TOTAL MAXIMUM DAILY LOAD (TMDL)

for

E. Coli

in the

Elk River Watersheds

(HUC 06030003 & 06030004)

Bedford, Coffee, Franklin, Giles, Grundy, Lawrence, Lincoln, Marshall, and Moore Counties, Tennessee

FINAL

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LIST OF ABBREVIATIONS

ADB	Assessment Database
AFO	Animal Feeding Operation
BMP	Best Management Practices
BST	Bacteria Source Tracking
CAFO	Concentrated Animal Feeding Operation
CFR	Code of Federal Regulations
CFS	Cubic Feet per Second
CFU	Colony Forming Units
DEM	Digital Elevation Model
DWR	Division of Water Resources
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
MGD	Million Gallons per Day
MOS	Margin of Safety
MRLC	Multi-Resolution Land Characteristic
MS4	Municipal Separate Storm Sewer System
MST	Microbial Source Tracking
NHD	National Hydrography Dataset
NMP	Nutrient Management Plan
NPS	Nonpoint Source
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
PCR	Polymerase Chain Reaction
PDFE	Percent of Days Flow Exceeded
PFGE	Pulsed Field Gel Electrophoresis
Rf3	Reach File v.3
RM	River Mile
SSO	Sanitary Sewer Overflow
STP	Sewage Treatment Plant
SWMP	Storm Water Management Program
TDEC	Tennessee Department of Environment & Conservation
TDOT	Tennessee Department of Transportation
TMDL	Total Maximum Daily Load
TWRA	Tennessee Wildlife Resources Agency
USGS	United States Geological Survey
UCF	Unit Conversion Factor
WCS	Watershed Characterization System
WLA	Waste Load Allocation
WWTP	Wastewater Treatment Plant

SUMMARY SHEET
Total Maximum Daily Load for E. coli in Elk River Watershed (HUC 06030003 & 06030004)

Impaired Waterbody Information

State: Tennessee
Counties: Bedford, Coffee, Franklin, Giles, Grundy, Lawrence, Lincoln, Marshall, and Moore
Watersheds: Elk River (HUC 06030003 & 06030004)
Constituents of Concern: E. coli
Waterbodies Addressed in This Document:

Waterbody ID	Waterbody	Miles Impaired
TN06030003010 – 1000	*ELK RIVER (from Norris Ck to Mulberry Ck)*	*13.91*
TN06030003030 – 1000	BOILING FORK CREEK	32.4
TN06030003032 – 1000	WAGNER CREEK	18.8
TN06030003041 – 0100	YELLOW BRANCH	7.1
TN06030003044 – 0100	BETSY WILLIS CREEK	22.5
TN06030003044 – 0700	CALDWELL CREEK	14.1
TN06030003044 – 0720	GILLIAM CREEK	0.76
TN06030003044 – 0721	JUANITA CREEK	2.12
TN06030003044 – 0730	TRUSSEL CREEK	4.3
TN06030003044 – 1000	*ELK RIVER (from Mud Ck to origin)*	*17.9*
TN06030003053 – 0100	BLUE CREEK	10.9
TN06030003056 – 0100	WEST FORK MULBERRY CREEK	55.9
TN06030003056 – 0250	EAST FORK MULBERRY CREEK	16.8
TN06030003060 – 1000	CANE CREEK	44.5
TN06030003063 – 1000	SWAN CREEK (from Elk River to McAfee Ck)	5.6
TN06030003063 – 2000	SWAN CREEK (from McAfee Ck to origin)	9.9
TN06030004013 – 1000	*ELK RIVER (from stateline to boundary of HUC8)*	*7.4*
TN06030004017 – 0800	PLEASANT RUN CREEK	1.7
TN06030004017 – 2000	RICHLAND CREEK (from Silver Ck to Dry Weakley Ck)	26.7
TN06030004023 – 1000	ROBERTSON FORK CREEK	16.64
TN06030004029 – 0410	UNNAMED TRIB TO WET WEAKLEY CREEK	0.75

Waterbody ID	Waterbody	Miles Impaired
TN06030004043 – 0300	CORN CREEK	4.0
TN06030004043 – 0400	TOWN CREEK	12.5
TN06030004043 – 0600	COFFEY BRANCH	3.4
TN06030004043 – 1000	RICHLAND CREEK (from Dry Weakley Ck to origin)	42.0

* Maximum water quality target is 487 CFU/100 mL for lakes, reservoirs, State Scenic Rivers, or Exceptional Tennessee Waters waterbodies and 941 CFU/100 mL for other waterbodies. Waterbodies utilizing the 487 CFU/100 mL target are italicized.

Designated Uses:

The designated use classifications for waterbodies in the Elk River Watershed include fish and aquatic life, irrigation, livestock watering & wildlife, and recreation. Elk River (entire length) is also designated for domestic water supply and industrial water supply. Richland Creek (mile 23.3 to origin), East Fork Mulberry Creek (mile 11.1 to origin), Spring Branch, Boiling Fork Creek, and Wagner Creek are also designated for domestic water supply and industrial water supply. Richland Creek (mile 0.0 to mile 20.0), Robertson Fork, Town Creek, Mulberry Creek, East Fork Mulberry Creek (mile 0.0 to mile 11.1), and Caldwell Creek are also classified for industrial water supply.

Water Quality Targets:

Derived from *State of Tennessee Water Quality Standards, Chapter 1200-4-3, General Water Quality Criteria, 2011 Version* 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, Exceptional Tennessee Water or ONRW (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.

For further information on Tennessee's general water quality standards, see:

http://tn.gov/sos/rules/1200/1200-04/1200-04-03.20110531.pdf

TMDL Scope:

Waterbodies identified on the Draft 2012 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.

Portions of the Elk River Watershed are located in Alabama. This TMDL only addresses the portion of the Elk River Watershed located in Tennessee. Alabama surface water criteria for pathogens are more stringent than the criteria applied to most waterbodies in this TMDL. However, the portion of the Elk River which flows from Tennessee into Alabama (06030004013-1000) is classified as an Exceptional Tennessee Water because of the presence of state endangered species. The water quality criteria for Exceptional Tennessee Waters are identical to the Alabama surface water criteria. Therefore, when the Elk River meets its TMDL and the water quality criteria it is based on, it will also meet the Alabama surface water criteria at the point where it enters the State of Alabama.

The E. coli TMDLs developed in this document supersede the fecal coliform TMDLs approved by EPA in 2004 for selected waterbodies in the Upper and Lower Elk River watersheds.

Analysis/Methodology:

The TMDLs for impaired waterbodies in the Elk 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 Exceptional Tennessee Waters and 941 CFU/100 mL maximum water quality criterion 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 zone represented by these existing loads. Load duration curves were also used to determine percent load reduction goals to meet the target maximum loading for E. coli. When sufficient data were available, load reductions were also determined based on geometric mean criterion.

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.

For each impaired waterbody, critical conditions were determined by evaluating the percent load reduction goals and the percent of samples exceeding TMDL target concentrations (percent exceedance), for each hydrologic flow zone, to meet the target (TMDL) loading for E. coli. The percent load reduction goal and/or the percent exceedance of the greatest magnitude corresponds with the critical flow zone(s).

Seasonal Variation:

The 10-year period used for WinHSPF model simulation period for development of 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.

Summary of TMDLs, WLAs, & LAs expressed as daily loads for Impaired Waterbodies in the Elk River Watershed (HUC 06030003 & 06030004)

HUC-12 Subwatershed (06030003 & 06030004__) or Drainage Area (DA)	Impaired Waterbody Name	Impaired Waterbody ID	TMDL	MOS	WLAs			LAs [c]
					WWTPs [a]	Collection Systems	MS4s [b,c]	
			[CFU/day]	[CFU/day]	[CFU/day]	[CFU/day]	[CFU/d/ac]	[CFU/d/ac]
Elk River DA (Multiple HUC12s)	Elk River	TN06030003044 – 1000	$1.20 \times 10^{10} \times Q$	$1.20 \times 10^{9} \times Q$	1.888×10^{10}	0	NA	$(1.772 \times 10^{5} \times Q) - (3.098 \times 10^{5})$
Caldwell Creek DA	Caldwell Creek	TN06030003044 – 0700	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	1.781×10^{10}	0	NA	$(1.607 \times 10^{6} \times Q) - (1.383 \times 10^{6})$
	Gilliam Creek	TN06030003044 – 0720						
	Juanita Creek	TN06030003044 – 0721						
	Trussel Creek	TN06030003044 – 0730						
0202	Betsy Willis Creek	TN06030003044 – 0100	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	NA	$2.436 \times 10^{6} \times Q$
Yellow Branch DA	Yellow Branch	TN06030003041 – 0100	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	NA	$6.208 \times 10^{6} \times Q$
0302 DAs	Boiling Fork Creek	TN06030003030 – 1000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	1.425×10^{10}	0	NA	$(8.548 \times 10^{5} \times Q) - (5.885 \times 10^{5})$
	Wagner Creek	TN06030003032 – 1000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	4.769×10^{9}	0	NA	$(2.247 \times 10^{6} \times Q) - (5.177 \times 10^{5})$
Blue Creek DA	Blue Creek	TN06030003053 – 0100	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	0	$4.947 \times 10^{6} \times Q$	$4.947 \times 10^{6} \times Q$
0501	West Fork Mulberry Creek	TN06030003056 – 0100	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	0	NA	$7.399 \times 10^{5} \times Q$
East Fork Mulberry Creek DA	East Fork Mulberry Creek	TN06030003056 – 0250	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	1.069×10^{10}	0	NA	$(8.180 \times 10^{5} \times Q) - (4.224 \times 10^{5})$
Elk River DA (Multiple HUC12s)	Elk River	TN06030003010 – 1000	$1.20 \times 10^{10} \times Q$	$1.20 \times 10^{9} \times Q$	4.915×10^{11}	0	NA	$(2.057 \times 10^{4} \times Q) - (9.362 \times 10^{5})$
0801+0802	Cane Creek	TN06030003060 – 1000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	NA	$3.327 \times 10^{5} \times Q$
0902	Swan Creek	TN06030003063 – 1000 + TN06030003063 – 2000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	2.564×10^{8}	0	NA	$(6.598 \times 10^{5} \times Q) - (8.173 \times 10^{3})$
0201 DAs	Corn Creek	TN06030004043 – 0300	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	NA	$6.785 \times 10^{6} \times Q$
	Town Creek	TN06030004043 – 0400	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	3.562×10^{9}	0	NA	$(5.200 \times 10^{6} \times Q) - (8.948 \times 10^{5})$
	Coffey Branch	TN06030004043 – 0600	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	NA	$1.079 \times 10^{7} \times Q$
0202	Robertson Fork Creek	TN06030004023 – 1000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	5.699×10^{9}	0	NA	$(6.168 \times 10^{5} \times Q) - (1.698 \times 10^{4})$

Summary of TMDLs, WLAs, & LAs expressed as daily loads for Impaired Waterbodies in the Elk River Watershed (HUC 06030003 & 06030004)

HUC-12 Subwatershed (06030003 & 06030004__) or Drainage Area (DA)	Impaired Waterbody Name	Impaired Waterbody ID	TMDL	MOS	WLAs			LAs [c]
					WWTPs [a]	Collection Systems	MS4s [b,c]	
			[CFU/day]	[CFU/day]	[CFU/day]	[CFU/day]	[CFU/d/ac]	[CFU/d/ac]
Pleasant Run DA	Pleasant Run Creek	TN06030004017 – 0800	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	NA	$2.261 \times 10^{7} \times Q$
Richland Creek DA (Multiple HUC12s)	Richland Creek	TN06030004017 – 2000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	1.466×10^{11}	0	NA	$(6.889 \times 10^{4} \times Q) - (4.879 \times 10^{5})$
Richland Creek DA (Multiple HUC12s)	Richland Creek	TN06030004043 – 1000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	4.132×10^{9}	0	NA	$(1.101 \times 10^{5} \times Q) - (2.198 \times 10^{4})$
Weakley Creek DA	UT to Weakley Creek	TN06030004029 – 0410	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	NA	$5.986 \times 10^{7} \times Q$
Elk River DA (Multiple HUC12s)	Elk River	TN06030004013 – 1000	$1.20 \times 10^{10} \times Q$	$1.20 \times 10^{9} \times Q$	6.393×10^{11}	NA	NA	$(9.349 \times 10^{3} \times Q) - (5.534 \times 10^{5})$

Notes: NA = Not Applicable.
Q = Mean Daily In-stream Flow (cfs).

a. WLAs for WWTPs are expressed as E. coli loads (CFU/day). All current and future WWTPs must meet water quality standards as specified in their NPDES permit.

b. Applies to any MS4 discharge loading in the subwatershed. Future MS4s will be assigned waste load allocations (WLAs) consistent with load allocations (LAs) assigned to precipitation induced nonpoint sources.

c. WLAs and LAs expressed as a “per acre” load are calculated based on the drainage area at the pour point of the HUC-12 or drainage area (see Table A-1).

E. COLI TOTAL MAXIMUM DAILY LOAD (TMDL)
ELK RIVER WATERSHED (HUC 06030003 & 06030004)

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 Elk River Watershed, identified on the Draft 2012 303(d) list as not supporting designated uses due to E. coli. TMDL analyses were performed primarily on a 12-digit hydrologic unit area (HUC-12) basis. In some cases, where appropriate, TMDLs were developed for an impaired waterbody drainage area only.

Portions of the Elk River Watershed are located in Alabama. This TMDL only addresses the portion of the Elk River Watershed located in Tennessee. Alabama surface water criteria for pathogens are more stringent than the criteria applied to most waterbodies in this TMDL. However, the portion of the Elk River which flows from Tennessee into Alabama (06030004013-1000) is classified as an Exceptional Tennessee Water because of the presence of state endangered species. The water quality criteria for Exceptional Tennessee Waters are identical to the Alabama surface water criteria. Therefore, when the Elk River meets its TMDL and the water quality criteria it is based on, it will also meet the Alabama surface water criteria at the point where it enters the State of Alabama.

The E. coli TMDLs developed in this document supersede the fecal TMDLs approved by EPA in 2004 for selected waterbodies in the Upper and Lower Elk River watersheds.

3.0 WATERSHED DESCRIPTION

The Elk River Watershed (HUC 06030003 & 06030004) is located in lower Middle Tennessee (Figure 1). The watershed includes parts of Bedford, Coffee, Franklin, Giles, Grundy, Lawrence, Lincoln, Marshall, and Moore counties. The Elk River Watershed lies within two Level III ecoregions (Southwestern Appalachians and Interior Plateau) and contains five Level IV subecoregions as shown in Figure 2 (USEPA, 1997):

- **Cumberland Plateau (68a)** tablelands and open low mountains are about 1000 feet higher than the Eastern Highland Rim (71g) to the west, and receive slightly more precipitation with cooler annual temperatures than the surrounding lower-elevation ecoregions. The plateau surface is less dissected with lower relief compared to the Cumberland Mountains (69d) or the Plateau Escarpment (68c). Elevations are generally

1200-2000 feet, with the Crab Orchard Mountains reaching over 3000 feet. Pennsylvanian-age conglomerate, sandstone, siltstone, and shale is covered by well-drained, acid soils of low fertility. Bituminous coal that has been extensively surface and underground mined underlies the region. Acidification of first and second order streams is common. Stream siltation and mine spoil bedload deposits continue as long-term problems in these headwater systems. Pockets of severe acid mine drainage persist.

- **Plateau Escarpment (68c)** is characterized by steep, forested slopes and high velocity, high gradient streams. Local relief is often 1000 feet or more. The geologic strata include Mississippian-age limestone, sandstone, shale, and siltstone, and Pennsylvanian-age shale, siltstone, sandstone, and conglomerate. Streams have cut down into the limestone, but the gorge talus slopes are composed of colluvium with huge angular, slabby blocks of sandstone. Vegetation community types in the ravines and gorges include mixed oak and chestnut oak on the upper slopes, mesic forests on the middle and lower slopes (beech-tulip poplar, sugar maple-basswood-ash-buckeye), with hemlock along rocky streamsides and river birch along floodplain terraces.

- **Western Highland Rim (71f)** is characterized by dissected, rolling terrain of open hills, with elevations of 400 to 1000 feet. The geologic base of Mississippian-age limestone, chert, and shale is covered by soils that tend to be cherty, acidic and low to moderate in fertility. Streams are characterized by coarse chert gravel and sand substrates with areas of bedrock, moderate gradients, and relatively clear water. The oak-hickory natural vegetation was mostly deforested in the mid to late 1800's, in conjunction with the iron ore related mining and smelting of the mineral limonite, but now the region is again heavily forested. Some agriculture occurs on the flatter areas between streams and in the stream and river valleys: mostly hay, pasture, and cattle, with some cultivation of corn and tobacco.

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

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

The Elk River Watershed (HUCs 06030003 & 06030004) has approximately 2,929 miles of streams (based on USEPA/TDEC Assessment Database (ADB)) and drains approximately 2,234 square miles into Wheeler Reservoir on the Tennessee River in Alabama. Watershed land use distribution is based on the Multi-Resolution Land Characteristic (MRLC) databases derived from Landsat Thematic Mapper digital images from around 2001. Although changes in the land use of the Elk River Watershed have occurred since 2001 as a result of rapid development, this is the most current land use data available. Land use for the Elk River Watershed is summarized in Table 1 and shown in Figure 3. Predominant land use in the Elk River Watershed is forest (51.81%) followed by pasture (34.85%). Urban areas represent approximately 6.10% of the total drainage area of the watershed. Details of land use distribution of impaired subwatersheds in the Elk River Watershed are presented in Appendix A.

