TOTAL MAXIMUM DAILY LOAD (TMDL)

for

E. Coli

in the

North Fork Forked Deer River Watershed (HUC 08010204)

Carroll, Crockett, Dyer, Gibson, Henderson,

and Madison Counties, Tennessee

FINAL

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LIST OF ABBREVIATIONS

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
CFU	Colony Forming Units
DA	Drainage Area
DEM	Digital Elevation Model
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^{++}
MFFD	Middle Fork Forked Deer
MGD	Million Gallons per Day
MOS	Margin of Safety
MRLC	Multi-Resolution Land Characteristic
MS4	Municipal Separate Storm Sewer System
MST	Microbial Source Tracking
NFFD	North Fork Forked Deer
NHD	National Hydrography Dataset
NMP	Nutrient Management Plan
NPS	Nonpoint Source
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
PCR	Polymerase Chain Reaction
PDFE	Percent of Days Flow Exceeded
PFGE	Pulsed Field Gel Electrophoresis
RM	River Mile
SSO	Sanitary Sewer Overflow
STP	Sewage Treatment Plant
SWMP	Storm Water Management Plan
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
UTK	University of Tennessee, Knoxville
WCS	Watershed Characterization System
WLA	Waste Load Allocation
WWTF	Wastewater Treatment Facility

SUMMARY SHEET

Total Maximum Daily Load for E. Coli in Selected Waterbodies of the North Fork Forked Deer River Watershed (HUC 08010204)

Impaired Waterbody Information

State: Tennessee
Counties: Carroll, Crockett, Dyer, Gibson, and Madison
Watershed: North Fork Forked Deer River (HUC 08010204)
Constituents of Concern: E. coli

Impaired Waterbodies Addressed in This Document (from the Final 2004 303(d) List):

Waterbody ID	Waterbody	RM not Fully Supporting
TN08010204001 – 1000	NORTH FORK FORKED DEER RIVER	15.5
TN08010204003 – 0100	TUCKER CREEK	8.74
TN08010204003 – 1000	POND CREEK	24.7
TN08010204004 – 0100	BETHEL BRANCH	30.4
TN08010204007 – 1000	MIDDLE FORK FORKED DEER RIVER	15.3
TN08010204010 – 1000	MIDDLE FORK FORKED DEER RIVER	9.5
TN08010204010 – 1100	BEECH CREEK	23.8*
TN08010204014 – 0100	DRY CREEK	9.0
TN08010204017 – 0100	DAVIS CREEK	32.6
TN08010204017 – 1000	BUCK CREEK	39.8
TN08010204022 – 0100	HARRIS CREEK	11.6
TN08010204022 – 1000	DOAKVILLE CREEK	36.0
TN08010204023 – 0200	JONES CREEK	50.6
TN08010204023 – 0210	LIGHT CREEK	30.91
TN08010204023 – 1000	LEWIS CREEK	46.3

* No load reduction calculated due to insufficient data.

Designated Uses:

The designated use classifications for all impaired waterbodies in the North Fork Forked Deer River watershed include fish and aquatic life, irrigation, livestock watering & wildlife, and recreation. Use classifications for North Fork Forked Deer River from the mouth to mile 5.8 include navigation.

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.

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.

TMDL Scope:

Waterbodies identified on the Final 2004 303(d) list as impaired due to E. coli. TMDLs were developed for impaired waterbodies on a HUC-12 subwatershed or waterbody drainage area basis. For nine segments, including Pond Creek, Beech Creek, Dry Creek, Buck Creek, Doakville Creek, Lewis Creek, two segments of the Middle Fork Forked Deer River (TN08010204007-1000 and TN08010204010-1000), and one segment of the North Fork Forked Deer River (TN08010204001-1000), the TMDL analyses were revised due to the availability of new data. These revised TMDLs supercede the Fecal Coliform TMDLs approved by EPA in 2002.

Analysis/Methodology:

The TMDLs for impaired waterbodies in the North Fork Forked Deer River watershed were developed using a load duration curve methodology to assure compliance with the E. Coli 126 CFU/100 mL geometric mean and the 487 CFU/100 mL maximum water quality criteria for lakes, reservoirs, State Scenic Rivers, or Tier II or III waterbodies and 941 CFU/100 mL maximum water quality criteria for all other waterbodies. 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 region 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. When sufficient data were available, load reductions were also determined based on the geometric mean criterion.

There are insufficient E. coli data available to calculate a load reduction for Beech Creek. A load duration curve was developed; however, no TMDL, waste load allocation, or load allocation was determined for Beech Creek at this time.

Critical Conditions:

Water quality data collected over a period of up to 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 and for load duration curve analysis included all seasons and a full range of flow and meteorological conditions.

Margin of Safety (MOS):

Explicit MOS = 10% of the E. coli water quality criteria for each impaired subwatershed or drainage area.

TMDLs, WLAs, & LAs

Summary of TMDLs, WLAs, & LAs for Impaired Waterbodies

HUC-12 Subwatershed (08010204__)	Impaired Waterbody Name	Impaired Waterbody ID	TMDL	WLAs[a]				LAs[e]
				WWTFs[b]		Leaking Collection Systems[c]	MS4s[d]	
				Monthly Avg.	Daily Max.			
			[% Red.]	[CFU/day]	[CFU /day]	[CFU /day]	[% Red.]	[% Red.]
0103	Dry Creek	TN08010204014 – 0100	>47.6	NA	NA	NA	NA	>52.9
0201	MFFD River	TN08010204010 – 1000	>61.1	1.240×10^{10}	9.263×10^{10}	0	NA	>65.0
	Beech Creek	TN08010204010 – 1100	*	NA	NA	NA	NA	*
0203	MFFD River	TN08010204007 – 1000	69.0	1.908×10^{9}	1.425×10^{10}	0	NA	72.1
0204	Davis Creek	TN08010204017 – 0100	>63.2	NA	NA	NA	NA	>67.0
	Buck Creek	TN08010204017 – 1000	>61.1	NA	NA	NA	NA	>65.0
0305	Bethel Branch	TN08010204004 – 0100	>95.3	NA	NA	NA	NA	>95.8
0306	Harris Creek	TN08010204022 – 0100	>61.1	NA	NA	0	NA	>65.0
	Doakville Creek	TN08010204022 – 1000	>85.8	NA	NA	NA	NA	>87.3
0402	NFFD River	TN08010204001 – 1000	>43.7	4.507×10^{10}	3.366×10^{11}	0	>49.3	>49.3
0403	Tucker Creek	TN08010204003 – 0100	>52.1	NA	NA	NA	NA	>56.9
	Pond Creek	TN08010204003 – 1000	>76.0	NA	NA	0	NA	>78.5
0404	Jones Creek	TN08010204023 – 0200	>89.5	NA	NA	0	>90.5	>90.5
	Light Creek	TN08010204023 – 0210	>89.5	NA	NA	0	>90.5	>90.5
	Lewis Creek	TN08010204023 – 1000	92.2	NA	NA	0	93.0	93.0

Note: *NA = Not applicable.*

* *Insufficient data available to calculate TMDL and LA.*

a. *There are no CAFOs in impaired subwatersheds of the North Fork Forked Deer River watershed. All current and future CAFOs are and will be assigned waste load allocations (WLAs) of zero.*

b. *WLAs for WWTFs expressed as E. coli loads (CFU/day). Future WWTFs must meet instream water quality standards at the point of discharge as specified in their NPDES permits.*

c. *The objective for leaking collection systems is a WLA of zero. It is recognized, however, that a WLA of 0 CFU/day may not be practical. For these sources, the WLA is interpreted to mean a reduction in E. coli 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.*

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

e. *The load allocations (LAs) listed apply to precipitation induced nonpoint sources only. The objective for all other nonpoint sources (leaking septic systems, illicit discharges, and animals access to streams) is a LA of zero. It is recognized, however, that for leaking septic systems a LA of 0 CFU/day may not be practical. For these sources, the LA is interpreted to mean a reduction in E. coli loading to the maximum extent feasible, consistent with the requirement that these sources not contribute to a violation of the water quality standard for E. coli.*

E. COLI TOTAL MAXIMUM DAILY LOAD (TMDL)
NORTH FORK FORKED DEER RIVER WATERSHED (HUC 08010204)

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 North Fork Forked Deer River Watershed identified on the Final 2004 303(d) list as not supporting designated uses due to Escherichia coli (E. coli). The North Fork Forked Deer River Watershed lies entirely in the state of Tennessee. TMDL analyses were performed on a waterbody drainage area basis. In many cases, the waterbody drainage area coincided with a 12-digit hydrologic unit area (HUC-12).

North Fork Forked Deer River watershed Fecal Coliform TMDLs, developed and approved by EPA in 2002, addressed waterbodies identified on the 1998 303(d) list and the 2000 assessment as not supporting designated uses due, in part, to pathogens. The current TMDLs supercede those for nine (9) of the ten (10) waterbodies addressed by the 2002 TMDL report. The nine waterbodies are Pond Creek, Beech Creek, Dry Creek, Buck Creek, Doakville Creek, Lewis Creek, two segments of the Middle Fork Forked Deer River (TN08010204007-1000 and TN08010204010-1000), and one segment of the North Fork Forked Deer River (TN08010204001-1000). The remaining waterbody has been delisted for pathogens (E. coli). The delisted waterbody is Turkey Creek. The TMDLs have been revised based on additional monitoring data.

3.0 WATERSHED DESCRIPTION

The North Fork Forked Deer River watershed (HUC 08010204) is located in west Tennessee (Figure 1) and lies within the Level III Southeastern Plains (65), Mississippi Alluvial Plain (73), and Mississippi Valley Loess Plains (74) ecoregions. The impaired subwatersheds lie in the Level IV Southeastern Plains and Hills (65e), Northern Mississippi Alluvial Plain (73a), Bluff Hills (74a), and Loess Plains (74b) ecoregions as shown in Figure 2 (USEPA, 1997):

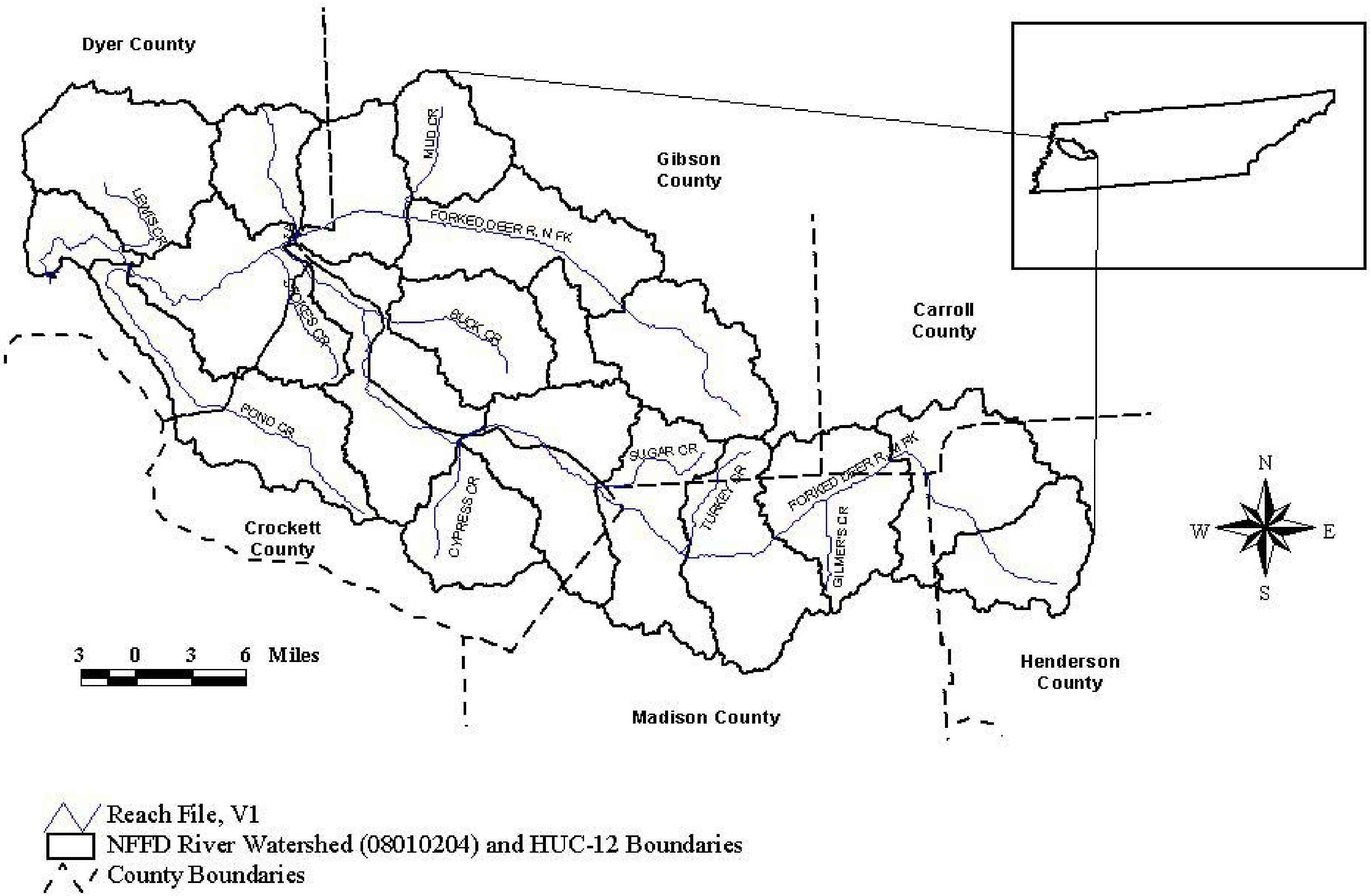

Figure 1. Location of the North Fork Forked Deer River Watershed and HUC-12 Subwatersheds.

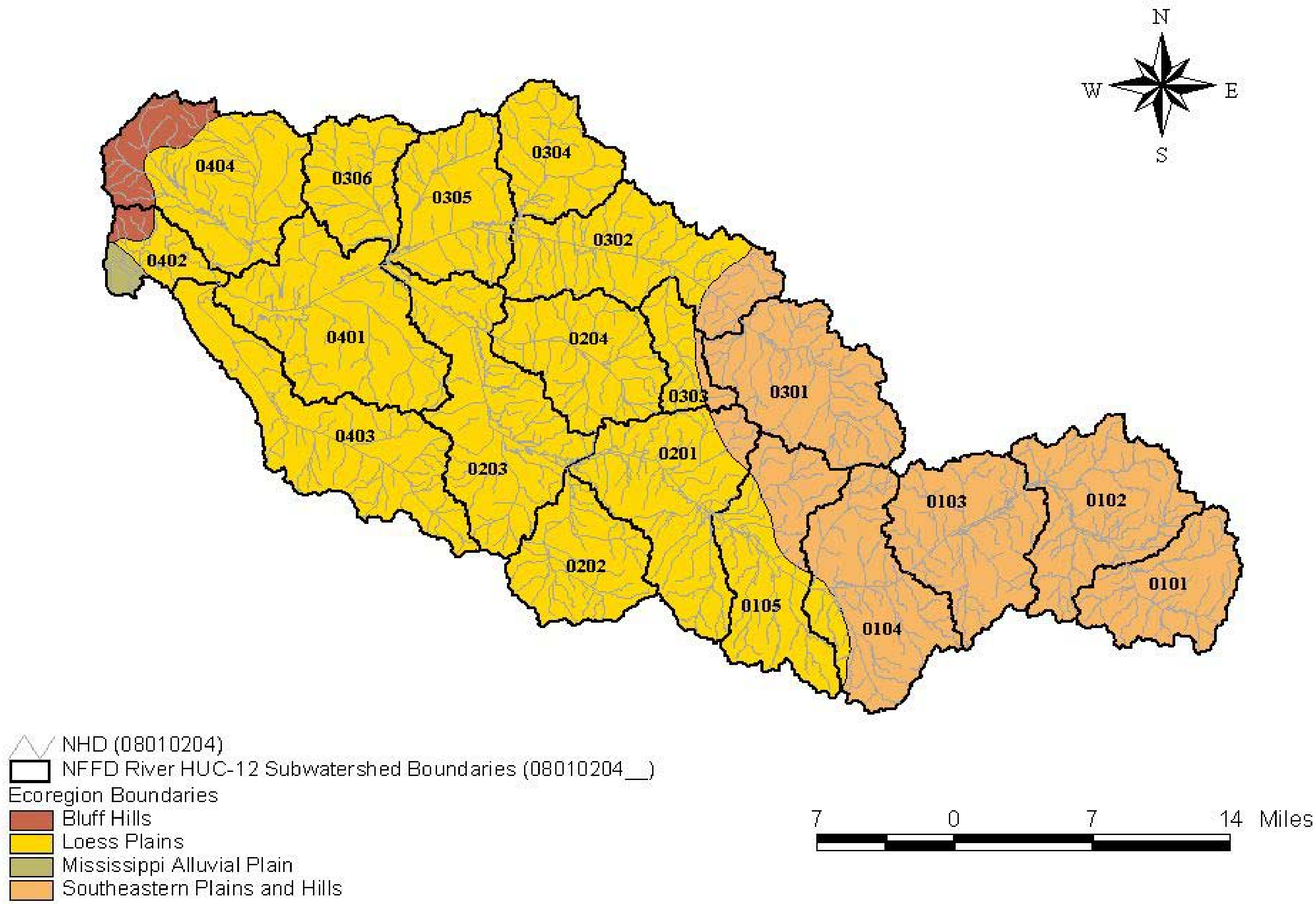

Figure 2. Level IV Ecoregions in the North Fork Forked Deer River Watershed

- The Southeastern Plains and Hills (65e) contain several north-south trending bands of sand and clay formations. With elevations reaching over 650 feet, and more rolling topography and more relief than the Loess Plains to the west, streams have increased gradient, generally sandy substrates, and distinctive faunal characteristics for West Tennessee.

- Within Tennessee, the Northern Mississippi Alluvial Plain (73a) is a relatively homogenous region of Quaternary alluvial deposits of sand, silt, clay, and gravel. It is bounded distinctly on the east by the Bluff Hills (74a) and on the west by the Mississippi River. The two main distinctions in the Tennessee portion of the ecoregion are between areas of loamy, silty, and sandy soils with better drainage, and areas of more clayey soils of poor drainage that may contain wooded swampland and oxbow lakes.

- Along the western edge of the Bluff Hills (74a) ecoregion, bordering the Mississippi Alluvial Plain, are deep loess hilly areas, often called bluff hills. Consisting of sand, clay, silt, and lignite, the bluffs are capped by loess greater than 60 feet deep. The disjunct ecoregion in Tennessee encompasses those thick loess areas that are generally the steepest, most dissected, and forested. Smaller streams of the Bluff Hills have localized reaches of increased gradient and small areas of gravel substrate that create aquatic habitats that are distinct from those of the Loess Plains (74b) to the east.

- The Loess Plains (74b) ecoregion within Tennessee consists of gently rolling, irregular plains, with 100-200 feet of local relief. The loess can be over 50 feet thick. Several large river systems and their tributaries cross the ecoregion with wide flood plains that are distinct from the adjacent uplands. Streams of the ecoregion are low-gradient and murky, with silt and sand bottoms. Many of the streams have been deforested and channelized. Valley plugs or channel blockages, where channel aggradation and driftwood accumulation combine to change flow patterns, are common along the low-gradient alluvial streams in this region.

The North Fork Forked Deer River watershed, located in Carroll, Crockett, Dyer, Gibson, Henderson, and Madison Counties, Tennessee, has a drainage area of approximately 956 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 North Fork Forked Deer River watershed have occurred since 1993 as a result of development, this is the most current land use data available. Land use for the North Fork Forked Deer River watershed is summarized in Table 1 and shown in Figure 3. Predominate land use in the North Fork Forked Deer River watershed is agriculture (71.8%) followed by forest (24.0%). Urban areas represent approximately 3.0% of the total drainage area of the watershed. Details of land use distribution of E. coli-impaired subwatersheds in the North Fork Forked Deer River watershed are presented in Appendix A.

4.0 PROBLEM DEFINITION

The State of Tennessee's Final 2004 303(d) list (TDEC, 2005) was approved by the U.S. Environmental Protection Agency (EPA), Region IV in August of 2005. The list identified 15 waterbody segments in the North Fork Forked Deer River watershed as not fully supporting designated use classifications due, in part, to E. coli. See Table 2 and Figure 4. The designated use classifications for these waterbodies include fish and aquatic life, irrigation, livestock watering & wildlife, recreation, and navigation.

Table 1. MRLC Land Use Distribution – North Fork Forked Deer River Watershed

Land Use	Area	
	[acres]	[%]
Bare Rock/Sand/Clay	73	0.0*
Deciduous Forest	77,507	12.7
Evergreen Forest	6,389	1.0
High Intensity Commercial/ Industrial/Transportation	3,378	0.6
High Intensity Residential	2,892	0.5
Low Intensity Residential	11,355	1.9
Mixed Forest	25,367	4.1
Open Water	7,260	1.2
Other Grasses (Urban/recreational)	860	0.1
Pasture/Hay	181,604	29.7
Quarries/Strip Mines/ Gravel Pits	122	0.0*
Row Crops	256,013	41.8
Small Grains	1,906	0.3
Transitional	639	0.1
Woody Wetlands	36,728	6.0
Total	**612,093**	**100.00**

* < 0.05%

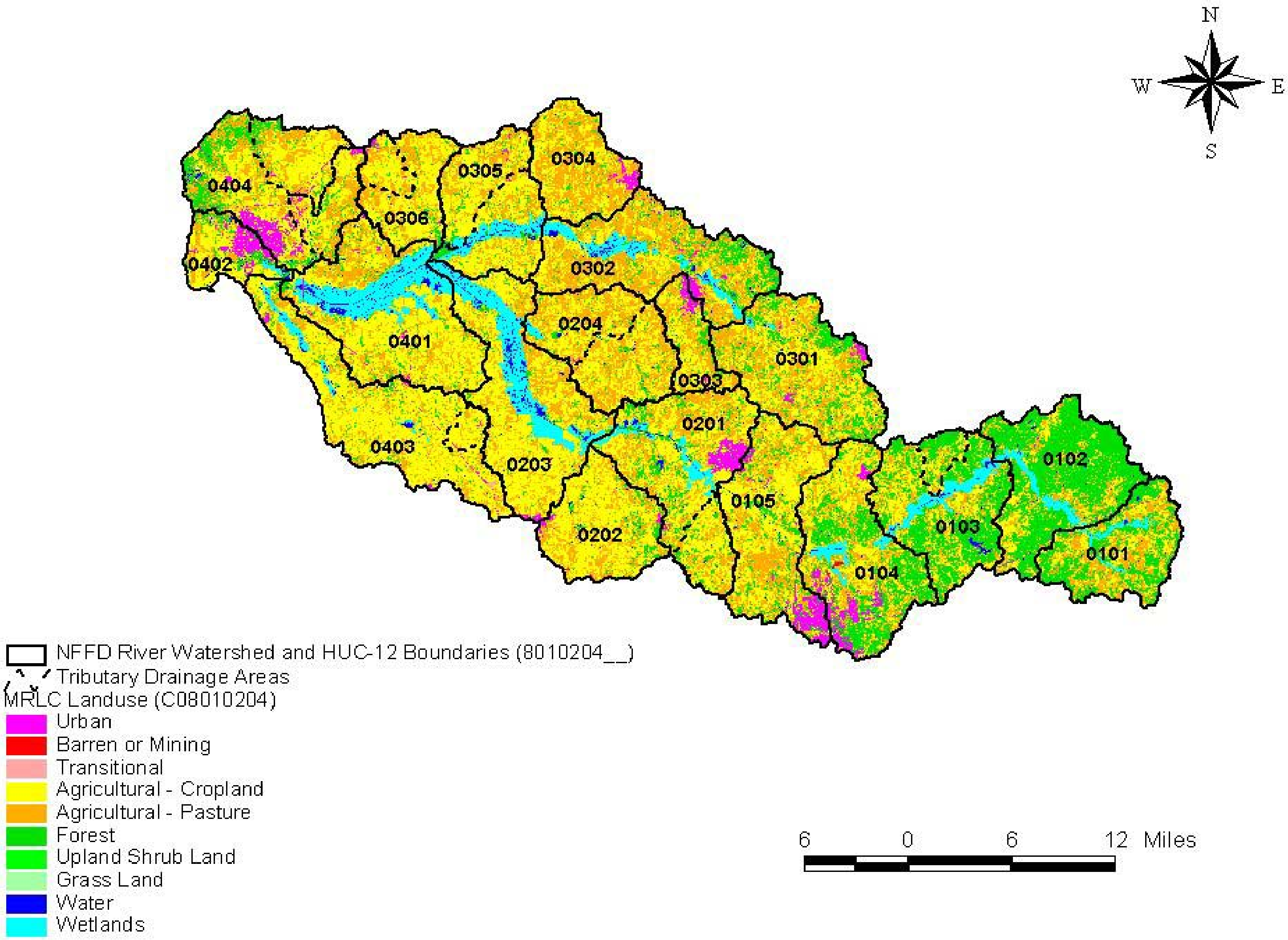

Figure 3. Land Use Characteristics of the North Fork Forked Deer River Watershed

Table 2. Final 2004 303(d) List for E. coli – North Fork Forked Deer River Watershed

Waterbody ID	Impacted Waterbody	Miles/Acres Impaired	CAUSE / TMDL Priority	Pollutant Source
TN08010204001 – 1000	NFFD RIVER	15.5	Phosphate Loss of biological integrity due to Siltation Escherichia coli	Nonirrigated Crop Production Channelization Undetermined Fecal Source
TN08010204003 – 0100	TUCKER CREEK	8.74	Physical Substrate Habitat Alteration Loss of biological integrity due to Siltation Escherichia coli	Nonirrigated Crop Production Pasture Grazing Channelization
TN08010204003 – 1000	POND CREEK	24.7	Low Dissolved Oxygen Phosphorus Loss of biological integrity due to Siltation Physical Substrate Habitat Alterations Escherichia coli	Nonirrigated Crop Production Channelization Undetermined Fecal Source
TN08010204004 – 0100	BETHEL BRANCH	30.4	Nitrates Phosphorus Physical Substrate Habitat Alterations Escherichia coli	Nonirrigated Crop Production Pasture Grazing Channelization
TN08010204007 – 1000	MFFD RIVER	15.3	Loss of biological integrity due to Siltation Physical Substrate Habitat Alterations Escherichia coli	Nonirrigated Crop Production Channelization Undetermined Fecal Source
TN08010204010 – 1000	MFFD RIVER	9.5	Escherichia coli	Undetermined Fecal Source
TN08010204010 – 1100	BEECH CREEK	23.8	Physical Substrate Habitat Alterations Escherichia coli	Nonirrigated Crop Production Channelization Undetermined Fecal Source
TN08010204014 – 0100	DRY CREEK	9.0	Physical Substrate Habitat Alterations Escherichia coli	Pasture Grazing Channelization
TN08010204017 – 0100	DAVIS CREEK	32.6	Nitrates Phosphorus Physical Substrate Habitat Alterations Escherichia coli	Nonirrigated Crop Production Channelization Undetermined Pathogen Source

Table 2. Final 2004 303(d) List for E. coli – North Fork Forked Deer River Watershed (Cont.)

