16. E. Coli Load Duration Curve for Greasy Branch

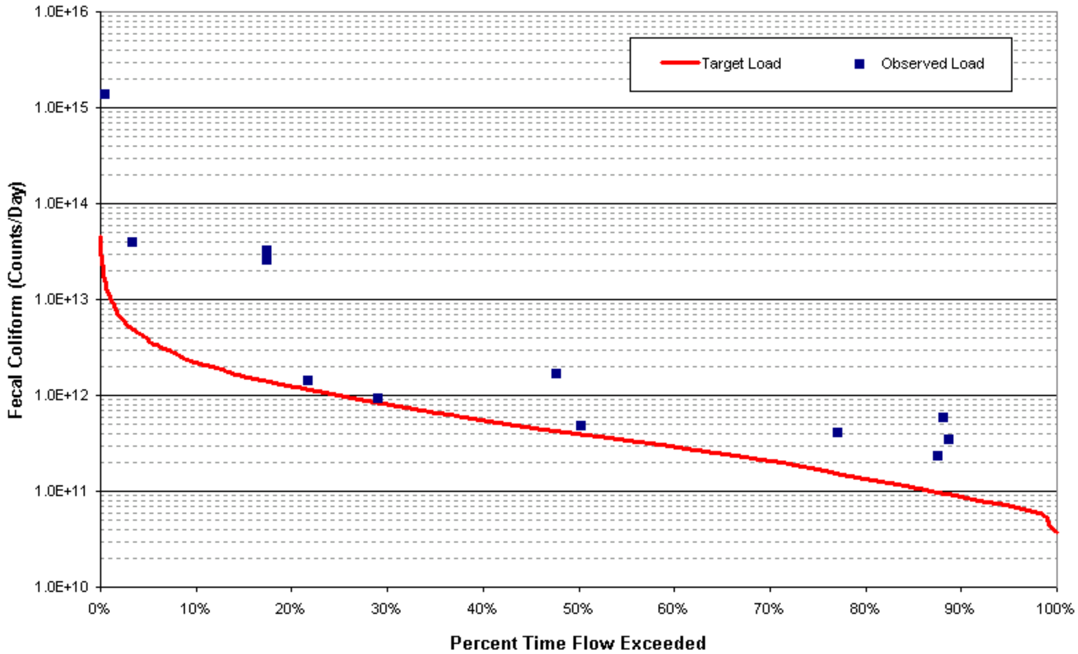


Figure C-17. Fecal Coliform Load Duration Curve for Pond Creek

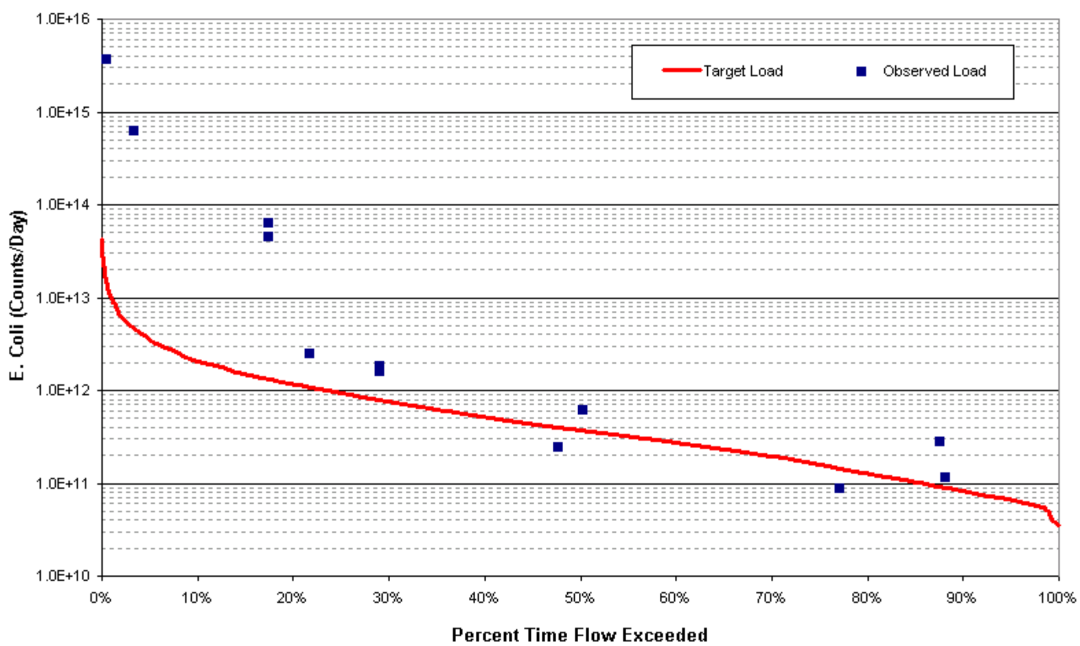


Figure C-18. E. Coli Load Duration Curve for Pond Creek Creek

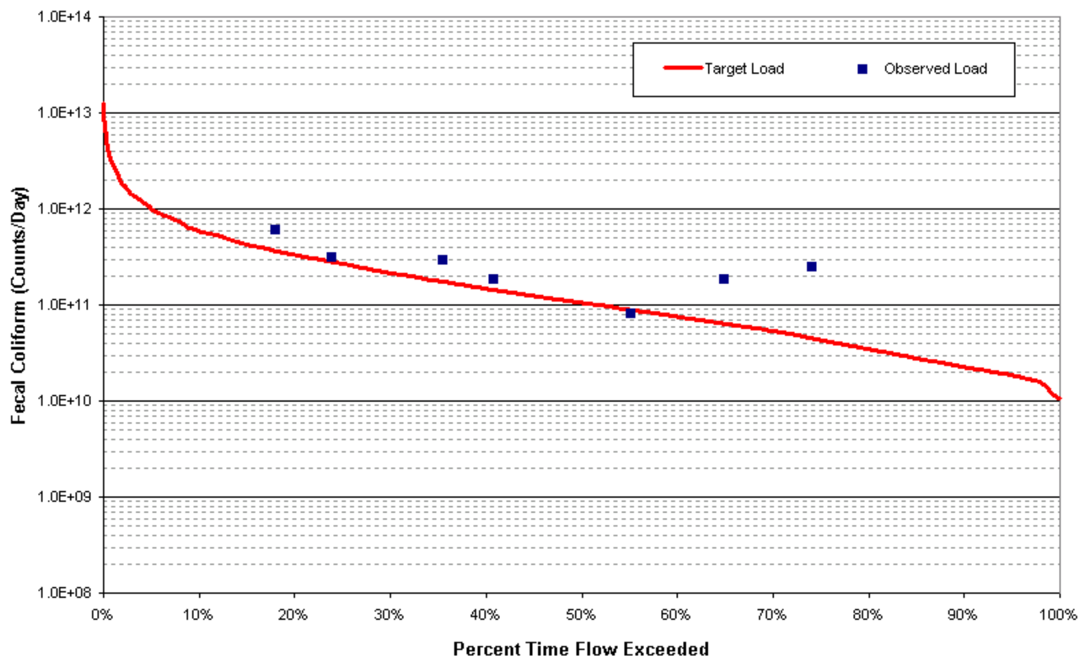


Figure C-19. Fecal Coliform Load Duration Curve for Bacon Creek

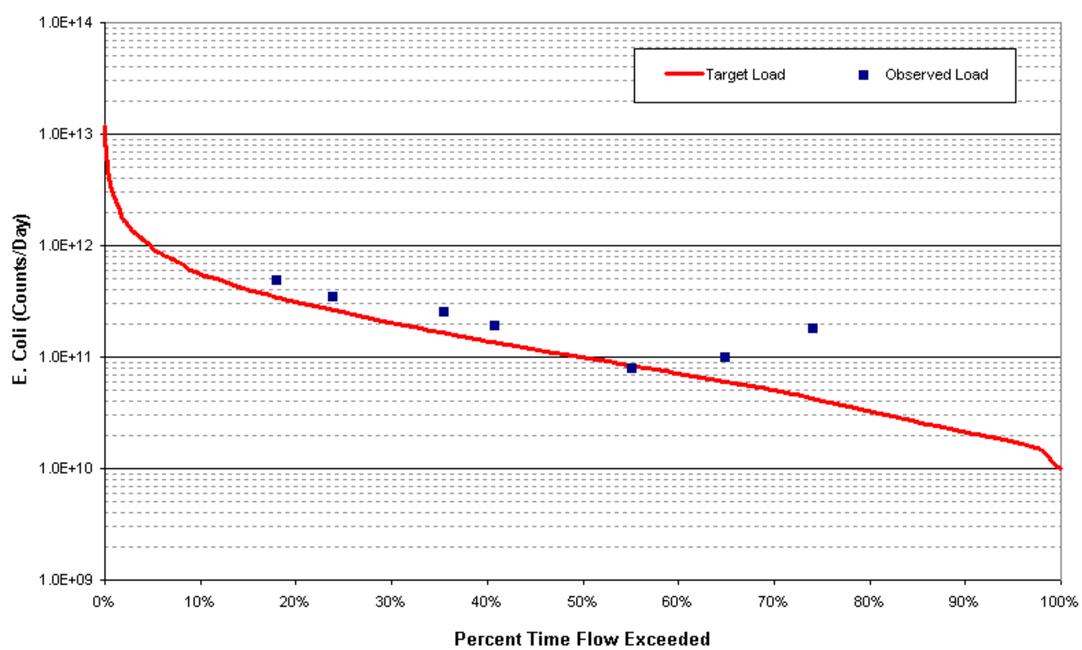


Figure C-20. E. Coli Load Duration Curve for Bacon Creek

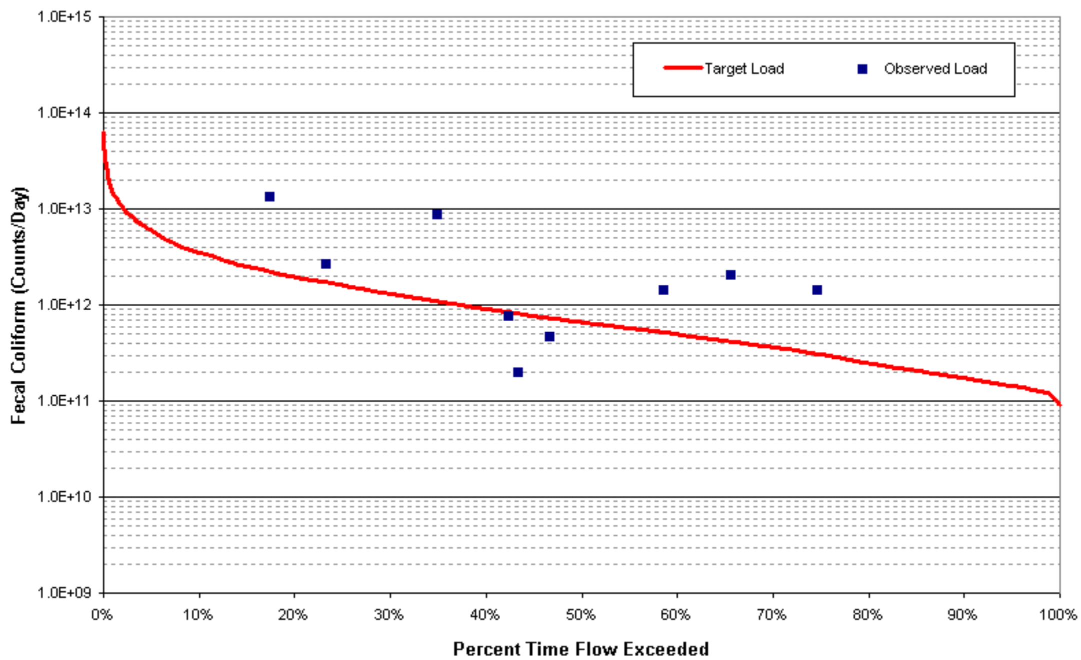


Figure C-21. Fecal Coliform Load Duration Curve for Sweetwater Creek at Mile 10.4