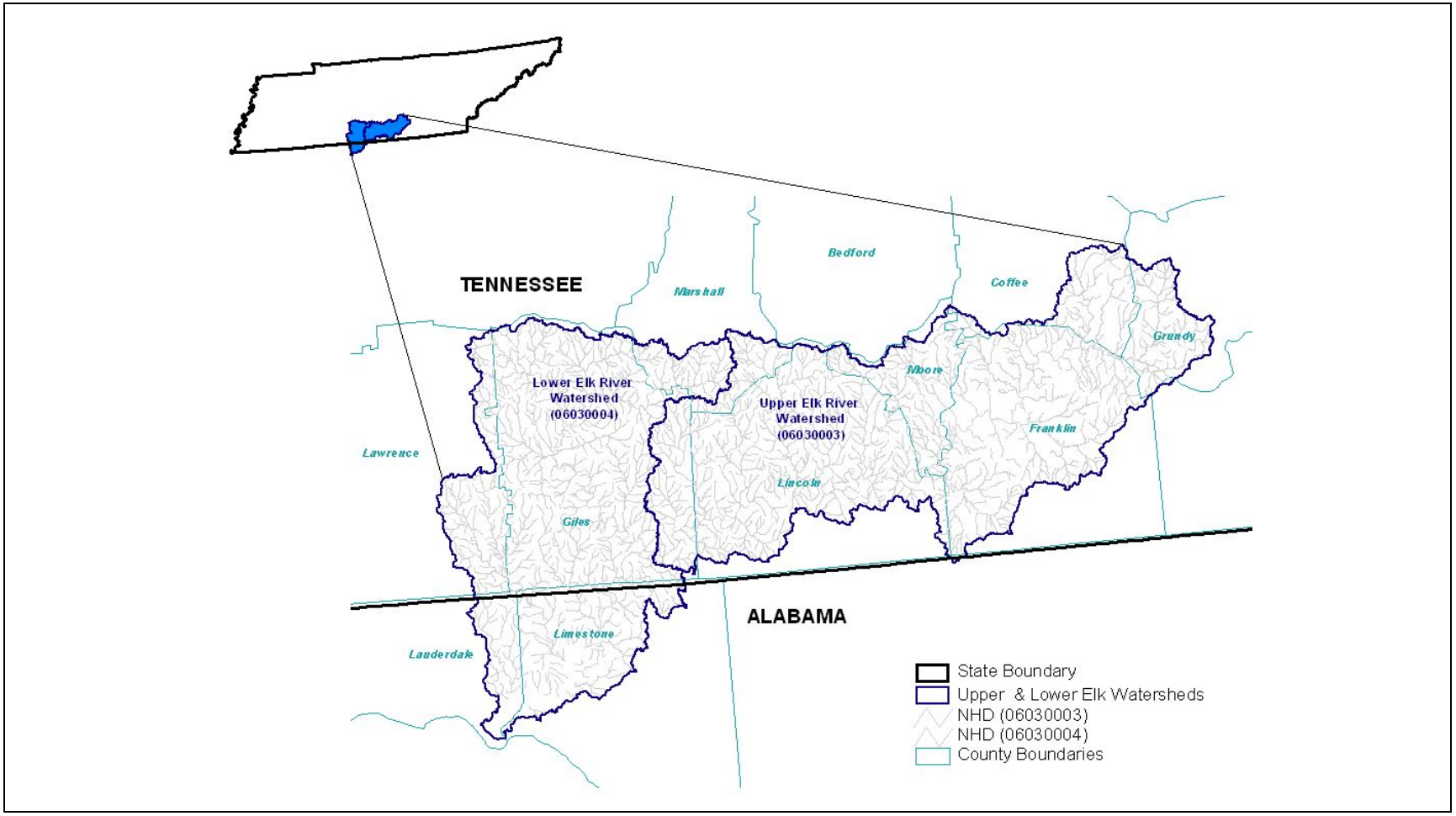

Figure 1. Location of the Elk River Watershed.

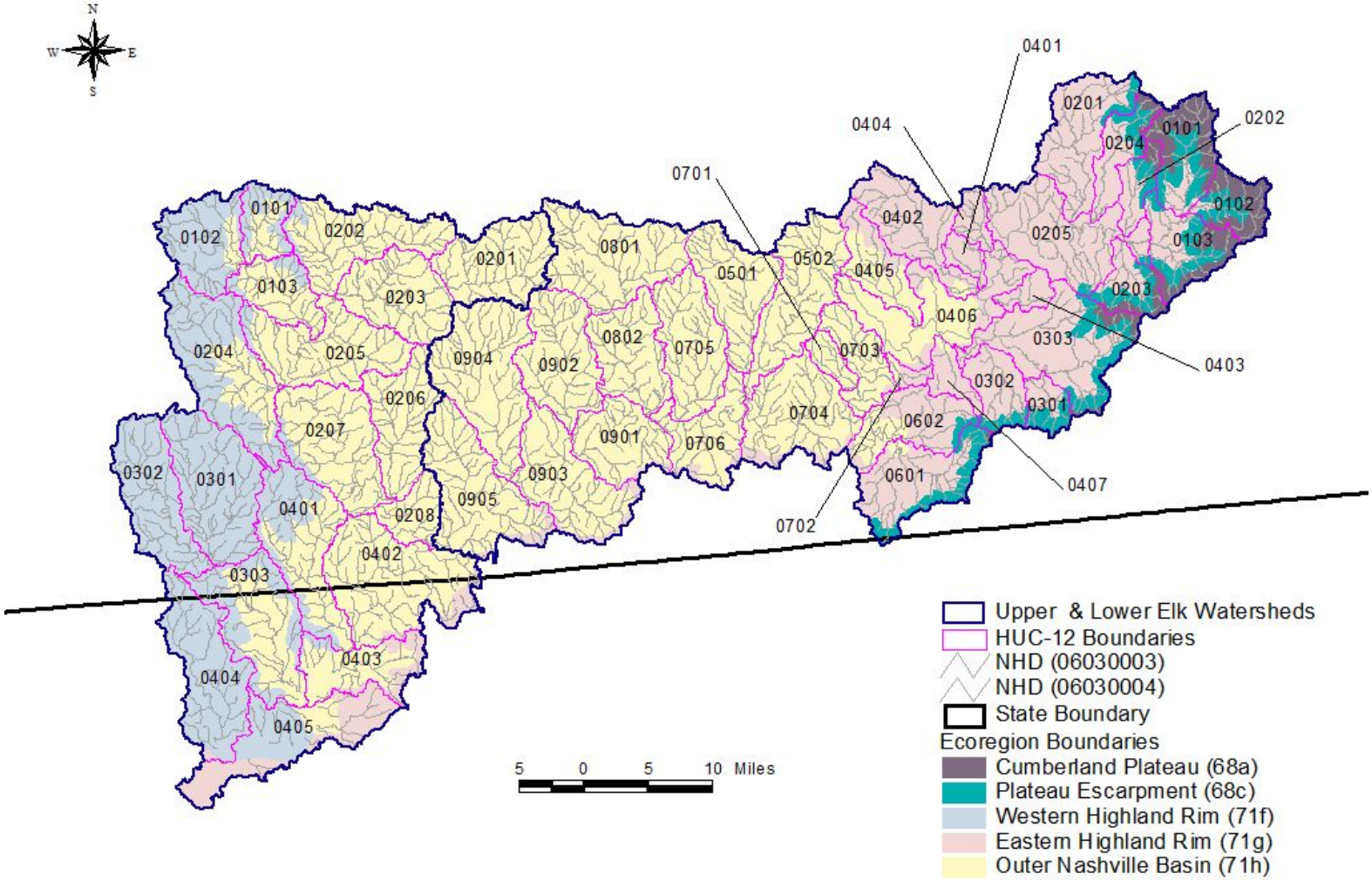

Figure 2. Level IV Ecoregions in the Elk River Watershed.

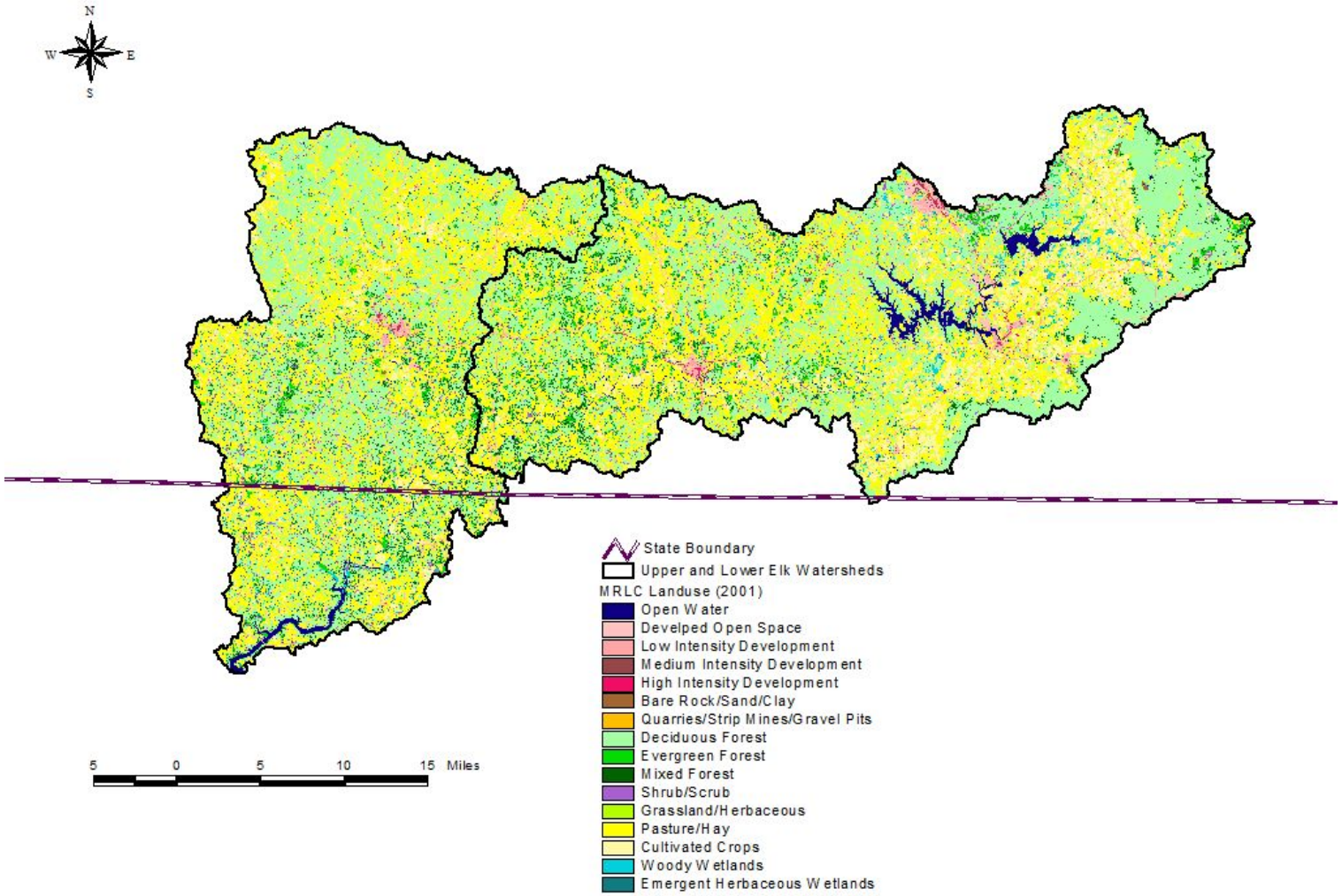

Figure 3. Land Use Characteristics of the Elk River Watershed.

Table 1. MRLC Land Use Distribution – Elk River Watersheds

Land use	Lower Elk River Watershed (TN & AL)		Upper Elk River Watershed (TN only)	
	[acres]	[%]	[acres]	[%]
Open Water	5,183	0.84	14,047	1.71
Developed Open Spaces	28,815	4.67	42,635	5.19
Low Intensity Residential	2,900	0.47	9,365	1.14
Medium Intensity Residential	679	0.11	2,464	0.30
High Intensity Residential	123	0.02	821	0.10
Bare Rock/Sand/Clay	185	0.03	739	0.09
Deciduous Forest	237,620	38.51	307,644	37.45
Evergreen Forest	20,115	3.26	25,959	3.16
Mixed Forest	31,469	5.10	28,588	3.48
Shrub/Scrub	19,868	3.22	22,837	2.78
Grasslands/Herbaceous	7,960	1.29	8,543	1.04
Pasture/Hay	229,413	37.18	271,910	33.10
Row Crops	27,643	4.48	76,480	9.31
Woody Wetlands	4,936	0.80	9,201	1.12
Emergent Herbaceous Wetlands	62	0.01	246	0.03
Total	617,034	100.0	821,480	100.0

Note: A spreadsheet was used for this calculation and values are approximate due to rounding.

4.0 PROBLEM DEFINITION

The State of Tennessee's Draft 2012 303(d) list (TDEC, 2012), http://tn.gov/environment/wpc/publications/pdf/2010_303d_final.pdf, was on Public Notice in July and August 2012. This list identified a number of waterbodies in the Elk River Watershed as not fully supporting designated use classifications due, in part, to E. coli (see Table 2 & Figure 4). The designated use classifications for these waterbodies include fish and aquatic life, irrigation, livestock watering & wildlife, and recreation. The Elk River (entire length) is also designated for domestic water supply and industrial water supply. Richland Creek (mile 23.3 to origin), East Fork Mulberry Creek (mile 11.1 to origin), Boiling Fork Creek, and Wagner Creek are also designated for domestic water supply and industrial water supply. Richland Creek (mile 0.0 to mile 20.0), Robertson Fork, Town Creek, Mulberry Creek, East Fork Mulberry Creek (mile 0.0 to mile 11.1), and Caldwell Creek are also classified for industrial water supply.

5.0 WATER QUALITY CRITERIA & TMDL TARGET

As previously stated, the designated use classifications for the Elk 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, 2011 Version* (TDEC, 2011).

Portions of the Elk River (from the Alabama state line to the confluence of Beans Creek and the portion in the Woods Reservoir Wildlife Refuge) have been classified as Exceptional Tennessee Waters because of the presence of state endangered species. As of October 1, 2012, none of the other impaired waterbodies in the Elk River Watershed have been classified as lakes, reservoirs, State Scenic Rivers, or Exceptional Tennessee Waters.

For further information concerning Tennessee's general water quality criteria and Tennessee's Antidegradation Statement, including the definition of Exceptional Tennessee Water, see:

http://tn.gov/sos/rules/1200/1200-04/1200-04-03.20110531.pdf

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 Exceptional Tennessee Waters. 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 941 CFU/100 ml have been selected as the appropriate numerical targets for TMDL development for the other impaired waterbodies.

Table 2 Draft 2012 303(d) List for E. coli Impaired Waterbodies – Elk River Watershed

Waterbody ID	Impacted Waterbody	Miles/Acres Impaired	Cause (Pollutant)	Pollutant Source
TN06030003010 – 1000	ELK RIVER (from Norris Ck to Mulberry Ck)	13.91	Escherichia coli	Pasture Grazing
TN06030003030 – 1000	BOILING FORK CREEK	32.4	Escherichia coli	Pasture Grazing
TN06030003032 – 1000	WAGNER CREEK	18.8	Nitrate+Nitrite Physical Substrate Habitat Alterations Escherichia coli	Urbanized High Density Area Municipal Point Source Channelization
TN06030003041 – 0100	YELLOW BRANCH	7.1	Alteration in stream-side or littoral vegetative cover Loss of biological integrity due to siltation Escherichia coli	Pasture Grazing
TN06030003044 – 0100	BETSY WILLIS CREEK	22.5	Alteration in stream-side or littoral vegetative cover Loss of biological integrity due to siltation Physical Substrate Habitat Alterations Escherichia coli	Pasture Grazing Nonirrigated Crop Production
TN06030003044 – 0700	CALDWELL CREEK	14.1	Alteration in stream-side or littoral vegetative cover Escherichia coli	Nonirrigated Crop Production Pasture Grazing Municipal Point Source
TN06030003044 – 0720	GILLIAM CREEK	0.76	Unionized Ammonia Nitrate+Nitrite Total Phosphorus Sludge Deposits Escherichia coli	Municipal Point Source Collection System Failure
TN06030003044 – 0721	JUANITA CREEK	2.12	Unionized Ammonia Nitrate+Nitrite Total Phosphorus Sludge Deposits Escherichia coli	Municipal Point Source Collection System Failure

Table 2 (cont'd) Draft 2012 303(d) List for E. coli Impaired Waterbodies – Elk River Watershed

Waterbody ID	Impacted Waterbody	Miles/Acres Impaired	Cause (Pollutant)	Pollutant Source
TN06030003044 – 0730	TRUSSEL CREEK	4.3	Unionized Ammonia Nitrate+Nitrite Total Phosphorus Iron Manganese Low Dissolved Oxygen Sludge Deposits Whole Effluent Toxicity Escherichia coli	Municipal Point Source Discharge Upstream Impoundment
TN06030003044 – 1000	ELK RIVER (from Mud Ck to origin)	17.9	Escherichia coli	Pasture Grazing
TN06030003053 – 0100	BLUE CREEK	10.9	Biological integrity loss due to undetermined cause Escherichia coli	Undetermined Source Pasture Grazing
TN06030003056 – 0100	WEST FORK MULBERRY CREEK	55.9	Escherichia coli	Pasture Grazing Animal Feeding Operations
TN06030003056 – 0250	EAST FORK MULBERRY CREEK	16.8	Escherichia coli	Pasture Grazing
TN06030003060 – 1000	CANE CREEK	44.5	Escherichia coli	Pasture Grazing
TN06030003063 – 1000	SWAN CREEK (from Elk River to McAfee Ck)	5.6	Nitrate+Nitrite Total Phosphorus Alteration in stream-side or littoral vegetative cover Escherichia coli	Pasture Grazing Specialty Crop Production
TN06030003063 – 2000	SWAN CREEK (from McAfee Ck to origin)	9.9	Nitrate+Nitrite Total Phosphorus Low Dissolved Oxygen Escherichia coli	Animal Feeding Operation (NPS)
TN06030004013 – 1000	ELK RIVER (from stateline to boundary of HUC8)	7.4	Escherichia coli	Pasture Grazing

Table 2 (cont'd) Draft 2012 303(d) List for E. coli Impaired Waterbodies – Elk River Watershed

Waterbody ID	Impacted Waterbody	Miles/Acres Impaired	Cause (Pollutant)	Pollutant Source
TN06030004017 – 0800	PLEASANT RUN CREEK	1.7	Nitrate+Nitrite Total Phosphorus Alteration in stream-side or littoral vegetative cover Loss of biological integrity due to siltation Escherichia coli	Municipal Urbanized Area Collection System Failure
TN06030004017 – 2000	RICHLAND CREEK (from Silver Ck to Dry Weakley Ck)	26.7	Loss of biological integrity due to siltation Escherichia coli	Collection System Failure Land Development Municipal Urbanized Area Pasture Grazing
TN06030004023 – 1000	ROBERTSON FORK CREEK	16.64	Escherichia coli	Pasture Grazing
TN06030004029 – 0410	UNNAMED TRIB TO WET WEAKLEY CREEK	0.75	Unionized Ammonia Loss of biological integrity due to siltation Escherichia coli	Animal Feeding Operations Silviculture
TN06030004043 – 0300	CORN CREEK	4.0	Loss of biological integrity due to siltation Nutrients Escherichia coli	Pasture Grazing Unrestricted Cattle Access
TN06030004043 – 0400	TOWN CREEK	12.5	Nitrate+Nitrite Total Phosphorus Escherichia coli	Pasture Grazing Municipal Point Source Discharges
TN06030004043 – 0600	COFFEY BRANCH	3.4	Escherichia coli	Pasture Grazing
TN06030004043 – 1000	RICHLAND CREEK (from Dry Weakley Ck to origin)	42.0	Escherichia coli	Pasture Grazing