Waterbody ID	Impacted Waterbody	Miles/Acres Impaired	CAUSE / TMDL Priority	Pollutant Source
TN08010204017 – 1000	BUCK CREEK	39.8	Low Dissolved Oxygen Phosphate Loss of biological integrity due to Siltation Physical Substrate Habitat Alterations Escherichia coli	Nonirrigated Crop Production Channelization Undetermined Pathogen Source
TN08010204022 – 0100	HARRIS CREEK	11.6	Physical Substrate Habitat Alterations Escherichia coli	Pasture Grazing Channelization
TN08010204022 – 1000	DOAKVILLE CREEK	36.0	Loss of biological integrity due to Siltation Physical Substrate Habitat Alterations Low dissolved Oxygen Escherichia coli	Nonirrigated Crop Production Channelization Undetermined Pathogen Source
TN08010204023 – 0200	JONES CREEK	50.6	Physical Substrate Habitat Alterations Escherichia coli	Channelization Undetermined Pathogen Source
TN08010204023 – 0210	LIGHT CREEK	30.91	Physical Substrate Habitat Alterations Escherichia coli	Channelization Undetermined Pathogen Source
TN08010204023 – 1000	LEWIS CREEK	46.3	Loss of biological integrity due to Siltation Other Habitat Alterations Escherichia coli	Nonirrigated Crop Production Discharges from MS4 area Channelization

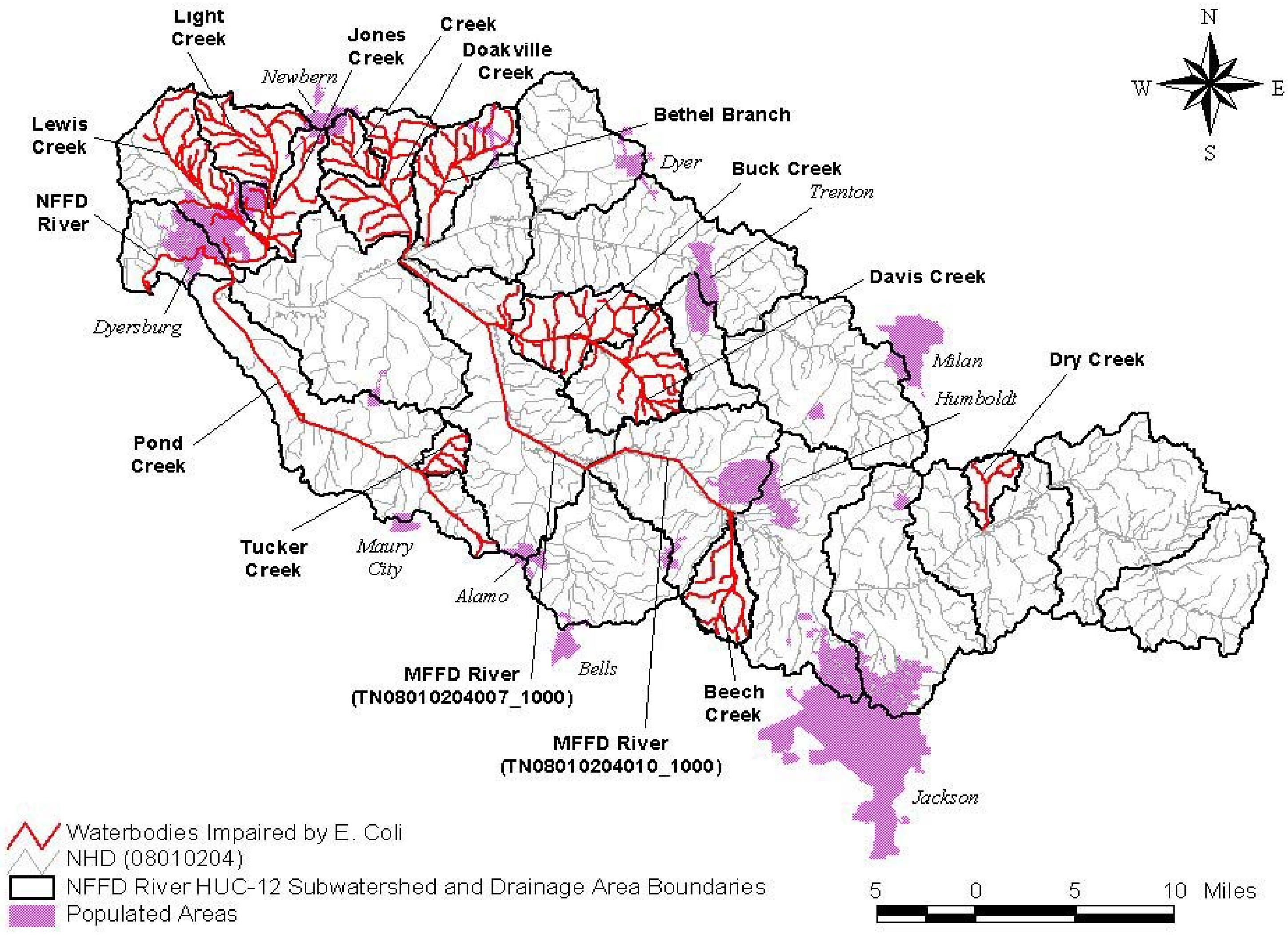

Figure 4. Waterbodies Impaired by E. Coli (as Documented on the Final 2004 303(d) List)

5.0 WATER QUALITY CRITERIA & TMDL TARGET

As previously stated, the designated use classifications for the North Fork Forked Deer River waterbodies include fish & aquatic life, recreation, irrigation, livestock watering & wildlife, and navigation. Of the use classifications with numeric criteria for E. coli, 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, 2004a). Section 1200-4-3-.03 (4) (f) states:

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

Portions of the Middle Fork Forked Deer River within the Horns Bluff Wildlife Refuge and the Tigrett Wildlife Management Area have been designated as Tier II streams. In addition, a portion of Dry Creek (headwaters), in the Milan Arsenal Wildlife Management Area, has been designated as a Tier II stream. As of February 2, 2006, none of the other E. coli impaired waterbodies in the North Fork Forked Deer River watershed have been designated as either State Scenic River, Tier II, or Tier III streams.

The geometric mean standard for the E. coli group of 126 colony forming units per 100 mL (CFU/100 mL) and the sample maximum of 487 CFU/100 mL have been selected as the appropriate numerical targets for TMDL development for impaired waterbodies designated as lakes, reservoirs, State Scenic Rivers, or Tier II or III streams. The geometric mean standard for the E. coli group of 126 CFU/100 mL and the sample maximum of 941 CFU/100 mL have been selected as the appropriate numerical targets for TMDL development for the other impaired waterbodies.

6.0 WATER QUALITY ASSESSMENT AND DEVIATION FROM TARGET

There are multiple water quality monitoring stations that provide data for waterbodies identified as impaired for E. coli in the North Fork Forked Deer River watershed. Monitoring stations located on Tier II waterbodies have been italicized:

- HUC-12 080102040103:
  - DRY000.3MN – Dry Creek, at Hwy 152
- HUC-12 080102040201:
  - MFFDE021.5GI – Middle Fork Forked Deer River, at Hwy 152W
  - BEECH001.8CK – Beech Creek, at Gasden Todd Levee Road

- HUC-12 080102040203:
  - *MFFDE014.6CK – Middle Fork Forked Deer River, at Hwy 54*
- HUC-12 080102040204:
  - DAVIS000.9GI – Davis Creek, at McMurry Road
  - DAVIS002.5GI – Davis Creek, at Hwy 54
  - BUCK001.2GI – Buck Creek, at Eaton Brazil Road
  - BUCK007.7GI – Buck Creek, at Walter Cresap Road
- HUC-12 080102040305:
  - BETHE001.8DY – Bethel Branch, at Nebo Road
  - BETHE004.2DY – Bethel Branch, at Banks-turner Road
  - BETHE006.1DY – Bethel Branch, at Scotts Road
- HUC-12 080102040306:
  - HARRI001.9DY – Harris Creek, at Edgewood Road
  - DOAKV002.0DY – Doakville Creek, at Tatumville Road
  - DOAKV005.4DY – Doakville Creek, at Edgewood Road
- HUC-12 080102040402:
  - NFFDE007.3DY – North Fork Forked Deer River, at Hwy 211
- HUC-12 080102040403:
  - TUCKE000.4CK – Tucker Creek, at Hwy 412
  - POND001.1DY – Pond Creek, at Sorrel Chapel Road
  - POND007.4DY – Pond Creek, at Palmer Road
  - POND011.3DY – Pond Creek, at Juno-Bargerton Road
  - POND012.9DY – Pond Creek, at East Road
  - POND014.9DY – Pond Creek, at Hwy 189
- HUC-12 080102040404:
  - JONES003.8DY – Jones Creek, at Owen Road
  - LIGHT002.2DY – Light Creek, at Hwy 211
  - LEWIS000.3DY – Lewis Creek, at Slaughter Pen Road
  - LEWIS002.5DY – Lewis Creek Drainage Ditch, at Fuller Road
  - LEWIS007.9DY – Lewis Creek, at Hwy 78

The locations of these monitoring stations are shown in Figure 5. Water quality monitoring results for these stations are tabulated in Appendix B. Examination of the data shows exceedances of the 487 CFU/100 mL (Tier II) and 941 CFU /100 mL (all other) maximum E. coli standard at all monitoring stations where E. coli samples were collected. Water quality monitoring results are summarized in Table 3.

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.

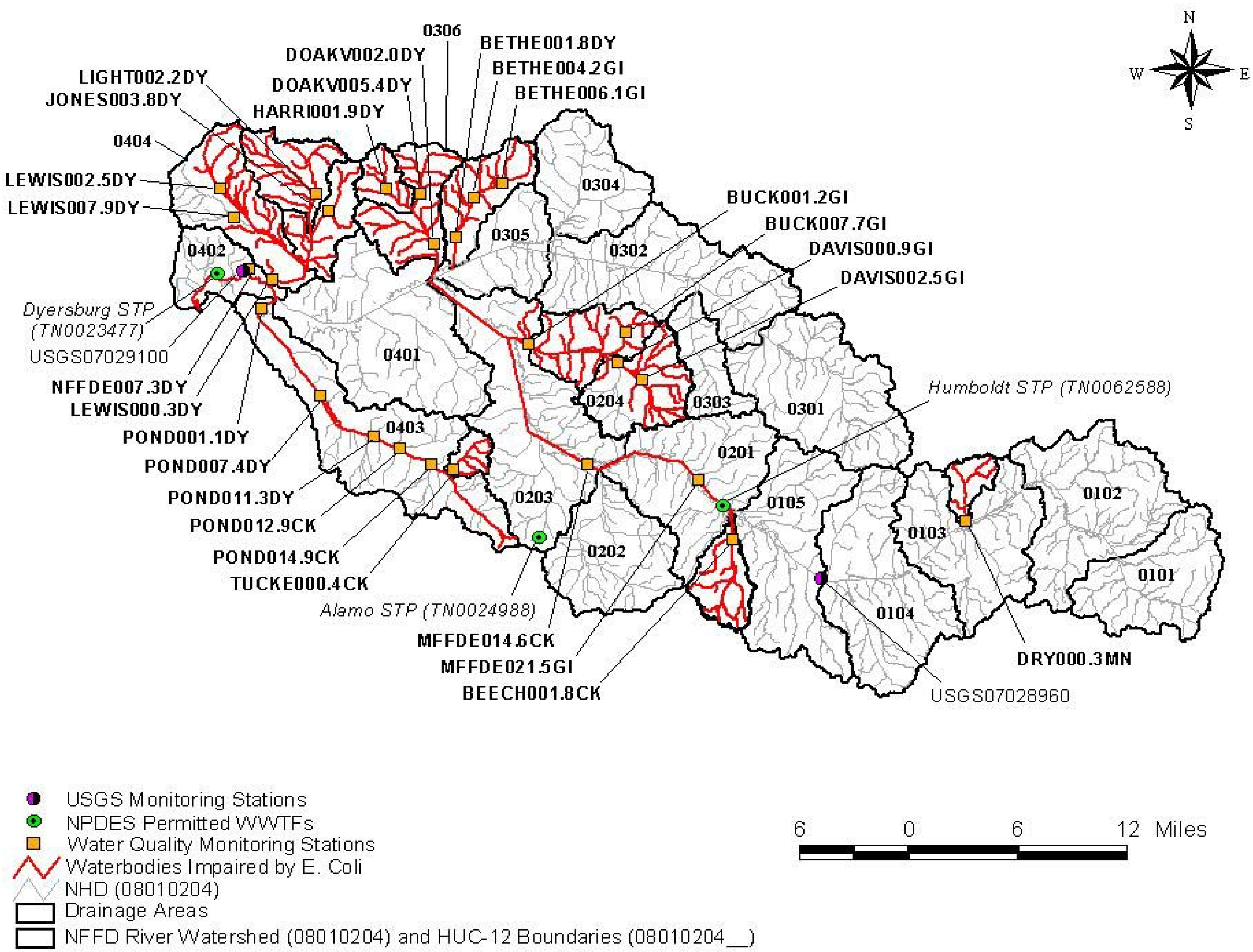

Figure 5. Monitoring Stations and NPDES permitted WWTFs in the North Fork Forked Deer River Watershed

Table 3. Summary of Water Quality Monitoring Data

Monitoring Station	E. Coli (Single Sample Max. WQ Target = 941 CFU/100 mL)*					
	Data Pts.	Date Range	[CFU/100 mL]			Exceed WQ Max. Target
			Min.	Avg.	Max.	
DRY000.3MN	4	12/02-6/03	62	>736.8	>2419.2	1
MFFDE021.5GI	10	4/98-3/03	33.6	>876	>2419.2	4
BEECH001.8CK	5	8/99-3/03	13.4	319.8	1233	1
MFFDE014.6CK	*6*	*6/99-3/03*	*14.2*	*624*	*1986.2*	*3*
DAVIS000.9GI	22	7/02-6/03, 9/02-10/02	30.1	>518	5172	2
DAVIS002.5GI	23	7/02-6/03, 9/02-10/02	57.3	>850	8164	5
BUCK001.2GI	29	4/98-6/03, 9/02-10/02	38.8	>741	5475	7
BUCK 007.7GI	15	10/02-6/03	10.7	>2200	>24192	4
BETHE001.8DY	24	6/99-6/03, 9/02-10/02	20	>585	>2419.2	6
BETHE004.2DY	22	7/02-6/03, 9/02-10/02	30	703	>2419.2	5
BETHE006.1DY	21	7/02-6/03, 9/02-10/02	142.1	>2753	>24192	9
HARRI001.9DY	16	7/02-6/03	68.3	>2328	>24192	6
DOAKV002.0DY	25	4/99-6/03, 9/02-10/02	40.8	>684	>2419.2	7
DOAKV005.4DY	22	7/02-6/03, 9/02-10/02	160.7	>1210	>2419.2	6
NFFDE007.3DY	32	4/98-12/04	1	>454	>2419.2	5
TUCKE000.4CK	17	9/02-6/03	33.1	>822	4884	5
POND001.1DY	24	7/02-6/03, 9/02-10/02	14.3	>315	>2419.2	2
POND007.4DY	22	7/02-6/03, 9/02-10/02	38.4	>455	>2419.2	2
POND011.3DY	21	8/02-6/03, 9/02-10/02	6.3	>406	>2419.2	3
POND012.9DY	22	8/02-6/03, 9/02-10/02	18.9	>610	3255	4
POND014.9DY	17	8/02-6/03	30.5	>1045	4884	5
JONES003.8DY	8	7/02-6/03	128.1	>3811	>24192	3
LIGHT002.2DY	8	7/02-6/03	45.7	>3779	>24192	3
LEWIS000.3DY	8	7/02-6/03	74.2	>4182	>24192	3
LEWIS002.5DY	8	7/02-6/03	8.5	>3449	>24192	2
LEWIS007.9DY	7	8/02-6/03	22.8	>3867	12033	3

* Single sample maximum water quality target is 487 CFU/100 mL for Tier II waterbodies and 941 CFU/100 mL for other waterbodies. Tier II waterbodies are italicized.

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 E. coli 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 were three (3) NPDES permitted WWTFs in the impaired subwatersheds of the North Fork Forked Deer River watershed authorized to discharge treated sanitary wastewater during the TMDL analysis period. These facilities are tabulated in Table 4 and the locations are shown in Figure 5. All three of the facilities are sewage treatment plants (STPs) serving municipalities and two of the three (Dyersburg STP [TN0023477] and Humboldt Board of Public Utilities STP [TN0062588]) are major facilities with design capacities equal to or greater than 1.0 million gallons per day (MGD). The permit limits for discharges from these WWTFs are in accordance with the coliform criteria specified in Tennessee Water Quality Standards for protection of the recreation use classification.

Non-permitted point sources of (potential) E. coli contamination of surface waters associated with STP collection systems include leaking collection systems and sanitary sewer overflows (SSOs).

Note: As stated in Section 5.0, the current coliform criteria are expressed in terms of E. coli concentration, whereas previous criteria were expressed in terms of fecal coliform and E. coli concentration. Due to differences in permit issuance dates, some permits still have fecal coliform limits instead of E. coli. As permits are reissued, limits for fecal coliform will be replaced by E. coli limits.

7.1.2 NPDES Regulated Municipal Separate Storm Sewer Systems (MS4s)

Municipal Separate Storm Sewer Systems (MS4s) are considered to be point sources of E. coli. Discharges from MS4s occur in response to storm events through road drainage systems, curb and gutter systems, ditches, and storm drains. Phase I of the EPA storm water program requires large and medium MS4s to obtain NPDES storm water permits. Large and medium MS4s are those located in incorporated places or counties serving populations greater than 100,000 people. At present, there are no MS4s of this size in the North Fork Forked Deer River watershed.

Table 4. WWTFs Permitted to Discharge Treated Sanitary Wastewater in North Fork Forked Deer River Watershed Impaired Subwatersheds

NPDES Permit No.	Facility Name	Receiving Stream
TN0023477	Dyersburg STP	NFFD River, mile 2.8
TN0024988	Alamo STP	Unnamed tributary to Buck Creek (mile 4.5)
TN0062588	Humboldt Board of Public Utilities STP	MFFD River, mile 23.4

As of March 2003, regulated small MS4s in Tennessee must also obtain NPDES permits in accordance with the Phase II storm water program. A small MS4 is designated as *regulated* if: a) it is located within the boundaries of a defined urbanized area that has a residential population of at least 50,000 people and an overall population density of 1,000 people per square mile; b) it is located outside of an urbanized area but within a jurisdiction with a population of at least 10,000 people, a population density of 1,000 people per square mile, and has the potential to cause an adverse impact on water quality; or c) it is located outside of an urbanized area but contributes substantially to the pollutant loadings of a physically interconnected MS4 regulated by the NPDES storm water program. Most regulated small MS4s in Tennessee obtain coverage under the *NPDES General Permit for Discharges from Small Municipal Separate Storm Sewer Systems* (TDEC, 2003). There are three permitted Phase II MS4s in the North Fork Forked Deer River Watershed:

NPDES Permit Number	Phase	Permittee Name
TNS075264	II	Dyersburg
TNS075361	II	Jackson
TNS075604	II	Madison County

The Tennessee Department of Transportation (TDOT) has been issued an individual MS4 permit (TNS077585) that authorizes discharges of storm water runoff from State road and interstate highway right-of-ways that TDOT owns or maintains, discharges of storm water runoff from TDOT owned or operated facilities, and certain specified non-storm water discharges. This permit covers all eligible TDOT discharges statewide, including those located outside of urbanized areas.

Information regarding storm water permitting in Tennessee may be obtained from the Tennessee Department of Environment and Conservation (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 E. coli 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 February 2006, there was one Class II CAFO in the North Fork Forked Deer River watershed with coverage under the general NPDES permit. This CAFO is not located in the drainage area of a 303(d)-listed waterbody. In addition, there are no Class I CAFOs with individual permits located in the 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 E. coli 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 E. coli 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.

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 (i.e., deer and other wildlife) often have direct access to waterbodies and can provide a concentrated source of coliform bacteria loading directly to a stream.

Data sources related to livestock operations include the 2002 Census of Agriculture. Livestock data, for counties containing E. coli-impaired subwatersheds, are summarized in Table 5. Note that, due to confidentiality issues, any tabulated item that identifies data reported by a respondent or allows a respondent's data to be accurately estimated or derived is suppressed and coded with a 'D' (USDA, 2004).

Table 5. Livestock Distribution in the North Fork Forked Deer River Watershed

County Name	Livestock Population (2002 Census of Agriculture)*						
	Beef Cow	Milk Cow	Hogs	Sheep	Poultry (Layers)	Poultry (Broilers)	Horses
Carroll	9300	232	1777	40	458	289	1193
Crockett	3490	3	474	(D)	111	0	498
Dyer	(D)	(D)	426	18	327	0	1021
Gibson	10,532	154	15,898	359	475	10	1282
Madison	(D)	(D)	(D)	204	874	17	1370

* In keeping with the provisions of Title 7 of the United States Code, no data are published in the 2002 Census of Agriculture that would disclose information about the operations of an individual farm or ranch. Any tabulated item that identifies data reported by a respondent or allows a respondent's data to be accurately estimated or derived is suppressed and coded with a 'D' (USDA, 2004).

7.2.3 Failing Septic Systems

Some coliform loading in the North Fork Forked Deer River watershed can be attributed to failure of septic systems and illicit discharges of raw sewage. Estimates from 2000 county census data of people in E. coli-impaired subwatersheds of the North Fork Forked Deer River watershed utilizing septic systems were compiled using the WCS and are summarized in Table 6. In western 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.

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. The North Fork Forked Deer River HUC-12 subwatershed 080102040402 (Dyersburg area) has the highest percentage of urban land area for impaired subwatersheds in the North Fork Forked Deer River watershed, with 20.9%. Land use for the North Fork Forked Deer River impaired HUC-12 subwatersheds and drainage areas is summarized in Figures 6-13 and tabulated in Appendix A.

Table 6. Population on Septic Systems in the North Fork Forked Deer River Watershed

HUC-12 Subwatershed (08010204__) or Drainage Area	Population on Septic Systems
Dry Creek DA	287
0201 (MFFD River)	2174
Beech Creek DA	582
0203 (MFFD River)	1821
Davis Creek DA	538
0204 (Buck Creek)	1046
Bethel Branch DA	741
Harris Creek DA	244
0306 (Doakville Creek)	1015
0402 (NFFD River)	432
Tucker Creek DA	141
0403 (Pond Creek)	2388
Jones Creek DA	1071
Light Creek DA	622
0404 (Lewis Creek)	1763

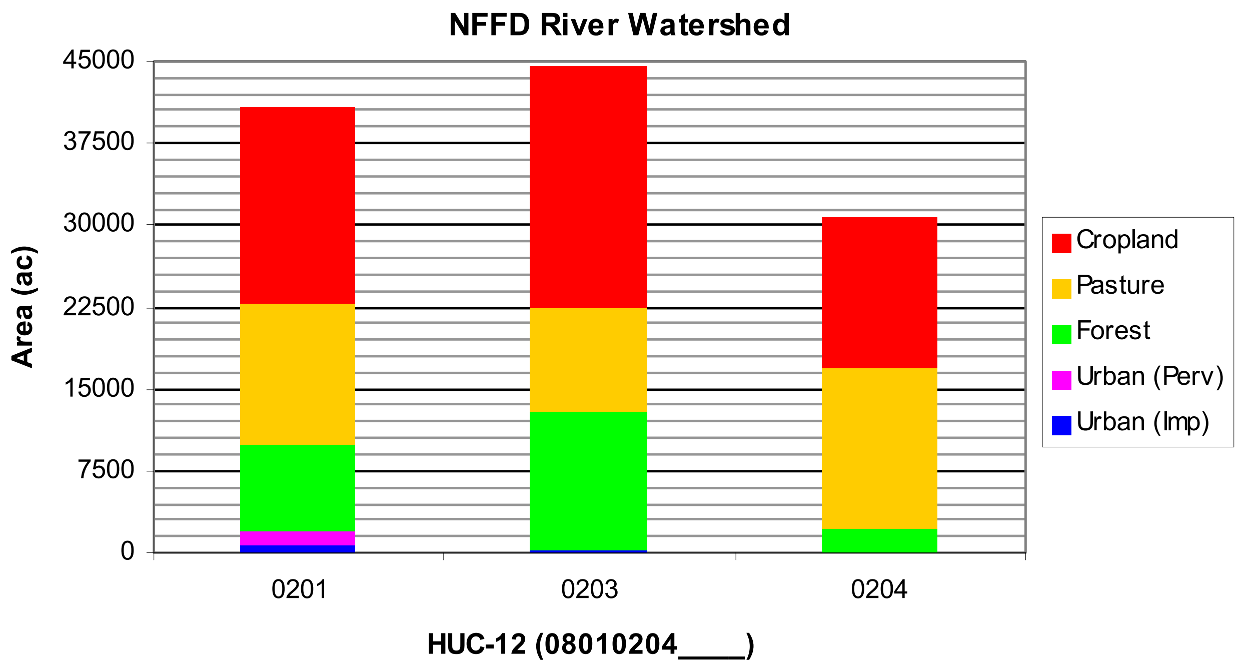

Figure 6. Land Use Area of North Fork Forked Deer River HUC-12 Subwatersheds 0201, 0203, and 0204.