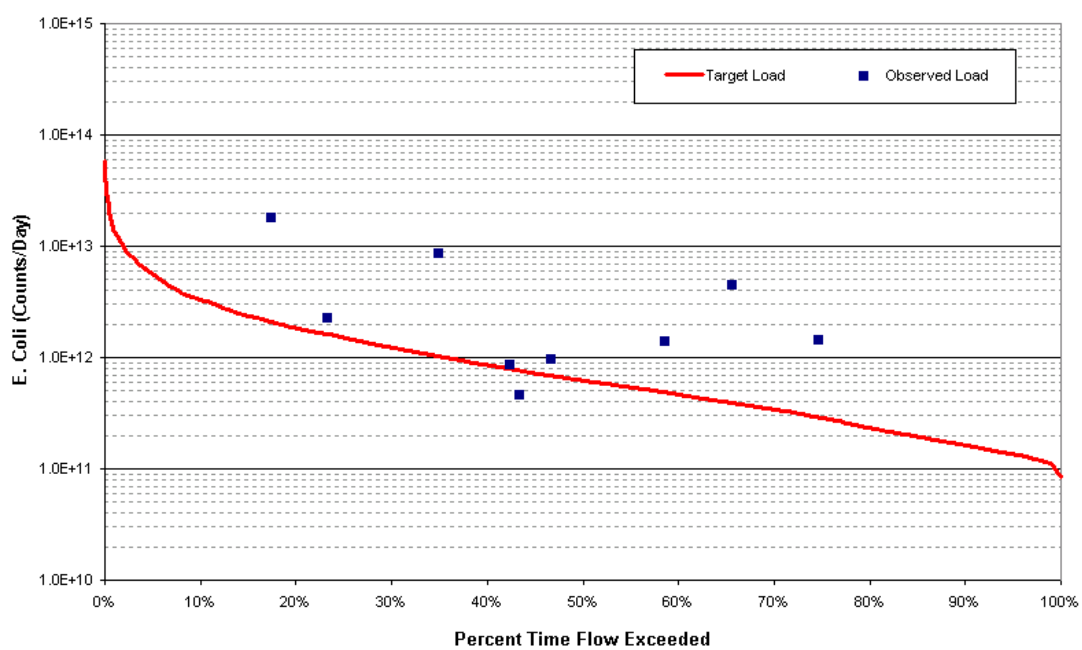


Figure C-22. E. Coli Load Duration Curve for Sweetwater Creek at Mile 10.4

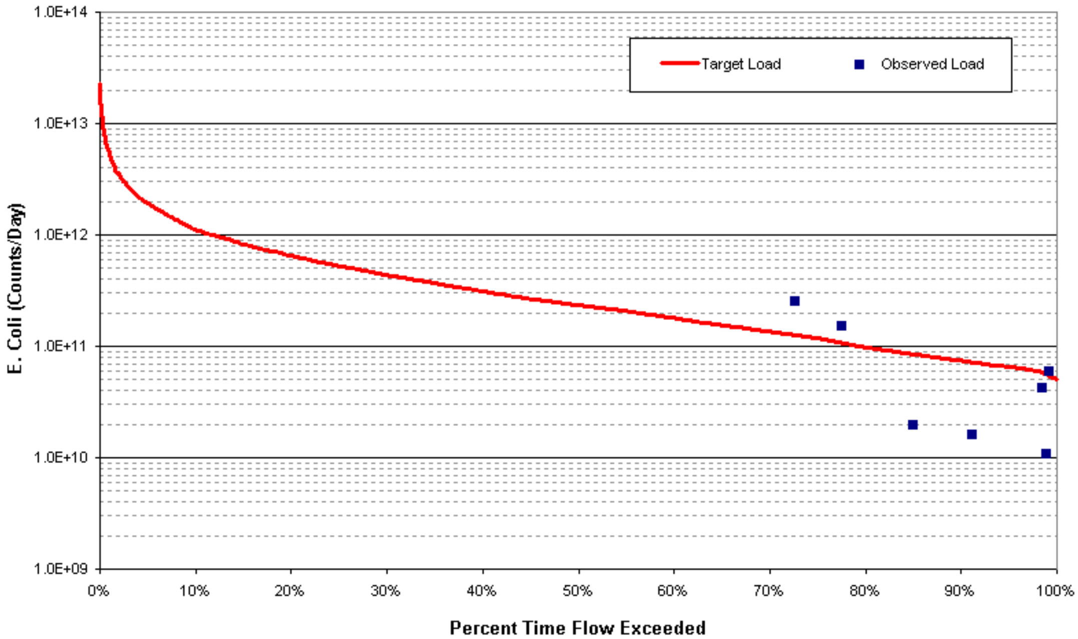


Figure C-23. E. Coli Load Duration Curve for Black Creek

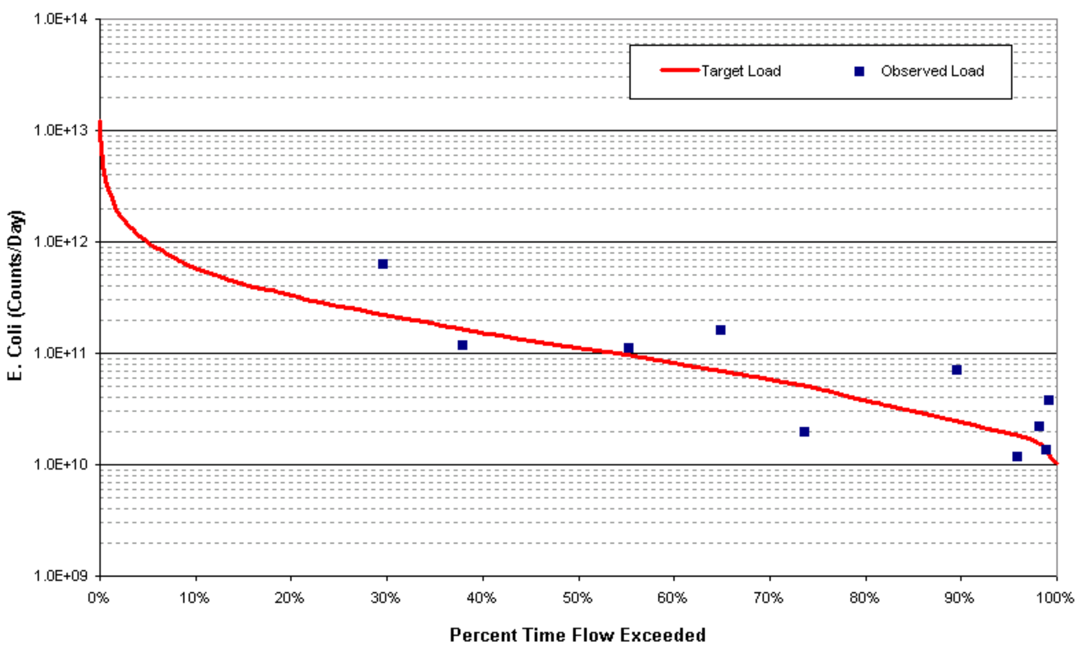


Figure C-24. E. Coli Load Duration Curve for Steekee Creek

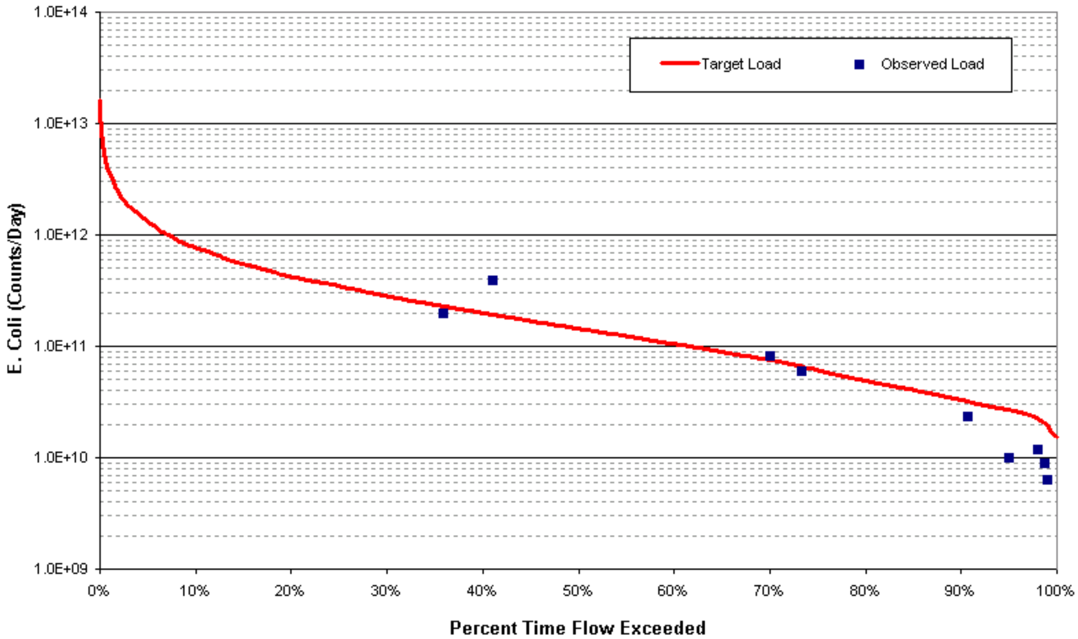


Figure C-25. E. Coli Load Duration Curve for Hines Creek

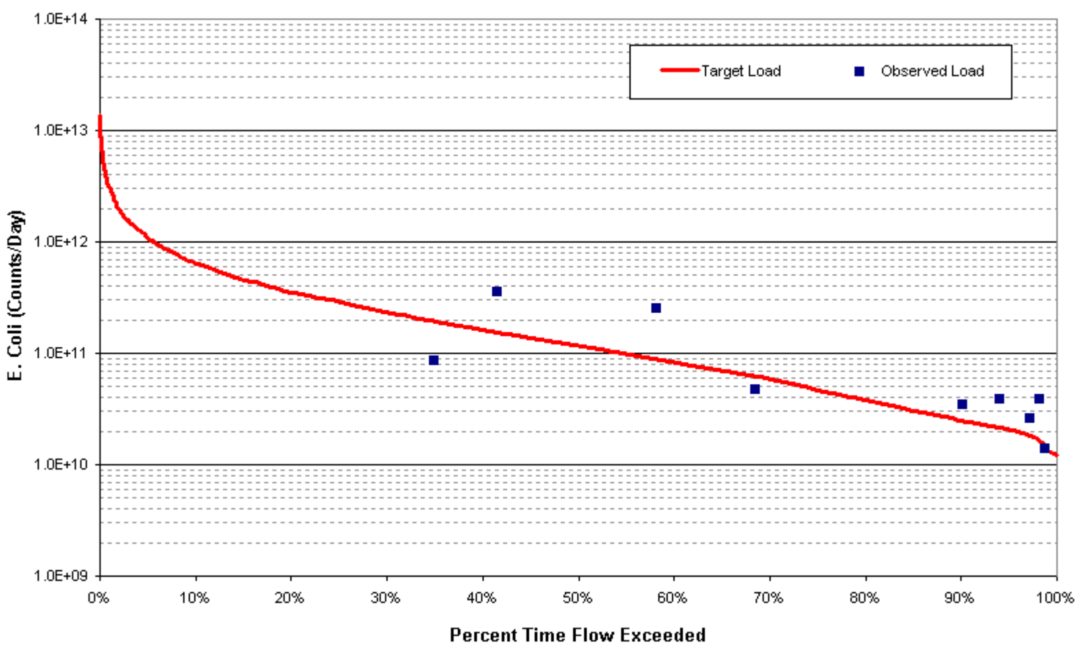


Figure C-26. E. Coli Load Duration Curve for Polecat Creek

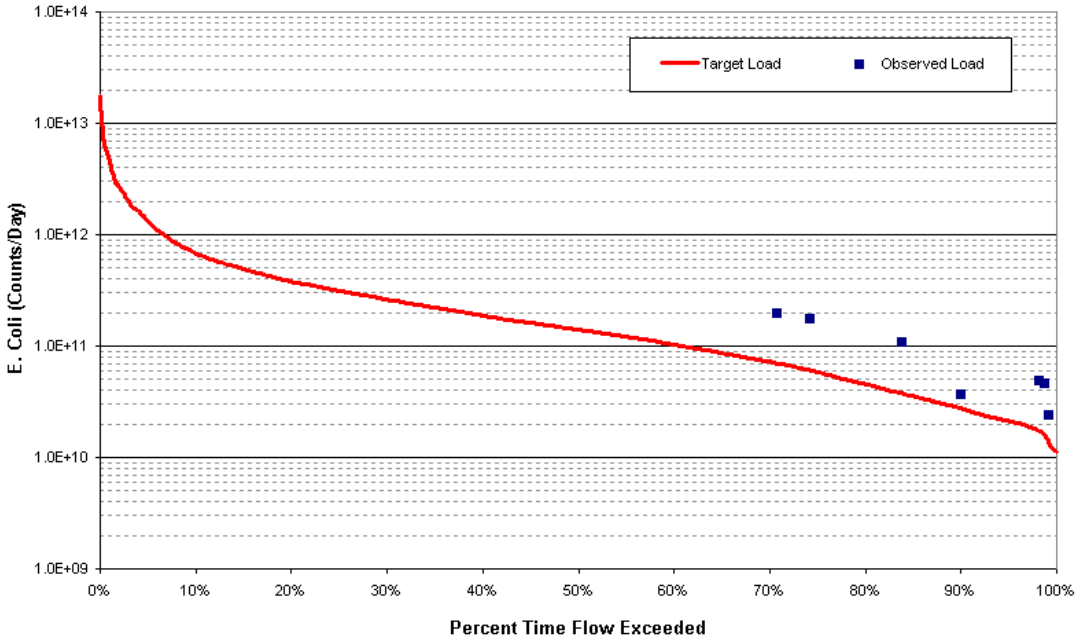


Figure C-27. E. Coli Load Duration Curve for Caney Creek

Table C-1. Required Reduction for Paint Rock Creek – E. Coli Analysis

Sample Date	Flow	PDFE	E. Coli			
			Sample Concentration	Required Reduction	Geometric Mean[a]	Required Reduction
	[cfs]	[%]	[cts/100 ml]	[%]	[cts/100 ml]	[%]
8/20/02	4.00	90.4%	228	**NR**		
8/29/02	3.49	94.3%	770	**NR**		
9/4/02	2.95	97.4%	488	**NR**		
9/10/02	2.66	98.3%	461	**NR**		
9/19/02	2.47	98.8%	1,733	51.1	584.88	80.7
9/24/02	15.35	57.3%	>2,419	65.0	938.01	88.0
10/1/02	10.61	67.8%	1,203	29.6	1,025.57	**89.0**
10/24/02	33.49	34.6%	411	**NR**		
10/28/02	24.96	42.8%	1,300	34.9		
		90th Percentile	**>1,870**	**>51.9**		

Note: NR = Not Required
[a] Geometric Mean is calculated whenever 5 or more samples are collected over a period of not more than 30 consecutive days.