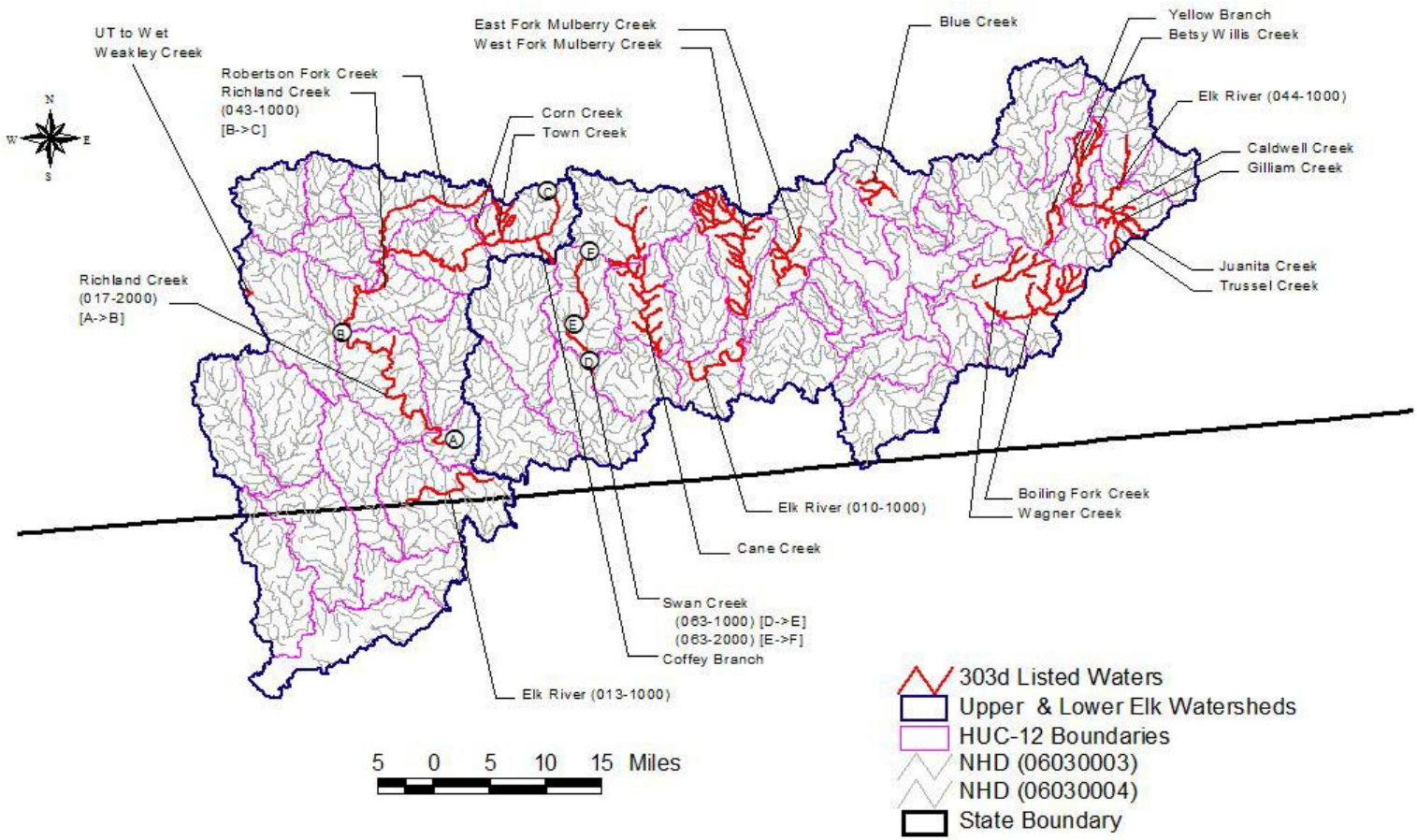

Figure 4. Waterbodies Impaired by E. Coli (as Documented on the Draft 2012 303(d) List).

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 Elk River Watershed:

- HUC-12 06030003_0103:
  - CALDW001.1GY – Caldwell Creek, Partin Springs Rd. on Garner Farm (Bells Cove Rd.)
  - ELK195.3GY – Elk River, at Pelham Industrial Park
  - GILLI1.3T1.8GY – Juanita Creek, off Hwy 41, ds of Monteagle STP #1 outfall
  - TRUSS1.7T0.7GY – UT of Trussel Creek, d/s of Monteagle STP #2 outfall
- HUC-12 06030003_0202:
  - BWILL000.2CE – Betsy Willis Creek, at Sherrell Rd.
- HUC-12 06030003_0205:
  - ELK187.4FR – Elk River, at Rutledge Ford Rd.
  - YELLO000.8FR – Yellow Branch, at Wilder Chapel Rd. (u/s 50 feet)
- HUC-12 06030003_0303:
  - BFORK010.1FR – Boiling Fork Creek, at Williams Cove Rd. (d/s Cowan)
  - BFORK013.4FR – Boiling Fork Creek, d/s Cowan STP
  - BFORK014.6FR – Boiling Fork Creek, in Cowan near RR tracks
  - WAGNE001.4FR – Wagner Creek, at Hwy 41A
  - WAGNE001.9FR – Wagner Creek, at Patty Lane (9th Ave South)
  - WAGNE002.4FR – Wagner Creek, immediately d/s Decherd STP
- HUC-12 06030003_0402:
  - BLUE000.1FR – Blue Creek, off Blue Creek Rd., (d/s Shahan Rd.)
- HUC-12 06030003_0501:
  - WFMUL001.4LI – West Fork Mulberry Creek, at Old Lynchburg Hwy (W side of Old Fayetteville Rd.)
- HUC-12 06030003_0502:
  - EFMUL006.2MR – East Fork Mulberry Creek, at Louse Creek Rd. (d/s Lynchburg)
  - EFMUL010.2MR – East Fork Mulberry Creek, off Goose Branch Rd., 1 mi d/s Lynchburg STP
  - EFMUL014.1MR – East Fork Mulberry Creek, at Cashion Rd. (u/s Lynchburg)
- HUC-12 06030003_0706:
  - ELK093.9LI – Elk River, at Eldad Rd., near Fayetteville WWTP
- HUC-12 06030003_0802:
  - CANE006.6LI – Cane Creek, Marsh Mill Rd. at Craighead Creek
  - CANE008.1LI – Cane Creek, at Brown Teal Rd.

- HUC-12 06030003_0902:
    - SWAN000.8LI – Swan Creek, d/s Hwy 273
    - SWAN008.2LI – Swan Creek, off Hwy 244 (near mailbox #81)
- HUC-12 06030004_0201:
    - COFFE000.2ML – Coffey Branch, off Coffey Branch Rd.
    - CORN000.4ML – Corn Creek, at Hwy 31A, u/s Charlie Thomas Rd.
    - TOWN000.8ML – Town Creek, d/s Cornersville STP, near Hwy 129
- HUC-12 06030004_0202:
    - RICHL055.5GS – Richland Creek, at Robertson Hollow Rd.
- HUC-12 06030004_0203:
    - RFORK005.5GS – Robertson Fork Creek, u/s Abernathy Rd. (in Lynnville)
- HUC-12 06030004_0207:
    - PRUN000.1GS – Pleasant Run Creek, d/s Hwy 31
    - RICHL018.3GS – Richland Creek, at Green Field
    - RICHL025.7GS – Richland Creek, at Hwy 64 south of Pulaski, 1 mi d/s Pulaski WWTP
    - RICHL029.9GS – Richland Creek, at Hwy 64 (USGS gaging station)
- HUC-12 06030004_0402:
    - ELK036.5GS – Elk River, at Prospect (Veto Rd.)

The location of these monitoring stations is shown in Figure 5. Water quality monitoring results for these stations are tabulated in Appendix B. Examination of the data shows exceedances of the 941 CFU/100 mL maximum E. coli standard at several monitoring stations. Water quality monitoring results for those stations with 10% or more of samples exceeding water quality maximum criteria are summarized in Table 3. 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.

Several of the water quality monitoring stations (Table 3 and Appendix B) have at least one E. coli sample value reported as >2419. For the purpose of calculating summary data statistics, TMDLs, Waste Load Allocations (WLAs), and Load Allocations (LAs), these data values are treated as (equal to) 2419. Therefore, the calculated results are considered to be estimates. Future E. coli sample analyses at these sites should follow established protocol. (See Section 9.4.)

Table 3 Summary of TDEC Water Quality Monitoring Data

HUC8	Monitoring Station	Date Range	E. Coli (Max WQ Target = 941 CFU/100 mL)**				
			Data Pts.	Min. [CFU/100 ml]	Avg. [CFU/100 ml]	Max. [CFU/100 ml]	No. Exceed. WQ Max. Target
Upper Elk River Watershed (06030003)	BFORK010.1FR	2002 – 2003	10	91	571.1	2,400	1
	BFORK013.4FR	2009	4	145	373.3	579.4	0
	BFORK014.6FR	2002 – 2003	10	44	646.8	2,400	2
	BLUE000.1FR	2009	5	185	456.0	1,203.3	1
	BWILL000.2CE	2009	5	517.2	804.9	1,046.2	1
	CALDW001.1GY	2009	5	185	317.0	435.2	0
	CANE006.6LI	2002 – 2003	11	52	811.2	2,400	4
	CANE008.1LI	2007 & 2009	5	105	287.4	687	0
	EFMUL006.2MR	2002 – 2003	11	59	581.0	1,600	3
	EFMUL010.2MR	2006 – 2009	9	179	525.7	1,120	2
	EFMUL014.1MR	2002 – 2006	12	70	555.0	1,300	3
	ELK093.9LI	*2002 – 2009*	*16*	*20*	*361.1*	*2,400*	*3*
	ELK187.4FR	2002 – 2003	9	19	627.7	2,400	2
	ELK195.3GY	*2009*	*5*	*186*	*316.3*	*461.1*	*0*
	GILLI1.3T1.8GY	2007 – 2008	14	20.1	801.0	2,419.2	4
	SWAN000.8LI	2007 – 2009	6	113	295.5	613	0
	SWAN008.2LI	2002 – 2009	15	20	902.5	2,400	6
	TRUSS1.7T0.7GY	2007 – 2008	11	4.1	315.0	2,419.6	1
	WAGNE001.4FR	2002 – 2003	7	730	1,134.3	2,400	3
	WAGNE001.9FR	2009	3	290.9	552.9	980.4	1
	WAGNE002.4FR	2009	5	325.5	1,320.5	2,419.6	2
	WFMUL001.4LI	2002 – 2009	16	39	467.3	2,000	3
	YELLO000.8FR	2009	5	325.5	587.6	1,299.7	1
Lower Elk R, Watershed (06030004)	COFFE000.2ML	2008 – 2009	8	261	712.3	1,120	2
	CORN000.4ML	2008 – 2009	8	1,733	2,279.9	2,420	8
	ELK036.5GS	*2007 & 2009*	*6*	*57*	*189.0*	*308*	*0*
	PRUN000.1GS	2007 – 2008	9	13	296.9	816	0

Table 3 (cont'd) Summary of TDEC Water Quality Monitoring Data

HUC8	Monitoring Station	Date Range	E. Coli (Max WQ Target = 941 CFU/100 mL)**				
			Data Pts.	Min. [CFU/100 ml]	Avg. [CFU/100 ml]	Max. [CFU/100 ml]	No. Exceed. WQ Max. Target
Lower Elk River Watershed (cont'd) (06030004	RFORK005.5GS	2002 – 2008	14	52	832.5	2,400	5
	RICHL018.3GS	2002 – 2003	10	4	369.1	2,400	1
	RICHL025.7GS	2008 – 2009	8	20	204.3	770	0
	RICHL029.9GS	2002 – 2009	14	10	360.6	2,000	1
	RICHL055.5GS	2002 – 2009	18	51	954.3	2,400	7
	TOWN000.8ML	2002 – 2008	13	9	535.0	2,400	2

** Maximum water quality target is 487 CFU/100 mL for lakes, reservoirs, State Scenic Rivers, or Exceptional Tennessee Waters waterbodies and 941 CFU/100 mL for other waterbodies. Waterbodies utilizing the 487 CFU/100 mL target are italicized.

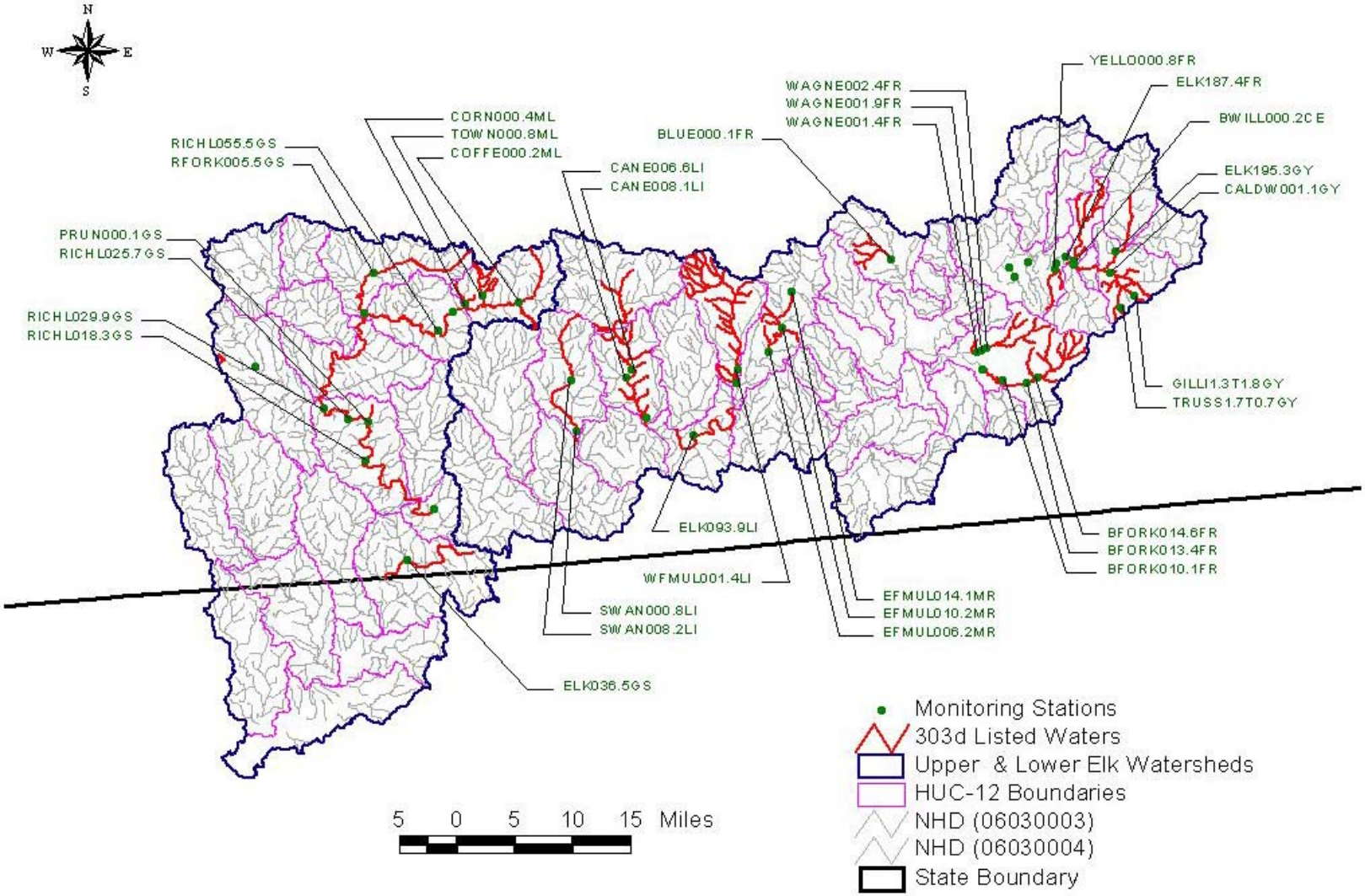

Figure 5. Water Quality Monitoring Stations in the Elk River Watershed

7.0 SOURCE ASSESSMENT

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

Under the Clean Water Act, sources are classified as either point or nonpoint sources. Under 40 CFR §122.2, (http://www.epa.gov/epacfr40/chapt-I.info/chi-toc.htm), 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 (http://cfpub1.epa.gov/npdes/index.cfm) regulates point source discharges. Point sources can be described by three broad categories: 1) NPDES regulated municipal (http://cfpub1.epa.gov/npdes/home.cfm?program_id=13) and industrial (http://cfpub1.epa.gov/npdes/home.dfm?program_id=14) wastewater treatment plants (WWTPs); 2) NPDES regulated industrial and municipal storm water discharges (http://cfpub1.epa.gov/npdes/home.cfm?program_id=6); and 3) NPDES regulated Concentrated Animal Feeding Operations (CAFOs) (http://cfpub1.epa.gov/npdes/home.cfm?program_id=7)). 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 Plants

Both treated and untreated sanitary wastewater contain coliform bacteria. There are 15 facilities in the Elk River Watershed that have NPDES permits authorizing the discharge of treated sanitary wastewater. All of these facilities are located in or near impaired subwatersheds or drainage areas. (see Figure 6 and Table 4). Five of the facilities are sewage treatment plants (STPs) serving municipalities and 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 WWTPs are in accordance with the coliform criteria specified in Tennessee Water Quality Standards for the 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 (LCSs) 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.*

Table 4 NPDES Permitted WWTPs with Collection Systems Serving Impaired Subwatersheds or Drainage Areas

NPDES Permit No.	Facility	Design Flow [MGD]	Receiving Stream
TN0061841	Cornersville STP	0.1	Town Ck @RM0.9
TN0021644	Cowan STP	0.4	Boiling Fk Ck @RM13.4
TN0020508	Decherd Water Works STP	1.0	Wagner Ck @RM2.4
TN0076007	Elkton STP	0.008	Elk River @RM49.2
TN0021814	Fayetteville STP	3.35	Elk River @RM90.0
TN0025101	Lynchburg STP	0.3	East Fork Mulberry Ck @RM11.1
TN0080985	Monteagle STP, Plant #3	0.5	Juanita Ck @RM1.3 & UT @RM1.0 to Trussell Ck
TN0078697	Pelham Industrial Park	0.03	Elk River @ RM195
TN0021687	Pulaski STP	4.0	Richland Ck @RM23.3
TN0054810	Richland School	0.016	Robertson Fork Ck @RM1.2
TN0074331	TDOT I-65 Welcome Center – Giles County	0.018	Elk River @RM49.2
TN0023469	Tullahoma STP	5.0	Rock Ck @RM11.0
TN0065498	Unity School	0.0072	Morton Br @RM1.0
TN0067202	University of Tennessee Space Institute (UTSI)	0.02	Rollins Ck Embayment @RM0.7
TN0021857	Winchester STP	3.2	Elk River @RM153.8

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 (http://cfpub.epa.gov/npdes/stormwater/swphases.cfm#phase1) 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. There are no Phase I MS4s located in the Elk River Watershed.

As of March 2003, regulated small MS4s in Tennessee must also obtain NPDES permits in accordance with the Phase II storm water program (http://cfpub.epa.gov/npdes/stormwater/swphases.cfm#phase2). 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* http://www.tn.gov/environment/wpc/stormh2o/finals/tns000000_ms4_phase_ii_2010.pdf. (TDEC, 2010). The city of Tullahoma is covered under Phase II of the NPDES Storm Water Program.