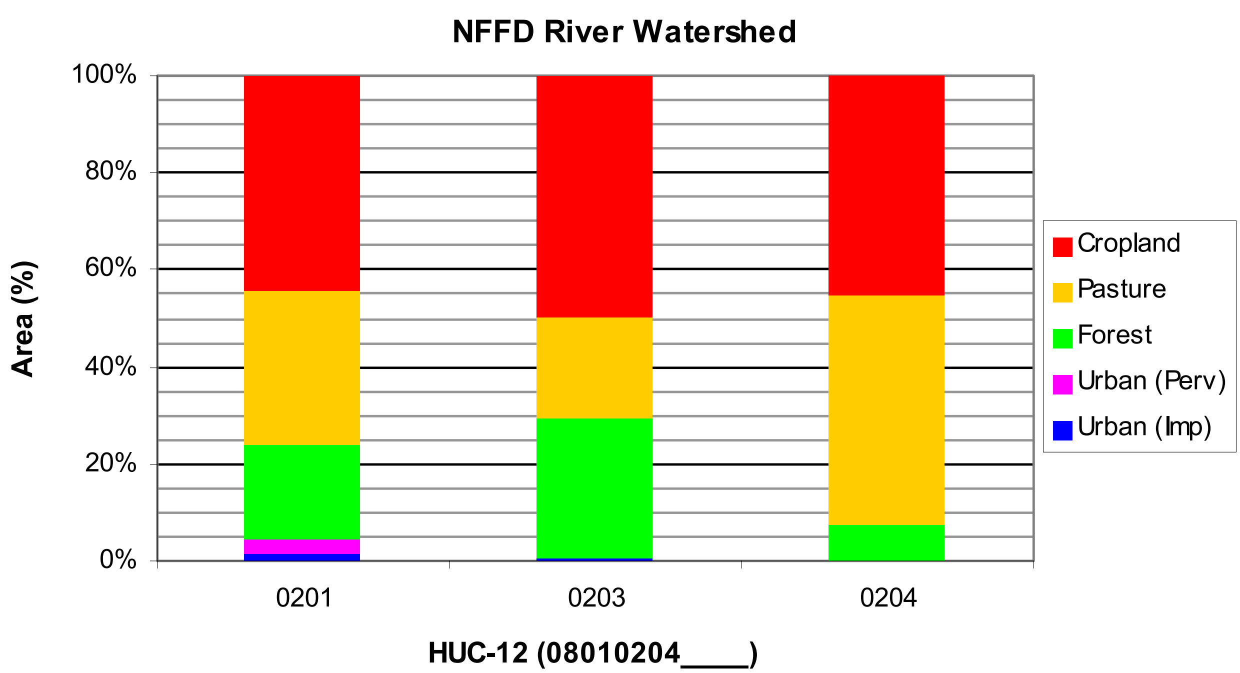

Figure 7. Land Use Percent of North Fork Forked Deer River HUC-12 Subwatersheds 0201, 0203, and 0204.

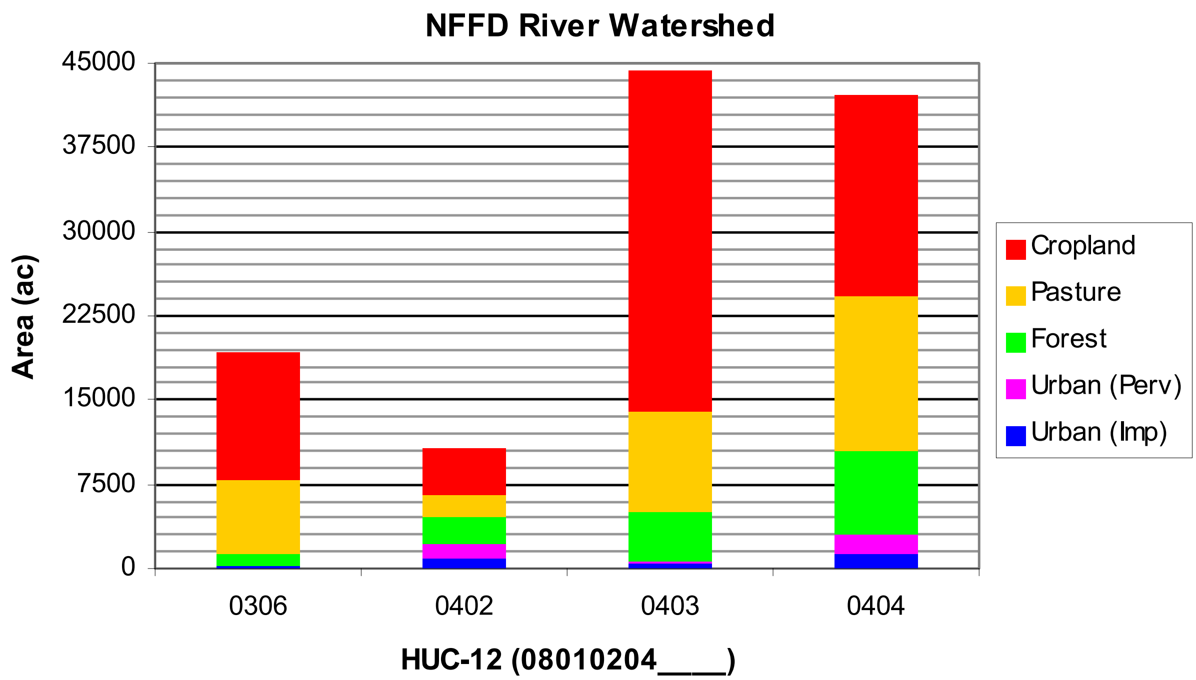

Figure 8. Land Use Area of North Fork Forked Deer River HUC-12 Subwatersheds 0306, 0402, 0403, and 0404.

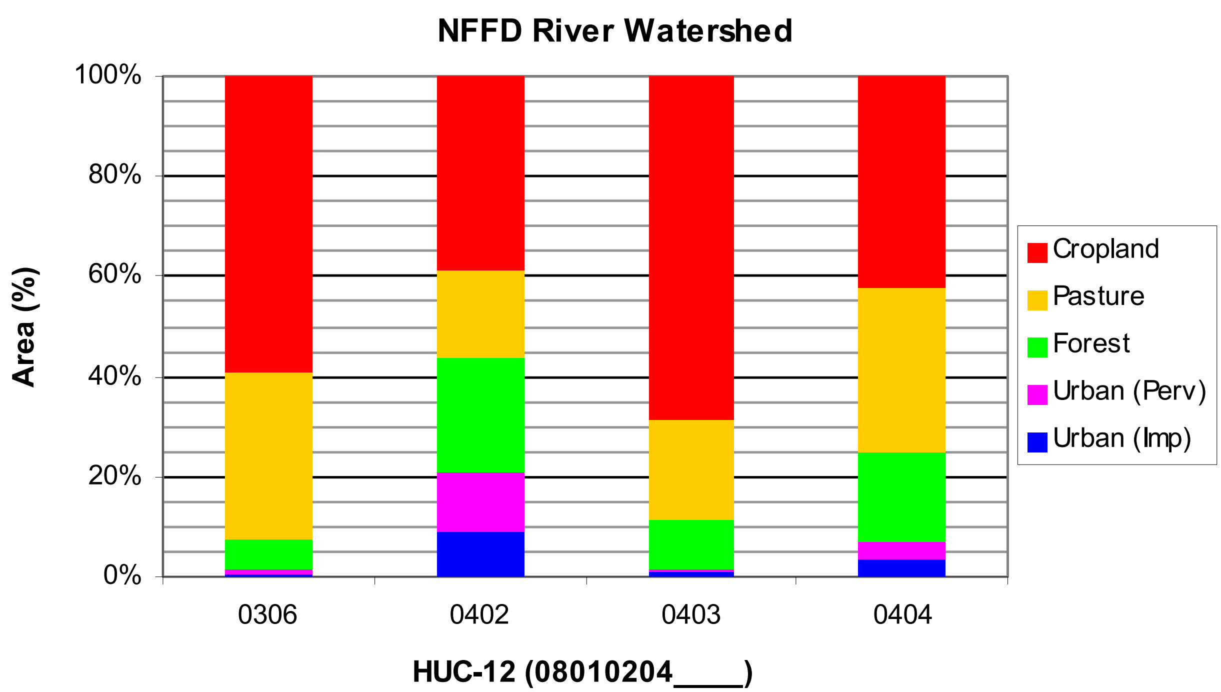

Figure 9. Land Use Percent of North Fork Forked Deer River HUC-12 Subwatersheds 0306, 0402, 0403, and 0404.

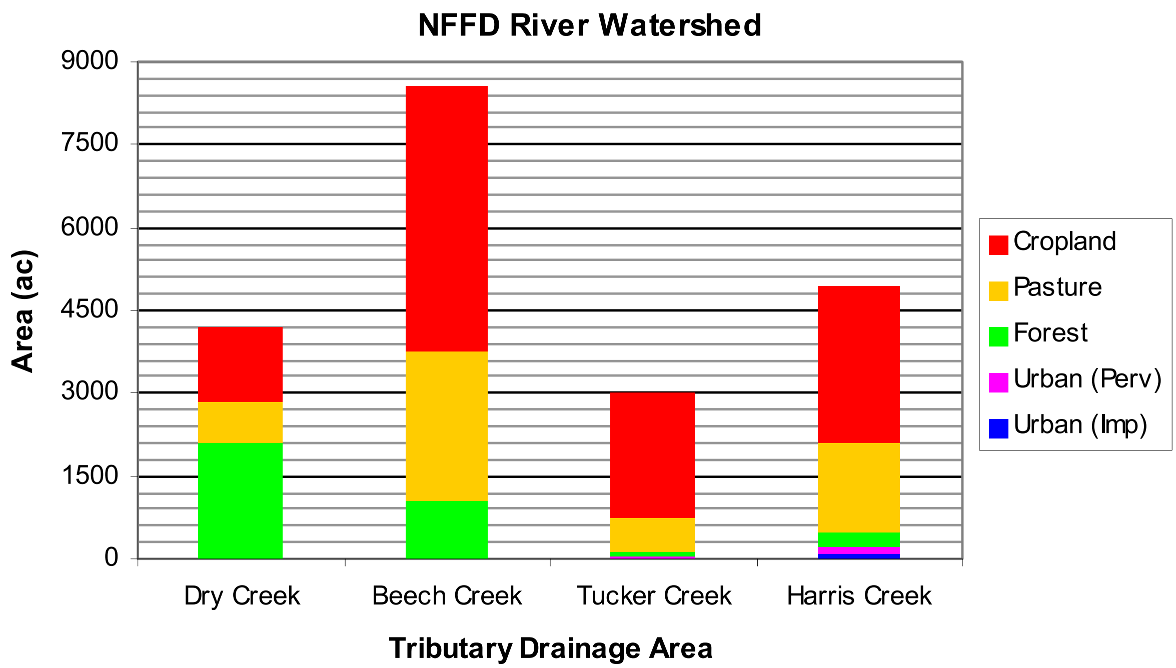

Figure 10. Land Use Area of North Fork Forked Deer River Watershed Tributary Drainage Areas Dry Creek, Beech Creek, Tucker Creek, and Harris Creek.

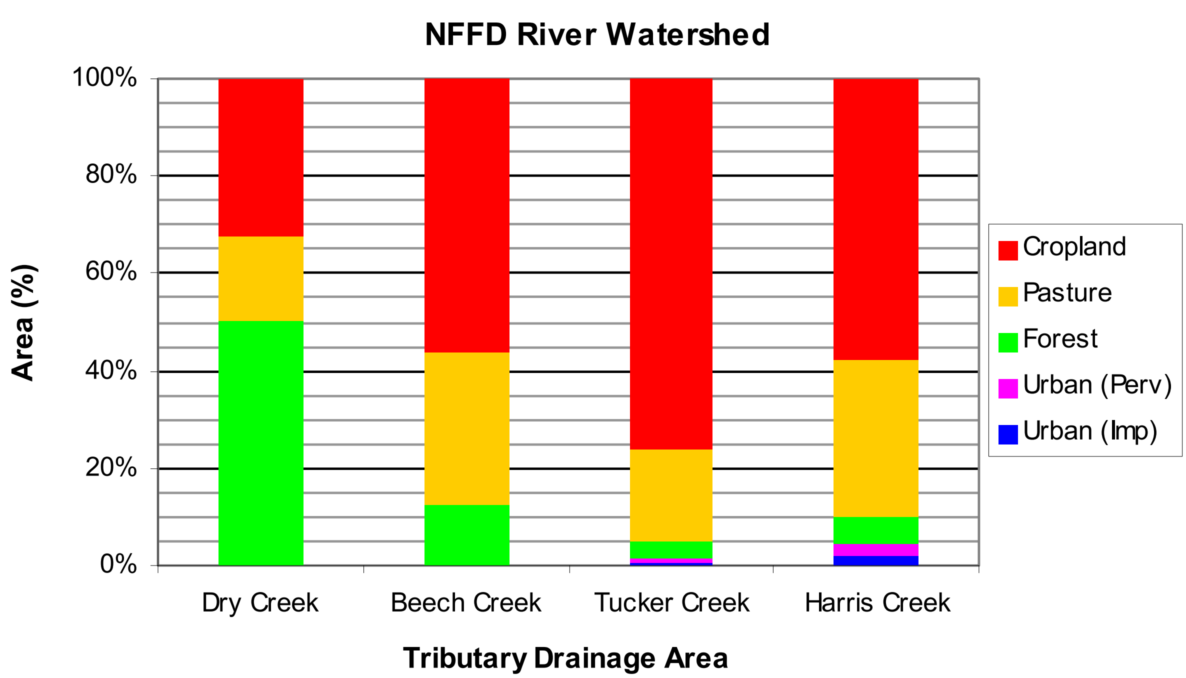

Figure 11. Land Use Percent of North Fork Forked Deer River Watershed Tributary Drainage Areas Dry Creek, Beech Creek, Tucker Creek, and Harris Creek.

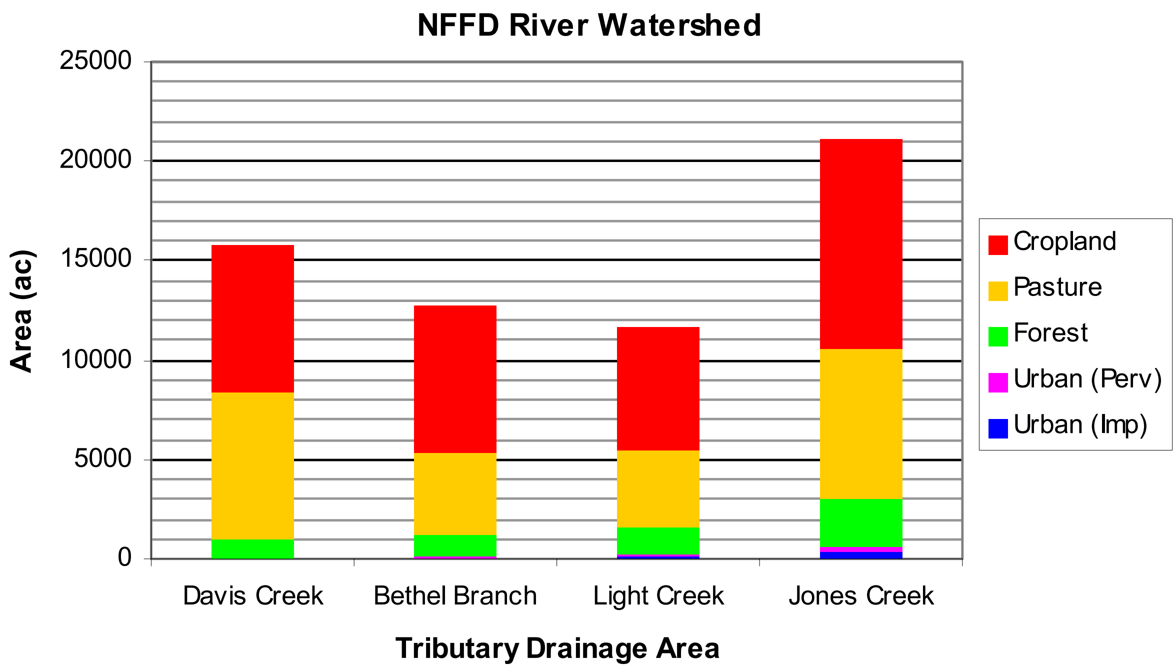

Figure 12. Land Use Area of North Fork Forked Deer River Watershed Tributary Drainage Areas Davis Creek, Bethel Branch, Light Creek, and Jones Creek.

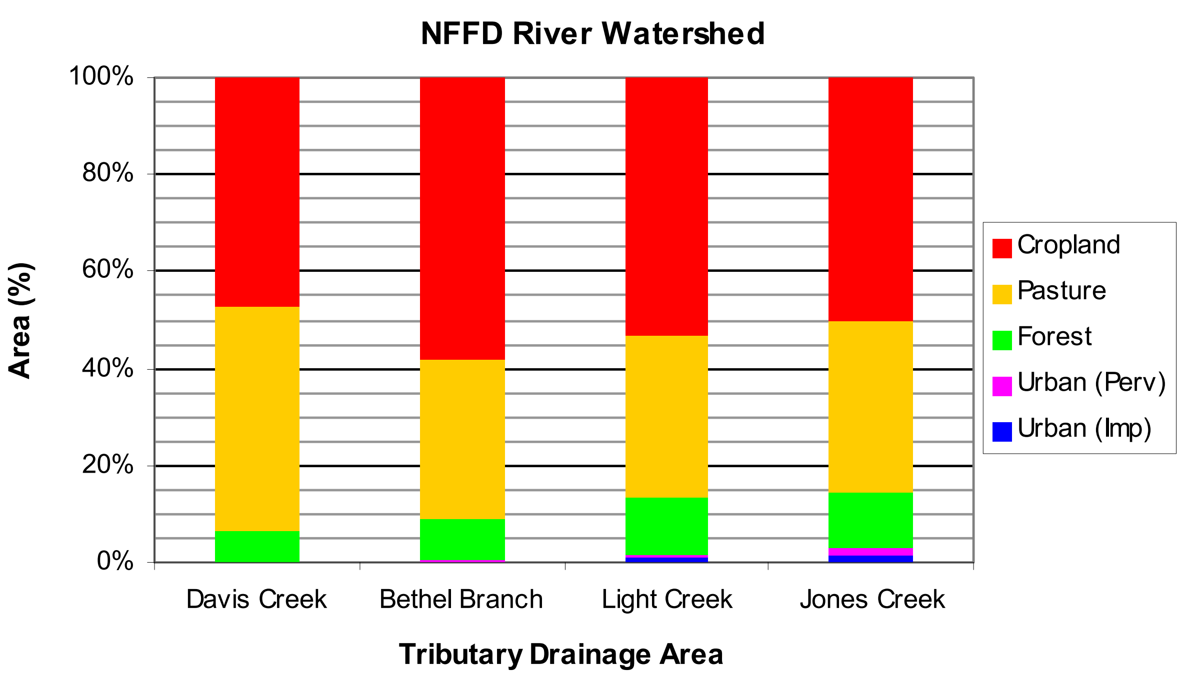

Figure 13. Land Use Percent of North Fork Forked Deer River Watershed Tributary Drainage Areas Davis Creek, Bethel Branch, Light Creek, and Jones Creek.

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 other appropriate measure.

This document describes 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.

8.1 Expression of TMDLs, WLAs, & LAs

In this document, the E. coli TMDL is expressed as the percent reduction in instream loading required to decrease existing E. coli concentrations to desired target levels. WLAs & LAs for precipitation-induced loading sources are also expressed as required percent reductions in E. coli loading. Allocations for loading that is independent of precipitation (WLAs for WWTFs and LAs for "other direct sources") are expressed as CFU/day.

8.2 TMDL Analysis Methodology

TMDLs for the North Fork Forked Deer River Watershed were developed using load duration curves for analysis of impaired HUC-12 subwatersheds or specific waterbody drainage areas. 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 are 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 targets according to the methods described in Appendix C.

8.3 Critical Conditions and Seasonal Variation

The critical condition for non-point source E. coli loading is an extended dry period followed by a rainfall runoff event. During the dry weather period, E. coli 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 analyses.

The ten-year period from January 1, 1995 to December 31, 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 analyses by using the entire period of flow and water quality data available for the impaired waterbodies. In most 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 E. coli appears to be dominant (see Section 9.3 and Table 8).

Seasonal variation was incorporated in the load duration curves by using the entire 10-year simulation period and all water quality data collected at the monitoring stations. Water quality data were collected during all seasons.

8.4 Margin of Safety

There are two methods for incorporating an MOS in the analysis: a) implicitly incorporate the MOS using conservative model assumptions; or b) explicitly specify a portion of the TMDL as the MOS and use the remainder for allocations. For development of E. coli TMDLs in the North Fork Forked Deer River Watershed, an explicit MOS, equal to 10% of the E. coli water quality targets (ref.: Section 5.0), was utilized for determination of WLAs and LAs:

Instantaneous Maximum (lake, reservoir, State Scenic River, Tier II, Tier III):

MOS = 49 CFU/100 ml

Instantaneous Maximum (other): MOS = 94 CFU/100 ml

30-Day Geometric Mean: MOS = 13 CFU/100 ml

8.5 Determination of TMDLs

E. coli load reductions were calculated for impaired segments in the North Fork Forked Deer River watershed using LDCs to evaluate compliance with the single sample maximum target concentrations according to the procedure in Appendix C. When sufficient data were available, load reductions were also developed to achieve compliance with the 30-day geometric mean target concentration. Both instream load reductions (where applicable) for a particular waterbody were compared and the largest calculated load reduction was selected as the TMDL. These TMDL load reductions for impaired segments and subsequent subwatersheds are shown in Table 7. In cases where the geometric mean could not be developed, it is assumed that achieving the load reduction based on the single sample maximum target concentrations should result in attainment of the geometric mean criteria.

8.6 Determination of WLAs & LAs

WLAs for MS4s and LAs for precipitation induced sources of E. coli loading were determined according to the procedures in Appendix C. These allocations represent the higher load reductions necessary to achieve instream targets after application of the explicit MOS. WLAs for existing WWTFs are equal to their existing NPDES permit limits. Since WWTF permit limits require that E. coli concentrations must comply with water quality criteria (TMDL targets) at the point of discharge and recognition that loading from these facilities is generally small in comparison to other loading sources, further reductions were not considered to be warranted. WLAs for CAFOs and LAs for “other direct sources” (non-precipitation induced) are equal to zero. WLAs & LAs are summarized in Table 7.

Table 7. WLAs & LAs for North Fork Forked Deer River, Tennessee

HUC-12 Subwatershed (08010204__)	Impaired Waterbody Name	Impaired Waterbody ID	TMDL	WLAs[a]				LAs[e]
				WWTFs[b]		Leaking Collection Systems[c]	MS4s[d]	
				Monthly Avg.	Daily Max.			
			[% Red.]	[CFU/day]	[CFU /day]	[CFU /day]	[% Red.]	[% Red.]
0103	Dry Creek	TN08010204014 – 0100	>47.6	NA	NA	NA	NA	>52.9
0201	MFFD River	TN08010204010 – 1000	>61.1	1.240×10^{10}	9.263×10^{10}	0	NA	>65.0
	Beech Creek	TN08010204010 – 1100	*	NA	NA	NA	NA	*
0203	MFFD River	TN08010204007 – 1000	69.0	1.908×10^{9}	1.425×10^{10}	0	NA	72.1
0204	Davis Creek	TN08010204017 – 0100	>63.2	NA	NA	NA	NA	>67.0
	Buck Creek	TN08010204017 – 1000	>61.1	NA	NA	NA	NA	>65.0
0305	Bethel Branch	TN08010204004 – 0100	>95.3	NA	NA	NA	NA	>95.8
0306	Harris Creek	TN08010204022 – 0100	>61.1	NA	NA	0	NA	>65.0
	Doakville Creek	TN08010204022 – 1000	>85.8	NA	NA	NA	NA	>87.3
0402	NFFD River	TN08010204001 – 1000	>43.7	4.507×10^{10}	3.366×10^{11}	0	>49.3	>49.3
0403	Tucker Creek	TN08010204003 – 0100	>52.1	NA	NA	NA	NA	>56.9
	Pond Creek	TN08010204003 – 1000	>76.0	NA	NA	0	NA	>78.5
0404	Jones Creek	TN08010204023 – 0200	>89.5	NA	NA	0	>90.5	>90.5
	Light Creek	TN08010204023 – 0210	>89.5	NA	NA	0	>90.5	>90.5
	Lewis Creek	TN08010204023 – 1000	92.2	NA	NA	0	93.0	93.0

Note: *NA = Not applicable.*

* *Insufficient data available to calculate TMDL and LA.*

a. *There are no CAFOs in impaired subwatersheds of the North Fork Forked Deer River watershed. All current and future CAFOs are and will be assigned waste load allocations (WLAs) of zero.*

b. *WLAs for WWTFs expressed as E. coli loads (CFU/day). Future WWTFs must meet instream water quality standards at the point of discharge as specified in their NPDES permits.*

c. *The objective for leaking collection systems is a WLA of zero. It is recognized, however, that a WLA of 0 CFU/day may not be practical. For these sources, the WLA is interpreted to mean a reduction in E. coli 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.*

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

e. *The load allocations (LAs) listed apply to precipitation induced nonpoint sources only. The objective for all other nonpoint sources (leaking septic systems, illicit discharges, and animals access to streams) is a LA of zero. It is recognized, however, that for leaking septic systems a LA of 0 CFU/day may not be practical. For these sources, the LA is interpreted to mean a reduction in E. coli loading to the maximum extent feasible, 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 North Fork Forked Deer River watershed through reduction of excessive E. coli 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, including elimination of bypasses and overflows. 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 derived from facility design flows and permitted E. coli limits and are expressed as average loads in CFU per day.

9.1.2 NPDES Regulated Municipal Separate Storm Sewer Systems (MS4s)

For existing and future 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 Plan (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. Both the *NPDES General Permit for Discharges from Small Municipal Separate Storm Sewer Systems* (TDEC, 2003) and the TDOT individual MS4 permit (TNS077585) require SWMPs to include the following 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

The permits also contain requirements regarding control of discharges of pollutants of concern into impaired waterbodies, implementation of provisions of approved TMDLs, and descriptions of methods to evaluate whether storm water controls are adequate to meet the requirements of approved TMDLs.

In order to evaluate SWMP effectiveness and demonstrate compliance with specified WLAs, MS4s must develop and implement appropriate monitoring programs. An effective monitoring program could include:

- Effluent monitoring at selected outfalls that are representative of particular land uses or geographical areas that contribute to pollutant loading before and after implementation of pollutant control measures.

- Analytical monitoring of pollutants of concern in receiving waterbodies, both upstream and downstream of MS4 discharges, over an extended period of time.

- Instream biological monitoring at appropriate locations to demonstrate recovery of biological communities after implementation of storm water control measures.

The Division of Water Pollution Control Jackson Environmental Field Office should be consulted for assistance in the determination of monitoring strategies, locations, frequency, and methods within 12 months after the approval date of this TMDL. Details of the monitoring plan and monitoring data should be included in the annual report required by the MS4 permit.