Table C-2. Required Load Reduction for Mud Creek – Fecal Coliform Analysis

Sample Date	Flow	PDFE	Fecal Coliform Sample Concentration	Fecal Coliform Required Reduction
	[cfs]	[%]	[cts/100 ml]	[%]
7/25/01	1.46	88.7%	1,700	47.1
8/20/01	1.53	87.5%	1,200	25.0
9/26/01	17.18	22.7%	2,500	64.0
10/16/01	2.36	78.3%	2,400	62.5
11/14/01	1.46	88.5%	10,900	91.7
12/12/01	21.20	18.6%	18,700	95.2
1/24/02	300.48	0.4%	23,000	96.1
2/26/02	7.02	46.9%	5,060	82.2
3/26/02	13.76	28.4%	1,400	35.7
3/26/02	13.76	28.4%	1,100	18.2
5/3/02	74.65	3.6%	1,560	42.3
5/22/02	5.95	52.5%	1	**NR**
5/22/02(dup)	5.95	52.5%	1	**NR**
		90th Percentile	**17,140**	**94.8**

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

Table C-3. Required Load Reduction for Mud Creek – E. Coli Analysis

Sample Date	Flow	PDFE	E. Coli Sample Concentration	E. Coli Required Reduction
	[cfs]	[%]	[cts/100 ml]	[%]
7/25/01	1.46	88.7%	27,550	96.9
8/20/01	1.53	87.5%	980	13.6
9/26/01	17.18	22.7%	2419.2	65.0
10/16/01	2.36	78.3%	200	**NR**
11/14/01	1.46	88.5%	8,260	89.8
12/12/01	21.20	18.6%	19,350	95.6
1/24/02	300.48	0.4%	43,520	98.1
2/26/02	7.02	46.9%	1,300	34.8
3/26/02	13.76	28.4%	1,203	29.6
3/26/02	13.76	28.4%	1,046	19.0
5/3/02	74.65	3.6%	23,820	96.4
5/22/02	5.95	52.5%	1	**NR**
5/22/02(dup)	5.95	52.5%	1	**NR**
		90th Percentile	**26,804**	**96.8**

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

Table C-4. Required Load Reduction for Greasy Branch – Fecal Coliform Analysis

Sample Date	Flow	PDFE	Fecal Coliform Sample Concentration	Fecal Coliform Required Reduction
	[cfs]	[%]	[cts/100 ml]	[%]
7/25/01	0.80	87.0%	1,640	45.1
8/20/01	0.65	92.2%	1,800	50.0
9/26/01	9.67	21.8%	2,000	55.0
10/16/01	1.34	75.3%	2,700	66.7
11/14/01	0.83	86.2%	6,800	86.8
12/12/01	11.97	17.2%	50,000	98.2
2/26/02	3.49	48.0%	5,420	83.4
2/26/02(dup)	3.49	48.0%	6,300	85.7
3/26/02	6.83	29.7%	2,100	57.1
3/26/02	6.83	29.7%	1,900	52.6
5/3/02	39.38	3.7%	5,000	82.0
5/22/02	3.34	49.3%	770	**NR**
		90th Percentile	**6,750**	**86.7**

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

Table C-5. Required Load Reduction for Greasy Branch – E. Coli Analysis

Sample Date	Flow	PDFE	E. Coli Sample Concentration	E. Coli Required Reduction
	[cfs]	[%]	[cts/100 ml]	[%]
7/25/01	0.80	87.0%	17,820	95.2
8/20/01	0.65	92.2%	2,280	62.9
9/26/01	9.67	21.8%	34,480	97.5
10/16/01	1.34	75.3%	300	**NR**
11/14/01	0.83	86.2%	1,580	46.4
12/12/01	11.97	17.2%	241,920	99.6
2/26/02	3.49	48.0%	1,733	51.1
2/26/02(dup)	3.49	48.0%	1,553	45.5
3/26/02	6.83	29.7%	1,420	40.4
3/26/02	6.83	29.7%	1,300	34.8
5/3/02	39.38	3.7%	57,940	98.5
5/22/02	3.34	49.3%	740	**NR**
		90th Percentile	**55,594**	**98.5**

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

Table C-6. Required Load Reduction for Pond Creek at Mile 11.0 – Fecal Coliform Analysis

Sample Date	Flow	PDFE	Fecal Coliform Sample Concentration	Fecal Coliform Required Reduction
	[cfs]	[%]	[cts/100 ml]	[%]
7/25/01	4.24	88.7%	3,400	73.5
8/20/01	4.40	87.5%	2,200	59.1
9/26/01	52.53	21.6%	1,100	18.2
10/16/01	6.92	77.0%	2,400	62.5
11/14/01	4.31	88.1%	5,700	84.2
12/12/01	64.04	17.4%	16,300	94.5
12/12/01	64.04	17.4%	20,600	95.6
1/24/02	869.84	0.4%	65,000	98.6
2/26/02	19.20	47.7%	3,600	75.0
3/26/02	37.78	29.0%	1,000	**NR**
3/26/02	37.78	29.0%	1,000	**NR**
5/3/02	230.82	3.3%	7,000	87.1
5/22/02	17.81	50.2%	1,100	18.2
		90th Percentile	**19,740**	**95.4**

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

Table C-7. Required Load Reduction for Pond Creek at Mile 11.0 – E. Coli Analysis

Sample Date	Flow	PDFE	E. Coli Sample Concentration	E. Coli Required Reduction
	[cfs]	[%]	[cts/100 ml]	[%]
7/25/01	4.24	88.7%	2,160	60.8
8/20/01	4.40	87.5%	2,620	67.7
9/26/01	52.53	21.6%	1,986.3	57.4
10/16/01	6.92	77.0%	520	**NR**
11/14/01	4.31	88.1%	1,119.9	24.4
12/12/01	64.04	17.4%	29,090	97.1
12/12/01	64.04	17.4%	41,060	97.9
1/24/02	869.84	0.4%	173,290	99.5
2/26/02	19.20	47.7%	517	**NR**
3/26/02	37.78	29.0%	1,733	51.1
3/26/02	37.78	29.0%	1,986	57.4
5/3/02	230.82	3.3%	111,990	99.2
5/22/02	17.81	50.2%	1,414	40.1
		90th Percentile	**97,804**	**99.1**

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

Table C-8. Required Load Reduction for Bacon Creek – Fecal Coliform Analysis

Sample Date	Flow	PDFE	Fecal Coliform Sample Concentration	Fecal Coliform Required Reduction
	[cfs]	[%]	[cts/100 ml]	[%]
1/28/03	6.18	42.3%	180	**NR**
3/18/03	6.56	40.7%	1160	22.4
4/16/03	12.80	23.8%	1000	**NR**
5/28/03	4.04	55.1%	820	**NR**
6/18/03	2.05	74.1%	5000	82.0
7/29/03	2.91	64.8%	2600	65.4
8/6/03	16.56	18.0%	1500	40.0
8/12/03	7.99	35.4%	1500	40.0
		90th Percentile	**3320**	**72.9**

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

Table C-9. Required Load Reduction for Bacon Creek – E. Coli Analysis

Sample Date	Flow	PDFE	E. Coli Sample Concentration	E. Coli Required Reduction
	[cfs]	[%]	[cts/100 ml]	[%]
1/28/03	6.18	42.3%	84	**NR**
3/18/03	6.56	40.7%	1203	29.6
4/16/03	12.80	23.8%	1120	24.4
5/28/03	4.04	55.1%	816	**NR**
6/18/03	2.05	74.1%	3590	76.4
7/29/03	2.91	64.8%	1414	40.1
8/6/03	16.56	18.0%	1203	29.6
8/12/03	7.99	35.4%	1300	34.9
		90th Percentile	**2067**	**59.0**

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

Table C-10. Required Load Reduction for Sweetwater Creek at Mile 10.4 – Fecal Coliform Analysis

Sample Date	Flow	PDFE	Fecal Coliform	
			Sample Concentration	Required Reduction
	[cfs]	[%]	[cts/100 ml]	[%]
1/14/03	33.11	46.7%	580	**NR**
1/28/03	36.93	43.3%	220	**NR**
3/18/03	38.26	42.3%	810	**NR**
4/16/03	78.45	23.3%	1400	35.7
5/28/03	23.74	58.5%	2500	64.0
6/18/03	14.06	74.6%	4200	78.6
7/29/03	18.95	65.5%	4400	79.6
8/6/03	101.47	17.4%	5400	83.3
8/12/03	49.85	34.8%	7300	87.7
		90th Percentile	**5780**	**84.4**

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

Table C-11. Required Load Reduction for Sweetwater Creek at Mile 10.4 – E. Coli Analysis

Sample Date	Flow	PDFE	E. Coli	
			Sample Concentration	Required Reduction
	[cfs]	[%]	[cts/100 ml]	[%]
1/14/03	33.11	46.7%	1203	**NR**
1/28/03	36.93	43.3%	517	**NR**
3/18/03	38.26	42.3%	921	**NR**
4/16/03	78.45	23.3%	1203	29.6
5/28/03	23.74	58.5%	2419	65.0
6/18/03	14.06	74.6%	4260	80.1
7/29/03	18.95	65.5%	9840	91.4
8/6/03	101.47	17.4%	7230	88.3
8/12/03	49.85	34.8%	7080	88.0
		90th Percentile	**7752**	**89.1**

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

Table C-12. Required Load Reduction for Black Creek – E. Coli Analysis

Sample Date	Flow	PDFE	E. Coli	
			Sample Concentration	Required Reduction
	[cfs]	[%]	[cts/100 ml]	[%]
8/6/02	4.10	84.9%	199	**NR**
8/14/02	3.48	91.1%	192	**NR**
9/5/02	2.84	98.4%	613	**NR**
9/9/02	2.76	98.8%	161	**NR**
9/19/02	2.68	99.1%	921	**NR**
10/3/02	5.20	77.5%	1203	29.6
10/10/02	6.11	72.6%	1733	51.1
		90th Percentile	**1415**	**40.1**

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

Table C-13. Required Load Reduction for Steekee Creek – E. Coli Analysis

Sample Date	Flow	PDFE	E. Coli			
			Sample Concentration	Required Reduction	Geometric Mean[a]	Required Reduction
	[cfs]	[%]	[cts/100 ml]	[%]	[cts/100 ml]	[%]
5/17/00	4.66	55.2%	980	13.6		
8/20/02	1.20	89.5%	>2419	65.0		
8/29/02	0.89	95.9%	549	**NR**		
9/4/02	0.75	98.1%	1203	29.6		
9/10/02	0.68	98.8%	816	**NR**		
9/19/02	0.64	99.1%	>2419	65.0	1258.23	**91.0**
9/24/02	3.36	64.8%	1986	57.4	1209.56	90.7
10/1/02	2.47	73.6%	326	**NR**	1089.83	89.6
10/24/02	7.96	37.9%	613	**NR**		
10/28/02	10.72	29.5%	>2419	65.0		
		90th Percentile	**>2419**	**>65.0**		

Note: NR = Not Required
[a] Geometric Mean is calculated whenever 5 or more samples are collected over a period of not more than 30 consecutive days.