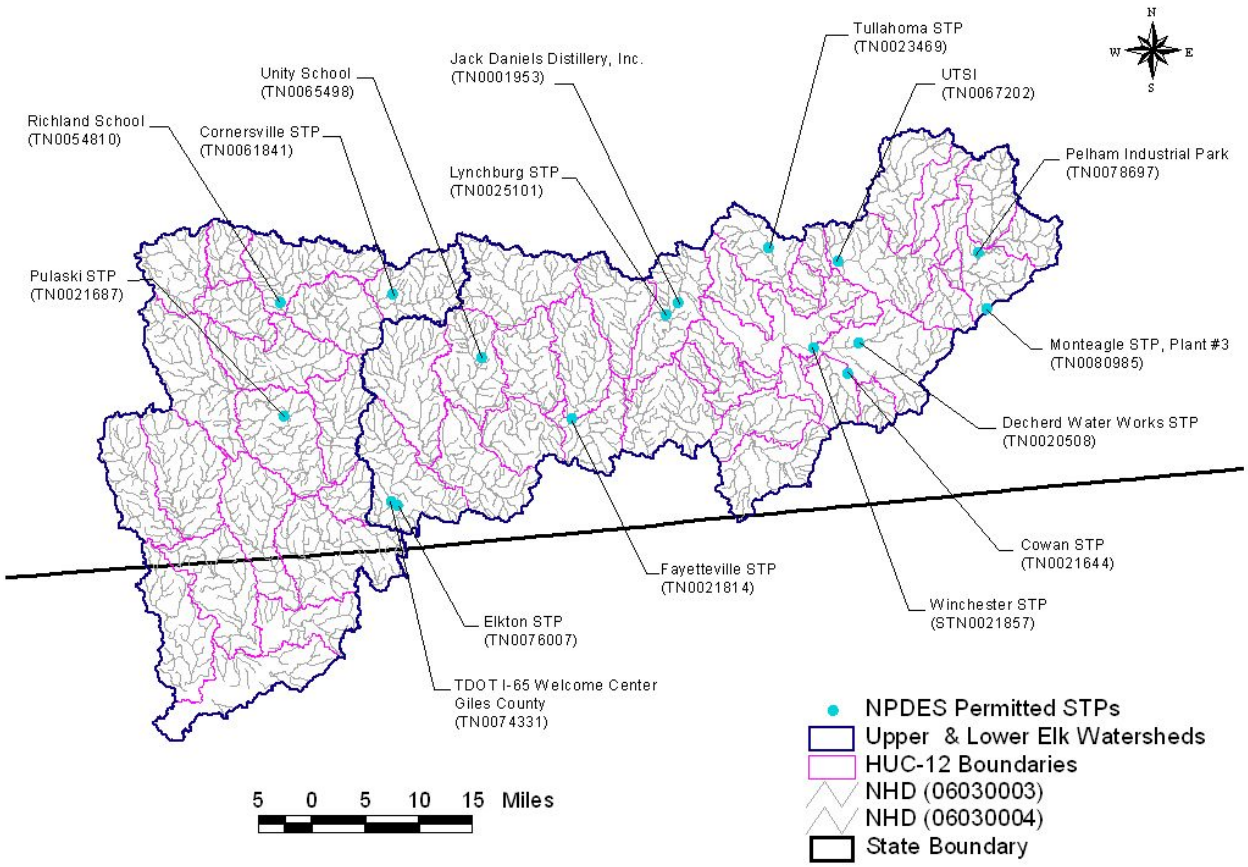

Figure 6. NPDES Regulated WWTPs in and near Impaired Subwatersheds and Drainage Areas of the Elk River Watershed.

The Tennessee Department of Transportation (TDOT) has been issued an individual MS4 permit (TNS077585) that authorizes discharges of storm water runoff from State roads 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. The TDOT MS4 will not be considered a potential source because: (1) The area covered by the permit is less than 0.5% of the total drainage area of the watershed; (2) Sampling of stormwater runoff from state highways indicates negligible contribution of E. coli; and (3) An extensive study conducted by California Dept. of Transportation (Caltrans) concluded that highway facilities, including maintenance stations, do not appear to be a significant source of pathogens in urban drainage.

For information regarding storm water permitting in Tennessee, see the TDEC website:

http://www.state.tn.us/environment/wpc/stormh2o/.

7.1.3 NPDES Concentrated Animal Feeding Operations (CAFOs)

Animal feeding operations (AFOs) are agricultural enterprises where animals are kept and raised in confined situations. AFOs congregate animals, feed, manure and urine, dead animals, and production operations on a small land area. Feed is brought to the animals rather than the animals grazing or otherwise seeking feed in pastures, fields, or on rangeland (USEPA, 2002a). Concentrated Animal Feeding Operations (CAFOs) are AFOs that meet certain criteria with respect to animal type, number of animals, and type of manure management system. CAFOs are considered to be potential point sources of pathogen loading and are required to obtain an NPDES permit. Most CAFOs in Tennessee obtain coverage under SOPC00000 or SOPCD0000, *General State Operating Permit for Concentrated Animal Feeding Operations* (http://tn.gov/environment/wpc/pdf/sopc00000pmt.pdf or http://tn.gov/environment/wpc/pdf/sopcd0000pmt.pdf), while larger, Class I CAFOs are required to obtain an individual NPDES permit.

As of June 1, 2013, there is one Class I CAFO with an individual permit located in the Elk River Watershed. There are 19 Class II CAFOs with coverage or pending coverage under the new general SOP permits. (See Figure 7.)

Table 5 NPDES Permitted CAFOs located within Impaired Subwatersheds or Drainage Areas

NPDES Permit No.	Permittee	Status	Type of Animals	# of Animals
TN0077755	Tosh Farms, Inc. - Huntland	Reissuance	Swine	4,100
SOPC00008	Steelman Pullet Farm	Active	Poultry-Pullets	46,000
SOPC00045	Thien Chanthavone	Active	Poultry-Broilers	113,600
SOPC00056	Chanthavisouk Chicken Barn Construction	Active	Poultry	100,000
SOPC00063	WCRV Farms	Active	Poultry-Broilers	226,600
SOPC00071	Newton Farms	Active	Poultry-Broilers	104,000
SOPC00076	Hop Lam Chicken Barns	Active	Poultry-Broilers	48,000
SOPC00077	A Fowl Place	Active	Poultry-Broilers	62,600
SOPC00097	Troyer Chicken Barn	Active	Poultry-Broilers	80,000
SOPC00098	Anthony Miller	Active	Poultry-Layers	44,250
SOPC00119	Mountain Brook Poultry	Active	Poultry-Broilers	64,000
SOPC00145	Michael Ferguson Poultry Farm	Active	Poultry-Breeders	76,000
SOPC00149	Suzanne & Ray Sawyers	Active	Poultry-Broilers	41,000
SOPC00154	Scottie Jason Morrison	Active	Poultry-Broilers	104,000
SOPC00162	Hasty Poultry	Incomplete	Poultry-Broilers	
SOPC00168	McGee Livestock-Marshall County Farm	Active	Poultry-Broilers	250,000
SOPC00169	McGee Livestock Farm	Active	Poultry-Broilers	400,000
SOPC00171	Jeffrey S. Harris	Active	Poultry-Broilers	76,000
SOPC00178	Martin Poultry Operation	Active	Poultry-Broilers	190,000
SOP-09026	Phipps Poultry Farm	New	Poultry-Broilers	150,000

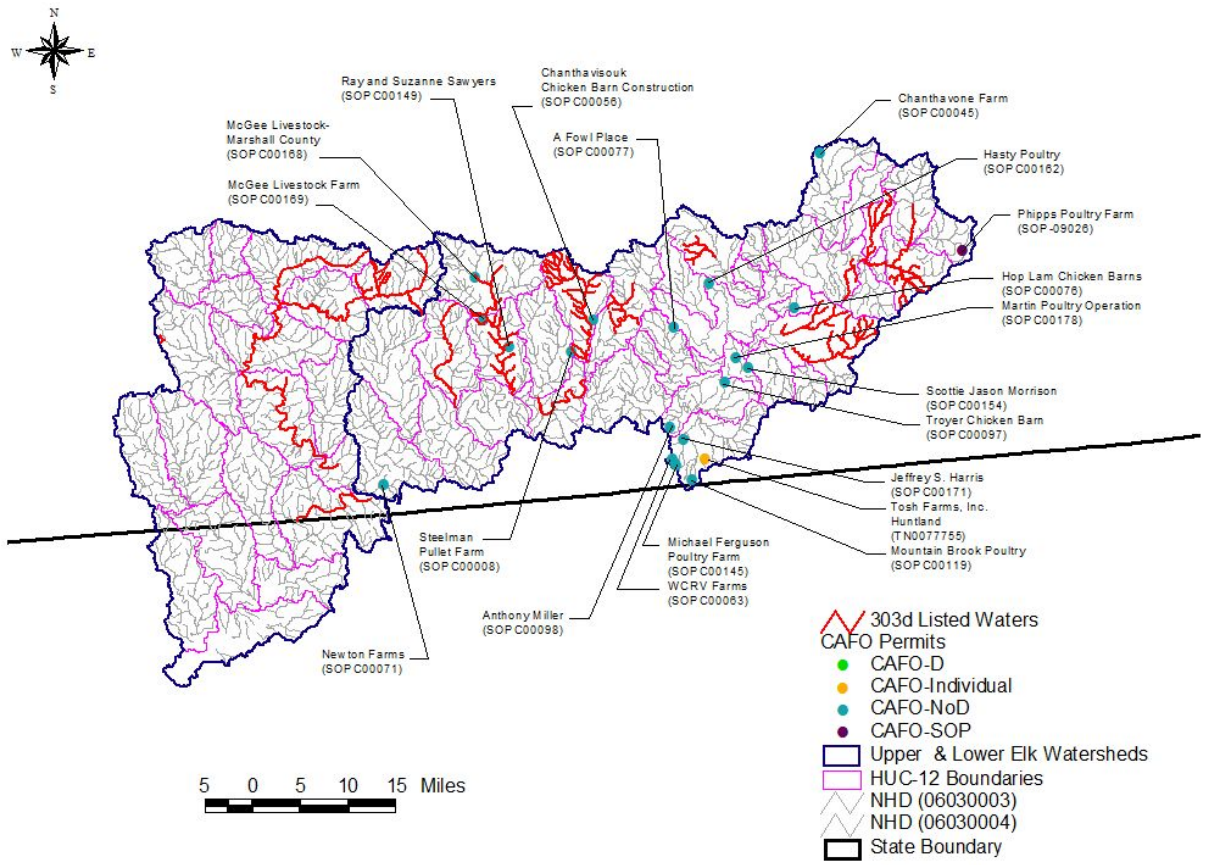

Figure 7. NPDES Regulated CAFOs in and near Impaired Subwatersheds and Drainage Areas of the Elk River Watershed.

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 Draft 2012 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 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 2007 Census of Agriculture http://www.agcensus.usda.gov/Publications/2007/Full_Report/Volume_1,_Chapter_2_County_Level/Tennessee/index.asp. Livestock data for counties located within the Elk River Watershed are summarized in Table 6. 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, 2009).

7.2.3 Failing Septic Systems

Some of the coliform loading in the Elk River Watershed can be attributed to failure of septic systems and illicit discharges of raw sewage. Estimates from 1997 county census data of people in the Elk River Watershed utilizing septic systems were compiled using the WCS and are summarized in Table 7. In middle Tennessee, it is estimated that there are approximately 2.47 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. Urban land use area in impaired subwatersheds in the Elk River Watershed ranges from 4% to 17%. Land use for the Elk River drainage areas is summarized in Figures 8 thru 13, and tabulated in Appendix A.

Table 6 Livestock Distribution in the Elk River Watershed

County	Livestock Population (2007 Census of Agriculture)							
	Beef Cow	Milk Cow	Poultry		Hogs	Sheep	Goats	Horse
			Layers	Broilers				
Bedford	32,648	1,117	69,340	7,494,442	(D)	500	3,559	5,611
Coffee	14,771	2,081	22,935	505,304	428	134	2,065	1,894
Franklin	17,718	880	(D)	2,442,558	7,722	261	2,498	1,930
Giles	33,998	1,032	130,510	61	575	983	2,975	3,818
Grundy	4,802	333	38,133	1,801,676	60	73	900	421
Lawrence	32,629	1,442	256,306	216,422	8,219	217	5,820	3,478
Lincoln	36,013	1,110	93,215	934,487	800	542	2,985	3,082
Marshall	18,999	3,158	1,766	(D)	1,836	790	5,620	3,248
Moore	6,964	239	539	946,100	496	(D)	700	674

* In keeping with the provisions of Title 7 of the United States Code, no data are published in the 2007 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, 2009).

Table 7 Estimated Population on Septic Systems in the Elk River Watershed

County	Total Population (2000 Census)	Total Population (1990 Census)	% of Population on Septic Systems (1990 Census)
Bedford	37,586	30,411	100.0
Coffee	48,014	40,339	68.1
Franklin	39,270	34,725	67.8
Giles	29,447	25,741	85.2
Grundy	14,332	13,362	94.9
Lawrence	39,926	35,303	100.0
Lincoln	31,340	28,157	74.9
Marshall	26,767	21,539	98.8
Moore	5,740	4,721	3.5

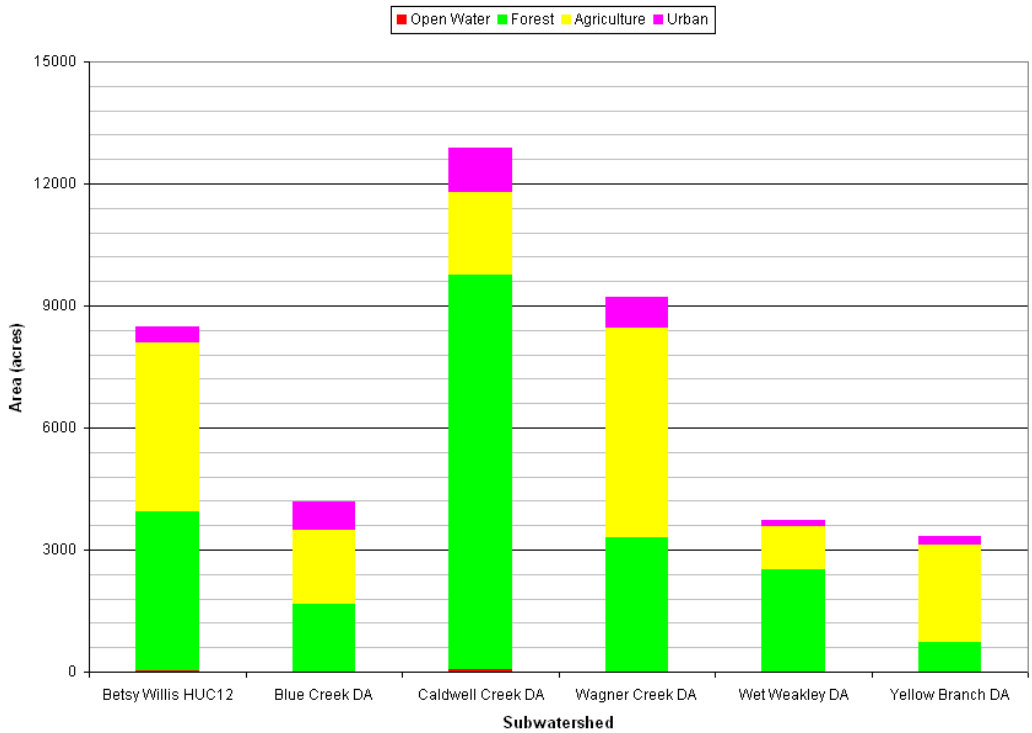

Figure 8. Land Use Area of Elk River E. coli-Impaired Subwatersheds (less than 20,000 acres)

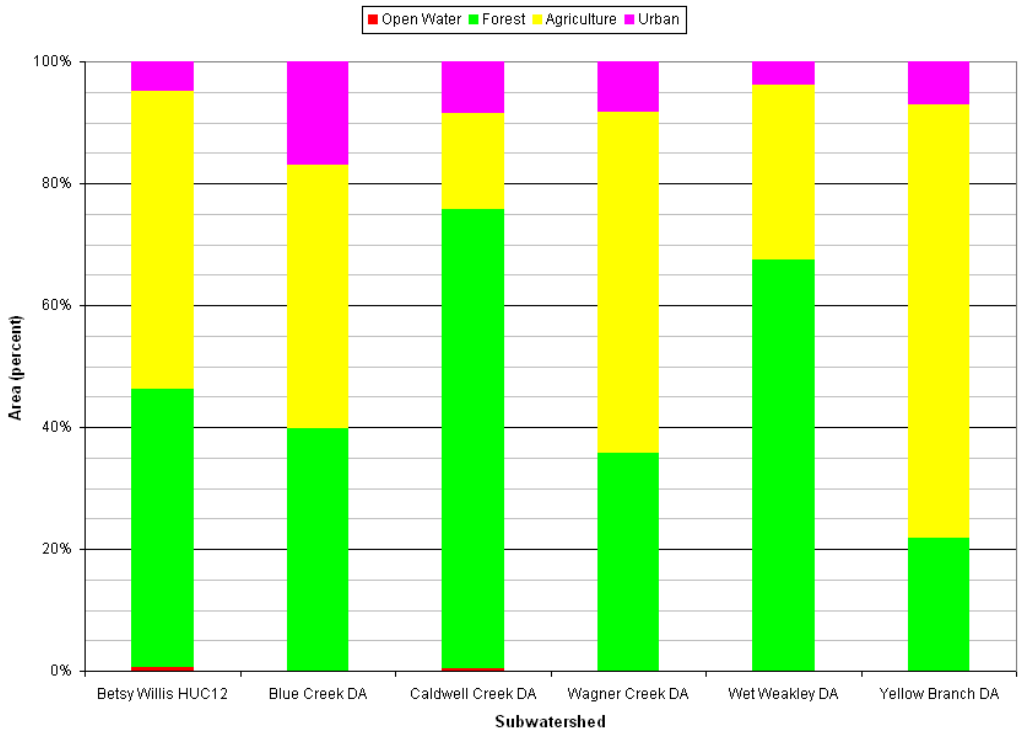

Figure 9. Land Use Percent of Elk River E. coli-Impaired Subwatersheds (less than 20,000 acres)