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 be 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. Final design plans and specifications for these systems must meet or exceed standards in the NRCS Field Office Technical Guide and other guidelines as accepted by the Departments of Environment and Conservation, or Agriculture.

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

9.2 Nonpoint Sources

The Tennessee Department of Environment & Conservation has no direct regulatory authority over most nonpoint source discharges. Reductions of E. coli 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 non-governmental levels to be successful.

BMPs have been utilized in the North Fork Forked Deer River watershed to reduce the amount of coliform bacteria transported to surface waters from agricultural sources. These BMPs (e.g., critical area planting, pasture and hayland planting, fencing, stream crossings, nutrient management, heavy use area, etc.) may have contributed to reductions in in-stream concentrations of coliform bacteria in one or more North Fork Forked Deer River E. coli-impaired subwatersheds during the TMDL evaluation period. The Tennessee Department of Agriculture (TDA) keeps a database of BMPs implemented in Tennessee. Those listed in the North Fork Forked Deer River watershed are shown in Figure 14. 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 TMDL analysis efforts.

It is further recommended that additional BMPs be implemented and monitored to document performance in reducing coliform bacteria loading to surface waters from agricultural sources. Demonstration sites for various types of BMPs should be established and maintained and their performance (in source reduction) evaluated 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.

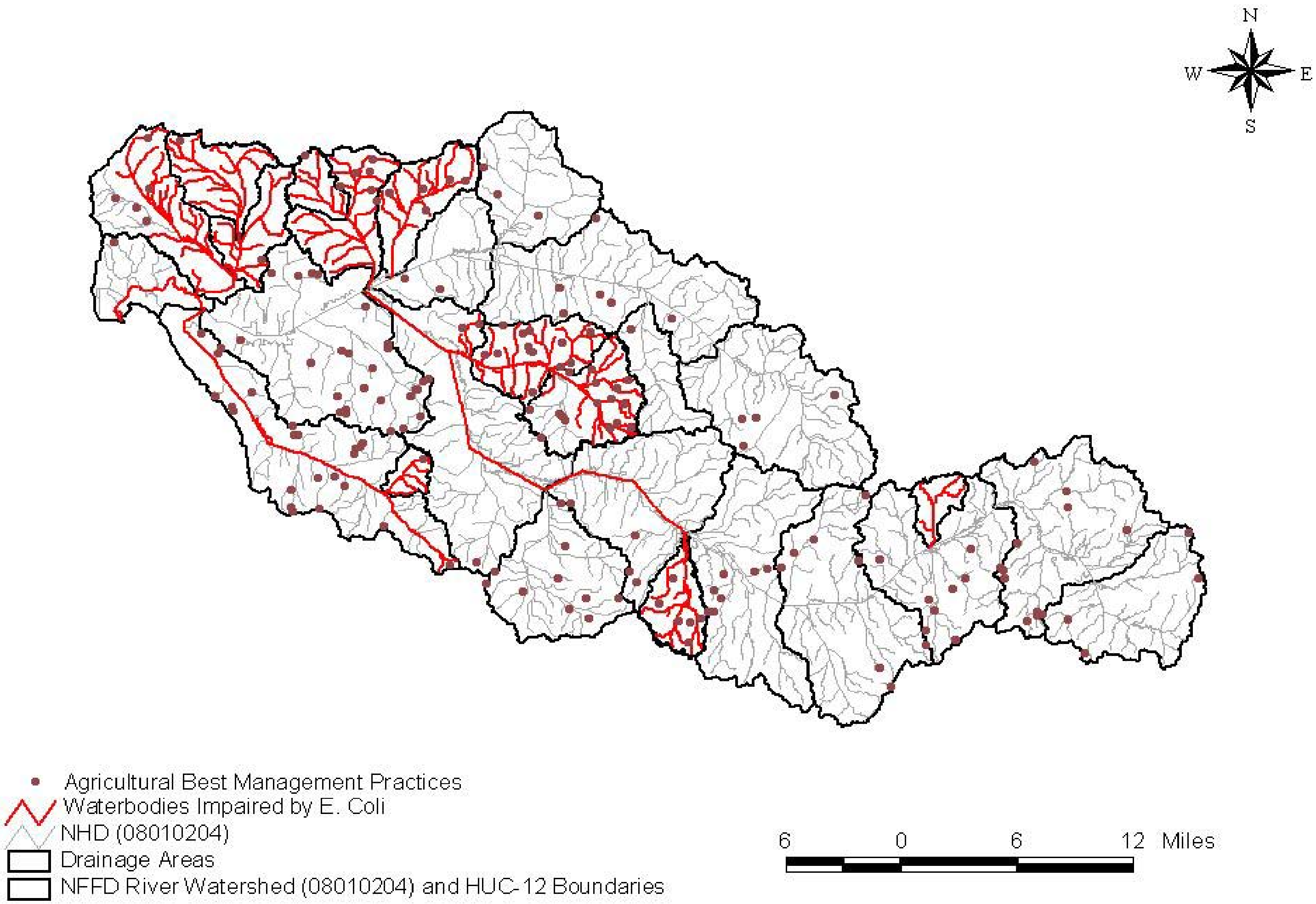

Figure 14. Tennessee Department of Agriculture Best Management Practices in the North Fork Forked Deer River Watershed

9.3 Example 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 E. coli by differentiating between point and non-point problems. The load duration curve analysis can be utilized for implementation planning. The E. coli load duration curve for North Fork Forked Deer River at Mile 7.3 (Figure 15) was analyzed to determine the frequency with which water quality monitoring data exceed the E. coli target maximum concentration of 941 CFU/100 mL under five flow conditions (low, dry, mid-range, moist, and high). Observation of the plot suggests the North Fork Forked Deer River subwatershed is impacted primarily by non-point-type sources.

Table 8 presents Load Duration Curve analysis statistics for E. coli and example 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 the North Fork Forked Deer River subwatershed will require BMPs targeting non-point sources (dominant under high flow/runoff conditions). The implementation strategies listed in Table 8 are a subset of the categories of BMPs and implementation strategies available for application to the North Fork Forked Deer River subwatersheds for reduction of E. coli loading and mitigation of water quality impairment.

See Appendix C for a detailed discussion of the Load Duration Curve Methodology applied to the North Fork Forked Deer River watershed.

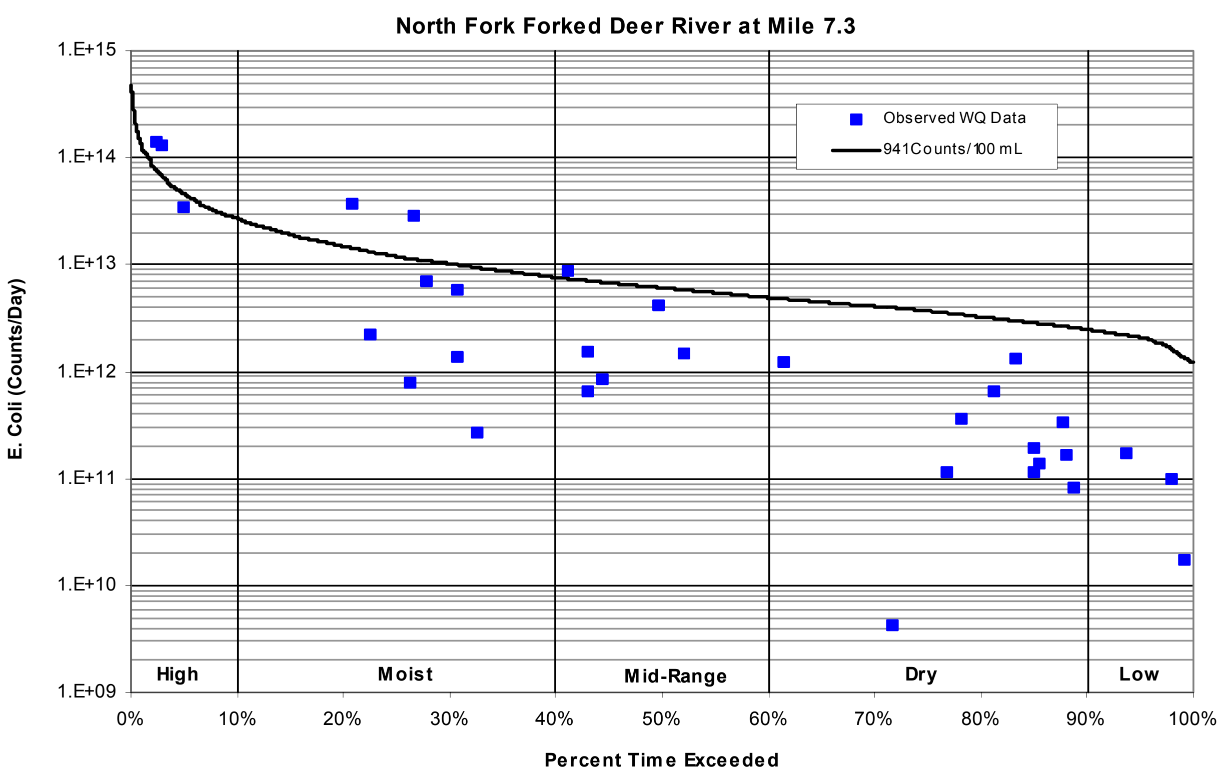

Figure 15. Load Duration Curve for Implementation Planning.

Table 8. Example Implementation Strategies

Flow Condition	High	Moist	Mid-range	Dry	Low
% Time Flow Exceeded	0-10	10-40	40-60	60-90	90-100
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[1]			M	H	H
Pasture Management/Land Application of Manure[1]	H	H	M	L	
Riparian Buffers[1]		H	H	H	
Potential for source area contribution under given hydrologic condition (H: High; M: Medium; L: Low)					

[1] Example Best Management Practices for Agricultural Source reduction. Actual BMPs applied may vary.

9.4 Additional Monitoring

Documenting progress in reducing the quantity of E. coli entering the North Fork Forked Deer River 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 E. coli. Future 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. Monitoring to document improvements and/or identify the need for additional remediation efforts is expected to continue during subsequent watershed cycles.

Additional monitoring and assessment activities are recommended for the North Fork Forked Deer River watershed E. coli-impaired subwatersheds to verify the assessment status of the stream reaches identified on the Final 2004 303(d) list as impaired due to E. coli. If it is determined that these stream reaches are still not fully supporting designated uses, then sufficient data to enable development of a TMDL must be acquired. Future monitoring activities should be representative of all seasons and a full range of flow and meteorological conditions. In addition, collection of E. coli data at sufficient frequency to support calculation of the geometric mean, as described in Tennessee's General Water Quality Criteria (TDEC, 2004a), is encouraged. Finally, for individual monitoring locations, where historical E. coli data are greater than 1000 colonies/100 mL (or future samples are anticipated to be), a 1:100 dilution should be performed as described in Protocol A of the *Quality System Standard Operating Procedure for Chemical and Bacteriological Sampling of Surface Water* (TDEC, 2004b).

Analysis of monitoring data suggests the potential for delisting Beech Creek for E. coli. However, inadequate data have been collected subsequent to its most recent assessment to confirm non-impairment status, thereby justifying delisting. Therefore, it is recommended that additional data be collected to confirm the status of impairment or to support delisting.

9.5 Source Identification

An important aspect of E. coli load reduction activities is the accurate identification of the actual sources of pollution. In cases where the sources of E. coli impairment are not readily apparent, Microbial Source Tracking (MST) is one approach to determining the sources of fecal pollution and E. coli 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 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 at the University of Tennessee, Knoxville (UTK) 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. Additional information can be found on the following UTK website: http://web.utk.edu/~hydro/Research/McKayAGU2004Abstract.pdf.

9.6 Evaluation of TMDL Implementation Effectiveness

The effectiveness of the TMDL implementation 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 E. coli 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 E. coli loading. These TMDLs will be re-evaluated during subsequent watershed cycles and revised as required to assure compliance with applicable water quality standards.

10.0 PUBLIC PARTICIPATION

In accordance with 40 CFR §130.7, the proposed E. coli TMDLs for the North Fork Forked Deer River watershed were placed on Public Notice for a 35-day period and comments solicited. Steps that were taken in this regard include:

1) Notice of the proposed TMDLs were posted on the TDEC website. The announcement invited public and stakeholder comment and provided a link to a downloadable version of the TMDL document.

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

3) Draft copies of the proposed TMDLs were sent to the city of Dyersburg, the city of Jackson, Madison County, and the Tennessee Department of Transportation.

4) Letters were sent to WWTFs located in E. coli-impaired subwatersheds in the North Fork Forked Deer River watershed, permitted to discharge treated effluent containing E. coli, 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. Letters were sent to the following facilities:

   Dyersburg STP (TN0023477)
   Alamo STP (TN0024988)
   Humboldt Board of Public Utilities STP (TN0062588)

Written comments were received from one stakeholder during the public comment period. These comments are included in Appendix F and the TDEC Division of Water Pollution Control responses are presented in Appendix G. No requests to hold public meetings were received regarding the proposed TMDLs as of close of business on July 24, 2006.

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 North Fork Forked Deer River Watershed

Table A-1. MRLC Land Use Distribution of North Fork Forked Deer River Subwatersheds

Land Use	HUC-12 Subwatershed (08010204____) or Drainage Area (DA)					
	0201		0203		0204	
	[acres]	[%]	[acres]	[%]	[acres]	[%]
Bare Rock/Sand/Clay	0	0.0	28	0.1	0	0.0
Deciduous Forest	3193	7.8	974	2.2	738	2.4
Evergreen Forest	322	0.8	56	0.1	85	0.3
High Intensity Commercial/Industrial/Transp.	261	0.6	47	0.1	24	0.1
High Intensity Residential	262	0.6	60	0.1	0	0.0
Low Intensity Residential	1344	3.3	193	0.4	27	0.1
Mixed Forest	1722	4.2	737	1.7	822	2.7
Open Water	523	1.3	1599	3.6	174	0.6
Other Grasses (Urban/recreation; e.g. parks)	93	0.2	4	0.0*	0	0.0
Pasture/Hay	12951	31.8	9468	21.3	14557	47.4
Row Crops	17665	43.4	22050	49.5	13896	45.2
Small Grains	348	0.9	32	0.1	0	0.0
Transitional	21	0.1	27	0.1	6	0.0
Woody Wetlands	2034	5.0	9259	20.8	389	1.3
Total	40740	100.0	44534	100.0	30720	100.0

* <0.05

Table A-1. MRLC Land Use Distribution of North Fork Forked Deer River Subwatersheds (Cont.)

Land Use	HUC-12 Subwatershed (08010204__) or Drainage Area (DA)							
	0306		0402		0403		0404	
	[acres]	[%]	[acres]	[%]	[acres]	[%]	[acres]	[%]
Bare Rock/Sand/Clay	0	0.0	0	0.0	18	0.0*	0	0.0
Deciduous Forest	758	4.0	1117	10.4	1518	3.4	4204	10.0
Evergreen Forest	25	0.1	66	0.6	139	0.3	320	0.8
High Intensity Commercial/Industrial/Transportatio	91	0.5	430	4.0	345	0.8	958	2.3
High Intensity Residential	33	0.2	564	5.3	56	0.1	554	1.3
Low Intensity Residential	120	0.6	1207	11.3	220	0.5	1391	3.3
Mixed Forest	244	1.3	603	5.6	741	1.7	2666	6.3
Open Water	28	0.1	298	2.8	375	0.8	186	0.4
Other Grasses (Urban/recreational; e.g. parks law	54	0.3	164	1.5	53	0.1	186	0.4
Pasture/Hay	6389	33.4	1889	17.6	8898	20.1	13713	32.6
Row Crops	11338	59.3	4145	38.7	30256	68.3	17831	42.4
Small Grains	0	0.0	0	0.0	69	0.2	0	0.0
Transitional	0	0.0	40	0.4	101	0.2	69	0.2
Woody Wetlands	36	0.2	201	1.9	1534	3.5	0	0.0
Total	19118	100.0	10724	100.0	44323	100.0	42078	100.0

* <0.05

Table A-1. MRLC Land Use Distribution of North Fork Forked Deer River Subwatersheds (Cont.)

Land Use	HUC-12 Subwatershed (08010204____) or Drainage Area (DA)							
	Dry Creek DA		Beech Creek DA		Davis Creek DA		Tucker Creek DA	
	[acres]	[%]	[acres]	[%]	[acres]	[%]	[acres]	[%]
Deciduous Forest	1422	33.8	583	6.8	416	2.6	70	2.3
Evergreen Forest	284	6.7	72	0.8	42	0.3	2	0.1
High Intensity Commercial/Industrial/Transp.	2	0.0*	2	0.0*	15	0.1	20	0.7
High Intensity Residential	0	0.0	0	0.0	0	0.0	0	0.0
Low Intensity Residential	3	0.1	0	0.0	8	0.1	22	0.7
Mixed Forest	359	8.5	332	3.9	457	2.9	33	1.1
Open Water	3	0.1	30	0.4	62	0.4	2	0.1
Other Grasses (Urban/recreation; e.g. parks)	0	0.0	0	0.0	0	0.0	1	0.0*
Pasture/Hay	743	17.7	2716	31.7	7349	46.5	573	18.9
Row Crops	1359	32.3	4744	55.4	7453	47.2	2242	74.0
Small Grains	0	0.0	55	0.6	0	0.0	64	2.1
Transitional	1	0.0*	6	0.1	2	0.0*	0	0.0
Woody Wetlands	35	0.8	22	0.3	0	0.0	0	0.0
Total	4211	100.0	8563	100.0	15806	100.0	3029	100.0

* <0.05

Table A-1. MRLC Land Use Distribution of North Fork Forked Deer River Subwatersheds (Cont.)

Land Use	HUC-12 Subwatershed (08010204____) or Drainage Area (DA)							
	Jones Creek DA		Light Creek DA		Bethel Branch DA		Harris Creek DA	
	[acres]	[%]	[acres]	[%]	[acres]	[%]	[acres]	[%]
Deciduous Forest	592	6.2	869	7.4	592	4.6	167	3.4
Evergreen Forest	73	0.8	45	0.4	23	0.2	5	0.1
High Intensity Commercial/Industrial/Transp.	206	2.2	123	1.1	11	0.1	80	1.6
High Intensity Residential	66	0.7	8	0.1	7	0.1	29	0.6
Low Intensity Residential	170	1.8	64	0.5	47	0.4	107	2.2
Mixed Forest	255	2.7	424	3.6	194	1.5	48	1.0
Open Water	48	0.5	6	0.1	46	0.4	5	0.1
Other Grasses (Urban/recreation; e.g. parks)	49	0.5	3	0.0*	0	0.0	57	1.1
Pasture/Hay	3607	38.0	3930	33.7	4143	32.5	1587	32.1
Row Crops	4419	46.6	6200	53.1	7443	58.4	2862	57.9
Transitional	6	0.1	2	0.0*	2	0.0*	0	0.0
Woody Wetlands	0	0.0	0	0.0	246	1.9	0	0.0
Total	9490	100.0	11674	100.0	12754	100.0	4948	100.0

* <0.05

APPENDIX B

Water Quality Monitoring Data

There are a number of water quality monitoring stations that provide data for waterbodies identified as impaired for E. coli in the North Fork Forked Deer River watershed. The location of these monitoring stations is shown in Figure 5. Monitoring data recorded at these stations for E. coli are tabulated in Table B-1.

Table B-1. Water Quality Monitoring Data – North Fork Forked Deer River Watershed

Monitoring Station	Date	E. Coli [CFU/100 mL]
BEECH001.8CK	6/16/1999	206.3
	8/12/1999	131.3
	11/12/2002	**1233**
	1/14/2003	13.4
	3/11/2003	14.8
BETHE001.8DY	6/15/1999	80.8
	8/11/1999	36.4
	7/11/2002	**>2419.2**
	8/8/2002	20
	9/5/2002	86.5
	9/12/2002	61.3
	9/19/2002	139.6
	9/26/2002	**1299.7**
	10/3/2002	37.9
	10/10/2002	**>2419.2**
	10/17/2002	111.2
	10/24/2002	116.9
	11/7/2002	**>2419.2**
	1/9/2003	79.8
	2/13/2003	201.4
	3/6/2003	238.2
	4/3/2003	146.7
	4/10/2003	**1732.9**
	4/16/2003	103.9
	4/24/2003	**1483**
	5/15/2003	131.3
	5/22/2003	387.3
	5/29/2003	74.9
	6/5/2003	203.5

Table B-1. Water Quality Monitoring Data – North Fork Forked Deer River Watershed (Cont.)

Monitoring Station	Date	E. Coli [CFU/100 mL]
BETHE004.2GI	7/11/2002	**>2419.2**
	8/8/2002	30
	9/5/2002	178.2
	9/12/2002	344.8
	9/19/2002	101.7
	9/26/2002	**>2419.2**
	10/3/2002	64.4
	10/10/2002	**>2419.2**
	10/17/2002	387.3
	10/24/2002	111.2
	11/7/2002	**>2419.2**
	1/9/2003	148.3
	2/13/2003	166.9
	3/6/2003	218.7
	4/3/2003	106.7
	4/10/2003	**1986.3**
	4/16/2003	67
	4/24/2003	776
	5/15/2003	218.7
	5/22/2003	488.4
	5/29/2003	143.9
	6/5/2003	248.9
BETHE006.1GI	7/11/2002	**>2419.2**
	8/8/2002	560
	9/5/2002	328.2
	9/12/2002	547.5
	9/19/2002	**980.4**
	9/26/2002	**9804**
	10/3/2002	**1119.9**
	10/10/2002	**>24192**
	10/17/2002	547.5
	11/7/2002	**>2419.2**
	1/9/2003	**1413.6**
	2/13/2003	770.1
	3/6/2003	410.6
	4/3/2003	**1119.9**
	4/10/2003	155.1
	4/16/2003	142.1

Table B-1. Water Quality Monitoring Data – North Fork Forked Deer River Watershed (Cont.)

Monitoring Station	Date	E. Coli [CFU/100 mL]
BETHE006.1GI	4/24/2003	**6867**
	5/15/2003	517.2
	5/22/2003	387.3
	5/29/2003	686.7
	6/5/2003	**>2419.2**
BUCK001.2GI	4/14/1998	**1413.6**
	4/15/1998	579.4
	4/16/1998	**4366**
	7/21/1998	38.8
	7/22/1998	167.8
	7/23/1998	44.8
	7/9/2002	177.7
	8/6/2002	91
	9/3/2002	307.6
	9/10/2002	140.1
	9/17/2002	**1299.7**
	9/24/2002	69.7
	10/1/2002	209.8
	10/8/2002	290.9
	10/15/2002	74.3
	12/22/2002	131.3
	11/5/2002	**>2419.2**
	12/3/2002	57.3
	1/7/2003	65
	2/4/2003	**5475**
	3/4/2003	51.2
	4/1/2003	55.4
	4/8/2003	**980.4**
	4/15/2003	117.8
	4/22/2003	**>2419.2**
	5/13/2003	65.7
	5/20/2003	78.9
	5/27/2003	123.6
	6/3/2003	185

Table B-1. Water Quality Monitoring Data – North Fork Forked Deer River Watershed (Cont.)

Monitoring Station	Date	E. Coli [CFU/100 mL]
BUCK007.7GI	10/1/2002	**1413.6**
	10/15/2002	613.1
	10/22/2002	172.3
	11/5/2002	**>24192**
	1/7/2003	93.3
	2/4/2003	**1785**
	3/4/2003	25.9
	4/1/2003	65
	4/8/2003	613.1
	4/15/2003	488.4
	4/22/2003	**>2419.2**
	5/13/2003	410.6
	5/20/2003	10.7
	5/27/2003	235.9
	6/3/2003	461.1
DAVIS000.9GI	7/9/2002	58.6
	8/6/2002	201.2
	9/3/2002	36.4
	9/10/2002	488.4
	9/17/2002	648.8
	9/24/2002	73.8
	10/1/2002	172.3
	10/8/2002	122.3
	10/22/2002	54.6
	11/5/2002	**>2419.2**
	12/3/2002	131.3
	1/7/2003	88.2
	2/4/2003	**5172**
	3/4/2003	30.1
	4/1/2003	95.9
	4/8/2003	290.9
	4/15/2003	161.6
	4/22/2003	261.3
	5/13/2003	189.2
	5/20/2003	261.3
	5/27/2003	93.3
	6/3/2003	344.8
	7/9/2002	58.6

Table B-1. Water Quality Monitoring Data – North Fork Forked Deer River Watershed (Cont.)

Monitoring Station	Date	E. Coli [CFU/100 mL]
DAVIS002.5GI	7/9/2002	164.8
	8/6/2002	275.5
	9/3/2002	178.5
	9/10/2002	122.3
	9/17/2002	**>2419.2**
	9/24/2002	216
	10/1/2002	90.6
	10/8/2002	579.4
	10/15/2002	172.3
	10/22/2002	387.3
	11/5/2002	**8164**
	12/3/2002	57.3
	1/7/2003	142.1
	2/4/2003	**2282**
	3/4/2003	80.9
	4/1/2003	193.5
	4/8/2003	387.3
	4/15/2003	155.3
	4/22/2003	111.2
	5/13/2003	135.4
	5/20/2003	261.3
	5/27/2003	**1553.1**
	6/3/2003	**1413.6**
DOAKV002.0DY	4/20/1999	**980.4**
	4/21/1999	816.2
	7/11/2002	**>2419.2**
	8/8/2002	**1130**
	9/5/2002	41.3
	9/12/2002	**1299.7**
	9/19/2002	206.3
	9/26/2002	74
	10/3/2002	70.6
	10/10/2002	**>2419.2**
	10/17/2002	40.8
	10/24/2002	48
	12/24/2002	58.6
	11/7/2002	**>2419.2**
	1/9/2003	166.9

Table B-1. Water Quality Monitoring Data – North Fork Forked Deer River Watershed (Cont.)

Monitoring Station	Date	E. Coli [CFU/100 mL]
DOAKV002.0DY	2/13/2003	365.4
	3/6/2003	160.7
	4/3/2003	613.1
	4/10/2003	**1986.3**
	4/16/2003	410.6
	4/24/2003	910
	5/15/2003	90.9
	5/22/2003	161.6
	5/29/2003	95.9
	6/5/2003	103.9
DOAKV005.4DY	7/11/2002	**>2419.2**
	8/8/2002	475
	9/5/2002	770.1
	9/12/2002	160.7
	9/19/2002	344.8
	9/26/2002	**1986.3**
	10/3/2002	275.5
	10/10/2002	**>2419.2**
	10/17/2002	613.1
	10/24/2002	686.7
	11/7/2002	**1986.3**
	1/9/2003	344.8
	2/13/2003	727
	3/6/2003	228.2
	4/3/2003	686.7
	4/10/2003	**1299.7**
	4/16/2003	228.2
	4/24/2003	**9208**
	5/15/2003	435.2
	5/22/2003	410.6
	5/29/2003	727
	6/5/2003	191.8

Table B-1. Water Quality Monitoring Data – North Fork Forked Deer River Watershed (Cont.)