Table C-14. Required Load Reduction for Hines Creek – E. Coli Analysis

Sample Date	Flow	PDFE	E. Coli			
			Sample Concentration	Required Reduction	Geometric Mean[a]	Required Reduction
	[cfs]	[%]	[cts/100 ml]	[%]	[cts/100 ml]	[%]
8/20/02	1.55	90.7%	613	**NR**		
8/29/02	1.30	95.0%	313	**NR**		
9/4/02	1.10	98.0%	435	**NR**		
9/10/02	1.00	98.7%	365	**NR**		
9/19/02	0.94	99.0%	276	**NR**	384.54	70.6
9/24/02	3.67	70.0%	921	**NR**	417.16	72.9
10/1/02	3.20	73.3%	770	**NR**	499.45	**77.4**
10/24/02	11.05	35.9%	727	**NR**		
10/28/02	9.22	41.1%	1733	51.1		
		90th Percentile	**1083**	**21.8**		

Note: NR = Not Required
[a] Geometric Mean is calculated whenever 5 or more samples are collected over a period of not more than 30 consecutive days.

Table C-15. Required Load Reduction for Polecat Creek – E. Coli Analysis

Sample Date	Flow	PDFE	E. Coli			
			Sample Concentration	Required Reduction	Geometric Mean[a]	Required Reduction
	[cfs]	[%]	[cts/100 ml]	[%]	[cts/100 ml]	[%]
8/20/02	1.19	90.1%	1203	29.6		
8/29/02	1.04	94.0%	1553	45.5		
9/4/02	0.88	97.2%	1203	29.6		
9/10/02	0.80	98.2%	1986	57.4		
9/19/02	0.74	98.7%	770	**NR**	1280.07	91.2
9/24/02	4.27	58.1%	>2419	65.0	1472.00	**92.3**
10/1/02	3.02	68.4%	649	**NR**	1236.30	90.9
10/24/02	9.40	34.9%	378	**NR**		
10/28/02	7.44	41.5%	1986	57.4		
		90th Percentile	**>2073**	**>59.1**		

Note: NR = Not Required
[a] Geometric Mean is calculated whenever 5 or more samples are collected over a period of not more than 30 consecutive days.

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

Sample Date	Flow	PDFE	E. Coli	
			Sample Concentration	Required Reduction
	[cfs]	[%]	[cts/100 ml]	[%]
8/6/02	1.82	83.8%	>2419	65.0
8/14/02	1.34	89.9%	1120	24.4
9/5/02	0.84	98.2%	>2419	65.0
9/9/02	0.78	98.7%	>2419	65.0
9/19/02	0.70	99.1%	1414	40.1
10/3/02	2.94	74.2%	>2419	65.0
10/10/02	3.39	70.7%	>2419	65.0
		90th Percentile	**>2419**	**>65.0**

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

APPENDIX D

Hydrodynamic Modeling Methodology

HYDRODYNAMIC MODELING METHODOLOGY

D.1 Model Selection

The Loading Simulation Program C++ (LSPC) was selected for flow simulation of pathogen-impaired waters in the subwatersheds of the Watts Bar 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 Watts Bar 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 Watts Bar 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 Bullrun Creek near Halls Crossroads, USGS Station 03535000, are shown in Table D-1 and Figures D-1 and D-2.

Table D-1. Hydrologic Calibration Summary: Bullrun Creek (USGS 03535000)

Simulation Name:	USGS03535000	**Simulation Period:**	
		Watershed Area (ac):	43607.17
Period for Flow Analysis			
Begin Date:	**10/01/80**	**Baseflow PERCENTILE:**	2.5
End Date:	**09/30/86**	*Usually 1%-5%*	
Total Simulated In-stream Flow:	**82.36**	Total Observed In-stream Flow:	**91.27**
Total of highest 10% flows:	**42.83**	Total of Observed highest 10% flows:	**47.36**
Total of lowest 50% flows:	**9.68**	Total of Observed Lowest 50% flows:	**10.06**
Simulated Summer Flow Volume (months 7-9):	**9.30**	Observed Summer Flow Volume (7-9):	**7.91**
Simulated Fall Flow Volume (months 10-12):	**14.00**	Observed Fall Flow Volume (10-12):	**15.95**
Simulated Winter Flow Volume (months 1-3):	**31.45**	Observed Winter Flow Volume (1-3):	**35.49**
Simulated Spring Flow Volume (months 4-6):	**27.61**	Observed Spring Flow Volume (4-6):	**31.92**
Total Simulated Storm Volume:	**76.18**	Total Observed Storm Volume:	**83.16**
Simulated Summer Storm Volume (7-9):	**7.76**	Observed Summer Storm Volume (7-9):	**5.88**
Errors (Simulated-Observed)		*Recommended Criteria*	Last run
Error in total volume:	**-9.76**	10	
Error in 50% lowest flows:	**-3.75**	10	
Error in 10% highest flows:	**-9.57**	15	
Seasonal volume error - Summer:	**17.59**	30	
Seasonal volume error - Fall:	**-12.22**	30	
Seasonal volume error - Winter:	**-11.39**	30	
Seasonal volume error - Spring:	**-13.50**	30	
Error in storm volumes:	**-8.39**	20	
Error in summer storm volumes:	**31.99**	50	

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

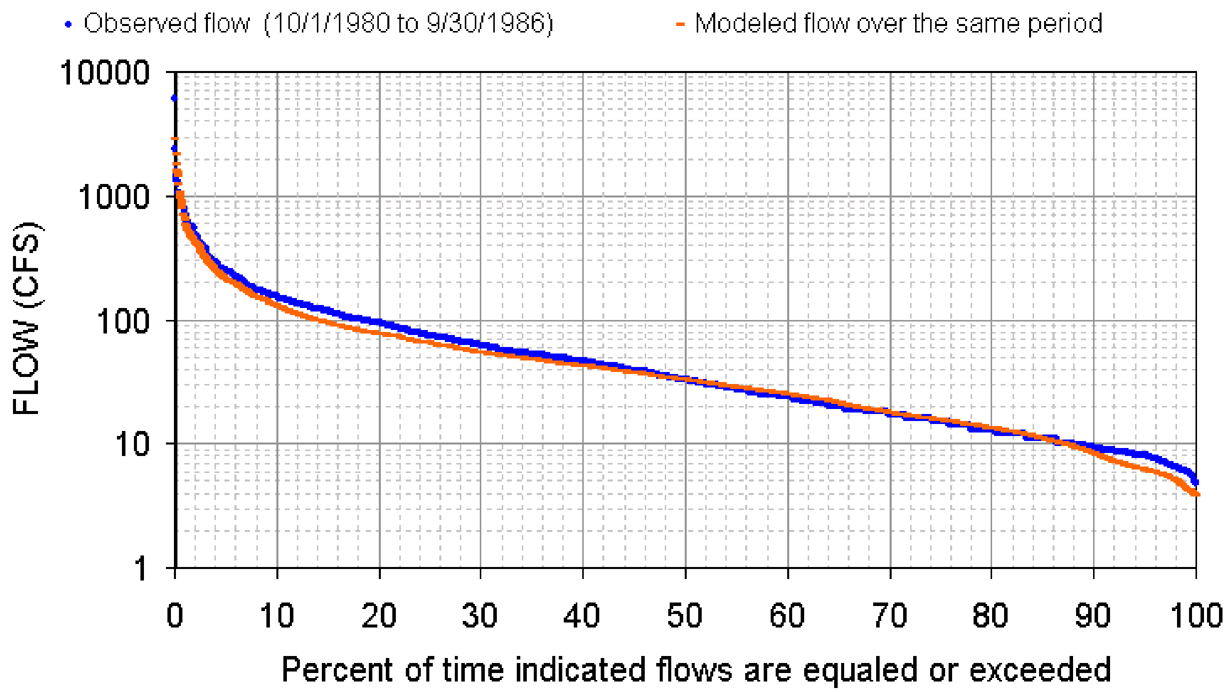


Figure D-1. Hydrologic Calibration: Bullrun Creek, USGS 03535000 (WYs1981-86)