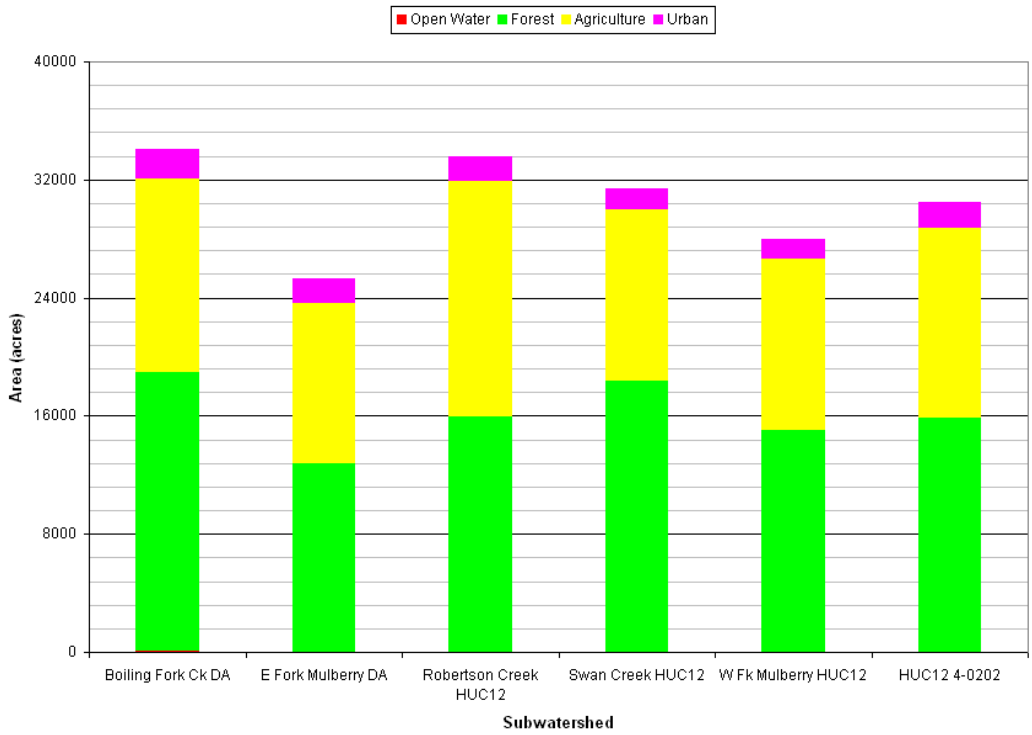

Figure 10. Land Use Area of Elk River E. coli-Impaired Subwatersheds (greater than 20,000 acres & less than 60,000 acres)

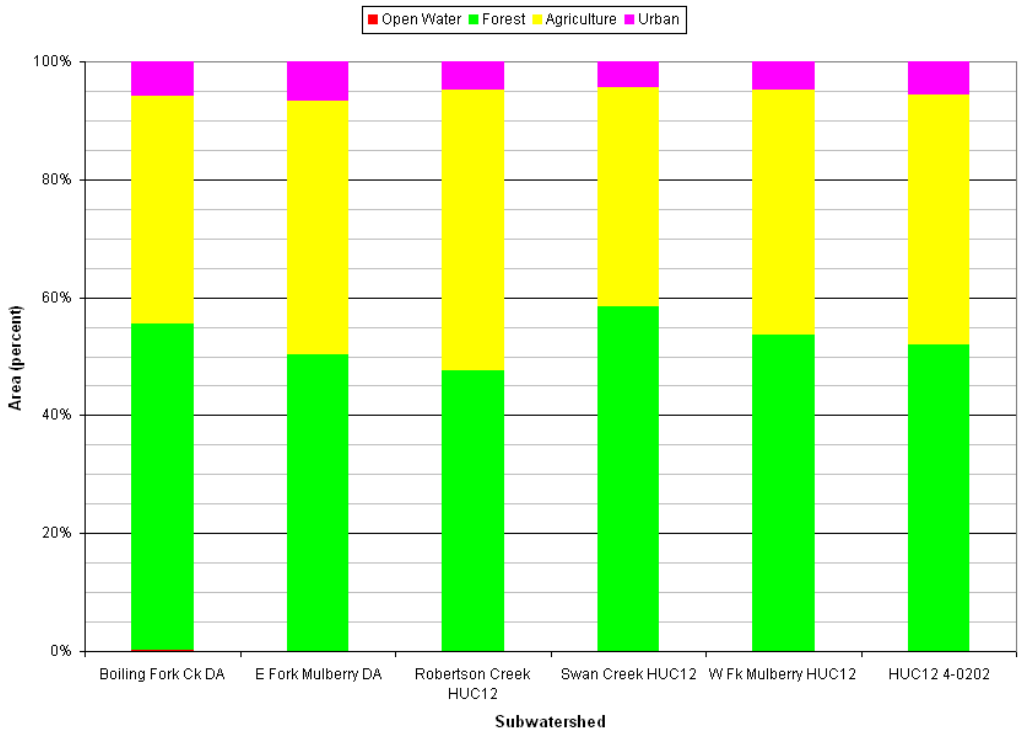

Figure 11. Land Use Percent of the Elk River E. coli-Impaired Subwatershed (greater than 20,000 acres & less than 60,000 acres)

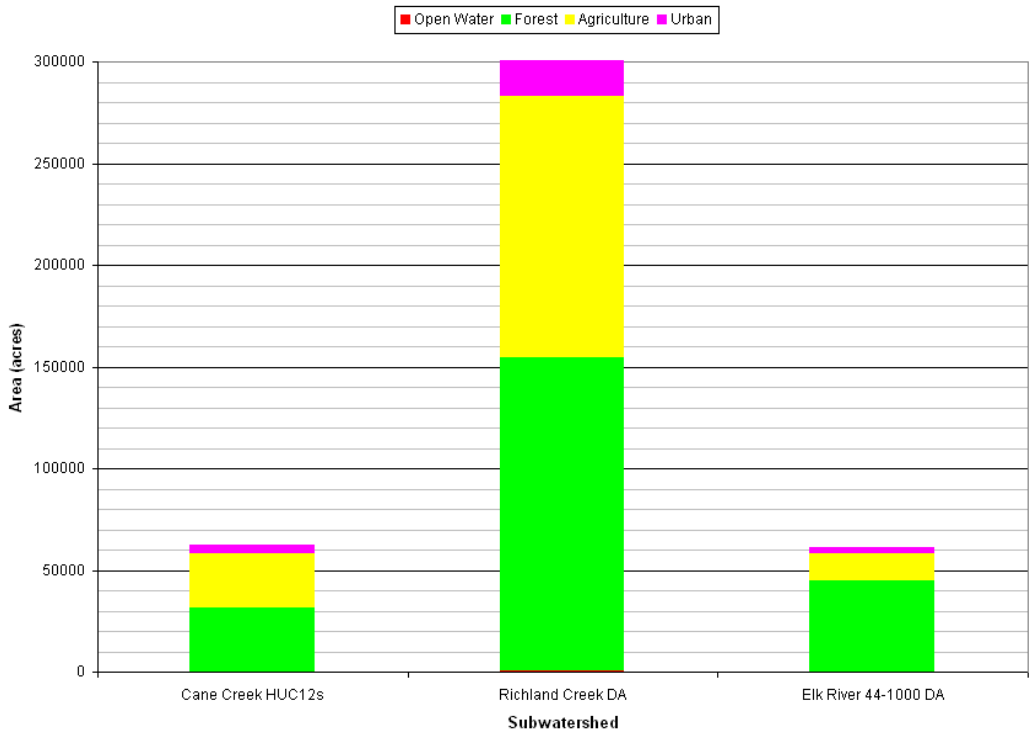

Figure 12. Land Use Area of Elk River E. coli-Impaired Subwatersheds (greater than 60,000 acres)

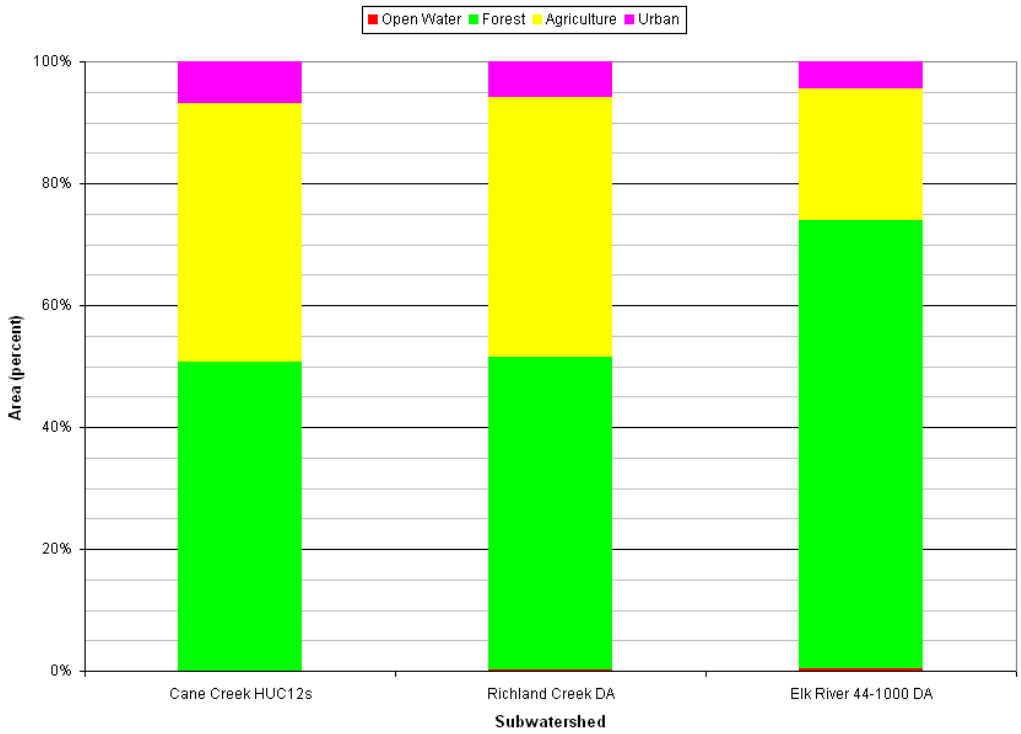

Figure 13. Land Use Percent of the Elk River E. coli-Impaired Subwatershed (greater than 60,000 acres)

8.0 DEVELOPMENT OF TOTAL MAXIMUM DAILY LOADS

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

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

The objective of a TMDL is to allocate loads among all of the known pollutant sources throughout a watershed so that appropriate control measures can be implemented and water quality standards achieved. 40 CFR §130.2 (i) (http://www.epa.gov/epacfr40/chapt-I.info/chi-toc.htm) 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), Load Allocation (LA), and Margin of Safety (MOS) development for waterbodies identified as impaired due to E. coli on the Draft 2012 303(d) list.

8.1 Expression of TMDLs, WLAs, & LAs

In this document, the E. coli TMDL is a daily load expressed as a function of mean daily flow (daily loading function). For implementation purposes, corresponding percent load reduction goals (PLRGs) to decrease E. coli loads to TMDL target levels, within each respective flow zone, are also expressed. WLAs & LAs for precipitation-induced loading sources are also expressed as daily loading functions in CFU/day/acre. Allocations for loading that is independent of precipitation (WLAs for WWTPs and LAs for “other direct sources”) are expressed as CFU/day.

8.2 Area Basis for TMDL Analysis

The primary area unit of analysis for TMDL development was the HUC-12 subwatershed containing one or more waterbodies assessed as impaired due to E. coli (as documented on the Draft 2012 303(d) List). In some cases, however, TMDLs may be developed for an impaired waterbody drainage area only. Determination of the appropriate area to use for analysis (see Table 8) was based on a careful consideration of a number of relevant factors, including: 1) location of impaired waterbodies in the HUC-12 subwatershed; 2) land use type and distribution; 3) water quality monitoring data; and 4) the assessment status of other waterbodies in the HUC-12 subwatershed.

8.3 TMDL Analysis Methodology

TMDLs for the Elk 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 zone 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 daily loading functions were expressed for TMDLs, WLAs, LAs, and MOS. In addition, load reductions (PLRGs) for each flow zone were calculated for prioritization of implementation measures according to the methods described in Appendix E.

Table 8 Determination of Analysis Areas for TMDL Development

HUC8	HUC-12 Subwatershed	Impaired Waterbody	Area
06030003	Multiple	Elk River (044-1000)	DA
	0103	Caldwell Creek	DA
		Gilliam Creek	DA
		Juanita Creek	DA
		Trussel Creek	DA
	0202	Betsy Willis Creek	HUC-12
	0205	Yellow Branch	DA
	0302	Boiling Fork Creek	DA
		Wagner Creek	DA
	0402	Blue Creek	DA
	0501	West Fork Mulberry Creek	HUC-12
	0502	East Fork Mulberry Creek	DA
	Multiple	Elk River (010-1000)	DA
	0801/0802	Cane Creek	HUC-12
	0902	Swan Creek	HUC-12
06030004	0201	Corn Creek	DA
		Town Creek	DA
		Coffey Branch	DA
	0202	Robertson Fork Creek	HUC-12
	0204	UT to Weakley Creek	DA
	0207	Pleasant Run Creek	DA
	Multiple	Richland Creek (017-2000)	DA
	Multiple	Richland Creek (043-1000)	DA
	Multiple	Elk River (013-1000)	DA

Note: HUC-12 = HUC-12 Subwatershed
DA = Waterbody Drainage Area

8.4 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, 2001 to December 31, 2010 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 all subwatersheds, water quality data have been collected during most flow ranges. For each Subwatershed, the critical flow zone has been identified based on the incremental levels of impairment relative to the target loads. Based on the location of the water quality exceedances on the load duration curves and the distribution of critical flow zones, no one delivery mode for E. coli appears to be dominant for waterbodies in the Elk River Watershed (see Section 9.1.2 and 9.1.3).

Seasonal variation was incorporated in the load duration curves by using the entire simulation period and all water quality data collected at the monitoring stations. Some water quality data were collected during all seasons. Most water quality data were collected during periods of mid-range to low flows.

8.5 Margin of Safety

There are two methods for incorporating MOS in TMDL 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 pathogen TMDLs in the Elk 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 (lakes, reservoirs, State Scenic Rivers, or Exceptional Tennessee Waters waterbodies):	MOS = 49 CFU/100 ml
Instantaneous Maximum (all other waterbodies):	MOS = 94 CFU/100 ml
30-Day Geometric Mean:	MOS = 13 CFU/100 ml

8.6 Determination of TMDLs

E. coli daily loading functions were calculated for impaired segments in the Elk River Watershed using LDCs to evaluate compliance with the single maximum target concentrations according to the procedure in Appendix C. These TMDL loading functions for impaired segments and subwatersheds are shown in Table 9.

8.7 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 available loading <u>after application of the explicit MOS</u>. WLAs for existing WWTPs are equal to their existing NPDES permit limits. Since WWTP permit limits require that E. coli concentrations must comply with water quality criteria (TMDL targets) at the point of discharge (with few exceptions in Tennessee) and recognition that loading from these facilities are 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 9.

Table 9. Summary of TMDLs, WLAs, & LAs expressed as daily loads for Impaired Waterbodies in the Elk River Watershed (HUC 06030003 & 06030004)

HUC-12 Subwatershed (06030003 & 06030004__) or Drainage Area (DA)	Impaired Waterbody Name	Impaired Waterbody ID	TMDL	MOS	WLAs			LAs [c]
					WWTPs [a]	Collection Systems	MS4s [b,c]	
			[CFU/day]	[CFU/day]	[CFU/day]	[CFU/day]	[CFU/d/ac]	[CFU/d/ac]
Elk River DA (Multiple HUC12s)	Elk River	TN06030003044 – 1000	$1.20 \times 10^{10} \times Q$	$1.20 \times 10^{9} \times Q$	1.888×10^{10}	0	NA	$(1.772 \times 10^{5} \times Q) - (3.098 \times 10^{5})$
Caldwell Creek DA	Caldwell Creek	TN06030003044 – 0700	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	1.781×10^{10}	0	NA	$(1.607 \times 10^{6} \times Q) - (1.383 \times 10^{6})$
	Gilliam Creek	TN06030003044 – 0720						
	Juanita Creek	TN06030003044 – 0721						
	Trussel Creek	TN06030003044 – 0730						
0202	Betsy Willis Creek	TN06030003044 – 0100	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	NA	$2.436 \times 10^{6} \times Q$
Yellow Branch DA	Yellow Branch	TN06030003041 – 0100	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	NA	$6.208 \times 10^{6} \times Q$
0302 DAs	Boiling Fork Creek	TN06030003030 – 1000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	1.425×10^{10}	0	NA	$(8.548 \times 10^{5} \times Q) - (5.885 \times 10^{5})$
	Wagner Creek	TN06030003032 – 1000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	4.769×10^{9}	0	NA	$(2.247 \times 10^{6} \times Q) - (5.177 \times 10^{5})$
Blue Creek DA	Blue Creek	TN06030003053 – 0100	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	0	$4.947 \times 10^{6} \times Q$	$4.947 \times 10^{6} \times Q$
0501	West Fork Mulberry Creek	TN06030003056 – 0100	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	0	NA	$7.399 \times 10^{5} \times Q$
East Fork Mulberry Creek DA	East Fork Mulberry Creek	TN06030003056 – 0250	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	1.069×10^{10}	0	NA	$(8.180 \times 10^{5} \times Q) - (4.224 \times 10^{5})$
Elk River DA (Multiple HUC12s)	Elk River	TN06030003010 – 1000	$1.20 \times 10^{10} \times Q$	$1.20 \times 10^{9} \times Q$	4.915×10^{11}	0	NA	$(2.057 \times 10^{4} \times Q) - (9.362 \times 10^{5})$
0801+0802	Cane Creek	TN06030003060 – 1000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	NA	$3.327 \times 10^{5} \times Q$
0902	Swan Creek	TN06030003063 – 1000 + TN06030003063 – 2000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	2.564×10^{8}	0	NA	$(6.598 \times 10^{5} \times Q) - (8.173 \times 10^{3})$
0201 DAs	Corn Creek	TN06030004043 – 0300	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	NA	$6.785 \times 10^{6} \times Q$
	Town Creek	TN06030004043 – 0400	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	3.562×10^{9}	0	NA	$(5.200 \times 10^{6} \times Q) - (8.948 \times 10^{5})$
	Coffey Branch	TN06030004043 – 0600	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	NA	$1.079 \times 10^{7} \times Q$
0202	Robertson Fork Creek	TN06030004023 – 1000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	5.699×10^{9}	0	NA	$(6.168 \times 10^{5} \times Q) - (1.698 \times 10^{4})$

Table 9 (cont'd). Summary of TMDLs, WLAs, & LAs expressed as daily loads for Impaired Waterbodies in the Elk River Watershed (HUC 06030003 & 06030004)

HUC-12 Subwatershed (06030003 & 06030004__) or Drainage Area (DA)	Impaired Waterbody Name	Impaired Waterbody ID	TMDL	MOS	WLAs			LAs [c]
					WWTPs [a]	Collection Systems	MS4s [b,c]	
			[CFU/day]	[CFU/day]	[CFU/day]	[CFU/day]	[CFU/d/ac]	[CFU/d/ac]
Pleasant Run DA	Pleasant Run Creek	TN06030004017 – 0800	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	NA	$2.261 \times 10^{7} \times Q$
Richland Creek DA (Multiple HUC12s)	Richland Creek	TN06030004017 – 2000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	1.466×10^{11}	0	NA	$(6.889 \times 10^{4} \times Q) - (4.879 \times 10^{5})$
Richland Creek DA (Multiple HUC12s)	Richland Creek	TN06030004043 – 1000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	4.132×10^{9}	0	NA	$(1.101 \times 10^{5} \times Q) - (2.198 \times 10^{4})$
Weakley Creek DA	UT to Weakley Creek	TN06030004029 – 0410	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	NA	$5.986 \times 10^{7} \times Q$
Elk River DA (Multiple HUC12s)	Elk River	TN06030004013 – 1000	$1.20 \times 10^{10} \times Q$	$1.20 \times 10^{9} \times Q$	6.393×10^{11}	NA	NA	$(9.349 \times 10^{3} \times Q) - (5.534 \times 10^{5})$

Notes: NA = Not Applicable.
Q = Mean Daily In-stream Flow (cfs).

a. WLAs for WWTPs are expressed as E. coli loads (CFU/day). All current and future WWTPs must meet water quality standards as specified in their NPDES permit.

b. Applies to any MS4 discharge loading in the subwatershed. Future MS4s will be assigned waste load allocations (WLAs) consistent with load allocations (LAs) assigned to precipitation induced nonpoint sources.

c. WLAs and LAs expressed as a "per acre" load are calculated based on the drainage area at the pour point of the HUC-12 or drainage area (see Table A-1).