Monitoring Station	Date	E. Coli [CFU/100 mL]
DRY000.3MN	6/17/1999	**>2419.2**
	12/10/2002	121
	2/11/2003	62
	6/10/2003	344.8
HARRI001.9DY	7/11/2002	**>2419.2**
	10/10/2002	**>2419.2**
	10/17/2002	68.3
	10/24/2002	218.7
	11/7/2002	**>2419.2**
	1/9/2003	**1299.7**
	2/13/2003	105
	3/6/2003	290.9
	4/3/2003	613.1
	4/10/2003	**1553.1**
	4/16/2003	435.2
	4/24/2003	**>24192**
	5/15/2003	547.5
	5/22/2003	172.6
	5/29/2003	344.8
	6/5/2003	148.3
JONES003.8DY	7/17/2002	128.1
	8/14/2002	**>24192**
	11/13/2002	**>2419.2**
	12/11/2002	148
	1/15/2003	116.9
	2/12/2003	933
	3/12/2003	131.7
	6/11/2003	**>2419.2**
LEWIS000.3DY	7/17/2002	579.4
	8/14/2002	**>24192**
	11/13/2002	105.8
	12/11/2002	495
	1/15/2003	74.2
	2/12/2003	**5475**
	3/12/2003	118.6
	6/11/2003	**>2419.2**

Table B-1. Water Quality Monitoring Data – North Fork Forked Deer River Watershed (Cont.)

Monitoring Station	Date	E. Coli [CFU/100 mL]
LEWIS002.5DY	7/17/2002	8.5
	8/14/2002	**>24192**
	11/13/2002	25.9
	12/11/2002	201
	1/15/2003	35
	2/12/2003	663
	3/12/2003	50.4
	6/11/2003	**>2419.2**
LEWIS007.9DY	8/14/2002	**12033**
	11/13/2002	22.8
	12/11/2002	364
	1/15/2003	152.9
	2/12/2003	**12033**
	3/12/2003	44.8
	6/11/2003	**>2419.2**
LIGHT002.2DY	7/17/2002	**>2419.2**
	8/14/2002	**>24192**
	11/13/2002	52
	12/11/2002	243
	1/15/2003	45.7
	2/12/2003	470
	3/12/2003	387.5
	6/11/2003	**>2419.2**
MFFDE014.6CK	6/16/1999	**1986.2**
	8/11/1999	41.1
	7/16/2002	**517.2**
	11/12/2002	**1153**
	1/14/2003	30.9
	3/11/2003	14.2
MFFDE021.5GI	4/14/1998	34.5
	4/15/1998	**>2419.2**
	4/16/1998	86
	7/21/1998	**>2419.2**
	7/22/1998	**1732.9**
	7/23/1998	143.9
	7/16/2002	328.2

Table B-1. Water Quality Monitoring Data – North Fork Forked Deer River Watershed (Cont.)

Monitoring Station	Date	E. Coli [CFU/100 mL]
MFFDE021.5GI	11/12/2002	**1467**
	1/14/2003	93.4
	3/11/2003	33.6
NFFDE007.3DY	4/14/1998	**1119.9**
	4/15/1998	206.3
	4/16/1998	613.1
	7/21/1998	37.3
	7/22/1998	63.1
	7/23/1998	46.4
	9/28/1998	58.1
	12/16/1998	648.8
	3/24/1999	27.2
	6/9/1999	98.4
	9/28/1999	57.8
	12/1/1999	29.5
	3/30/2000	117.4
	6/20/2000	410.6
	9/6/2000	12.1
	12/14/2000	1
	3/13/2001	**>2419.2**
	6/27/2001	30.1
	9/12/2001	74.8
	12/17/2001	**1732.9**
	3/12/2002	**1842**
	6/18/2002	240
	9/24/2002	547.5
	12/16/2002	157.6
	3/25/2003	129.1
	6/19/2003	686.7
	9/16/2003	195.6
	12/11/2003	**>2419.2**
	3/18/2004	240
	6/8/2004	86.5
	9/27/2004	120
	12/15/2004	65.7

Table B-1. Water Quality Monitoring Data – North Fork Forked Deer River Watershed (Cont.)

Monitoring Station	Date	E. Coli [CFU/100 mL]
POND001.1DY	6/15/1999	**1413.6**
	7/10/2002	410.6
	8/7/2002	61.8
	9/4/2002	14.3
	9/11/2002	22.6
	9/18/2002	123.6
	9/25/2002	103.4
	10/2/2002	59.4
	10/9/2002	517.2
	10/16/2002	51.2
	10/23/2002	95.9
	11/6/2002	**>2419.2**
	12/4/2002	186
	1/8/2003	52.1
	2/5/2003	839
	3/5/2003	24.6
	4/2/2003	69.7
	4/9/2003	613.1
	4/16/2003	51.2
	4/23/2003	246
	5/14/2003	41
	5/21/2003	74
	5/28/2003	178.2
	6/4/2003	195.1
POND007.4DY	7/10/2002	107.1
	8/7/2002	**>2419.2**
	9/4/2002	307.6
	9/18/2002	45.5
	9/25/2002	163.1
	10/2/2002	275.5
	10/9/2002	38.4
	10/16/2002	184.2
	10/23/2002	39.3
	11/6/2002	**>2419.2**
	12/4/2002	325.5
	1/8/2003	68.9
	2/5/2003	909
	3/5/2003	178.9

Table B-1. Water Quality Monitoring Data – North Fork Forked Deer River Watershed (Cont.)

Monitoring Station	Date	E. Coli [CFU/100 mL]
POND007.4DY	4/2/2003	114.5
	4/9/2003	547.5
	4/16/2003	155.3
	4/23/2003	520
	5/14/2003	146
	5/21/2003	933
	5/28/2003	43.5
	6/4/2003	77.6
POND011.3DY	8/7/2002	**1203.3**
	9/4/2002	6.3
	9/18/2002	137.1
	9/25/2002	89.1
	10/2/2002	547.5
	10/9/2002	52.9
	10/16/2002	190.4
	10/23/2002	65.7
	11/6/2002	**>2419.2**
	12/4/2002	307.6
	1/8/2003	111.9
	2/5/2003	452
	3/5/2003	13.5
	4/2/2003	32.7
	4/9/2003	166.9
	4/16/2003	38.2
	4/23/2003	422
	5/14/2003	218
	5/21/2003	**1860**
	5/28/2003	40.8
	6/4/2003	153.9
POND012.9CK	8/7/2002	41
	9/4/2002	18.9
	9/11/2002	**>2419.2**
	9/18/2002	**1607**
	9/25/2002	248
	10/2/2002	613.1
	10/9/2002	67.6
	10/16/2002	275.5

Table B-1. Water Quality Monitoring Data – North Fork Forked Deer River Watershed (Cont.)

Monitoring Station	Date	E. Coli [CFU/100 mL]
POND012.9CK	10/23/2002	135.4
	11/2/2002	**>2419.2**
	12/4/2002	260.2
	1/8/2003	75.4
	2/5/2003	728
	3/5/2003	24.9
	4/2/2003	40.4
	4/9/2003	156.5
	4/16/2003	20.1
	4/23/2003	359
	5/14/2003	296
	5/21/2003	**3255**
	5/28/2003	66.9
	6/4/2003	290.9
POND014.9CK	8/7/2002	91.2
	10/2/2002	**1413.6**
	10/9/2002	816.4
	10/16/2002	218.7
	11/6/2002	**>2419.2**
	12/4/2002	48.8
	1/8/2003	44.8
	2/5/2003	**1497**
	3/5/2003	30.5
	4/2/2003	38.8
	4/9/2003	166.4
	4/16/2003	166.9
	4/23/2003	**1354**
	5/14/2003	146
	5/21/2003	**4884**
	5/28/2003	42.2
	6/4/2003	111.2
TUCKE000.4CK	9/18/2002	**1119.9**
	10/9/2002	261.3
	10/16/2002	275.5
	10/23/2002	58.3
	11/6/2002	**>2419.2**
	12/4/2002	**1413.6**

Table B-1. Water Quality Monitoring Data – North Fork Forked Deer River Watershed (Cont.)

Monitoring Station	Date	E. Coli [CFU/100 mL]
TUCKE000.4CK	1/8/2003	33.1
	2/5/2003	**1664**
	3/5/2003	206.3
	4/2/2003	84.2
	4/9/2003	272.3
	4/16/2003	93.3
	4/23/2003	408
	5/14/2003	256
	5/21/2003	**4884**
	5/28/2003	387.3
	6/4/2003	131.3

APPENDIX C

Load Duration Curve Development
and
Determination of Required Load Reductions

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), 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 other appropriate measure.

C.1 Development of TMDLs

E. coli TMDLs, WLAs, and LAs were developed for impaired subwatersheds in the North Fork Forked Deer River watershed using Load Duration Curves (LDCs) to determine the reduction in pollutant loading required to decrease existing, instream E. coli concentrations to target levels. TMDLs are expressed as required percent reductions in pollutant loading.

C.1.1 Development of Flow Duration Curves

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. 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 U.S. Geological Survey (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 North Fork Forked Deer River Watershed were derived from LSPC hydrologic simulations based on parameters derived from calibration at USGS Stations 07028960, Middle Fork Forked Deer River near Fairview, and 07029100, North Fork Forked Deer River at Dyersburg (see Appendix D for details of calibration). The data used, in each case, included the period of record from 1/1/95 – 12/31/04. For example, a flow-duration curve for North Fork Forked Deer River at mile 7.3 was constructed using simulated daily mean flow for the period from 1/1/95 through 12/31/04 (mile 7.3 corresponds to the location of monitoring station NFFDE007.3DY). This flow duration curve is shown in Figure C-1 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.

C.1.2 Development of Load Duration Curves and Determination of Required Load Reductions

When a water quality target 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).

E. coli load duration curves for impaired waterbodies in the North Fork Forked Deer River Watershed were developed from the flow duration curves developed in Section C.1.1, E. coli target concentrations, and available water quality monitoring data. Load duration curves and required load reductions were developed using the following procedure (North Fork Forked Deer River at mile 7.3 [NFFD 7.3] is shown as an example):

1. A target load duration curve (LDC) was generated for NFFD River at mile 7.3 by applying the E. coli target concentration of 941 CFU/100 mL to each of the ranked flows used to generate the flow duration curve (ref.: Section C.1.1) and plotting the results. The E. coli target maximum load corresponding to each ranked daily mean flow is:

   $(\text{Target Load})_{\text{NFFD 7.3}}$ = (941 CFU/100 mL) x (Q) x (UCF)

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

2. Daily loads were calculated for each of the water quality samples collected at monitoring station NFFDE007.3DY (ref.: Table B-1) by multiplying the sample concentration by the daily mean flow for the sampling date and the required unit conversion factor. NFFDE007.3DY was selected for LDC analysis because it has numerous sampling points, well distributed across the full range of flow conditions, and multiple 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.*

   Example (12/17/01 sampling event):
   Modeled Flow = 3323.93 cfs
   Concentration = 1732.9 CFU/100 mL
   Daily Load = 1.409×10^{14}

3. Using the flow duration curves developed in C.1.1, 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 E. coli load duration curve for NFFD River at mile 7.3 is shown in Figure C-2.

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.

Example (7/12/01 sampling event):
Target Concentration = 941 CFU/100 mL
Measured Concentration = 1732.9 CFU/100 mL
Reduction to Target = 45.7%

5. The 90th percentile value for all of the E. coli sampling data at NFFDE007.3DY monitoring site was determined. If the 90th percentile value exceeded the target maximum E. coli concentration, the reduction required to reduce the 90th percentile value to the target maximum concentration was calculated (Table C-1).

   Example: Target Concentration = 941 CFU/100 mL
   90th Percentile Concentration = 1672 CFU/100 mL
   Reduction to Target = 43.7%

6. For cases where five or more samples were collected over a period of not more than 30 consecutive days, the geometric mean E. coli concentration was determined and compared to the target geometric mean E. coli concentration of 126 CFU/100mL. 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.

   Example: Insufficient monitoring data were available for NFFD River at Mile 7.3
   Sufficient data were available for Pond Creek at Mile 12.9
   Sampling Period = 9/11/02 – 10/9/02
   Geometric Mean Concentration > 525 CFU/100 mL
   Target Concentration = 126 CFU/100 mL
   Reduction to Target > 76.0%

   Note: One sample value, dated 9/11/02, in the above example was equal to >2419.2. Therefore, the geometric mean and reduction to target were expressed as greater than (>) their respective calculated values.

7. The load reductions required to meet the target maximum (Step 5) and target 30-day geometric mean concentrations (Step 6) of E. coli were compared and the load reduction of the greatest magnitude selected as the TMDL for NFFD River at mile 7.3.

Load duration curves, required load reductions, and TMDLs of other impaired waterbodies were derived in a similar manner and are shown in Figures C-1 through C-16 and Tables C-1 through C-15. Note that Figures C-4, C-5, C-10, and C-13 present E. coli samples on load duration curves for geometric mean analyses. The target lines represent 30-day geometric mean targets rather than daily maximum targets as in the standard load duration curve methodology. Individual samples cannot be compared to corresponding target values. Rather, the geometric mean of all samples is compared to the target concentration. The figures are presented for descriptive purposes.

C.2 Development of WLAs and LAs

As previously discussed, a TMDL can be expressed as the sum of all point source loads (WLAs), nonpoint source loads (LAs), and an appropriate margin of safety (MOS) that takes into account any uncertainty concerning the relationship between effluent limitations and water quality:

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

Expanding the terms:

$$TMDL = [\Sigma WLAs]_{WWTF} + [\Sigma WLAs]_{MS4} + [\Sigma WLAs]_{CAFO} + [\Sigma LAs]_{DS} + [\Sigma LAs]_{SW} + MOS$$

For E. coli 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. E. coli loading from MS4s is the result of buildup/wash-off processes associated with storm events.

LA terms include:

- $[\Sigma LAs]_{DS}$ is the allowable E. coli load from "other direct sources". These sources include leaking septic systems, illicit discharges, and animals access to streams. The LA specified for all sources of this type is zero CFU/day (or to the maximum extent feasible).

- $[\Sigma LAs]_{SW}$ represents the required reduction in 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 (i.e., precipitation induced).

Since WWTFs discharge must comply with instream water quality criteria (TMDL target) at the point of discharge, $[WLAs]_{CAFO} = 0$, and $[LAs]_{DS} = 0$, the expression relating TMDLs to precipitation-based point and nonpoint sources may be simplified to:

$$TMDL - MOS = [WLAs]_{MS4} + [\Sigma LAs]_{SW}$$

WLAs for MS4s and LAs for precipitation-based nonpoint sources are equal and expressed as the percent reduction in loading required to decrease instream E. coli concentrations to TMDL target values minus MOS. As stated in Section 8.4, an explicit MOS, equal to 10% of the E. coli water quality targets (ref.: Section 5.0), was utilized for determination of the WLAs and LAs:

Instantaneous Maximum (lake, reservoir, State Scenic River, Tier II, and Tier III):

Target – MOS = (487 CFU/100 ml) – 0.1(487 CFU/100 ml)

Target – MOS = 438 CFU/100 ml

Instantaneous Maximum (other):

Target – MOS = (941 CFU/100 ml) – 0.1(941 CFU/100 ml)

Target – MOS = 847 CFU/100 ml

30-Day Geometric Mean:

Target – MOS = (126 CFU/100 ml) – 0.1(126 CFU/100 ml)

Target – MOS = 113 CFU/100 ml

C.2.1 Development of WLAs for MS4s and LAs for Precipitation-Based Nonpoint Sources

WLAs for MS4s and LAs for precipitation-based nonpoint sources were developed using methods similar to those described in Section C.1.2 (again, using NFFD River at mile 7.3 as an example):

8. An allocation LDC was generated for NFFD River at mile 7.3 by applying the E. coli "target – MOS" concentration of 847 CFU/100 mL to each of the ranked flows used to generate the flow duration curve (ref.: Section C.1.1) and plotting the results on the target LDC developed in Step 1. The E. coli target maximum allocated load corresponding to each ranked daily mean flow is:

   $(\text{Target Load} - \text{MOS})_{\text{NFFD 7.3}} = (847\ \text{CFU/100 mL}) \times (Q) \times (\text{UCF})$

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

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

   Example – 12/17/01 sampling event:
   Target Concentration – MOS = 847 CFU/100 mL
   Measured Concentration = 1732.9 CFU/100 mL
   Reduction to Target – MOS = 51.1%

10. If the 90th percentile value for all of the E. coli sampling data at NFFDE007.3DY monitoring site (calculated in Step 5) exceeded the "target maximum – MOS" E. coli concentration, the reduction required to reduce the 90th percentile value to the "target maximum – MOS" concentration was calculated (Table C-5).

    Example: Target Concentration – MOS = 847 CFU/100 mL
    90th Percentile Concentration = 1672 CFU/100 mL
    Reduction to Target – MOS = 49.3%

11. For cases where five or more samples were collected over a period of not more than 30 consecutive days, the geometric mean E. coli concentration was determined and compared to the "target geometric mean E. coli concentration – MOS" of 113 CFU/100 mL. If the sample geometric mean exceeded the "target geometric mean – MOS" concentration, the reduction required to reduce the sample geometric mean value to the "target geometric mean – MOS" concentration was calculated.

    Example: Insufficient monitoring data were available for NFFD River at Mile 7.3
    Sufficient data were available for Pond Creek at Mile 12.9
    Sampling Period = 9/11/02 – 10/9/02
    Geometric Mean Concentration > 525 CFU/100 mL
    Target Concentration – MOS = 113 CFU/100 mL
    Reduction to Target – MOS = 78.5%

    Note: One sample value, dated 9/11/02, in the above example was equal to >2419.2. Therefore, the geometric mean and reduction to "target – MOS" were expressed as greater than (>) their respective calculated values.

12. The load reductions required to meet the "target maximum – MOS" (Step 10) and "target 30-day geometric mean – MOS" concentrations (Step 11) of E. coli were compared and the load reduction of the greatest magnitude selected as the WLA for MS4s and/or LA for precipitation-based nonpoint sources for NFFD River at mile 7.3.

Load duration curves, required load reductions, WLAs for MS4s, and LAs for precipitation-based nonpoint sources of other impaired waterbodies were derived in a similar manner and are shown in Figures C-2 through C-16 and Tables C-1 through C-15. For waterbodies with multiple water quality monitoring stations and/or sufficient data for calculating 90th percentile and geometric mean reductions, only results for the most protective (largest percent) reductions are presented. TMDLs, WLAs, & LAs for impaired subwatersheds in the North Fork Forked Deer River Watershed are summarized in Table C-16.

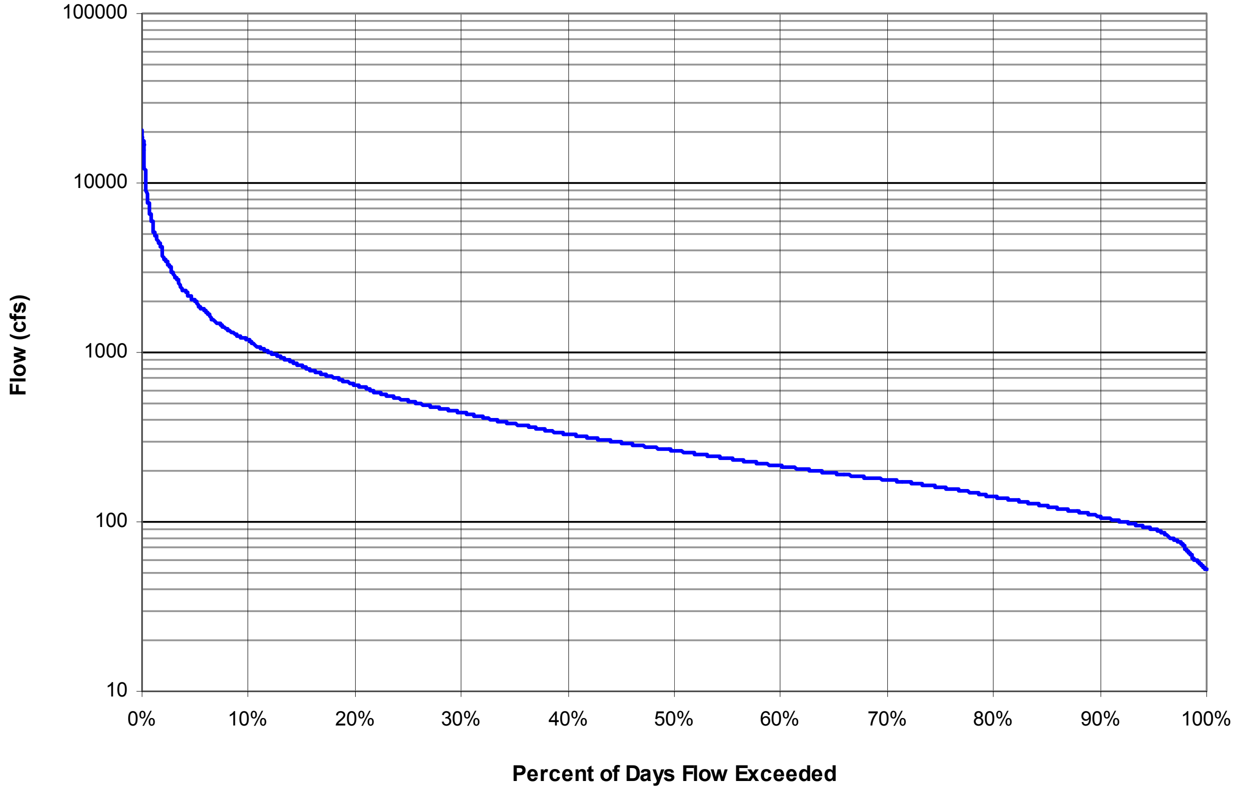

Figure C-1. Flow Duration Curve for North Fork Forked Deer River at Mile 7.3

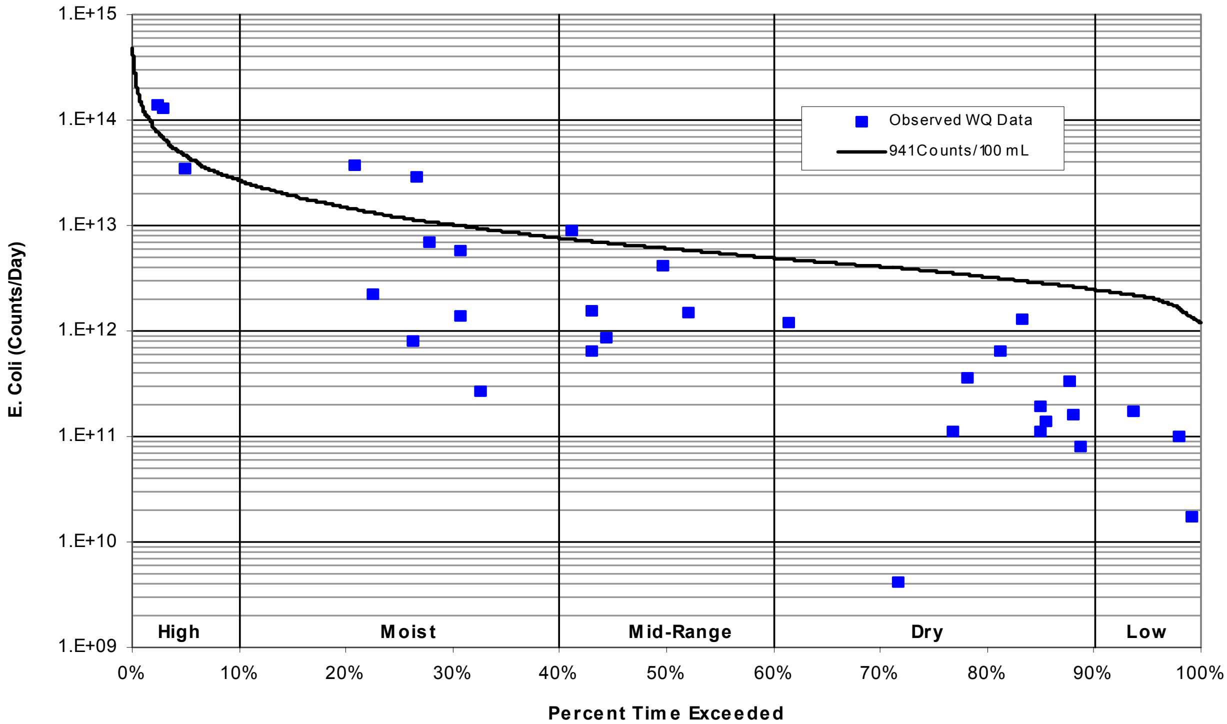

Figure C-2. E. Coli Load Duration Curve for North Fork Forked Deer River at Mile 7.3