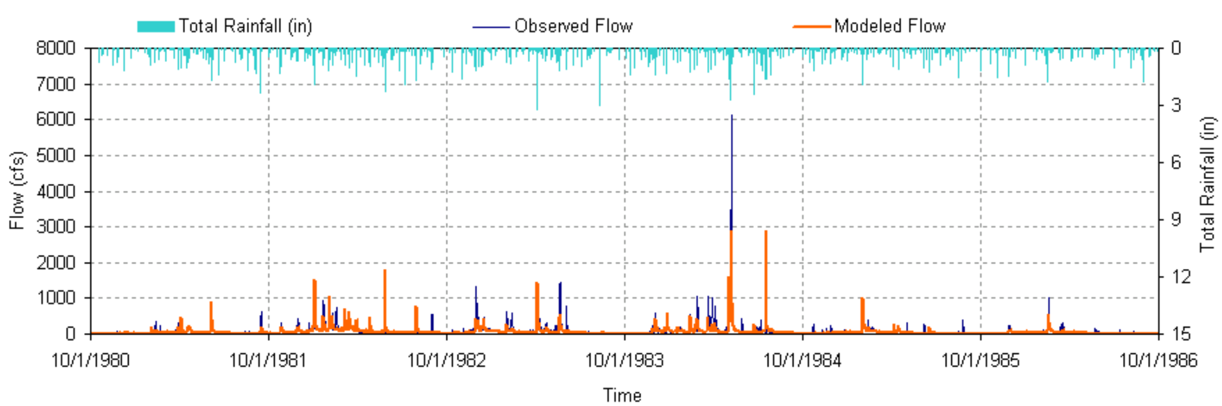


Figure D-2. 6-Year Hydrologic Comparison: Bullrun Creek, USGS 03535000

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 Watts Bar waterbodies are summarized in Table E-1.

Table E-1. WLAs & LAs for Watts Bar, Tennessee

HUC-12 Subwatershed (06010201__) 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]
0306	PAINT ROCK CREEK	TN06010201011 – 1000	**89.0**	**NA***	**NA**	**NA**	**89.0**	**89.0**	**0**
0305	MUD CREEK	TN06010201013 – 0100	**99.1**	**NA***	**NA**	**0**	**99.1**	**99.1**	**0**
	GREASY BRANCH	TN06010201013 – 0200							
	POND CREEK	TN06010201013 – 1000 & 2000							
0304	BACON CREEK	TN06010201015 – 0100	**89.1**	**7.154×10^9**	**0**	**0**	**89.1**	**89.1**	**0**
	SWEETWATER CREEK	TN06010201015 – 1000							
0503	BLACK CREEK	TN06010201040 – 0600	**40.1**	**7.869×10^9**	**0**	**NA**	**NA**	**40.1**	**0**
0302	STEEKEE CREEK	TN06010201065 – 1000	**91.0**	**NA***	**NA**	**NA**	**91.0**	**91.0**	**0**
0303	HINES CREEK	TN06010201087 – 1000	**92.3**	**NA***	**NA**	**NA**	**92.3**	**92.3**	**0**
	POLECAT CREEK	TN060102011149 – 1000							
0402	CANEY CREEK	TN060102011621 – 1000	**>65.0**	**NA***	**NA**	**NA**	**NA**	**>65.0**	**0**

Note: NA = Not Applicable.

* *Future WWTFs must meet instream water quality standards at the point of discharge as specified in their NPDES permit.*

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

Watershed Projects in the Watts Bar Watershed

TDA-NPS FY-2004 WORK PLAN

NAME OF PROJECT:
Pond Creek Protection and Water Quality Improvement Project

LEAD ORGANIZATION:

University of Tennessee Agricultural Extension Service

COOPERATING ORGANIZATIONS:

1. Tennessee Department of Agriculture
2. Tennessee Department of Environment and Conservation
3. USDA Natural Resources Conservation Service
4. Tennessee Valley Authority
5. United State Environmental Protection Agency

Tennessee Department of Agriculture (TDA) will provide technical support and advice to producers as requested. TDA has provided funding assistance to initiate work on the watershed inventory with TVA.

Tennessee Department of Environment and Conservation (TDEC) will provide technical advice to watershed coordinator on water sampling protocols. TDEC has partnered with the University of Tennessee on a number of similar water quality projects around the state.

USDA Natural Resources Conservation Service (NRCS) will continue to provide technical support and assistance to producers in best management practice (BMP) designs and cost-share assistance from federal programs (when available).

Tennessee Valley Authority (TVA) has provided start-up funds to support the watershed coordinator's activities.

United State Environmental Protection Agency (EPA) Region IV office, Atlanta has worked closely with the University of Tennessee to initiate this project.

PROJECT ABSTRACT:

1. Name of Lead Agency.
University of Tennessee Agricultural Extension Service

2. Project Location.
Pond Creek, McMinn, Monroe and Loudon counties, in the Upper Tennessee Basin (TN06010202013)

3. Project Objective.
The ultimate objective of this project is to implement agricultural BMPs that will improve water quality and remove the Pond Creek watershed from the 303(d) list of impaired watersheds for Tennessee.

4. Introduction.
In April 2003, with support from the Tennessee Valley Authority, Tennessee Department of Agriculture and the Environmental Protection Agency, the University of Tennessee Agricultural Extension Service initiated a long-term project to improve water quality in Pond Creek. Agriculture in the Pond Creek watershed is typical of beef cow-calf and dairy systems in the Southeastern United States. Pond Creek is listed on the 303(d) list as an impaired stream in Tennessee for pathogens and nutrients. Dairy and beef cattle operations are the main agricultural activities in the watershed and are suspected to be responsible for much of the pollution. Support for this project is only guaranteed through 2004. There is an urgent need to build on the work of these initial efforts to improve water quality in Pond Creek.

5. Outputs.
During the project whole farm nutrient management plans will be developed with livestock operations in the watershed. Improvements in manure storage, handling and distribution will reduce pollution levels from these operations. Best management practices (BMPs) will be installed on both dairy and beef operations with cost-share assistance from federal and state funding sources. A stakeholder Watershed Management Group will be formed and a Watershed management plan will be developed and implemented. Changes in water quality will be monitored from monthly samples taken at eight sites along the watershed. Lessons from the experiences in Pond Creek will be shared with agencies and others within Tennessee and the Southeastern United States. The approaches developed in Pond Creek will be used as a model for similar watersheds.

6. Expected Outcomes.
Livestock producers in Pond Creek will be better educated about the impact of their operations on water quality. Producers will make changes to their current manure handling and animal husbandry practices that will reduce the potential for the loading of pollutants to Pond Creek. Water quality in Pond Creek will be improved and Pond Creek removed from the 303(d) listed streams in Tennessee.

PROJECT OBJECTIVE:

The University of Tennessee Institute of Agriculture (UTIA), in collaboration with other agencies in Tennessee, is proposing to expand a water quality improvement project in the Pond Creek watershed (TN06010202013) in the Upper Tennessee Basin of Eastern Tennessee. The project will seek to identify nonpoint source impairments from agriculture in the Pond Creek Watershed, install best management practices (BMPs) and restore it to the condition of fully supporting its designated uses.

Collaborating agencies that have invested time, money and other resources in support of this project are the Tennessee Department of Agriculture (TDA) non-point source program, the Tennessee Department of Environment and Conservation (TDEC), the Natural Resources Conservation Service (NRCS), the Tennessee Valley Authority (TVA) and the United States Environmental Protection Agency (EPA) Region 4, Water Management Division. Representatives of these agencies have been working on various projects within Pond Creek. Significant work and collaboration between these agencies in the Pond Creek watershed have created the need for additional financial support to enhance the efforts of these agencies.

The ultimate objective of this project is to implement agricultural BMPs that will improve water quality and remove the Pond Creek watershed from the 303(d) list of impaired watersheds for Tennessee.

Specific objectives of the project are to:

1. Provide science-based water quality information to producers that will encourage them to actively work to protect and improve the waters of the Pond Creek watershed.
2. Establish a Pond Creek Watershed Group comprised of local stakeholders (producers and commodity, environmental and civic organizations), as well as the partnering agencies identified in this proposal. This group, with guidance from Extension professionals, will develop a Local Watershed Restoration Plan.
3. Conduct an inventory of the Pond Creek watershed using aerial, infrared remote-sensing techniques.
4. Establish two model farms (one dairy, and one beef) that will develop whole farm nutrient management plans, and implement other appropriate best management practices (BMP). These farms will serve as an example to other producers and will host a field day.
5. Continue monitoring to document improvements to the watershed.
6. Develop whole farm nutrient management plans for all producers in the Pond Creek watershed, with technical assistance provided by Natural Resources Conservation Service (NRCS).
7. Secure funding to assist producers with BMP implementation.

The project focus includes working with stakeholders in the watershed to monitor water quality, developing whole farm nutrient management plans (NMPs) and implementing best management practices (BMPs). Producers will be encouraged to seek cost-share funds for BMP implementation from current programs administered by USDA.

Additional funding to expand this water quality improvement project will enable us to reach, educate and effect much-needed change in the Pond Creek watershed, and ensure greater community participation in watershed management and watershed management decisions.

TDA-NPS LONG TERM GOALS SUPPORTED:

This project will support most of the long-term goals listed in the Tennessee Program Management Document (http://www.state.tn.us/agriculture/nps/npsdoc/index.htm). This project will specifically support the following goals:

Long Term Goal 1
Hold regularly scheduled meetings with stakeholders, to create new partnerships, strengthen existing partnerships and foster greater trust, commitment and accountability. This will be achieved through the formation of a watershed management group.