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 Elk 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.

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.

9.1 Application of Load Duration Curves for Implementation Planning

The Load Duration Curve (LDC) methodology (Appendix C) is a form of water quality analysis and presentation of data that aids in guiding implementation by targeting management strategies for 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 source problems. The load duration curve analysis can be utilized for implementation planning. See Cleland (2003) for further information on duration curves and TMDL development, and: http://www.tmdls.net/tipstools/docs/TMDLsCleland.pdf .

9.1.1 Flow Zone Analysis for Implementation Planning

A major advantage of the duration curve framework in TMDL development is the ability to provide meaningful connections between allocations and implementation efforts (USEPA, 2006). Because the flow duration interval serves as a general indicator of hydrologic condition (i.e., wet versus dry and to what degree), allocations and reduction goals can be linked to source areas, delivery mechanisms, and the appropriate set of management practices. The use of duration curve zones (e.g., high flow, moist, mid-range, dry, and low flow) allows the development of allocation tables (USEPA, 2006) (Appendix E), which can be used to guide potential implementation actions to most effectively address water quality concerns.

For the purposes of implementation strategy development, available E. coli data are grouped according to flow zones, with the number of flow zones determined by the HUC-12 subwatershed or drainage area size, the total contributing area (for non-headwater HUC-12s), and/or the baseflow characteristics of the waterbody. In general, for drainage areas greater than 40 square miles, the duration curves will be divided into five zones (Figure 14): 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%). For smaller drainage areas, flows occurring in the low flow zone (baseflow conditions) are often extremely low and difficult to measure accurately. In many small drainage areas, extreme dry conditions are characterized by zero flow for a significant percentage of time. For this reason, the low flow zone is best characterized as a broader range of conditions (or percent time) with subsequently fewer flow zones. Therefore, for most HUC-12 subwatershed drainage areas less than 40 square miles, the duration curves will be divided into four zones: high flows (exceeded 0-10% of the time), moist conditions (10-40%), median or mid-range flows (40-70%), and

low flows (70-100%). Some small (<40 mi^2) waterbody drainage areas have sustained baseflow (no zero flows) throughout their period of record. For these waterbodies, the duration curves will be divided into five zones.

Given adequate data, results (allocations and percent load reduction goals) will be calculated for all flow zones; however, less emphasis is placed on the upper 10% flow range for pathogen (E. coli) TMDLs and implementation plans. The highest 10 percent flows, representing flood conditions, are considered non-recreational conditions: unsafe for wading and swimming. Humans are not expected to enter the water due to the inherent hazard from high depths and velocities during these flow conditions. As a rule of thumb, the *USGS Field Manual for the Collection of Water Quality Data* (Lane, 1997) advises its personnel not to attempt to wade a stream for which values of depth (ft) multiplied by velocity (ft/s) equal or exceed 10 ft^2/s to collect a water sample. Few observations are typically available to estimate loads under these adverse conditions due to the difficulty and danger of sample collection. Therefore, in general, the 0-10% flow range is beyond the scope of pathogen TMDLs and subsequent implementation strategies.

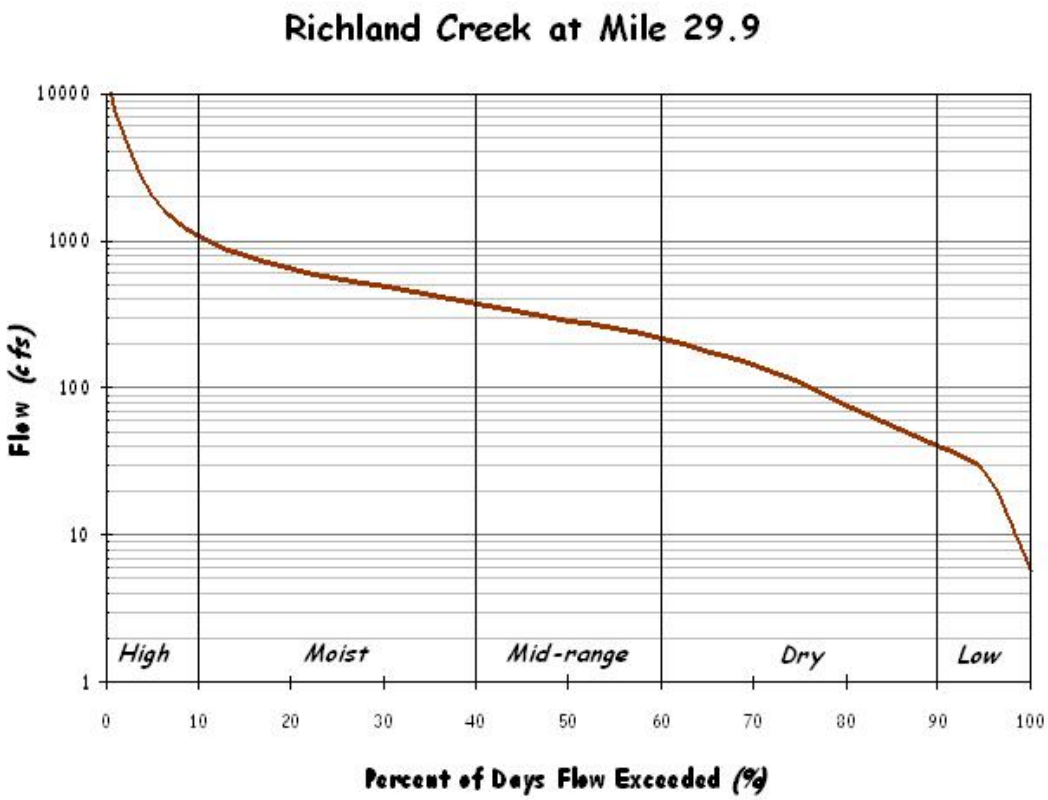

Figure 14. Five-Zone Flow Duration Curve for Richland Creek at RM 29.9

9.1.2 Existing Loads and Percent Load Reductions

Each impaired waterbody has a characteristic set of pollutant sources and existing loading conditions that vary according to flow conditions. In addition, maximum allowable loading (assimilative capacity) of a waterbody varies with flow. Therefore, existing loading, allowable loading, and percent load reduction expressed at a single location on the LDC (for a single flow condition) do not appropriately represent the TMDL in order to address all sources under all flow conditions (i.e., at all times) to satisfy implementation objectives. The LDC approach provides a methodology for determination of assimilative capacity and existing loading conditions of a waterbody for each flow zone. Subsequently, each flow zone, and the sources contributing to impairment under the corresponding flow conditions, can be evaluated independently. Lastly, the critical flow zone (with the highest percent load reduction goal) and/or the highest percent of samples exceeding the TMDL target can be identified for prioritization of implementation actions.

Existing loading is calculated for each individual water quality sample as the product of the sample flow (cfs) times the single sample E. coli concentration (times a conversion factor). A percent load reduction is calculated for each water quality sample as that required to reduce the existing loading to the product of the sample flow (cfs) times the single sample maximum water quality standard (times a conversion factor). For samples with negative percent load reductions (non-exceedance: concentration below the single sample maximum water quality criterion), the percent reduction is assumed to be zero. The percent load reduction goal (PLRG) for a given flow zone is calculated as the mean of all the percent load reductions for a given flow zone. (See Appendix E.)

9.1.3 Critical Conditions

The critical condition for each impaired waterbody is defined as the flow zone with the largest PLRG and/or percent exceedance, excluding the “high flow” zone because these extremely high flows are not representative of recreational flow conditions, as described in Section 9.1.1. If the PLRG and/or percent exceedance in this zone is greater than all the other zones, the zone with the second highest PLRG and/or percent exceedance will be considered the critical flow zone. The critical conditions are such that if water quality standards were met under those conditions, they would likely be met overall.

9.2 Point Sources

9.2.1 NPDES Regulated Municipal and Industrial Wastewater Treatment Plants

All present and future discharges from industrial and municipal wastewater treatment plants are required to be in compliance with the conditions of their NPDES permits at all times, including elimination of bypasses and overflows. With few exceptions, 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 WWTPs are derived from facility design flows and permitted E. coli limits and are expressed as average loads in CFU per day.

9.2.2 NPDES Regulated Municipal Separate Storm Sewer Systems (MS4s)

For present and future regulated discharges from municipal separate storm sewer systems (MS4s), WLAs are and will be implemented through Phase I & II MS4 permits. These permits will require the development and implementation of a Storm Water Management Program (SWMP) that will reduce the discharge of pollutants to the "maximum extent practicable" and not cause or contribute to violations of State water quality standards. Both the *NPDES General Permit for Discharges from Small Municipal Separate Storm Sewer Systems* (TDEC, 2010) and the TDOT individual MS4 permit (TNS077585) require SWMPs to include minimum control measures. 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.

For guidance on the six minimum control measures for MS4s regulated under Phase I or Phase II, a series of fact sheets are available at: http://cfpub1.epa.gov/npdes/stormwater/swfinal.cfm?program_id=6 .

For further information on Tennessee's *NPDES General Permit for Discharges from Small Municipal Separate Storm Sewer Systems*, see: http://state.tn.us/environment/wpc/ppo/TN%20Small%20MS4%20Modified%General%20Permit%202003.pdf .

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 (e.g., monthly) in receiving waterbodies, both upstream and downstream of MS4 discharges, over an extended period of time. In addition, intensive collection of pollutant monitoring data during the recreation season (June – September) at sufficient frequency to support calculation of the geometric mean.

When applicable, the appropriate Division of Water Resources 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 TMDLs or designation as a regulated MS4. Details of the monitoring plans and monitoring data should be included in annual reports required by MS4 permits.

9.2.3 NPDES Regulated Concentrated Animal Feeding Operations (CAFOs)

WLAs provided to most CAFOs will be implemented through the appropriate CAFO State Operating Permit or the facility's individual permit. Provisions of the SOP include development and implementation of Nutrient Management Plan (NMPs) and requirements for CAFO liquid waste management systems. For further information, see: http://state.tn.us/environment/wpc/permits/cafo.shtml.

9.3 Nonpoint Sources

The Tennessee Department of Environment & Conservation has no direct regulatory authority over most nonpoint source (NPS) discharges. Reductions of E. coli loading from nonpoint sources 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. 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.

Local citizen-led and implemented management measures have the potential to provide the most efficient and comprehensive avenue for reduction of loading rates from nonpoint sources. An excellent example of stakeholder involvement and action is described in the *Big Rock Creek Watershed Final Management Plan*, March 2003 (NCDRP, 2003), prepared by the Center for Watershed Protection for The Nature Conservancy, Duck River Project. The development of this plan was funded, in part, under an agreement with the Tennessee Department of Agriculture, Nonpoint Source Program and a U.S. Environmental Protection Agency Assistance Agreement (#C9994674-01-0). This plan was based on an extensive evaluation of stream conditions, various investigations and analyses, and usage surveys of conservation practices in the Big Rock Creek Subwatershed. The plan establishes Subwatershed goals and recommendations to meet these goals. A number of restoration projects are identified and prioritized and plan implementation is divided into three phases for implementation. To read about The Nature Conservancy's Duck River Project, please visit them at:

http://nature.org/wherewework/northamerica/states/tennessee/preserves/art10169.html

9.3.1 Urban Nonpoint Sources

Management measures to reduce pathogen loading from urban nonpoint sources are similar to those recommended for MS4s (Sect. 9.2.2). Specific categories of urban nonpoint sources include stormwater, illicit discharges, septic systems, pet waste, and wildlife.

Stormwater: Most mitigation measures for stormwater are not designed specifically to reduce bacteria concentrations (ENSR, 2005). Instead, BMPs are typically designed to remove sediment and other pollutants. Bacteria in stormwater runoff are, however, often attached to particulate matter. Therefore, treatment systems that remove sediment may also provide reductions in bacteria concentrations.

Illicit discharges: Removal of illicit discharges to storm sewer systems, particularly of sanitary wastes, is an effective means of reducing pathogen loading to receiving waters (ENSR, 2005). These include intentional illegal connections from commercial or residential buildings, failing septic systems, and improper disposal of sewage from campers and boats.

Septic systems: When properly installed, operated, and maintained, septic systems effectively reduce pathogen concentrations in sewage. To reduce the release of pathogens, practices can be employed to maximize the life of existing systems, identify failed systems, and replace or remove failed systems (USEPA, 2005a). Alternatively, the installation of public sewers may be appropriate.

Pet waste: If the waste is not properly disposed of, these bacteria can wash into storm drains or directly into water bodies and contribute to pathogen impairment. Encouraging pet owners to

properly collect and dispose of pet waste is the primary means for reducing the impact of pet waste (USEPA, 2002b).

Wildlife: Reducing the impact of wildlife on pathogen concentrations in waterbodies generally requires either reducing the concentration of wildlife in an area or reducing their proximity to the waterbody (ENSR, 2005). The primary means for doing this is to eliminate human inducements for congregation. In addition, in some instances population control measures may be appropriate.

Two additional urban nonpoint source resource documents provided by EPA are:

National Management Measures to Control Nonpoint Source Pollution from Urban Areas (http://www.epa.gov/owow/nps/urbanmm/index.html) helps citizens and municipalities in urban areas protect bodies of water from polluted runoff that can result from everyday activities. The scientifically sound techniques it presents are among the best practices known today. The guidance will also help states to implement their nonpoint source control programs and municipalities to implement their Phase II Storm Water Permit Programs (Publication Number EPA 841-B-05-004, November 2005).

The Use of Best Management Practices (BMPs) in Urban Watersheds (http://www.epa.gov/nrmrl/pubs/600r04184/600r04184chap1.pdf) is a comprehensive literature review on commonly used urban watershed Best Management Practices (BMPs) that heretofore was not consolidated. The purpose of this document is to serve as an information source to individuals and agencies/municipalities/watershed management groups/etc. on the existing state of BMPs in urban stormwater management (Publication Number EPA/600/R-04/184, September 2004).

9.3.2 Agricultural Nonpoint Sources

BMPs have been utilized in the Elk River Watershed to reduce the amount of coliform bacteria transported to surface waters from agricultural sources. These BMPs (e.g., animal waste management systems, waste utilization, stream stabilization, fencing, heavy use area treatment, livestock exclusion, etc.) may have contributed to reductions in in-stream concentrations of coliform bacteria in one or more Elk River Watershed E. coli-impaired subwatersheds during the TMDL evaluation period. The Natural Resources Conservation Service (NRCS) keeps a database of BMPs implemented in Tennessee. Those listed in the Elk River Watershed are shown in Figure 15. It is recommended that additional information (e.g., livestock access to streams, manure application practices, etc.) be provided and evaluated to better identify and quantify agricultural sources of coliform bacteria loading in order to minimize uncertainty in future modeling efforts.

It is further recommended that 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.

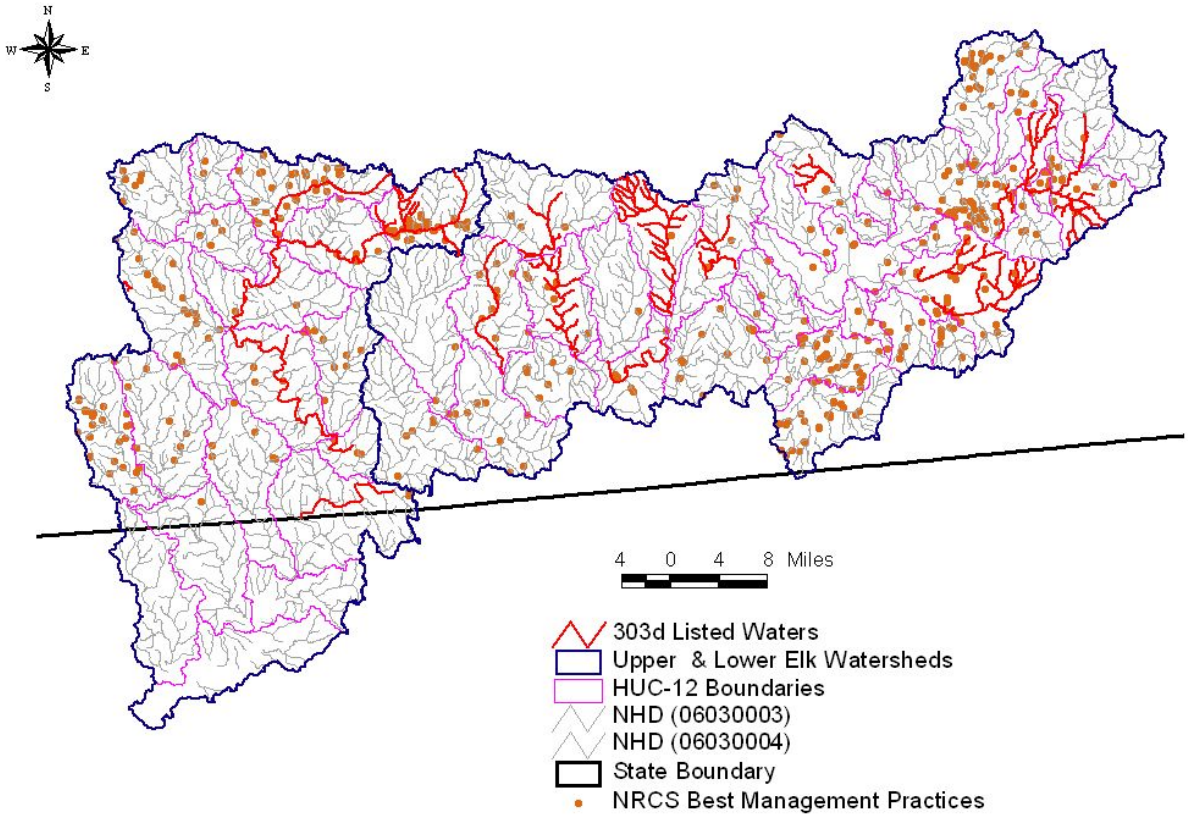

Figure 15. NRCS Best Management Practices located in the Elk River Watershed.

For additional information on agricultural BMPs in Tennessee, see: http://state.tn.us/agriculture/nps/bmpa.ntml .

An additional agricultural nonpoint source resource provided by EPA is *National Management Measures to Control Nonpoint Source Pollution from Agriculture* (http://www.epa.gov/owow/nps/agmm/index.html): a technical guidance and reference document for use by State, local, and tribal managers in the implementation of nonpoint source pollution management programs. It contains information on the best available, economically achievable means of reducing pollution of surface and groundwater from agriculture (EPA 841-B-03-004, July 2003).

9.3.3 Other Nonpoint Sources

Additional nonpoint source references (not specifically addressing urban and/or agricultural sources) provided by EPA include:

National Management Measures to Control Nonpoint Source Pollution from Forestry (http://www.epa.gov/owow/nps/forestrymgmt/) helps forest owners protect lakes and streams from polluted runoff that can result from forestry activities. These scientifically sound techniques are the best practices known today. The report will also help states to implement their nonpoint source control programs (EPA 841-B-05-001, May 2005).