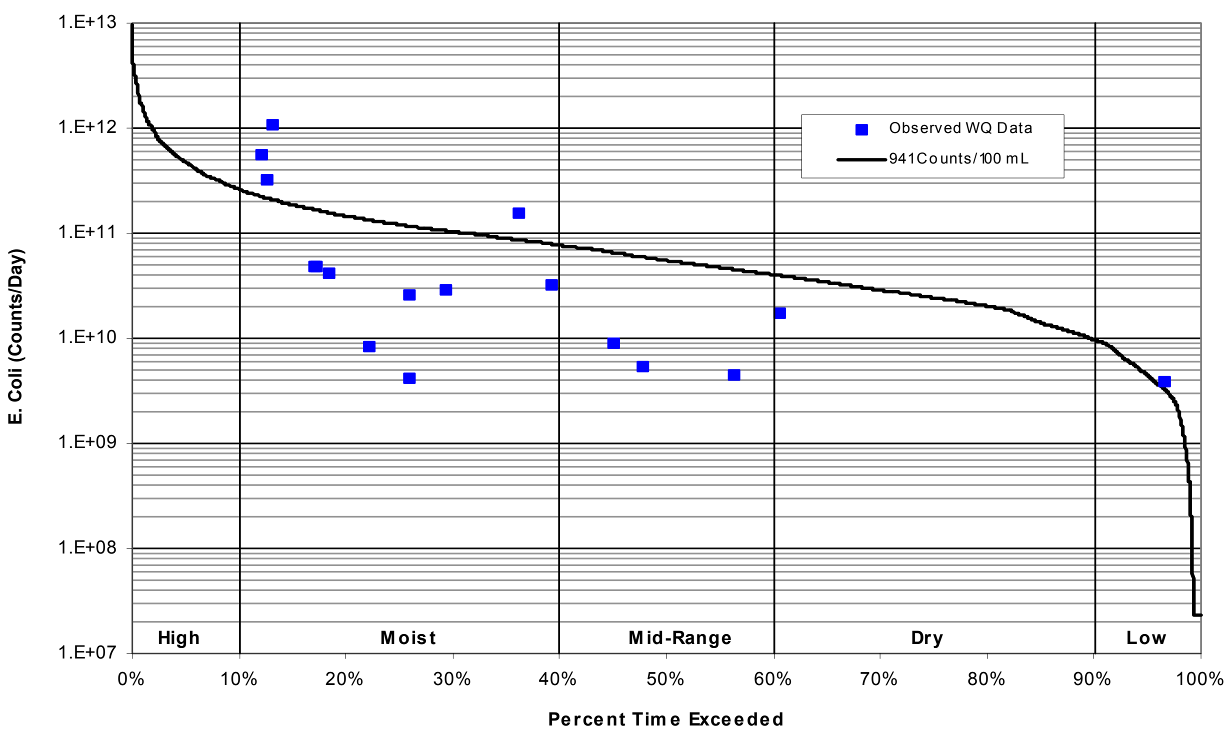

Figure C-3. E. Coli Load Duration Curve for Tucker Creek at Mile 0.4

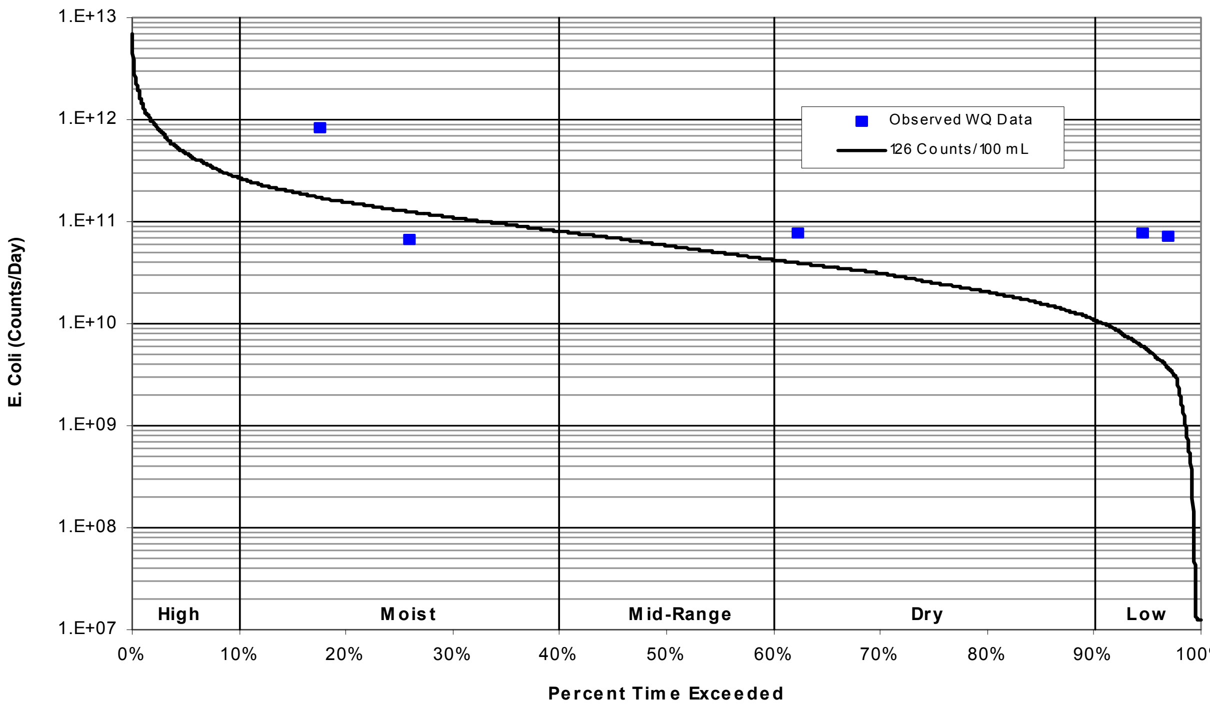

Figure C-4. E. Coli Load Duration Curve for Pond Creek at Mile 12.9 (Geometric Mean data [9/11/02-10/9/02])

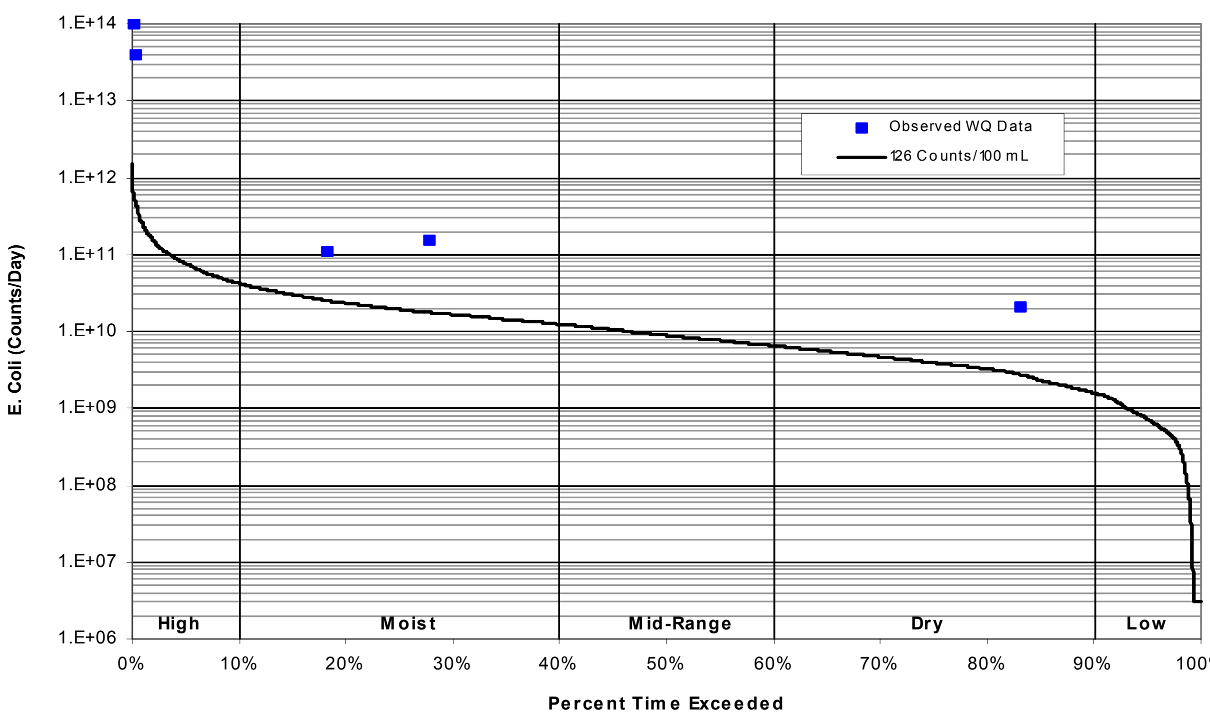

Figure C-5. E. Coli Load Duration Curve for Bethel Branch at Mile 6.1 (Geometric Mean data [9/19/02-10/17/02])

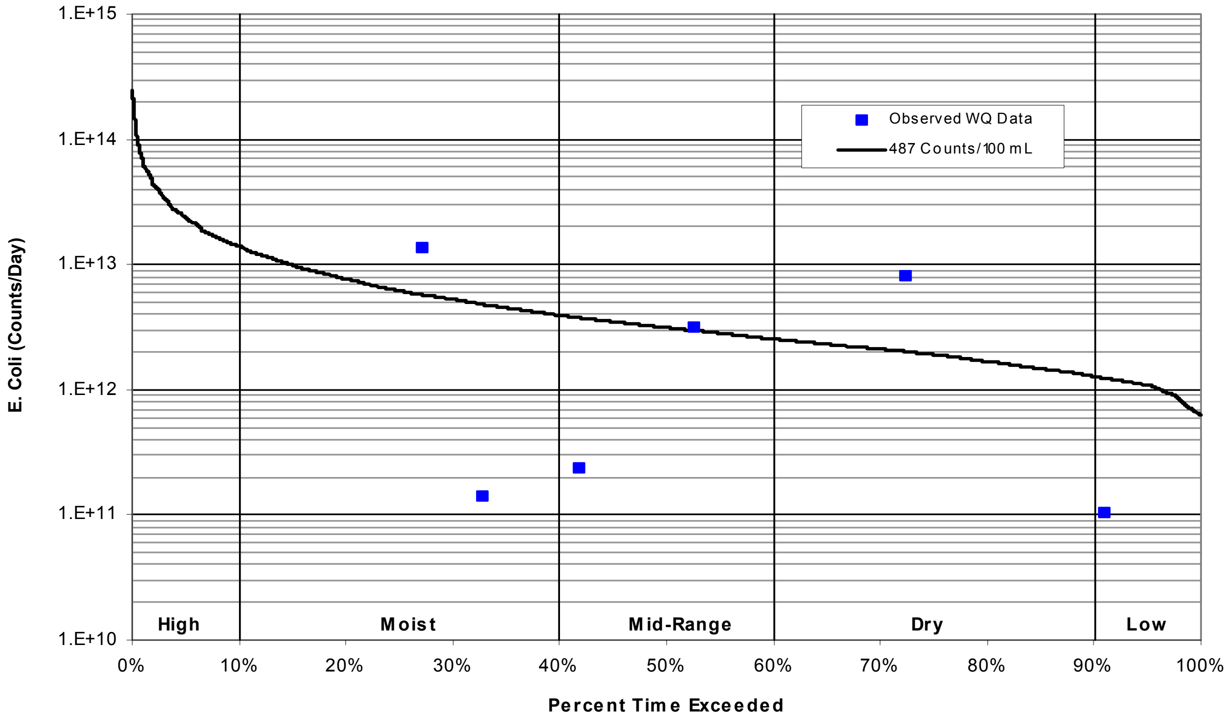

Figure C-6. E. Coli Load Duration Curve for Middle Fork Forked Deer River at Mile 14.6

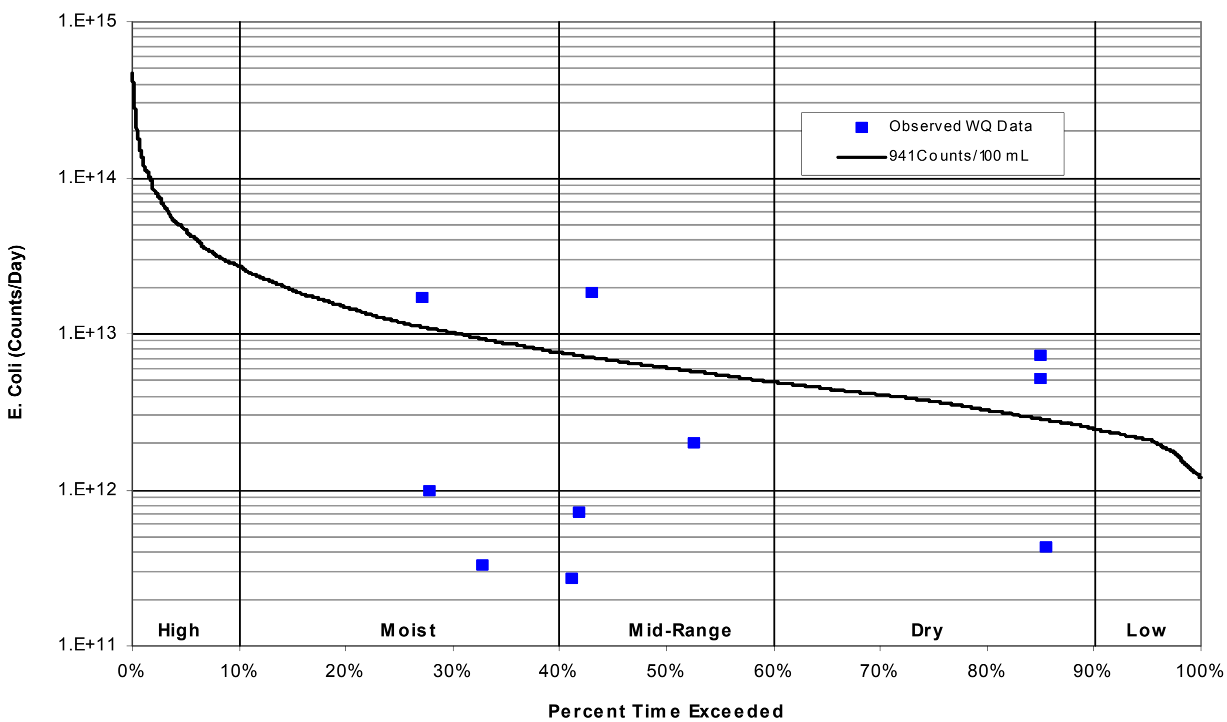

Figure C-7. E. Coli Load Duration Curve for Middle Fork Forked Deer River at Mile 21.5

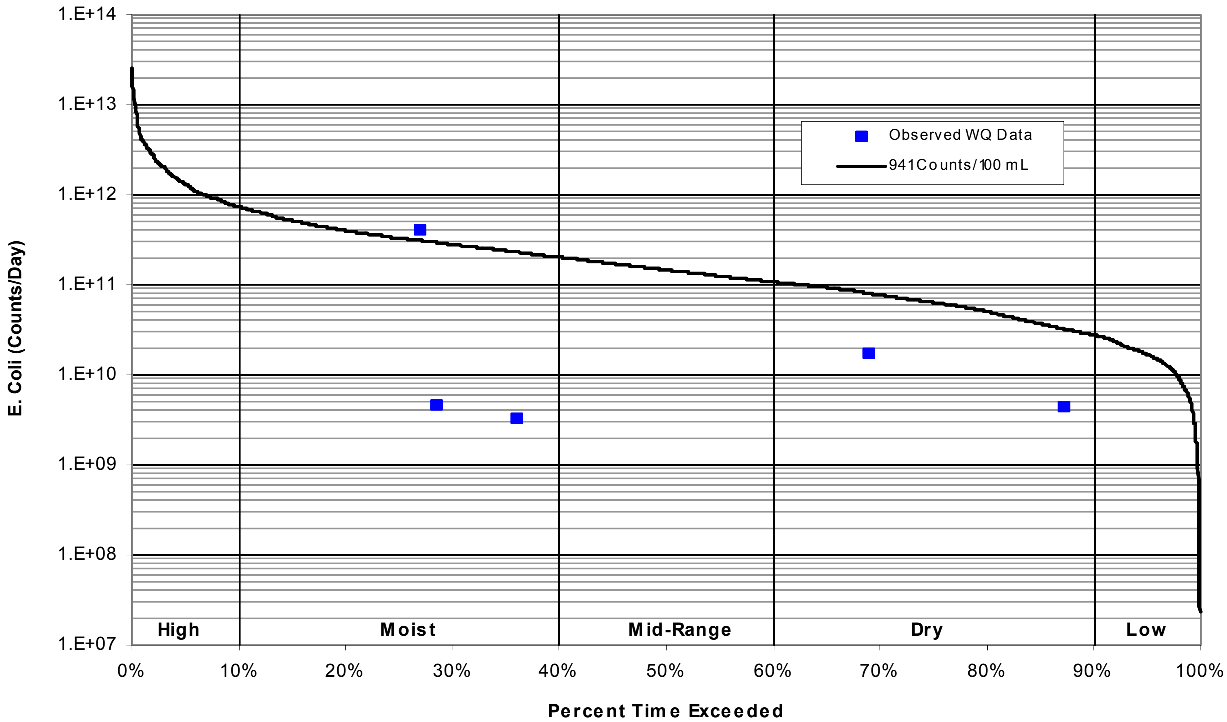

Figure C-8. E. Coli Load Duration Curve for Beech Creek at Mile 1.8

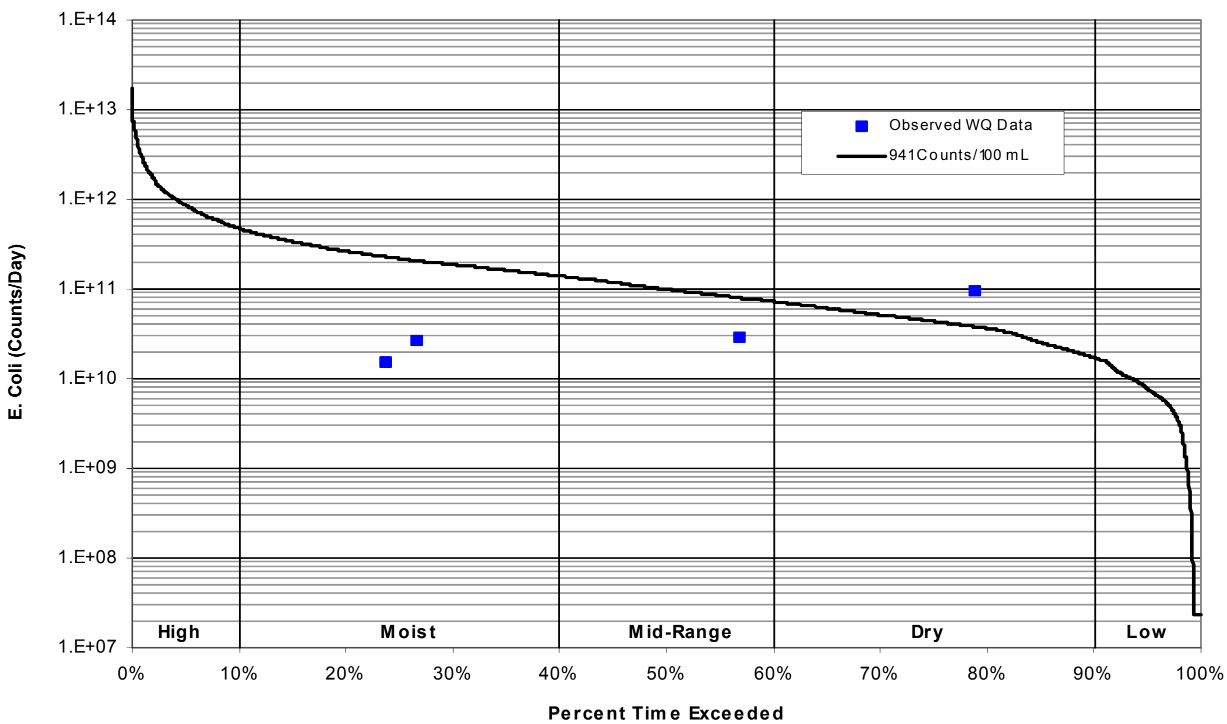

Figure C-9. E. Coli Load Duration Curve for Dry Creek at Mile 0.3

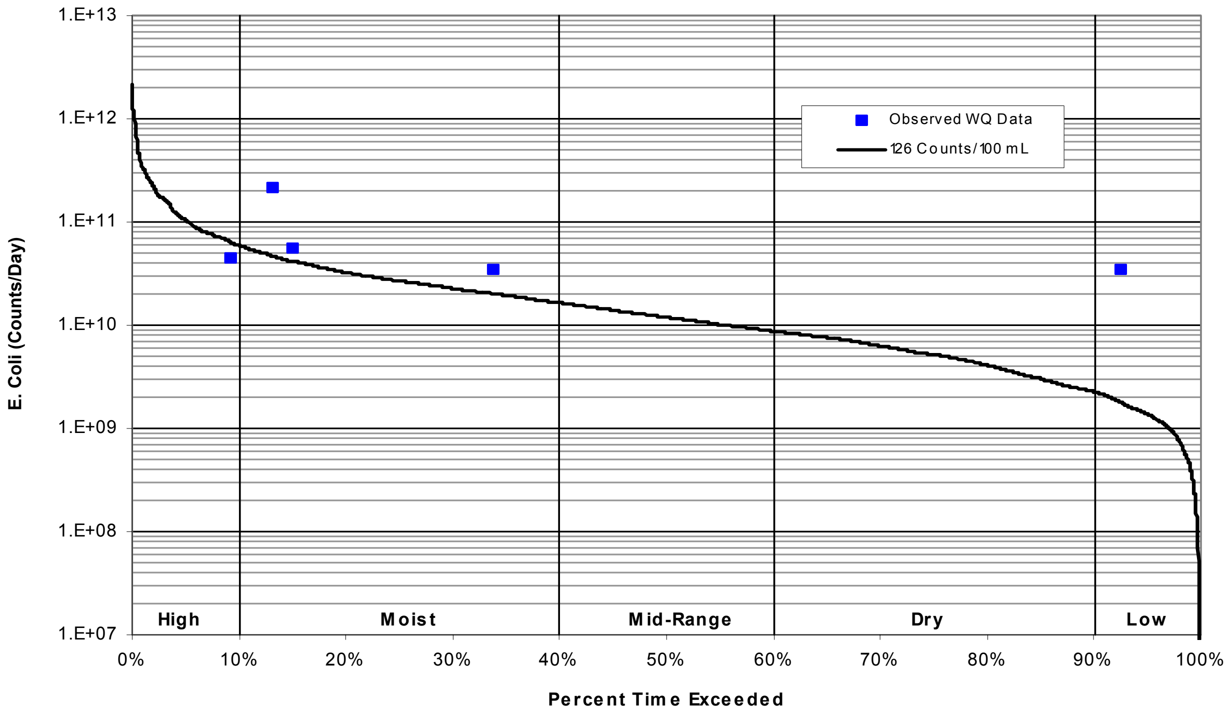

Figure C-10. E. Coli Load Duration Curve for Davis Creek at Mile 2.5 (Geometric Mean data [9/17/02-10/15/02])