Long Term Goal 2
Fully implement all developed TMDLs for nonpoint sources in compliance with existing regulations, policies or agreements by 2015. This will be achieved through the development of a watershed plan in collaboration with the watershed management group.

Long Term Goal 3
Restore all waters impaired by nonpoint sources that are listed on the 1998 303(d) List to the condition of fully supporting their designated uses by 2015, in cooperation with local, state, and federal partners. Changes in agricultural practices in Pond Creek will reduce the impact of agriculture in particular dairy and beef operations on water quality in Pond Creek.

Long Term Goal 5
Improve the knowledge of stakeholders and citizens concerning the origins, magnitude, and prevention of nonpoint source pollution.

Long Term Goal 7
Use the maximum allowable percentage of funding annually to assist partners with water quality monitoring and assessment, for the duration of the TDA-NPS Program.

PROJECT LOCATION:

1. Name of the watershed.
Pond Creek, McMinn, Monroe and Loudon counties, in the Upper Tennessee Basin (TN06010202013)

2. Names of impaired waterbodies from the 303(d) List
Mud Creek (7.2 miles), Greasy Branch (7.3 miles) and Pond Creek (21.1 miles)

3. Waterbody segment numbers, from the 303(d) List
Mud Creek (TN06010201013-0100), Greasy Branch (TN06010201013-0200), and Pond Creek (TN06010201013-1000 7 2000).

4. Latitude and longitude coordinates for the project.
Coordinates for the water sampling points along the watershed are summarized below (Table 1).

Table 1. Pond Creek Watershed General Descriptions.

Site	Latitude	Longitude	Total Subbasin Drainage Area	Land Use per subbasin
1	N 35°43"53.42'	W -84°26"30.73'	641 ha	Agriculture (326 ha), mixed forest (263 ha)
2	N 35°42"19.11'	W -84°27"32.18'	467 ha	Agriculture (309 ha) -Dairy, mixed forest
3	N 35°41"18.28'	W -84°27"59.80'	948 ha	Agriculture (822 ha)-Dairy and Emu
4	N 35°39"57.57'	W -84°28"59.47'	1217 ha	Agriculture (947 ha-Dairy, mixed forest
5	N 35°38"46.15'	W -84°29"7.77'	774 ha	Agriculture (627 ha)-Dairy, mixed forest
6	N 35°38"37.13'	W -84°29"40.55'	1458 ha	Agriculture (1018 ha)-Dairy, evergreen forest
7	N 35°38"20.38'	W -84°29"30.91'	1096 ha	Agriculture (866 ha)-Dairy, mixed forest
8	N 35°36"41.58'	W -84°30"56.63'	1508 ha	Agriculture (1202 ha)-Dairy, mixed forest

PROJECT LEADERS EXPERIENCE:

Dr. Forbes Walker will act as project leader. Dr. Walker serves as the environmental soils specialist for the University of Tennessee Agricultural Extension Service. He has statewide responsibilities in the areas of coordinating educational programs in Tennessee in the areas of plant residue management, waste utilization, bio-remediation, nutrient cycling and management, and resource management. He managed the previous 319(h) project that collected water quality data in Pond Creek from 2001 to 2002, and has been responsible for obtaining funds to hire the current watershed coordinator. Dr. Walker is responsible for supervising, assisting and advising the watershed coordinator in the running of the project.

Dr. George Smith is an adviser to the Pond Creek project. He is a Professor in Agricultural Economics responsible for water quality and waste management issues. Dr. Smith chairs an interdisciplinary Clean Water priority program team for the Extension Service and serves as water quality coordinator for Tennessee. Dr. Smith has initiated and managed a number of water quality related projects in the state, and has produced a variety of water quality educational materials including publications, videos and CD-ROM formats.

Ms. Lena Beth Carmichael is the Pond Creek Watershed Coordinator. Her role is to provide information, communication and coordination to assist farmers in Pond Creek. She works to identify cooperators in the watershed. She assists farmers and agency personnel in the development of whole-farm nutrient management plans on cooperating farms, identify sources of funding for cost-share assistance and will assist in the implementation and installation of BMPs. She is advised and assisted by the University of Tennessee Extension agents for Monroe, McMinn and Loudon counties, as well as the NRCS District Conservationists for the same counties.

INTRODUCTION:

From June 2001 to July 2002, an intensive water quality monitoring and modeling project, entitled "*Determination and Verification of Loading Rate Parameters to Support BASINS NPSM/HSPF Model Analysis for Predicting Pathogen and Nutrient Loadings in Two Impaired Watersheds in Tennessee,*" was conducted in the Pond Creek watershed. This project was a collaboration between the University of Tennessee Agricultural Extension Service and TDEC. Funding for this 12-month project was made available through an EPA 319 water quality grant (contract number ED 01-00524-00) administered by the TDA non-point source program.

As part of this project, monthly water samples were collected at eight different locations in the watershed. Monitoring results indicate elevated pathogen (fecal coliform, *Esherichia coli* and others) and nutrient levels, including total phosphorus and total (Kjeldahl) nitrogen (Table 2). These results are consistent with similar analyses conducted by TDEC field staff that resulted in 63.8 miles of this stream being listed in the 303(d) list of impacted watersheds in 1998 (TDEC, 1998; http://www.state.tn.us/environment/water.htm). TDEC identified the causes of the impairment to be siltation, nutrients and habitat alterations from animal feeding operations. This watershed is in an area of intensive family-owned dairy and beef cow-calf operations. None of these operations would be defined as concentrated animal feeding operations (CAFOs) under the federal definitions, but their impact on water quality in the area is significant.

Table 2. Summary of Selected Preliminary Concentrations of Pathogens and Nutrients in Pond Creek: August and December 2001

Site	August 2001				December 2001			
	*Fecal Coliform (CFUs / 100 mL)	*E. coli (CFUs/ 100 mL)	Total N (mg / L)	Total P (mg / L)	*Fecal Coliform (CFUs / 100 mL)	*E. coli (CFUs/ 100 mL)	Total N (mg / L)	Total P (mg / L)
PC1	1250	740	0.42	0.22	9600	10760	0.50	0.18
PC2	1600	2780	0.67	0.22	18000	32550	1.21	0.22
PC3	2100	2500	0.69	0.23	20800	41060	1.10	0.21
PC4	2200	2620	0.69	0.33	20600	41060	1.01	0.19
PC5	4900	3110	0.76	0.28	14600	20350	0.91	0.18
GS	1800	2280	1.06	0.26	50000	241920	0.54	0.16
PC6	700	1400	0.41	0.22	10500	7940	0.95	0.44
MC	1200	980	1.76	0.36	18700	19350	1.23	0.23

* CFUs = Colony forming units

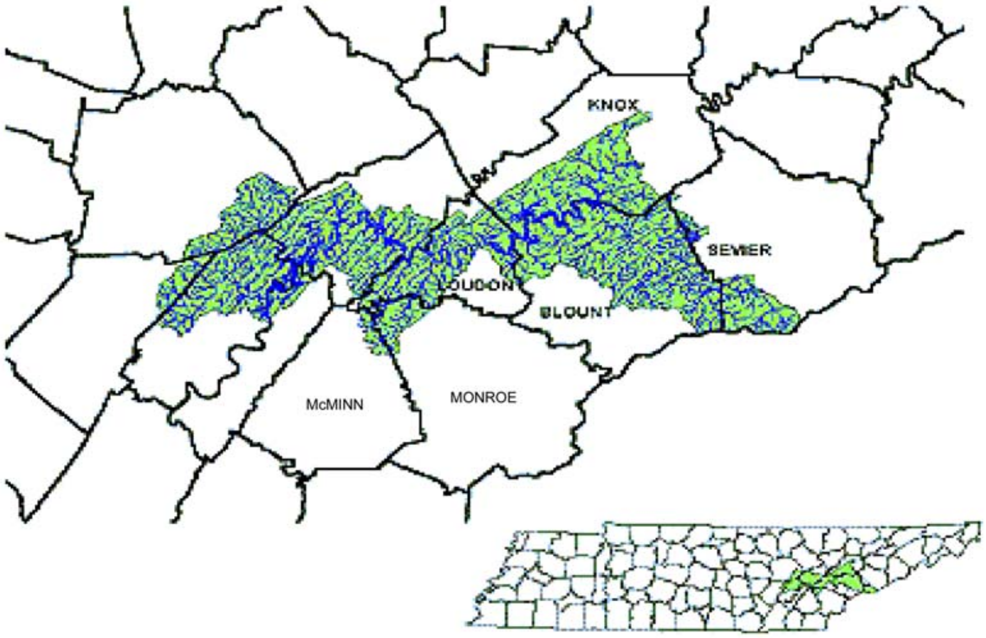
In 1998 TDEC listed and described 795 impaired water bodies. Ninety-six of the impaired water bodies were listed due to excessive pathogens and 60 were listed due to high nutrient content. Agriculture was identified as the leading source of pollutants in the state, responsible for 15 percent of the evaluated impairments (http://www.epa.gov/owow/tmdl/states/tnfact.html). In the proposed final 2002 303 (d) list 7.2 miles of Mud Creek, 7.3 miles of Greasy Branch and 21.1 miles of Pond Creek are listed as being impaired for pathogens and pathogens and nutrients due to pasture grazing (http://www.state.tn.us/environment/water.php).