In addition, the EPA website, http://www.epa.gov/owow/nps/bestnpsdocs.html , contains a list of guidance documents endorsed by the Nonpoint Source Control Branch at EPA headquarters. The list includes documents addressing urban, agriculture, forestry, marinas, stream restoration, nonpoint source monitoring, and funding.

9.4 Additional Monitoring

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 in-stream water quality targets for E. coli.

9.4.1 Water Quality Monitoring

Activities recommended for the Elk River Watershed:

> Evaluate the effectiveness of implementation measures (see Sect. 9.6). Includes BMP performance analysis and monitoring by permittees and stakeholders. Where required TMDL loading reduction has been fully achieved, adequate data to support delisting should be collected.
>
> Provide additional data to clarify status of ambiguous sites (e.g., geometric mean data) for potential listing. Analyses of existing data at several monitoring sites on unlisted waterbodies in the Elk River Watershed suggest levels of impairment. Therefore, additional data are required for listing determination.
>
> Continue ambient (long-term) monitoring at appropriate sites and key locations.

Comprehensive water quality monitoring activities include sampling during all seasons and a broad 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, 2011), 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, 2004).

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

The USEPA has published a fact sheet that discusses BST methods and presents examples of BST application to TMDL development and implementation (USEPA, 2002b). Various BST projects and descriptions of the application of BST techniques used to guide implementation of effective BMPs to remove or reduce fecal contamination are presented. The fact sheet can be found on the following EPA website: http://water.epa.gov/scitech/wastetech/upload/2002_10_15_mtb_bacsortk.pdf.

A multi-disciplinary group of researchers at the University of Tennessee, Knoxville (UTK) has developed and tested a series of different microbial assay methods based on real-time PCR to detect fecal bacterial concentrations and host sources in water samples (Layton, 2006). 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/JournalPapers/Layton06AEM.pdf . BST technology was utilized in a study conducted in Stock Creek (Little River watershed) (Layton, 2004). Microbial source tracking using real-time PCR assays to quantify *Bacteroides* 16S rRNA genes was used to determine the percent of fecal contamination attributable to cattle. E. coli loads attributable to cattle were calculated for each of nine sampling sites in the Stock Creek subwatershed on twelve sampling dates. At the site on High Bluff Branch (tributary to Stock Creek), none of the sample dates had E. coli loads attributable to cattle above the threshold. This suggests that at this site removal of E. coli attributable to cattle would have little impact on the total E. coli loads. The E. coli load attributable to cattle made a large contribution to the total E. coli load at each of the eight remaining sampling sites. At two of the sites (STOCK005.3KN and GHOLL000.6KN), 50–75% of the E. coli attributable to cattle loads alone was above the 126 CFU/100mL threshhold. This suggests that removal of the E. coli attributable to cattle at these sites would reduce the total E. coli load to acceptable limits.

9.5 Source Area Implementation Strategy

Implementation strategies are organized according to the dominant landuse type and the sources associated with each (Table 10 and Appendix E). Each HUC-12 subwatershed is grouped and targeted for implementation based on this source area organization. Three primary categories are identified: predominantly urban, predominantly agricultural, and mixed urban/agricultural. See Appendix A for information regarding landuse distribution of impaired subwatersheds. For the purpose of implementation evaluation, urban is defined as residential, commercial, and industrial landuse areas with predominant source categories such as point sources (WWTPs), collection systems/septic systems (including SSOs and CSOs), and urban stormwater runoff associated with MS4s. Agricultural is defined as cropland and pasture, with predominant source categories associated with livestock and manure management activities. A fourth category (infrequent) is associated with forested (including non-agricultural undeveloped and unaltered [by humans]) landuse areas with the predominant source category being wildlife.

All impaired waterbodies and corresponding HUC-12 subwatersheds or drainage areas have been classified according to their respective source area types in Table 10. The implementation for each area will be prioritized according to the guidance provided in Sections 9.5.1 and 9.5.2, below. For all impaired waterbodies, the determination of source area types serves to identify the predominant sources contributing to impairment (i.e., those that should be targeted initially for implementation). However, it is not intended to imply that sources in other landuse areas are not contributors to impairment and/or to grant an exemption from addressing other source area contributions with implementation strategies and corresponding load reduction. For mixed use areas, implementation will follow the guidance established for both urban and agricultural areas, at a minimum.

Appendix E provides source area implementation examples for urban and agricultural subwatersheds, development of percent load reduction goals, and determination of critical flow zones (for implementation prioritization) for E. coli impaired waterbodies. Load duration curve analyses (TMDLs, WLAs, LAs, and MOS) and percent load reduction goals for all flow zones for all E. coli impaired waterbodies in the Elk River Watershed are summarized in Table E-56.

Table 10. Source area types for waterbody drainage area analyses.

HUC-12 / Waterbody Name	Source Area Type*			
	Urban	Agricultural	Mixed	Forested
Betsy Willis Creek		ò		
Blue Creek	ò			
Boiling Fork Creek			ò	
Caldwell Creek			ò	
Cane Creek			ò	
E Fork Mulberry Creek			ò	
Elk River (010-1000)		ò		
Elk River (044-1000)			ò	
Gilliam Creek		ò		
Juanita Creek		ò		
Swan Creek (063-1000)			ò	
Swan Creek (063-2000)			ò	
Trussel Creek		ò		
Wagner Creek		ò		
W Fork Mulberry Creek			ò	
Yellow Branch		ò		
Coffey Branch			ò	
Corn Creek			ò	
Elk River (013-1000)		ò		
Pleasant Run Creek		ò		
Richland Creek (017-2000)			ò	
Richland Creek (043-1000)			ò	
Robertson Fork Creek			ò	
Town Creek			ò	
UT to Wet Weakley Creek		ò		

* All waterbodies potentially have significant source contributions from other source type/landuse areas.

9.5.1 Urban Source Areas

For impaired waterbodies and corresponding HUC-12 subwatersheds or drainage areas classified as predominantly urban, implementation strategies for E. coli load reduction will initially and primarily target source categories similar to those listed in Table 11 (USEPA, 2006). Table 11 presents example urban area management practices and the corresponding potential relative effectiveness under each of the hydrologic flow zones. Each implementation strategy addresses a range of flow conditions and targets point sources, non-point sources, or a combination of each. For each waterbody, the existing loads and corresponding PLRG for each flow zone are calculated according to the method described in Section E.4. The resulting determination of the critical flow zone further focuses the types of urban management practices appropriate for development of an effective load reduction strategy for a particular waterbody.

Table 11. Example Urban Area Management Practice/Hydrologic Flow Zone Considerations.

Management Practice	Duration Curve Zone (Flow Zone)				
	High	**Moist**	**Mid-Range**	**Dry**	**Low**
Bacteria source reduction					
Remove illicit discharges			L	M	H
Address pet & wildlife waste		H	M	M	L
Combined sewer overflow management					
Combined sewer separation		H	M	L	
CSO prevention practices		H	M	L	
Sanitary sewer system					
Infiltration/Inflow mitigation	H	M	L	L	
Inspection, maintenance, and repair		L	M	H	H
SSO repair/abatement	H	M	L		
Illegal cross-connections					
Septic system management					
Managing private systems		L	M	H	M
Replacing failed systems		L	M	H	M
Installing public sewers		L	M	H	M
Storm water infiltration/retention					
Infiltration basin		L	M	H	
Infiltration trench		L	M	H	
Infiltration/Biofilter swale		L	M	H	
Storm Water detention					
Created wetland		H	M	L	

Table 11 (cont'd). Example Urban Area Management Practice/Hydrologic Flow Zone Considerations.

Management Practice	Duration Curve Zone (Flow Zone)				
	High	**Moist**	**Mid-Range**	**Dry**	**Low**
Low impact development					
Disconnecting impervious areas		L	M	H	
Bioretention	L	M	H	H	
Pervious pavement		L	M	H	
Green Roof		L	M	H	
Buffers		H	H	H	
New/existing on-site wastewater treatment systems					
Permitting & installation programs		L	M	H	M
Operation & maintenance programs		L	M	H	M
Other					
Point source controls		L	M	H	H
Landfill control		L	M	H	
Riparian buffers		H	H	H	
Pet waste education & ordinances		M	H	H	L
Wildlife management		M	H	H	L
Inspection & maintenance of BMPs	L	M	H	H	L
Note: Potential relative importance of management practice effectiveness under given hydrologic condition (*H: High, M: Medium, L: Low*)					

9.5.2 Agricultural Source Areas

For impaired waterbodies and corresponding HUC-12 subwatersheds or drainage areas classified as predominantly agricultural, implementation strategies for E. coli load reduction will initially and primarily target source categories similar to those listed in Table 12 (USDA, 1988). Table 12 present example agricultural area management practices and the corresponding potential relative effectiveness under each of the hydrologic flow zones. Each implementation strategy addresses a range of flow conditions and targets point sources, non-point sources, or a combination of each. For each waterbody, the existing loads and corresponding PLRG for each flow zone are calculated according to the method described in Section E.4. The resulting determination of the critical flow zone further focuses the types of agricultural management practices appropriate for development of an effective load reduction strategy for a particular waterbody.

Table 12. Example Agricultural Area Management Practice/Hydrologic Flow Zone Considerations.

Flow Condition	High	Moist	Mid-range	Dry	Low
% Time Flow Exceeded	0-10	10-40	40-60	60-90	90-100
Grazing Management					
Prescribed Grazing (528A)	H	H	M	L	
Pasture & Hayland Mgmt (510)	H	H	M	L	
Deferred Grazing (352)	H	H	M	L	
Planned Grazing System (556)	H	H	M	L	
Proper Grazing Use (528)	H	H	M	L	
Proper Woodland Grazing (530)	H	H	M	L	
Livestock Access Limitation					
Livestock Exclusion (472)			M	H	H
Fencing (382)			M	H	H
Stream Crossing			M	H	H
Alternate Water Supply					
Pipeline (516)			M	H	H
Pond (378)			M	H	H
Trough or Tank (614)			M	H	H
Well (642)			M	H	H
Spring Development (574)			M	H	H
Manure Management					
Managing Barnyards	H	H	M	L	
Manure Transfer (634)	H	H	M	L	
Land Application of Manure	H	H	M	L	
Composting Facility (317)	H	H	M	L	
Vegetative Stabilization					
Pasture & Hayland Planting (512)	H	H	M	L	
Range Seeding (550)	H	H	M	L	
Channel Vegetation (322)	H	H	M	L	
Brush (& Weed) Mgmt (314)	H	H	M	L	

Table 12 (cont'd). Example Agricultural Area Management Practice/Hydrologic Flow Zone Considerations.

Flow Condition	High	Moist	Mid-range	Dry	Low
% Time Flow Exceeded	0-10	10-40	40-60	60-90	90-100
Vegetative Stabilization (cont'd)					
Conservation Cover (327)		H	H	H	
Riparian Buffers (391)		H	H	H	
Critical Area Planting (342)		H	H	H	
Wetland restoration (657)		H	H	H	
CAFO Management					
Waste Management System (312)	H	H	M		
Waste Storage Structure (313)	H	H	M		
Waste Storage Pond (425)	H	H	M		
Waste Treatment Lagoon (359)	H	H	M		
Mulching (484)	H	H	M		
Waste Utilization (633)	H	H	M		
Water & Sediment Control Basin (638)	H	H	M		
Filter Strip (393)	H	H	M		
Sediment Basin (350)	H	H	M		
Grassed Waterway (412)	H	H	M		
Diversion (362)	H	H	M		
Heavy Use Area Protection (561)					
Constructed Wetland (656)					
Dikes (356)	H	H	M		
Lined Waterway or Outlet (468)	H	H	M		
Roof Runoff Mgmt (558)	H	H	M		
Floodwater Diversion (400)	H	H	M		
Terrace (600)	H	H	M		
Potential for source area contribution under given hydrologic condition (H: High; M: Medium; L: Low)					

Note: Numbers in parentheses are the U.S. Soil Conservation Service practice number.

9.5.3 Forestry Source Areas

There are no impaired waterbodies with corresponding HUC-12 subwatersheds or drainage areas classified as source area type predominantly forested, with the predominant source category being wildlife, in the Elk River Watershed.

9.6 Evaluation of TMDL Implementation Effectiveness

Evaluation of the effectiveness of TMDL implementation strategies should be conducted on multiple levels, as appropriate:

- HUC-12 or waterbody drainage area (i.e., TMDL analysis location)
- Subwatersheds or intermediate sampling locations
- Specific landuse areas (urban, pasture, etc.)
- Specific facilities (WWTP, CAFO, uniquely identified portion of MS4, etc.)
- Individual BMPs

In order to conduct an implementation effectiveness analysis on measures to reduce E. coli source loading, monitoring results should be evaluated in one of several ways. Sampling results can be compared to water quality standards (e.g., load duration curve analysis) for determination of impairment status, results can be compared on a before and after basis (temporal), or results can be evaluated both upstream and downstream of source reduction measures or source input (spatial). Considerations include period of record, data collection frequency, representativeness of data, and sampling locations.

In general, periods of record greater than 5 years (given adequate sampling frequency) can be evaluated for determination of relative change (trend analysis). For watersheds in second or successive TMDL cycles, data collected from multiple cycles can be compared. If implementation efforts have been initiated to reduce loading, evaluation of routine monitoring data may indicate improving or worsening conditions over time and corresponding effectiveness of implementation efforts.

Water quality data for implementation effectiveness analysis can be presented in multiple ways. For example, Figure 16 shows best fit curve analyses (regressions) of flow (percent time exceeded) versus fecal coliform loading, for a historical (2002) TMDL analysis period versus a more recent post-implementation period of sampling data (revised TMDL), for Oostanaula Creek at mile 28.4 (Hiwassee River watershed). The LDC of the single sample maximum water quality standard is also plotted to illustrate the relative degree of impairment for each period. Figure 17 shows a LDC analysis of fecal coliform loading statistics for Oostanaula Creek for the same two periods. In addition, the 90th percentiles for each flow zone are plotted for comparison. Lastly, Figure 18 shows fecal coliform concentration data statistics for recent versus historical data. The individual flow zone analyses are presented in a box and whisker plot of recent [2] versus historical [1] data. Note that Figures 16-18 present the same data, from approved TMDLs (2 cycles), each clearly illustrating improving conditions between historical and recent periods.

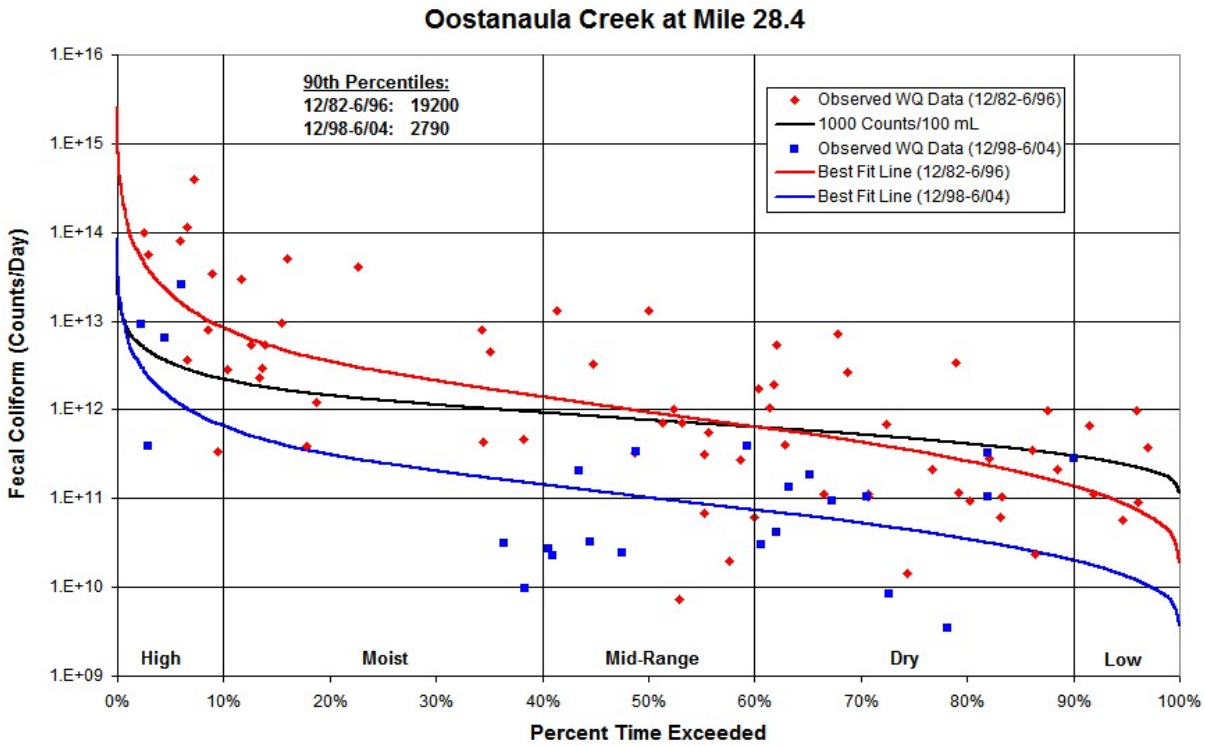

Figure 16. Example Graph of TMDL implementation effectiveness (LDC regression analysis).

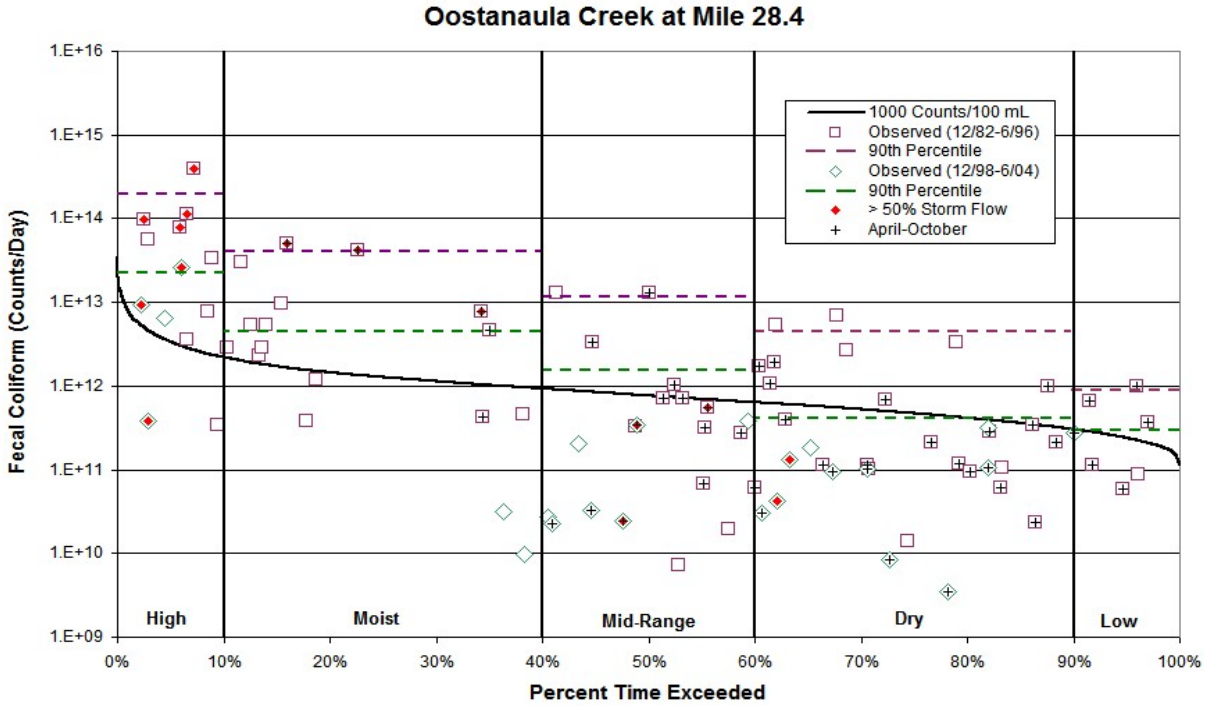

Figure 17. Example Graph of TMDL implementation effectiveness (LDC analysis).