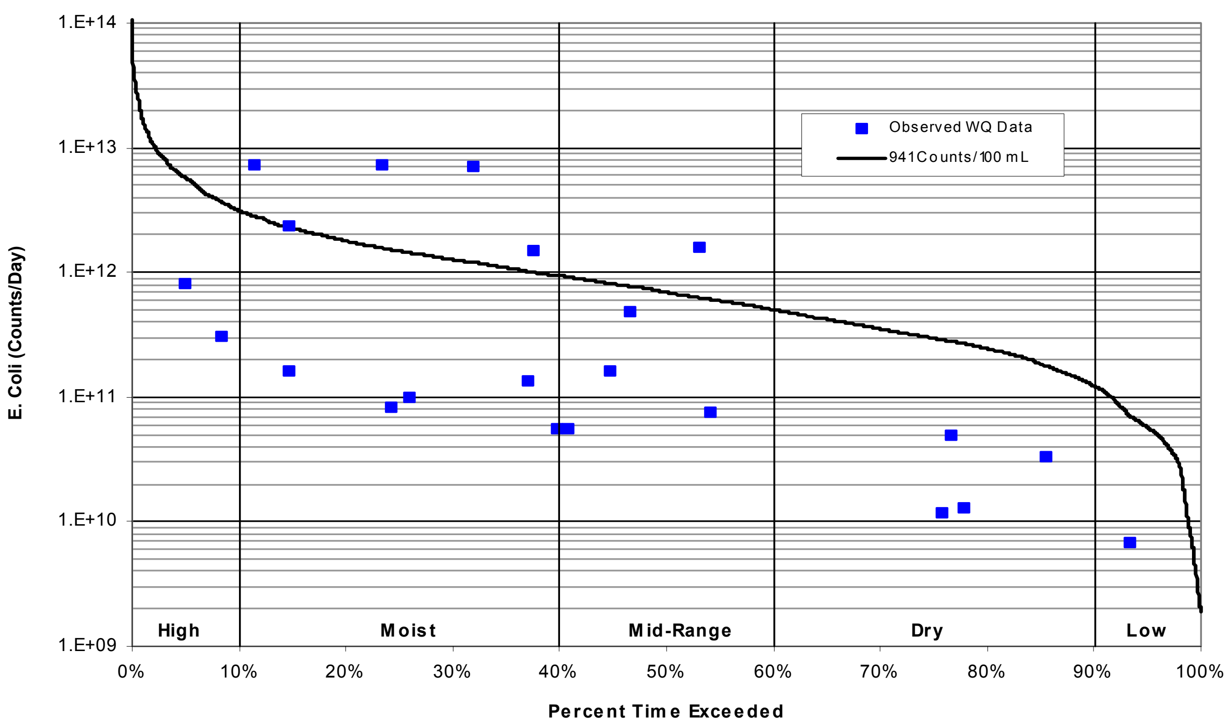

Figure C-11. E. Coli Load Duration Curve for Buck Creek at Mile 1.2

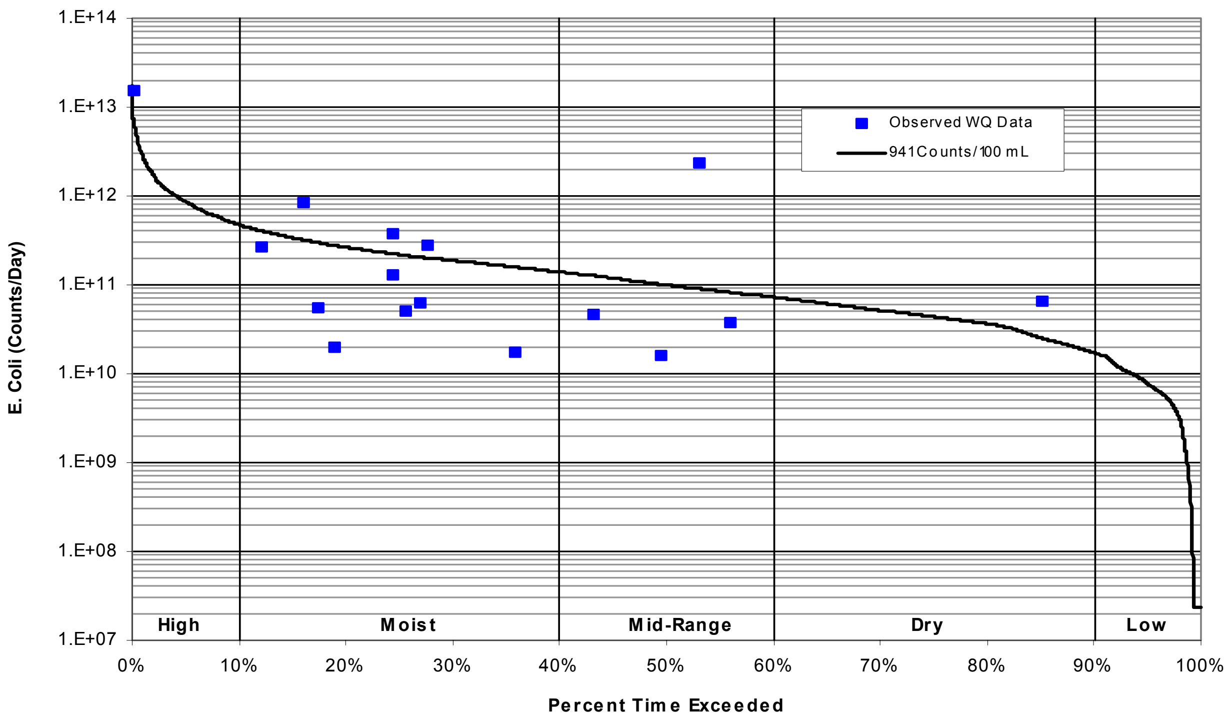

Figure C-12. E. Coli Load Duration Curve for Harris Creek at Mile 1.9

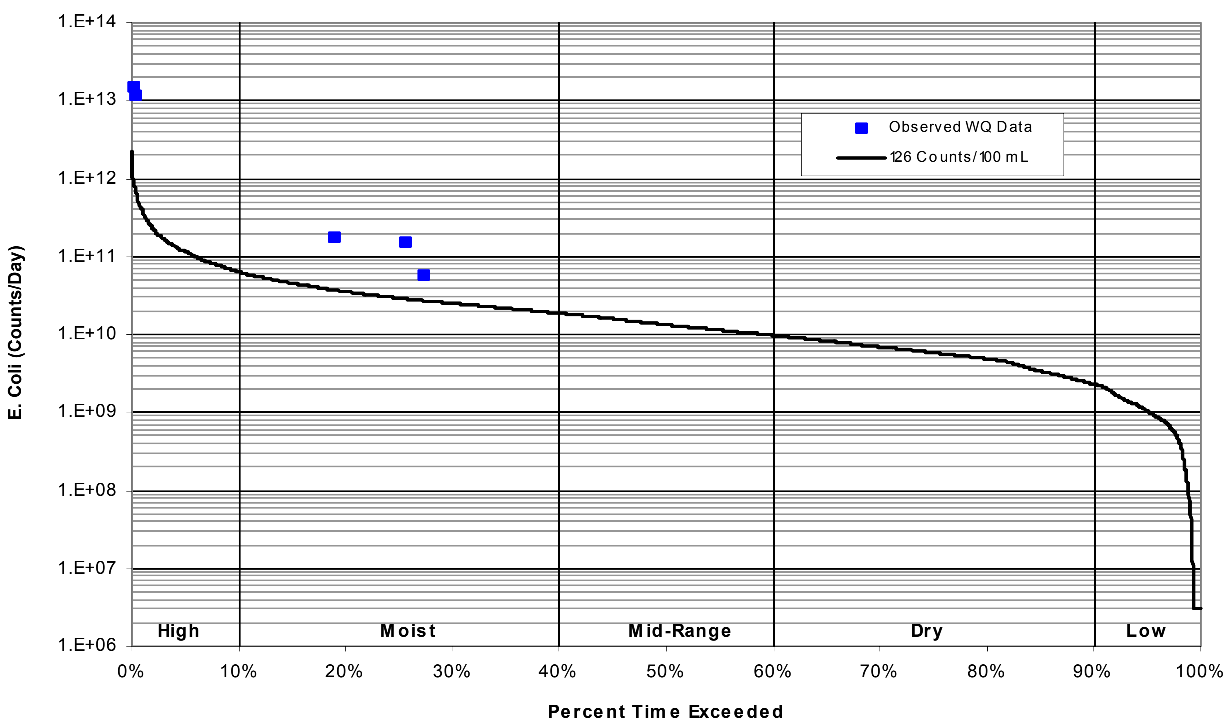

Figure C-13. E. Coli Load Duration Curve for Doakville Creek at Mile 5.4 (Geometric Mean data [9/26/02-10/24/02])

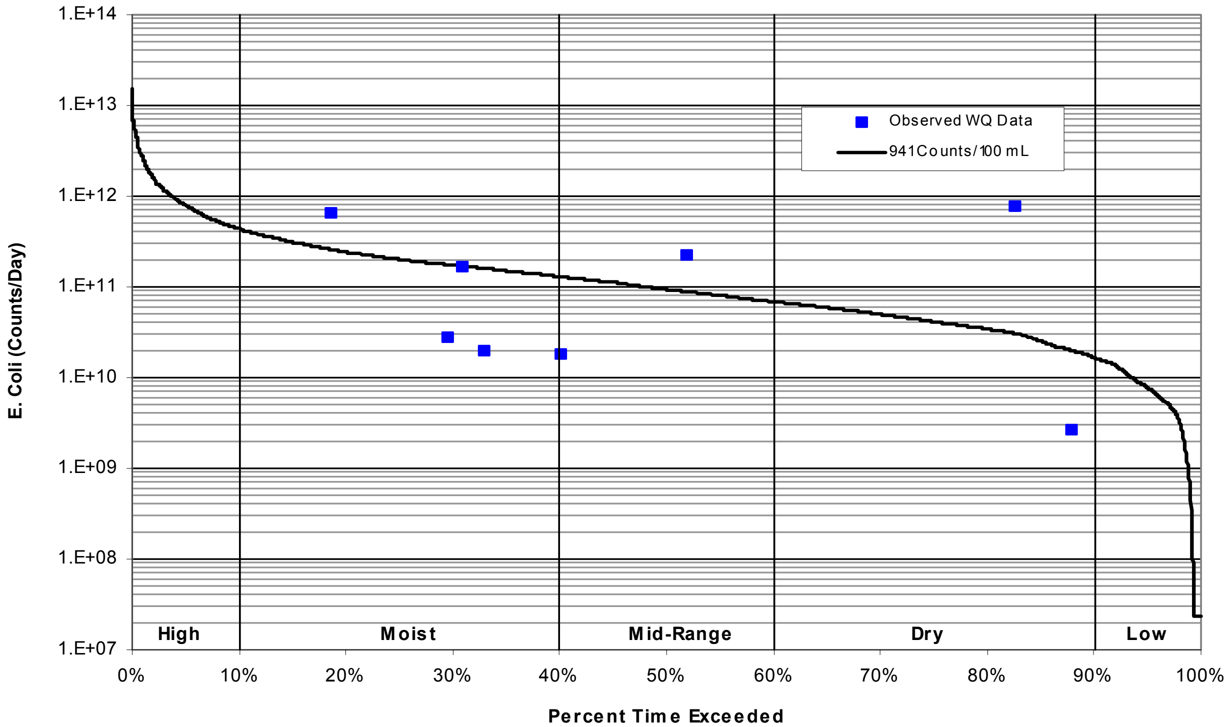

Figure C-14. E. Coli Load Duration Curve for Jones Creek at Mile 3.8

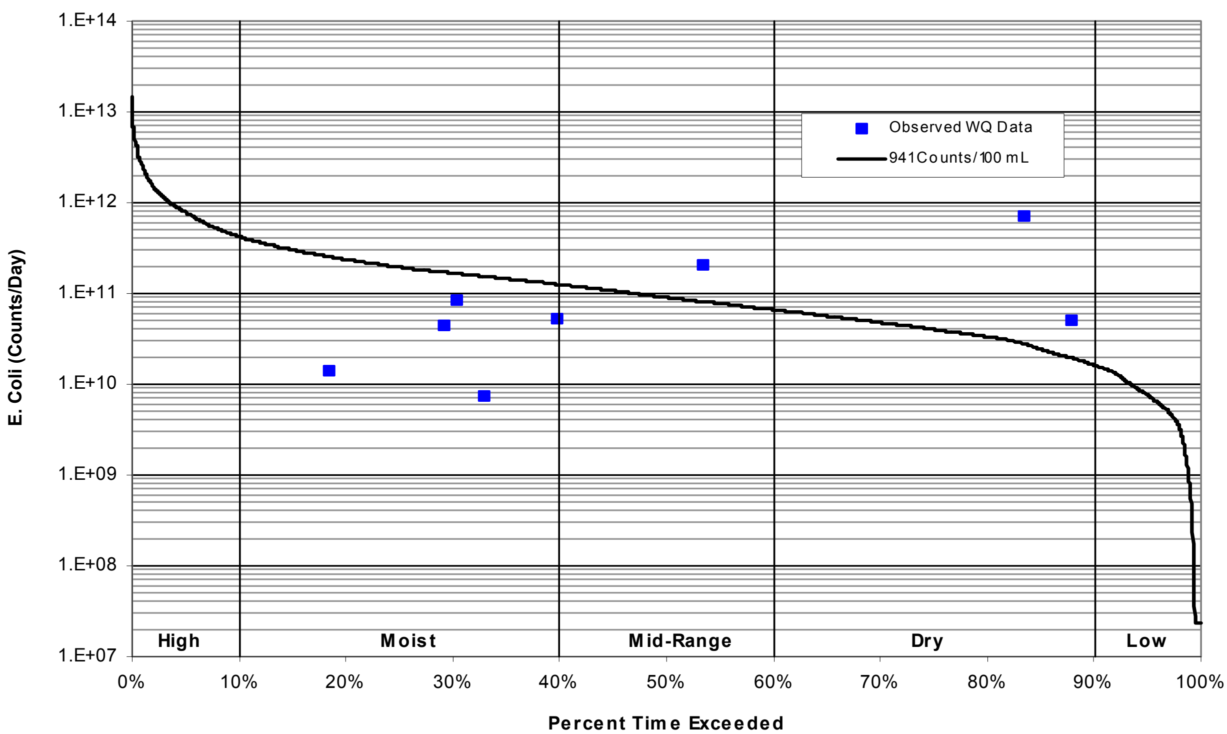

Figure C-15. E. Coli Load Duration Curve for Light Creek at Mile 2.2

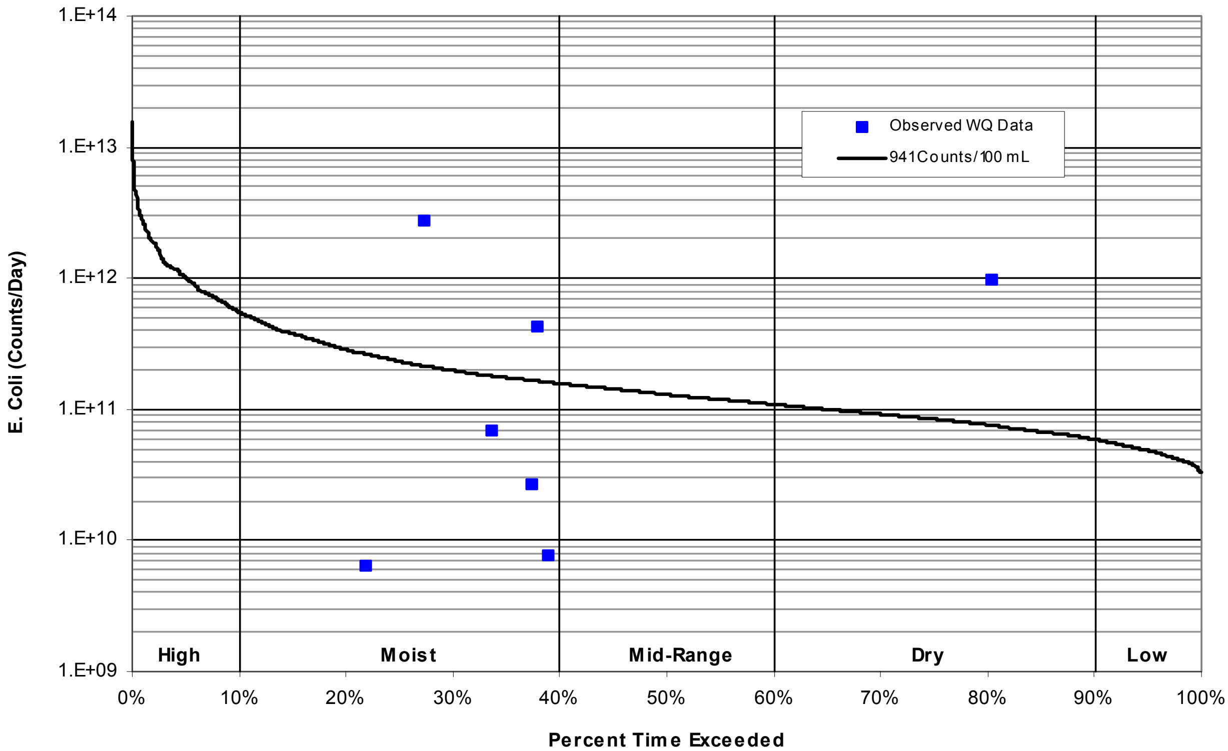

Figure C-16. E. Coli Load Duration Curve for Lewis Creek at Mile 7.9

Table C-1. Required Load Reduction for North Fork Forked Deer River at Mile 7.3 – E. Coli Analysis

PDFE	Flow	Sample Date	E. Coli	
			Sample Conc.	Required Load Reduction
[%]	[cfs]		[CFU/100 ml]	[%]
2.436%	3323.93	12/17/01	**1732.9**	**45.7**
2.984%	2872.62	3/12/02	**1842**	**48.9**
4.900%	2033.83	6/19/03	686.7	**NR**
20.805%	622.926	12/11/03	**>2419.2**	**>61.1**
22.475%	572.941	12/16/02	157.6	**NR**
26.198%	494.525	12/15/04	65.7	**NR**
26.608%	488.884	3/13/01	**>2419.2**	**>61.1**
27.895%	470.349	4/16/98	613.1	**NR**
30.632%	435.008	3/25/03	129.1	**NR**
30.687%	434.029	9/24/02	547.5	**NR**
32.549%	407.64	3/24/99	27.2	**NR**
41.117%	321.678	4/14/98	**1119.9**	**16.0**
42.924%	307.139	4/15/98	206.3	**NR**
43.060%	306.448	6/8/04	86.5	**NR**
44.402%	297.049	3/30/00	117.4	**NR**
49.630%	265.986	12/16/98	648.8	**NR**
52.012%	252.482	3/18/04	240	**NR**
61.484%	207.416	6/18/02	240	**NR**
71.612%	172.132	12/14/00	1	**NR**
76.759%	153.793	6/27/01	30.1	**NR**
78.073%	148.866	6/9/99	98.4	**NR**
81.303%	136.645	9/16/03	195.6	**NR**
83.301%	129.279	6/20/00	410.6	**NR**
84.971%	123.828	7/21/98	37.3	**NR**
85.026%	123.428	7/22/98	63.1	**NR**
85.491%	121.988	7/23/98	46.4	**NR**
87.791%	115.359	9/27/04	120	**NR**
88.037%	114.707	9/28/98	58.1	**NR**
88.749%	112.503	12/1/99	29.5	**NR**
93.759%	95.139	9/12/01	74.8	**NR**
98.002%	70.049	9/28/99	57.8	**NR**
99.206%	58.1306	9/6/00	12.1	**NR**
	90th Percentile (all)		**>1672**	**>43.7**

Table C-2. Required Load Reduction for Tucker Creek at Mile 0.4 – E. Coli Analysis

PDFE	Flow	Sample Date	E. Coli	
			Sample Conc.	Required Load Reduction
[%]	[cfs]		[CFU/100 ml]	[%]
12.154%	9.58474	11/6/02	**>2419.2**	**>61.1**
12.675%	9.33134	12/4/02	**1413.6**	**33.4**
13.085%	9.13689	5/21/03	**4884**	**80.7**
17.137%	7.24335	4/9/03	272.3	**NR**
17.273%	7.18524	10/16/02	275.5	**NR**
18.423%	6.7421	5/14/03	256	**NR**
22.174%	5.80669	10/23/02	58.3	**NR**
25.869%	5.04313	1/8/03	33.1	**NR**
25.897%	5.04054	3/5/03	206.3	**NR**
29.318%	4.59068	10/9/02	261.3	**NR**
36.217%	3.74764	2/5/03	**1664**	**43.4**
39.201%	3.42443	5/28/03	387.3	**NR**
45.031%	2.83478	6/4/03	131.3	**NR**
47.796%	2.56964	4/2/03	84.2	**NR**
56.255%	1.9696	4/16/03	93.3	**NR**
60.553%	1.72286	4/23/03	408	**NR**
96.606%	0.142073	9/18/02	**1119.9**	**16.0**
	90th Percentile (all)		**>1966**	**>52.1**

Table C-3. Required Load Reduction for Pond Creek at Mile 12.9 (Geometric Mean data) – E. Coli Analysis

PDFE	Flow	Sample Date	E. Coli		
			Sample Conc.	Geometric Mean	Required Load Reduction
[%]	[cfs]		[CFU/100 ml]	[CFU/100 mL]	[%]
94.689%	1.87011	9/4/02	18.9		
96.879%	1.21349	9/11/02	**>2419.2**		
94.498%	1.94958	9/18/02	1607		
62.332%	12.7313	9/25/02	248		
17.629%	55.6127	10/2/02	613.1	**>407**	
25.897%	40.6544	10/9/02	67.6	**>525**	**>76.0**
18.505%	53.2771	10/16/02	275.5	**>340**	
26.745%	39.2931	10/23/02	135.4	**>207**	

Table C-4. Required Load Reduction for Bethel Branch at Mile 6.1 (Geometric Mean data) – E. Coli Analysis

PDFE	Flow	Sample Date	E. Coli		
			Sample Conc.	Geometric Mean	Required Load Reduction
[%]	[cfs]		[CFU/100 ml]	[CFU/100 mL]	[%]
9/5/02	0.137191	97.317%	328.2		
9/12/02	0.084319	98.193%	547.5		
9/19/02	0.882611	83.082%	**980.4**		
9/26/02	159.547	0.301%	**9804**		
10/3/02	5.72007	27.868%	**1119.9**	**1141**	
10/10/02	170.41	0.246%	**>24192**	**>2697**	
10/17/02	8.19165	18.259%	547.5	**>2697**	**>95.3**

Table C-5. Required Load Reduction for Middle Fork Forked Deer River at Mile 14.6 – E. Coli Analysis

PDFE	Flow	Sample Date	E. Coli	
			Sample Conc.	Required Load Reduction
[%]	[cfs]		[CFU/100 ml]	[%]
27.074%	481.19	11/12/02	**1153**	**57.8**
32.685%	404.111	3/11/03	14.2	**NR**
41.774%	316.33	1/14/03	30.9	**NR**
52.532%	249.222	7/16/02	**517.2**	**5.8**
72.434%	169.495	6/16/99	**1986.2**	**75.5**
90.884%	103.999	8/11/99	41.1	**NR**
	90th Percentile (all)		**1570**	**69.0**

Table C-6. Required Load Reduction for Middle Fork Forked Deer River at Mile 21.5 – E. Coli Analysis

PDFE	Flow	Sample Date	E. Coli	
			Sample Conc.	Required Load Reduction
[%]	[cfs]		[CFU/100 ml]	[%]
27.074%	481.19	11/12/02	**1467**	**35.9**
27.895%	470.349	4/16/98	86	**NR**
32.685%	404.111	3/11/03	33.6	**NR**
41.117%	321.678	4/14/98	34.5	**NR**
41.774%	316.33	1/14/03	93.4	**NR**
42.924%	307.139	4/15/98	**>2419.2**	**61.1**
52.532%	249.222	7/16/02	328.2	**NR**
84.971%	123.828	7/21/98	**>2419.2**	**61.1**
85.026%	123.428	7/22/98	**1732.9**	**45.7**
85.491%	121.988	7/23/98	143.9	**NR**
	90th Percentile (all)		**>2419**	**>61.1**

Table C-7. Required Load Reduction for Beech Creek at Mile 1.8 – E. Coli Analysis

PDFE	Flow	Sample Date	E. Coli	
			Sample Conc.	Required Load Reduction
[%]	[cfs]		[CFU/100 ml]	[%]
27.046%	13.5416	11/12/02	**1233**	**23.7**
28.442%	12.9533	3/11/03	14.8	**NR**
36.053%	10.0707	1/14/03	13.4	**NR**
68.957%	3.50937	6/16/99	206.3	**NR**
87.189%	1.40163	8/12/99	131.3	**NR**
	90th Percentile (all)		822	0.0

Table C-8. Required Load Reduction for Dry Creek at Mile 0.3 – E. Coli Analysis

PDFE	Flow	Sample Date	E. Coli	
			Sample Conc.	Required Load Reduction
[%]	[cfs]		[CFU/100 ml]	[%]
23.707%	9.96847	2/11/03	62	**NR**
26.554%	9.02441	12/10/02	121	**NR**
56.748%	3.47822	6/10/03	344.8	**NR**
78.839%	1.65049	6/17/99	**>2419.2**	**>61.1**
	90th Percentile (all)		**>1797**	**>47.6**

Table C-9. Required Load Reduction for Davis Creek at Mile 2.5 (Geometric Mean data) – E. Coli Analysis

PDFE	Flow	Sample Date	E. Coli		
			Sample Conc.	Geometric Mean	Required Load Reduction
[%]	[cfs]		[CFU/100 ml]	[CFU/100 mL]	[%]
92.445%	0.586019	9/3/02	178.5		
94.799%	0.45554	9/10/02	122.3		
92.417%	0.586237	9/17/02	**>2419.2**		
33.780%	6.55197	9/24/02	216		
9.225%	20.5578	10/1/02	90.6	**>253**	
13.195%	15.1851	10/8/02	579.4	**>320**	
15.083%	13.4337	10/15/02	172.3	**>343**	**>63.3**
30.003%	7.32744	10/22/02	387.3	**>238**	

Table C-10. Required Load Reduction for Buck Creek at Mile 1.2 – E. Coli Analysis

PDFE	Flow	Sample Date	E. Coli	
			Sample Conc.	Required Load Reduction
[%]	[cfs]		[CFU/100 ml]	[%]
4.955%	250.68	12/22/02	131.3	**NR**
8.295%	159.858	5/20/03	78.9	**NR**
11.361%	123.293	11/5/02	**>2419.2**	**>61.1**
14.645%	99.8208	4/8/03	**980.4**	**4.0**
14.755%	98.9797	5/13/03	65.7	**NR**
23.460%	67.9828	4/16/98	**4366**	**78.4**
24.199%	66.2296	3/4/03	51.2	**NR**
25.979%	62.3679	1/7/03	65	**NR**
31.946%	52.1864	2/4/03	**5475**	**82.8**
37.011%	44.1717	5/27/03	123.6	**NR**
37.613%	43.3141	4/14/98	**1413.6**	**33.4**
39.776%	41.0636	4/1/03	55.4	**NR**
40.816%	39.9617	12/3/02	57.3	**NR**
44.703%	35.3249	6/3/03	185	**NR**
46.510%	33.7135	4/15/98	579.4	**NR**
53.134%	27.1765	4/22/03	**>2419.2**	**>61.1**
54.093%	26.5087	4/15/03	117.8	**NR**
75.801%	12.5127	7/21/98	38.8	**NR**
76.649%	12.1336	7/22/98	167.8	**NR**
77.854%	11.6801	7/23/98	44.8	**NR**
85.464%	7.71736	7/9/02	177.7	**NR**
93.375%	3.06065	8/6/02	91	**NR**
	90th Percentile (all)		**>2419**	**>61.1**

Table C-11. Required Load Reduction for Harris Creek at Mile 1.9 – E. Coli Analysis

PDFE	Flow	Sample Date	E. Coli	
			Sample Conc.	Required Load Reduction
[%]	[cfs]		[CFU/100 ml]	[%]
0.246%	255.466	10/10/02	**>2419.2**	**61.1**
12.045%	17.6132	4/3/03	613.1	**NR**
15.959%	13.9845	11/7/02	**>2419.2**	**61.1**
17.410%	13.027	5/22/03	172.6	**NR**
18.861%	12.0397	10/17/02	68.3	**NR**
24.391%	9.71739	4/10/03	**1553.1**	**39.4**
24.446%	9.70658	5/15/03	547.5	**NR**
25.650%	9.28601	10/24/02	218.7	**NR**
26.937%	8.88608	3/6/03	290.9	**NR**
27.676%	8.67491	1/9/03	**1299.7**	**27.6**
35.806%	6.85817	2/13/03	105	**NR**
43.252%	5.51869	5/29/03	344.8	**NR**
49.411%	4.41255	6/5/03	148.3	**NR**
53.134%	3.91825	4/24/03	**>24192**	**96.1**
56.009%	3.56926	4/16/03	435.2	**NR**
85.108%	1.08725	7/11/02	**>2419.2**	**61.1**
	90th Percentile (all)		**>2419.2**	**>61.1**

Table C-12. Required Load Reduction for Doakville Creek at Mile 5.4 (Geometric Mean data) – E. Coli Analysis

PDFE	Flow	Sample Date	E. Coli		
			Sample Conc.	Geometric Mean	Required Load Reduction
[%]	[cfs]		[CFU/100 ml]	[CFU/100 mL]	[%]
97.126%	0.212865	9/5/02	770.1		
98.002%	0.131725	9/12/02	160.7		
93.540%	0.429784	9/19/02	344.8		
0.301%	236.214	9/26/02	**1986.3**		
27.375%	8.76698	10/3/02	275.5	**472**	
0.246%	255.466	10/10/02	**>2419.2**	**>593**	
18.861%	12.0397	10/17/02	613.1	**>775**	
25.650%	9.28601	10/24/02	686.7	**>890**	**>85.8**

Table C-13. Required Load Reduction for Jones Creek at Mile 3.8 – E. Coli Analysis

PDFE	Flow	Sample Date	E. Coli	
			Sample Conc.	Required Load Reduction
[%]	[cfs]		[CFU/100 ml]	[%]
18.615%	11.1814	11/13/02	>2419.2	**61.1**
29.537%	7.63581	12/11/02	148	**NR**
30.851%	7.31475	2/12/03	933	**NR**
32.904%	6.9207	1/15/03	116.9	**NR**
40.159%	5.59872	3/12/03	131.7	**NR**
51.848%	3.85907	6/11/03	>2419.2	**61.1**
82.590%	1.3302	8/14/02	>24192	**96.1**
87.955%	0.859942	7/17/02	128.1	**NR**
	90th Percentile (all)		**>8951**	**>89.5**

Table C-14. Required Load Reduction for Light Creek at Mile 2.2 – E. Coli Analysis