To date, no agricultural nutrient management plans (NMPs) have been developed in Tennessee on a watershed scale; however, Pond Creek is poised to be the first. Little is understood about the impact that NMPs have on agriculture in watersheds such as Pond Creek or what strategies could be used to obtain positive participation of stakeholders to implement the practices necessary to improve water quality. The approach and methods developed for improving water quality in Pond Creek will serve as a model for other watershed restoration projects in Tennessee and the Southeastern United States.

Agriculture in the Pond Creek watershed is typical of beef cow-calf and dairy systems in the Southeastern United States. Pond Creek is an ideal watershed to conduct a water quality project of this scope because:

1. It is centrally located within the Eastern part of the state in the Watts Bar watershed between Knoxville and Chattanooga (see Figures 1A & 1B)
2. It is close to an important interstate highway (Interstate 75) and readily accessible to other states (Georgia and Kentucky).
3. It is relatively small, approximately 16 miles long by 4 miles at its widest, encompassing approximately 23,460 acres.
4. Land use in the watershed is typical for this region with 49 percent in pasture, 16 percent cropland and 32 percent forested (Frady et al., 1999).
5. It covers parts of three counties (Monroe, McMinn and Loudon), which means the workload would be shared among agency staff in three counties.
6. A number of agencies (UTIA, Extension, NRCS, TDA, TDEC, TVA) have personnel working in the watershed and have an excellent reputation with agricultural producers in the area.

Funding to support the activities of a watershed coordinator for Pond Creek have been secured from TVA (April to September 2003). Additional funds to support the activities of the watershed coordinator until December 2004 are expected from the EPA Region IV Watersheds and Nonpoint Source Section.



www.state.tn.us/environment/wpc/wshed1.htm

Figure 1A. Watts Bar watershed containing Pond Creek watershed, HUC 06010201

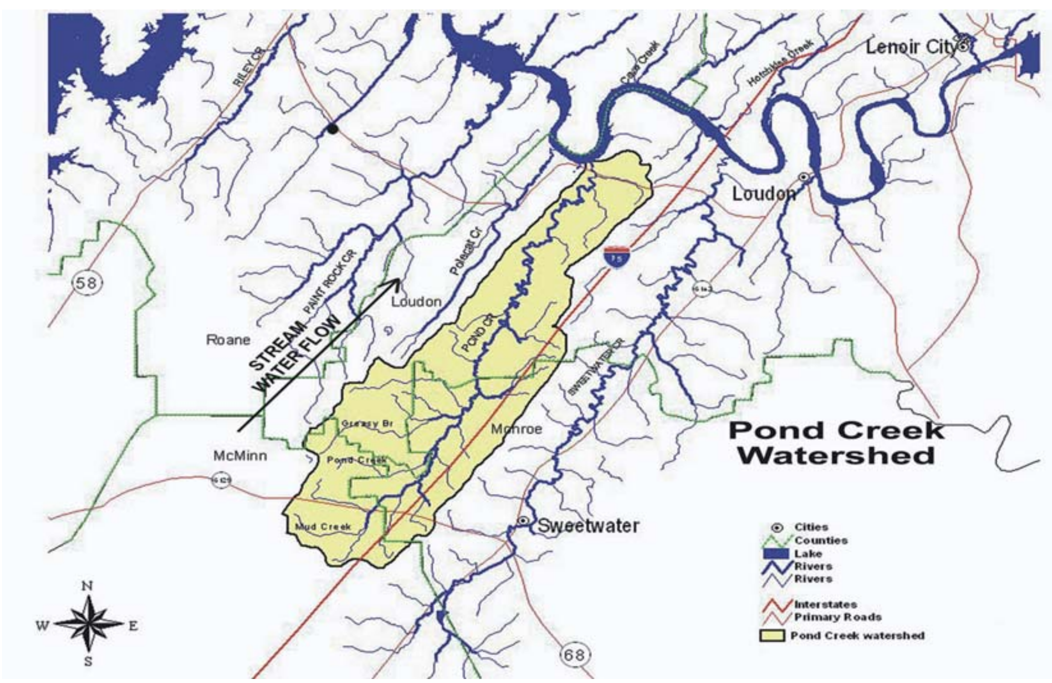


Figure 1B. Map of Pond Creek Watershed

PROJECT IMPLEMENTATION:

The project will implemented by the University of Tennessee Agricultural Extension Service in collaboration with the Tennessee Department of Agriculture (TDA), Tennessee Department of Environment and Conservation (TDEC), USDA Natural Resources Conservation Service (NRCS), Tennessee Valley Authority (TVA) and the United State Environmental Protection Agency (EPA). To date financial support for this project has been secured from the TDA and TVA. A grant to continue support until 2004 has been submitted to the EPA 104(b)(3) Water Quality Cooperative Agreements program. Continued support of the activities of the watershed coordinator and funds to assist producers with the implementation of BMPs beyond 2004 is vital for the success of this project.

During the initial phase of this project (April to Sept. 2003) an inventory of the Pond Creek watershed is being developed by the University of Tennessee Agricultural Extension Service in collaboration with the Tennessee Valley Authority (TVA). A detailed photo interpretation of aerial photographs taken in March 2002 is currently underway (June 2003) by the TVA. The information collected in this interpretation will be integrated into a GIS-based (Integrated Pollutant Source Identification or IPSI) model and used to identify likely source of point and non-point source pollutants.

An additional field inventory of the dairy operations in the watershed is being conducted by the Pond Creek watershed coordinator. Basic nutrient management plans are being developed for each dairy operation in the watershed to assess the ability of each operation to handle and adequately use the manure that is generated on the farm. These plans will identify help prioritize those operations that pose a potential risk to the watershed. There is a need to work with producers to develop more detailed whole farm nutrient management plans that take into account all aspects of manure storage and handling on the farm, as well as field practices that can help to minimize the impact of runoff from agricultural fields. Some best management practices (BMPs), such as changes in manure handling and application practices and reduction in commercial fertilizer use, can be implemented with little or no cost. Other BMPs, such as improvements to manure storage structures, the development of stream crossings, alternative water sources for cattle and stream bank restoration, require substantial capital investment as well as technical assistance. The University of Tennessee Agricultural Extension Service and agencies such as the Natural Resources Conservation Service (NRCS) are able to provide producers with technical assistance. Outside funding sources will be needed to assist many producers in implementing many structural BMPs.

A Pond Creek Watershed Group, with the assistance of the watershed coordinator will be established among stakeholders in the watershed. With other partners the watershed group, will develop a Local Watershed Restoration Plan that will contribute to the State’s development of a TMDL and serve as a key resource for its implementation.

The watershed coordinator will implement a program of water quality sampling. The eight locations established in the previous 319(h) grant (identified earlier in the proposal) will be sampled on a monthly basis and sent to the University of Tennessee Biosystems Engineering and Environmental Science Department water quality laboratory for pathogen analysis.

Beef and dairy farms will be selected as models for other operations in the watershed. These operations will be the focus of BMP implementation and field day events for other producers in the watershed. The watershed coordinator and University of Tennessee specialists will work with all producers in the watershed to develop and implement whole farm nutrient management plans and identify sources of funding to assist producers with the implementation of BMPs.

Educational materials will be developed by the University of Tennessee Agricultural Extension Service to educate stakeholders in the watershed about water quality issues. These materials will be distributed to a wider audience throughout Tennessee through the ongoing educational programs offered by the Extension Service. Lessons learned from the approaches developed and implemented in Pond Creek will be shared with other audiences through the scientific literature, and presentations at meetings and conferences.

MILESTONES:

Within one month of the contract start date, collect and analyze eight water quality monitoring samples for pathogens. Samples will be collected and analyzed each month of the project.

Within three months of contract start date, a detailed whole farm nutrient management plan for at least one dairy operation in Pond Creek watershed will be developed. At least one plan for other dairy operations will be produced every three months.

Within one year of contract start date, establish Pond Creek stakeholder watershed management group.

Within one year of contract start date, produce Extension education publications and newsletter for watershed stakeholders.

Within eighteen months of contract start date, develop watershed management plan.

Within two years of contract start date, attend and present results of Pond Creek watershed project at state and national water quality meetings and conferences.

Within 30 months of contract start date, host watershed tour for watershed stakeholders.

Submit Progress and Close-Out Reports as specified in the contract.

MEASURES OF SUCCESS:

1. Development of whole farm nutrient management plans for most dairy operations in the watershed.
2. Installation of appropriate BMPs on dairy and beef operations in the watershed: whole farm nutrient management plans, improved manure storage structures, stream crossings, alternative watering systems for cattle.
3. Statistically significant improvements in water quality monitoring data (reduction in pathogen loads to water).
4. Prevent Pond Creek from being listed for impairments other than pathogens and nutrients.
5. Establishment of a stakeholder Watershed Management group.
6. Development of Watershed Management plan.
7. Development and distribution of Extension education materials to producers in watershed

APPENDIX G

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 WATTS BAR WATERSHED (HUC 06010201), TENNESSEE

Announcement is hereby given of the availability of Tennessee's proposed Total Maximum Daily Load (TMDL) for pathogens in the Watts Bar watershed, located in 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 Watts Bar 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 pasture land and 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 75-99% in the listed waterbodies.

The proposed Watts Bar 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 June 13, 2005 to:

Division of Water Pollution Control
Watershed Management Section
6th 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.