PDFE	Flow	Sample Date	E. Coli	
			Sample Conc.	Required Load Reduction
[%]	[cfs]		[CFU/100 ml]	[%]
18.423%	10.969	11/13/02	52	**NR**
29.264%	7.45145	12/11/02	243	**NR**
30.386%	7.19158	2/12/03	470	**NR**
33.014%	6.69423	1/15/03	45.7	**NR**
39.721%	5.46212	3/12/03	387.5	**NR**
53.490%	3.52035	6/11/03	>2419.2	**>61.1**
83.520%	1.20397	8/14/02	>24192	**>96.1**
87.955%	0.842024	7/17/02	>2419.2	**>61.1**
	90th Percentile (all)		**>8951**	**>89.5**

Table C-15. Required Load Reduction for Lewis Creek at Mile 7.9 – E. Coli Analysis

PDFE	Flow	Sample Date	E. Coli	
			Sample Conc.	Required Load Reduction
[%]	[cfs]		[CFU/100 ml]	[%]
21.900%	11.5358	11/13/02	22.8	**NR**
27.375%	9.28272	2/12/03	**12033**	**92.2**
33.616%	7.8045	12/11/02	364	**NR**
37.339%	7.24453	1/15/03	152.9	**NR**
37.914%	7.15184	6/11/03	**>2419.2**	**>61.1**
38.982%	6.99936	3/12/03	44.8	**NR**
80.290%	3.30217	8/14/02	**12033**	**92.2**
	90th Percentile (all)		**12033**	**92.2**

Table C-16. TMDLs, WLAs, & LAs for North Fork Forked Deer River Watershed

HUC-12 Subwatershed (08010204__)	Impaired Waterbody Name	Impaired Waterbody ID	TMDL	WLAs[a]				LAs[e]
				WWTFs[b]		Leaking Collection Systems[c]	MS4s[d]	
				Monthly Avg.	Daily Max.			
			[% Red.]	[CFU/day]	[CFU /day]	[CFU /day]	[% Red.]	[% Red.]
0103	Dry Creek	TN08010204014 – 0100	>47.6	NA	NA	NA	NA	>52.9
0201	MFFD River	TN08010204010 – 1000	>61.1	1.240×10^{10}	9.263×10^{10}	0	NA	>65.0
	Beech Creek	TN08010204010 – 1100	*	NA	NA	NA	NA	*
0203	MFFD River	TN08010204007 – 1000	69.0	1.908×10^{9}	1.425×10^{10}	0	NA	72.1
0204	Davis Creek	TN08010204017 – 0100	>63.2	NA	NA	NA	NA	>67.0
	Buck Creek	TN08010204017 – 1000	>61.1	NA	NA	NA	NA	>65.0
0305	Bethel Branch	TN08010204004 – 0100	>95.3	NA	NA	NA	NA	>95.8
0306	Harris Creek	TN08010204022 – 0100	>61.1	NA	NA	0	NA	>65.0
	Doakville Creek	TN08010204022 – 1000	>85.8	NA	NA	NA	NA	>87.3
0402	NFFD River	TN08010204001 – 1000	>43.7	4.507×10^{10}	3.366×10^{11}	0	>49.3	>49.3
0403	Tucker Creek	TN08010204003 – 0100	>52.1	NA	NA	NA	NA	>56.9
	Pond Creek	TN08010204003 – 1000	>76.0	NA	NA	0	NA	>78.5
0404	Jones Creek	TN08010204023 – 0200	>89.5	NA	NA	0	>90.5	>90.5
	Light Creek	TN08010204023 – 0210	>89.5	NA	NA	0	>90.5	>90.5
	Lewis Creek	TN08010204023 – 1000	92.2	NA	NA	0	93.0	93.0

Note: *NA = Not applicable.*

* *Insufficient data available to calculate TMDL and LA.*

a. *There are no CAFOs in impaired subwatersheds of the North Fork Forked Deer River watershed. All current and future CAFOs are and will be assigned waste load allocations (WLAs) of zero.*

b. *WLAs for WWTFs expressed as E. coli loads (CFU/day). Future WWTFs must meet instream water quality standards at the point of discharge as specified in their NPDES permits.*

c. *The objective for leaking collection systems is a WLA of zero. It is recognized, however, that a WLA of 0 CFU/day may not be practical. For these sources, the WLA is interpreted to mean a reduction in E. coli 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.*

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

e. *The load allocations (LAs) listed apply to precipitation induced nonpoint sources only. The objective for all other nonpoint sources (leaking septic systems, illicit discharges, and animals access to streams) is a LA of zero. It is recognized, however, that for leaking septic systems a LA of 0 CFU/day may not be practical. For these sources, the LA is interpreted to mean a reduction in E. coli loading to the maximum extent feasible, consistent with the requirement that these sources not contribute to a violation of the water quality standard for E. coli.*

APPENDIX D

Hydrodynamic Modeling Methodology

D.1 Model Selection

The Loading Simulation Program C++ (LSPC) was selected for flow simulation of E. coli-impaired waters in the North Fork Forked Deer River 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 impaired waterbodies were 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, USGS monitoring stations (see Section C.1), and water quality monitoring stations. Watershed delineation was based on the National Hydrography Dataset (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 water quality 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 the Jackson Experiment Station meteorological station was available for the time period from January 1970 through December 2004. Meteorological data for a selected 11-year period was used for all simulations. The first year of this period was used for model stabilization with simulation data from the subsequent 10-year period (1/1/95 – 12/31/04) used for TMDL analyses.

D.3 Model Calibration

Hydrologic calibration of the watershed model involves comparison of simulated streamflow to historic streamflow data from USGS stream gaging stations for the same period of time. USGS continuous record stations located in the North Fork Forked Deer River watershed with sufficiently long and recent historical records were selected as the basis of the hydrology calibration. Two USGS stations were selected due to the transition in Level III ecoregions at the approximate midpoint of the watershed coinciding with one of the USGS stations and the dissimilarity in hydrologic characteristics between the two regions. The other USGS station is located near the mouth of the North Fork Forked Deer River. 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 calibrations for Middle Fork Forked Deer River near Fairview, USGS Station 07028960, and North Fork Forked Deer River at Dyersburg, USGS Station 07029100, are shown in Tables D-1 and D-2 and Figures D-1 and D-2, respectively.

Table D-1. Hydrologic Calibration Summary: Middle Fork Forked Deer River near Fairview (USGS 07028960)

Simulation Name:	**MFFDR08 (calibration)**	**Simulation Period:**	
	MFFD River near Fairview	**Watershed Area (ac):**	135040.00
Period for Flow Analysis	(USGS 07028960)		
Begin Date:	**10/01/97**	**Baseflow PERCENTILE:**	2.5
End Date:	**09/30/04**	*Usually 1%-5%*	
Total Simulated In-stream Flow:	**145.38**	Total Observed In-stream Flow:	**148.15**
Total of highest 10% flows:	**77.93**	Total of Observed highest 10% flows:	**79.42**
Total of lowest 50% flows:	**19.64**	Total of Observed Lowest 50% flows:	**20.11**
Simulated Summer Flow Volume (months 7-9):	**17.48**	Observed Summer Flow Volume (7-9):	**18.20**
Simulated Fall Flow Volume (months 10-12):	**35.58**	Observed Fall Flow Volume (10-12):	**36.36**
Simulated Winter Flow Volume (months 1-3):	**53.74**	Observed Winter Flow Volume (1-3):	**53.54**
Simulated Spring Flow Volume (months 4-6):	**38.58**	Observed Spring Flow Volume (4-6):	**40.05**
Total Simulated Storm Volume:	**125.53**	Total Observed Storm Volume:	**123.86**
Simulated Summer Storm Volume (7-9):	**12.50**	Observed Summer Storm Volume (7-9):	**12.12**
Errors (Simulated-Observed)		*Recommended Criteria*	Last run
Error in total volume:	**-1.87**	10	
Error in 50% lowest flows:	**-2.33**	10	
Error in 10% highest flows:	**-1.87**	15	
Seasonal volume error - Summer:	**-3.98**	30	
Seasonal volume error - Fall:	**-2.13**	30	
Seasonal volume error - Winter:	**0.38**	30	
Seasonal volume error - Spring:	**-3.69**	30	
Error in storm volumes:	**1.35**	20	
Error in summer storm volumes:	**3.12**	50	

Table D-2. Hydrologic Calibration Summary: North Fork Forked Deer River at Dyersburg (USGS 07029100)

Simulation Name:	**NFFDR12 (calibration)**	**Simulation Period:**	
	NFFD River at Dyersburg	**Watershed Area (ac):**	600960.00
Period for Flow Analysis	(USGS 07029100)		
Begin Date:	**10/01/80**	**Baseflow PERCENTILE:**	2.5
End Date:	**09/30/85**	*Usually 1%-5%*	
Total Simulated In-stream Flow:	**99.95**	Total Observed In-stream Flow:	**101.07**
Total of highest 10% flows:	**51.10**	Total of Observed highest 10% flows:	**45.89**
Total of lowest 50% flows:	**11.39**	Total of Observed Lowest 50% flows:	**11.01**
Simulated Summer Flow Volume (months 7-9):	**6.11**	Observed Summer Flow Volume (7-9):	**10.99**
Simulated Fall Flow Volume (months 10-12):	**31.63**	Observed Fall Flow Volume (10-12):	**26.39**
Simulated Winter Flow Volume (months 1-3):	**28.85**	Observed Winter Flow Volume (1-3):	**30.39**
Simulated Spring Flow Volume (months 4-6):	**33.37**	Observed Spring Flow Volume (4-6):	**33.30**
Total Simulated Storm Volume:	**90.43**	Total Observed Storm Volume:	**91.31**
Simulated Summer Storm Volume (7-9):	**3.71**	Observed Summer Storm Volume (7-9):	**8.54**
Errors (Simulated-Observed)		*Recommended Criteria*	Last run
Error in total volume:	**-1.11**	10	
Error in 50% lowest flows:	**3.40**	10	
Error in 10% highest flows:	**11.35**	15	
Seasonal volume error - Summer:	**-44.43**	30	
Seasonal volume error - Fall:	**19.83**	30	
Seasonal volume error - Winter:	**-5.09**	30	
Seasonal volume error - Spring:	**0.22**	30	
Error in storm volumes:	**-0.96**	20	
Error in summer storm volumes:	**-56.57**	50	

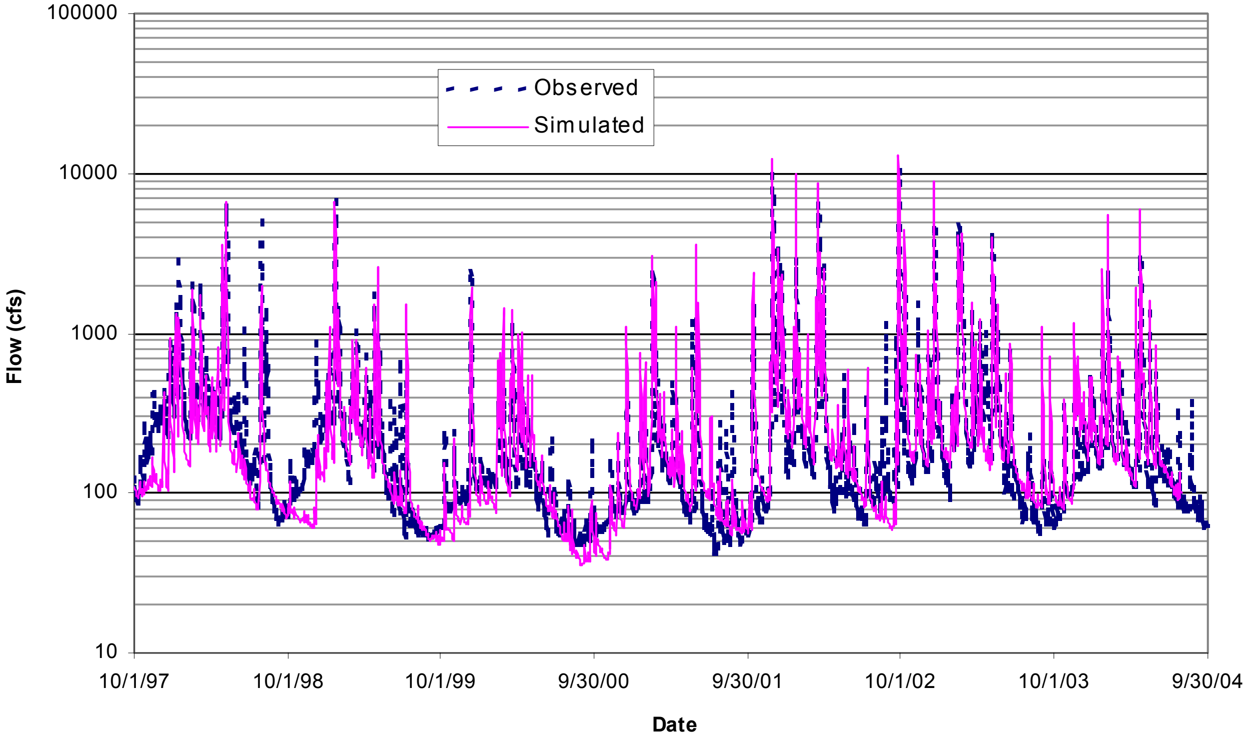

Figure D-1. Hydrologic Calibration: North Fork Forked Deer River near Fairview (USGS 07028960)

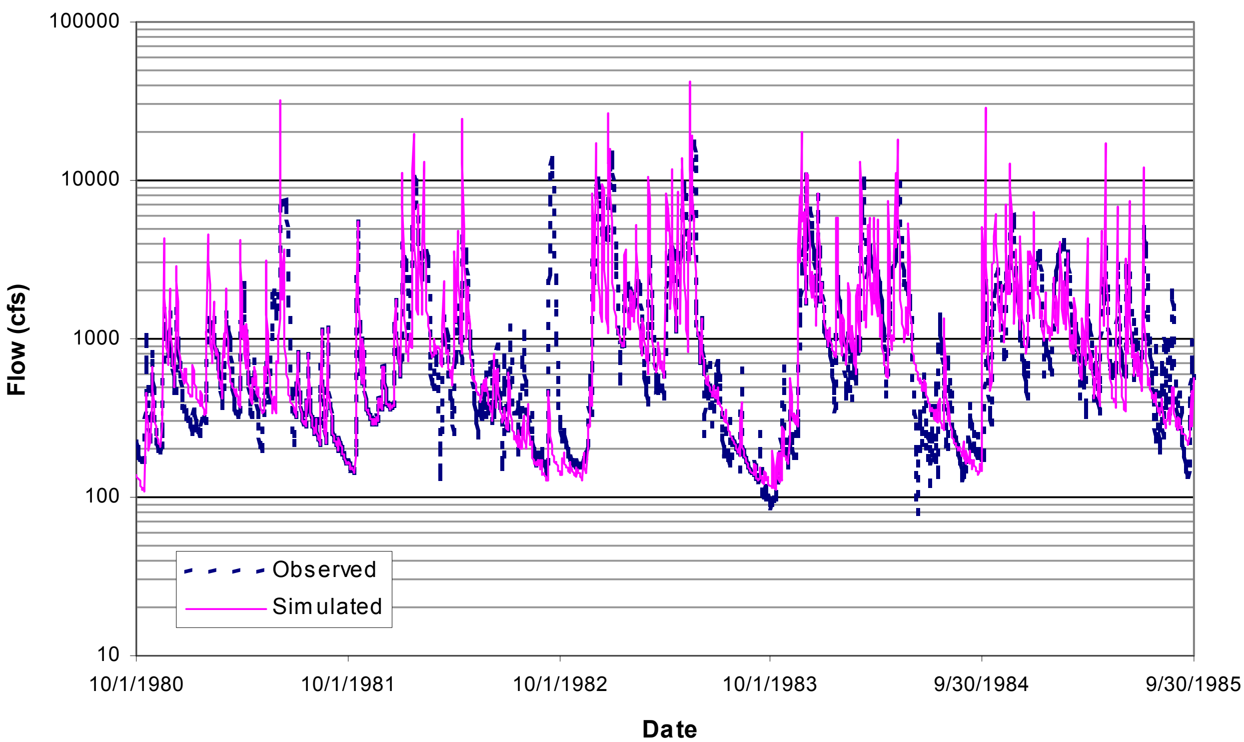

Figure D-2. Hydrologic Calibration: North Fork Forked Deer River at Dyersburg (USGS 07029100)

APPENDIX E

Public Notice of Proposed Total Maximum Daily Loads (TMDLs) for E. Coli in the North Fork Forked Deer River Watershed (HUC 08010204)

DIVISION OF WATER POLLUTION CONTROL

PUBLIC NOTICE OF AVAILABILITY OF PROPOSED TOTAL MAXIMUM DAILY LOAD (TMDL) FOR E. COLI IN THE NORTH FORK FORKED DEER RIVER WATERSHED (HUC 08010204), TENNESSEE

Announcement is hereby given of the availability of Tennessee's proposed total maximum daily load (TMDL) for E. coli in the North Fork Forked Deer (NFFD) River watershed, located in western 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 are listed on Tennessee's Final Version Year 2004 303(d) list as not supporting designated use classifications due, in part, to discharge of E. coli from pasture grazing, discharges from MS4 areas, and undetermined fecal/pathogen sources. The TMDL utilizes Tennessee's general water quality criteria, recently collected site specific water quality data, continuous flow data from two USGS discharge monitoring stations located in the watershed, a calibrated hydrologic model, and load duration curves to establish allowable loadings of E. coli which will result in reduced in-stream concentrations and attainment of water quality standards. The TMDL requires reductions of E. coli loading on the order of 44-95% for the listed waterbodies.

The proposed NFFD River E. coli TMDL document can be downloaded from the following 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:

Dennis M. Borders, P.E., Watershed Management Section
Telephone: 615-532-0706

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

Persons wishing to comment on the proposed TMDL are invited to submit their comments in writing no later than July 24, 2006 to:

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

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

The TMDL and supporting information are on file at the Division of Water Pollution Control, 7th Floor L & C Annex, 401 Church Street, Nashville, Tennessee. They may be inspected during normal office hours. Copies of the information on file are available on request.

APPENDIX F

Public Comments Received

From: kathy krone <kkrone@stategazette.com>
To: <Dennis.Borders@state.tn.us>
Date: 7/5/2006 5:47:46 PM
Subject: North Fork Forked Deer TMDL

Dennis,

My name is Kathy Krone. I am a reporter for the State Gazette in Dyersburg, TN.

I got the TDEC notice abut the proposed TMDL for E. coli in the North Fork Forked Deer River. I'm trying to read through the document. I'm not sure I understand everything.

Table 2 shows that 15 waterbodies within the watershed are impaired by E. coli (and sometimes other things).

Table 3, on the other hand, lists 26 monitoring stations and all of them appear to have exceeded the water quality maximum target at least once (if I'm reading the chart correctly).

If I'm interpreting it correctly, Table 7 appears to indicate that the proposed TMDL limits will require significant reductions. For example, Dry Creek will need a reduction of greater than 47.6 percent.

You apparently hope to implement these reductions through:
· Maintaining current municipal and industrial wastewater treatment facilities at current levels.
· Implementation of municipal storm sewer regulations, such as those Dyersburg is following now.
· Regulating animal feeding operations.
· Relying upon citizen-led measures to lower nonpoint sources. (How realistic is that?)
· Encouraging farmers to use BMPs.

How much do you expect those measures to reduce E. coli?

Will you develop TMDLs for the other items impairing waterbodies within the watershed, such as phosphates, siltation, habitat alterations and nitrates?

Perhaps we could talk about this. My phone number is (731) 285-4091. I have a meeting at 11 a.m. Thursday and another at 4 p.m. Thursday.

Thanks,
Kathy Krone
State Gazette
Dyersburg, TN

The following follow-up message from Kathy Krone was forwarded to the Division of Water Pollution Control by Tisha Calabrese-Benton, TDEC's Public Information Officer:

From:	Sherry Wang
To:	Borders, Dennis
Date:	7/12/2006 12:20:11 PM
Subject:	Fwd: Follow-up Reporter Question

>>> Tisha Calabrese 07/12/06 9:40 AM >>>
Hi Sherry,

Please see Kathy Krone's follow-up questions in bold below. Could you please help me answer these?

One more quick question before I sit down and really absorb this information: Looking at the methods proposed for reducing E. coli levels, I'm not sure I understand how you intend to get as much of a decrease as is needed (such as a 47.6 percent decrease on Dry Creek). The wastewater treatment facilities will remain fairly unchanged. No concentrated animal feeding operations were reported in the watershed. Farmers reportedly have been using BMPs for years. And, citizen-led environmental measures don't happen very often in this part of the country.

Which of these measures is expected to have the biggest impact in the North Fork Forked Deer watershed? Is that enough to bring the total down to the proposed levels?

Thanks!
Tisha

Tisha Calabrese-Benton
Deputy Communications Director
Tennessee Dept. of Environment and Conservation
865.594.5442 - Knoxville Office
865.594.6105 - Knoxville Fax
865.599.3685 - Mobile
Tisha.Calabrese@state.tn.us

APPENDIX G

Responsiveness Summary

Reponses to Kathy Krone's comments

Note: responses (**bolded**) follow each individual comment.

Table 2 shows that 15 waterbodies within the watershed are impaired by E. coli (and sometimes other things). **Yes, there are 15 waterbody segments on the 2004 303(d) list identified as not supporting designated uses due in part to E. Coli. The TMDL addresses all 15 waterbodies.**

Table 3, on the other hand, lists 26 monitoring stations and all of them appear to have exceeded the water quality maximum target at least once (if I'm reading the chart correctly). **Water quality assessment is based on monitored data. Many waterbodies have multiple water quality monitoring stations located on a single (303(d)) waterbody segment. All data are evaluated for TMDL analysis. For example, Lewis Creek (TN08010204023 - 1000) has three (3) water quality monitoring stations. The required load reduction is based on the most protective (highest calculated percent reduction) of the three stations.**

If I'm interpreting it correctly, Table 7 appears to indicate that the proposed TMDL limits will require significant reductions. For example, Dry Creek will need a reduction of greater than 47.6 percent. **Yes, that is correct.**

You apparently hope to implement these reductions through:

• Maintaining current municipal and industrial wastewater treatment facilities at current levels. **Yes, at current permit limits for E. Coli.**

• Implementation of municipal storm sewer regulations, such as those Dyersburg is following now. **According to the Small MS4 General NPDES Permit, Section 4.1.2, "You must develop and fully implement your program in five years from the permit issuance date (February 27, 2003)."**

• Regulating animal feeding operations. **The Clean Water Act exempts discharges associated with normal farming operations. Animal Feeding Operations (AFOs) are agricultural operations where animals are kept and raised in confined situations. AFOs that meet the regulatory definition of a concentrated animal feeding operation (CAFO) have the potential of being regulated under the NPDES permitting program. A CAFO that either meets the large (Class I) CAFO size criteria, the medium (Class II) criteria or has otherwise been designated as a CAFO by the Director of the Division of Water Pollution Control is required to be covered by NPDES permits and in compliance with the requirements of those permits no later than April 2006. As of February 2006, there were no Class I, Class II, or other designated CAFOs located in the drainage areas of 303(d) listed waterbodies in the North Fork Forked Deer River watershed.**

• Relying upon citizen-led measures to lower nonpoint sources. (How realistic is that?) **In watersheds with dedicated and proactive watershed groups, these citizen-led, local organizations have the potential to be a major driving force in affecting change and facilitating long-term effort for pollutant load reduction from nonpoint sources. Examples of watersheds with active watershed groups in eastern Tennessee are the Little**

River and Lower Clinch River watersheds; in middle Tennessee, the Harpeth River and Stones River watersheds; and in western Tennessee, the Wolf River and Hatchie River watersheds.

• Encouraging farmers to use BMPs. **The Tennessee Department of Agricultural (TDA) Nonpoint Source Program for Tennessee provides funding for watershed restoration (i.e., BMP implementation) under Section 319 of the Clean Water Act. According to TDA's Nonpoint Source Program Request for Proposals FY 2006 website (http://state.tn.us/agriculture/nps/319-RFPF.pdf), "The highest priority for funding are projects that target waters of the state assessed as impaired from nonpoint source pollution and published in the 303(d) List." In addition, the Natural Resources Conservation Service (NRCS), an agency of the U. S. Department of Agriculture, provides technical assistance, information, and advice to citizens in their efforts to conserve soil, water, plant, animal, and air resources on private land. The local NRCS has an extensive history of conservation practices with partnerships in the North Fork Forked Deer River watershed.**

How much do you expect those measures to reduce E. coli? **TMDL implementation is an adaptive and iterative process. Implementation of a combination of appropriately selected, properly designed BMPs, including proper installation and routine maintenance, should achieve adequate efficiency of pollutant removal. Tennessee's Watershed Approach (five-year watershed cycle) provides the opportunity for additional stream monitoring to revisit and evaluate the effectiveness of corrective measures, track progress over time, and to apply additional measures in an iterative process. We believe if all stakeholders fulfill their respective responsibilities, the water quality of all impaired waterbodies in the North Fork Forked Deer River watershed should be significantly improved and ultimately restored.**

Will you develop TMDLs for the other items impairing waterbodies within the watershed, such as phosphates, siltation, habitat alterations and nitrates? **The state of Tennessee must develop TMDLs for all pollutants on all waterbodies on the 303(d) list. TMDLs for nutrients and sediment in the North Fork Forked Deer River watershed will be developed within the next five years.**

Reponses to Kathy Krone's follow-up comments

One more quick question before I sit down and really absorb this information: Looking at the methods proposed for reducing E. coli levels, I'm not sure I understand how you intend to get as much of a decrease as is needed (such as a 47.6 percent decrease on Dry Creek). The wastewater treatment facilities will remain fairly unchanged. No concentrated animal feeding operations were reported in the watershed. Farmers reportedly have been using BMPs for years. **TDA's Nonpoint Source Program prioritizes funding to projects that target waters on the state's 303(d) list. This is a relatively recent prioritization. Those represented in Figure 14 (TMDL document) are from TDA's database as of September 2002, the latest information provided to TDEC.** And, citizen-led environmental measures don't happen very often in this part of the country.

Which of these measures is expected to have the biggest impact in the North Fork Forked Deer watershed? **See Section 9.3 and Table 8 (TMDL document). Implementation of corrective measures should be targeted to the types of strategies that will address exceedances occurring under the appropriate flow conditions for a given waterbody.** Is that enough to bring the total down to the proposed levels? **If all sources are accurately identified and implementation strategies are comprehensive and appropriately selected, designed, installed, and maintained, then the water quality of impaired waterbodies should be restored to meet their designated uses.**