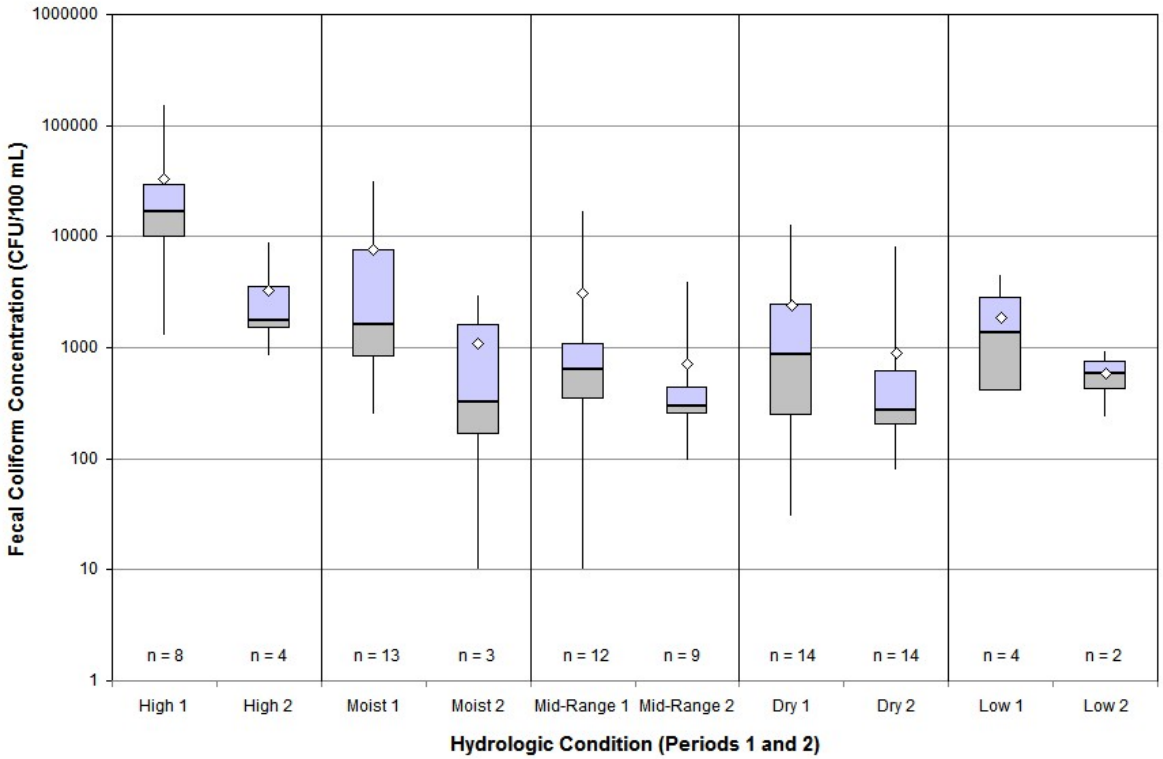

Figure 18. Example Graph of TMDL implementation effectiveness (box and whisker plot).

10.0 PUBLIC PARTICIPATION

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

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

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

3) Letters were sent to WWTPs located in E. coli-impaired subwatersheds or drainage areas in the Elk River Watershed, permitted to discharge treated effluent containing pathogens, advising them of the proposed TMDLs and their availability on the TDEC website. The letters also stated that a copy of the draft TMDL document would be provided on request. A letter was sent to the following facilities:

   Cornersville STP (TN0061841)
   Cowan STP (TN0021644)
   Decherd Water Works STP (TN0020508)
   Elkton STP (TN0076007)
   Fayetteville STP (TN0021814)
   Lynchburg STP (TN0025101)
   Monteagle STP, Plant #3 (TN0080985)
   Pelham Industrial Park (TN0078697)
   Pulaski STP (TN0021687)
   Richland School (TN0054810)
   TDOT I-65 Welcome Center – Giles County (TN0074331)
   Tullahoma STP (TN0023469)
   Unity School (TN0065498)
   University of Tennessee Space Institute (TN0067202)
   Winchester STP (TN0021857)

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

   City of Tullahoma, Tennessee (TNS077631)
   Tennessee Dept. of Transportation (TNS077585)

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

Natural Resources Conservation Service
Tennessee Department of Agriculture
Tennessee Wildlife Resources Agency
The Nature Conservancy

No comments were received during the public notice period.

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 Resources staff:

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APPENDIX A

Land Use Distribution in the Elk River Watershed

Table A-1 2001 MRLC Land Use Distribution of Impaired HUC-12s & Drainage Areas

Land Use	Impaired Subwatershed (06030003 & 06030004____)					
	Elk River (044-1000) DA (in 0101-0103+0205)		Caldwell Creek DA (in 0103)		0202 (Betsy Willis Creek)	
	[acres]	[%]	[acres]	[%]	[acres]	[%]
Unclassified	0.0	0.00	0.0	0.00	0.0	0.00
Open Water	201.2	0.33	56.7	0.44	43.3	0.51
Developed Open Space	2,090.7	3.43	799.6	6.21	253.2	2.98
Low Intensity Development	566.9	0.93	256.2	1.99	137.7	1.62
Medium Intensity Development	67.1	0.11	29.6	0.23	13.6	0.16
High Intensity Development	6.1	0.01	1.3	0.01	0.8	0.01
Bare Rock	18.3	0.03	3.9	0.03	54.4	0.64
Deciduous Forest	38,424.9	63.04	8,335.1	64.73	3,379.4	39.77
Evergreen Forest	1,792.0	2.94	390.2	3.03	22.9	0.27
Mixed Forest	1,920.0	3.15	490.6	3.81	210.7	2.48
Shrub/Scrub	1,273.9	2.09	293.6	2.28	52.7	0.62
Grassland/Herbaceous	591.3	0.97	82.4	0.64	85.8	1.01
Pasture/Hay	9,210.0	15.11	1,495.0	11.61	1,843.1	21.69
Row Crops	4,016.8	6.59	535.7	4.16	2,311.3	27.20
Woody Wetlands	768.0	1.26	100.4	0.78	84.1	0.99
Emergent Herbaceous Wetland	18.3	0.03	5.2	0.04	1.7	0.02
Subtotal – Urban	2,731	4.48	1,086.8	8.44	405.3	4.77
Subtotal - Agriculture	13,227	21.70	2,030.7	15.77	4,154.3	48.89
Subtotal – Forest	44,807	73.51	9,701.3	75.34	3,891.7	45.80
Total	**60,965**	**100.0**	**12,876**	**100.00**	**8,495**	**100.00**

Table A-1 (cont'd) 2001 MRLC Land Use Distribution of Impaired HUC-12s & Drainage Areas

Land Use	Impaired Subwatershed (06030003 & 06030004____)					
	Yellow Branch DA (in 0205)		Boiling Fork Creek DA (in 0303)		Wagner Creek DA (in 0303)	
	[acres]	[%]	[acres]	[%]	[acres]	[%]
Unclassified	0.0	0.00	0.0	0.00	0.0	0.00
Open Water	0.0	0.00	81.8	0.24	1.8	0.02
Developed Open Space	162.4	4.86	1,380.4	4.05	435.7	4.73
Low Intensity Development	63.8	1.91	538.5	1.58	249.6	2.71
Medium Intensity Development	9.7	0.29	81.8	0.24	47.0	0.51
High Intensity Development	0.0	0.00	20.5	0.06	36.8	0.40
Bare Rock	1.7	0.05	88.6	0.26	21.2	0.23
Deciduous Forest	559.2	16.73	16,510.1	48.44	2,250.4	24.43
Evergreen Forest	9.0	0.27	235.2	0.69	60.8	0.66
Mixed Forest	58.2	1.74	937.3	2.75	281.0	3.05
Shrub/Scrub	28.4	0.85	439.7	1.29	101.3	1.10
Grassland/Herbaceous	57.8	1.73	524.9	1.54	256.1	2.78
Pasture/Hay	1,450.7	43.40	8,139.2	23.88	3,213.9	34.89
Row Crops	928.6	27.78	5,003.5	14.68	1,933.5	20.99
Woody Wetlands	13.0	0.39	95.4	0.28	323.3	3.51
Emergent Herbaceous Wetland	0.0	0.00	3.4	0.01	0.0	0.00
Subtotal – Urban	236.0	7.06	2,021.2	5.93	769.2	8.35
Subtotal - Agriculture	2,379.2	71.18	13,142.6	38.56	5,147.5	55.88
Subtotal – Forest	727.3	21.76	18,834.6	55.26	3,294.1	35.76
Total	**3,343**	**100.0**	**34,080**	**100.00**	**9,213**	**100.00**

Table A-1 (cont'd) 2001 MRLC Land Use Distribution of Impaired HUC-12s & Drainage Areas

Land Use	Impaired Subwatershed (06030003 & 06030004____)					
	Blue Creek DA (in 0402)		0501 (W Fork Mulberry Creek)		E Fork Mulberry Creek DA (in 0502)	
	[acres]	[%]	[acres]	[%]	[acres]	[%]
Unclassified	0.0	0.00	0.0	0.00	0.0	0.00
Open Water	0.0	0.00	2.8	0.01	2.5	0.01
Developed Open Space	481.4	11.51	1,284.2	4.59	1,323.9	5.23
Low Intensity Development	226.7	5.42	39.2	0.14	222.8	0.88
Medium Intensity Development	2.1	0.05	16.8	0.06	121.5	0.48
High Intensity Development	0.0	0.00	2.8	0.01	32.9	0.13
Bare Rock	0.0	0.00	2.8	0.01	55.7	0.22
Deciduous Forest	1,219.6	29.16	11,552.1	41.29	9,965.9	39.37
Evergreen Forest	13.4	0.32	1,194.7	4.27	607.5	2.40
Mixed Forest	34.3	0.82	724.6	2.59	410.1	1.62
Shrub/Scrub	139.3	3.33	1,233.8	4.41	1,334.0	5.27
Grassland/Herbaceous	36.4	0.87	277.0	0.99	359.5	1.42
Pasture/Hay	1,271.5	30.40	11,333.9	40.51	10,489.9	41.44
Row Crops	533.3	12.75	302.2	1.08	369.6	1.46
Woody Wetlands	224.6	5.37	8.4	0.03	20.3	0.08
Emergent Herbaceous Wetland	0.0	0.00	2.8	0.01	0.0	0.00
Subtotal – Urban	710.2	16.98	1,342.9	4.80	1,701.1	6.72
Subtotal - Agriculture	1,804.8	43.15	11,636.0	41.59	10,859.5	42.90
Subtotal – Forest	1,667.6	39.87	14,996.2	53.60	12,752.9	50.38
Total	**4,183**	**100.00**	**27,978**	**100.0**	**25,316**	**100.00**

Table A-1 (cont'd) 2001 MRLC Land Use Distribution of Impaired HUC-12s & Drainage Areas

Land Use	Impaired Subwatershed (06030003 & 06030004____)					
	0801+0802 (Cane Creek)		0902 (Swan Creek)		Richland Creek DA (0101-0208)	
	[acres]	[%]	[acres]	[%]	[acres]	[%]
Unclassified	0.0	0.00	0.0	0.00	0.0	0.00
Open Water	31.1	0.05	31.4	0.10	420.7	0.14
Developed Open Space	3,316.5	5.33	1,157.7	3.69	14,783.6	4.92
Low Intensity Development	678.2	1.09	91.0	0.29	2,073.3	0.69
Medium Intensity Development	255.1	0.41	97.3	0.31	540.9	0.18
High Intensity Development	56.0	0.09	9.4	0.03	150.2	0.05
Bare Rock	31.1	0.05	0.0	0.00	150.2	0.05
Deciduous Forest	22,767.2	36.59	12,763.1	40.68	127,734.3	42.51
Evergreen Forest	3,185.8	5.12	2,183.7	6.96	5,739.2	1.91
Mixed Forest	2,930.7	4.71	2,199.3	7.01	8,443.5	2.81
Shrub/Scrub	2,096.9	3.37	865.9	2.76	6,851.0	2.28
Grassland/Herbaceous	504.0	0.81	310.6	0.99	4,116.6	1.37
Pasture/Hay	24,459.6	39.31	10,839.9	34.55	115,594.9	38.47
Row Crops	1,879.1	3.02	809.5	2.58	12,890.6	4.29
Woody Wetlands	43.6	0.07	15.7	0.05	1,021.6	0.34
Emergent Herbaceous Wetland	0.0	0.00	0.0	0.00	30.0	0.01
Subtotal – Urban	4,305.8	6.92	1,355.4	4.32	17,548	5.84
Subtotal - Agriculture	26,338.7	42.33	11,649.3	37.13	128,486	42.76
Subtotal – Forest	31,559.2	50.72	18,338.3	58.45	154,086	51.28
Total	**62,235**	**100.00**	**31,374**	**100.0**	**300,541**	**100.00**

Table A-1 (cont'd) 2001 MRLC Land Use Distribution of Impaired HUC-12s & Drainage Areas

Land Use	Impaired Subwatershed (06030003 & 06030004____)					
	0201 (Corn, Coffey, & Town Creeks)		0202 (Robertson Creek)		Wet Weakley Creek DA (in 0204)	
	[acres]	[%]	[acres]	[%]	[acres]	[%]
Unclassified	0.0	0.00	0.0	0.00	0.0	0.00
Open Water	3.1	0.01	13.4	0.04	0.0	0.00
Developed Open Space	1,605.2	5.26	1,530.2	4.56	145.5	3.90
Low Intensity Development	112.9	0.37	80.5	0.24	0.7	0.02
Medium Intensity Development	27.5	0.09	13.4	0.04	0.0	0.00
High Intensity Development	6.1	0.02	6.7	0.02	0.0	0.00
Bare Rock	3.1	0.01	0.0	0.00	0.0	0.00
Deciduous Forest	13,342.0	43.72	14,268.7	42.52	2,410.5	64.62
Evergreen Forest	708.0	2.32	288.6	0.86	25.0	0.67
Mixed Forest	1,190.2	3.90	597.3	1.78	7.1	0.19
Shrub/Scrub	372.3	1.22	365.8	1.09	44.8	1.20
Grassland/Herbaceous	238.0	0.78	392.6	1.17	32.1	0.86
Pasture/Hay	12,014.5	39.37	14,218.4	42.37	904.9	24.26
Row Crops	891.1	2.92	1,741.6	5.19	158.5	4.25
Woody Wetlands	3.1	0.01	36.9	0.11	1.1	0.03
Emergent Herbaceous Wetland	0.0	0.00	0.0	0.00	0.0	0.00
Subtotal – Urban	1,751.7	5.74	1,630.9	4.86	146.2	3.92
Subtotal - Agriculture	12,905.6	42.29	15,960.0	47.56	1,063.5	28.51
Subtotal – Forest	15,856.6	51.96	15,950.0	47.53	2,520.5	67.57
Total	**30,517**	**100.00**	**33,554**	**100.0**	**3,730**	**100.00**

APPENDIX B

Water Quality Monitoring Data For Elk River Watersheds

There are a number of water quality monitoring stations that provide data for waterbodies identified as impaired for pathogens in the Elk River Watersheds. The location of these monitoring stations is shown in Figure 5. Monitoring data recorded by TDEC at these stations are tabulated in Tables B-1 (Upper Elk) and B-2 (Lower Elk).

Table B-1. Monitoring Data for Upper Elk River Watershed

Monitoring Station	Date	E. Coli [cts./100 mL]
BFORK010.1FR	8/29/02	91
	9/5/02	110
	10/29/02	2400
	11/12/02	490
	12/12/02	290
	2/24/03	920
	3/12/03	330
	4/1/03	360
	5/20/03	260
	6/24/03	460
BFORK013.4FR	10/20/09	579.4
	10/22/09	145
	10/29/09	461.1
	11/2/09	307.6
BFORK014.6FR	8/29/02	120
	9/5/02	72
	10/29/02	2400
	11/12/02	820
	12/12/02	260
	2/24/03	44
	3/12/03	62
	4/1/03	140
	5/20/03	550
	6/24/03	2000
BLUE000.1FR	10/20/09	365.4
	10/22/09	1203.3
	10/29/09	307.6
	11/2/09	218.7
	11/9/09	185

Table B-1 (cont'd). Monitoring Data for Upper Elk River Watershed

Monitoring Station	Date	E. Coli [cts./100 mL]
BWILL000.2CE	10/20/09	517.2
	10/22/09	770.1
	10/29/09	1046.2
	11/2/09	920.8
	11/9/09	770.1
CALDW001.1GY	10/20/09	270
	10/22/09	387.3
	10/29/09	307.6
	11/2/09	435.2
	11/9/09	185
CANE006.6LI	8/7/02	180
	9/10/02	91
	10/7/02	1700
	11/7/02	1200
	12/3/02	120
	1/6/03	210
	2/12/03	52
	3/10/03	100
	4/16/03	870
	5/20/03	2000
CANE008.1LI	7/25/07	199
	10/21/09	102
	10/22/09	105
	10/29/09	218
	11/2/09	687
	11/5/09	228
EFMUL006.2MR	8/14/02	1100
	9/12/02	650
	10/23/02	490
	11/13/02	380
	12/4/02	380
	1/14/03	59
	2/26/03	190
	3/11/03	72

Table B-1 (cont'd). Monitoring Data for Upper Elk River Watershed

Monitoring Station	Date	E. Coli [cts./100 mL]
EFMUL006.2MR (cont'd)	4/8/03	1600
	5/22/03	1300
	6/25/03	170
EFMUL010.2MR	8/8/06	470
	8/24/06	1100
	7/26/07	179
	7/26/07	1120
	10/21/09	435
	10/22/09	313
	10/29/09	365
	11/2/09	488
	11/5/09	261
EFMUL014.1MR	8/14/02	420
	9/12/02	250
	10/23/02	650
	11/13/02	330
	12/4/02	240
	1/14/03	160
	2/26/03	1100
	3/11/03	70
	4/8/03	1100
	5/22/03	770
	6/25/03	1300
	8/24/06	270
ELK093.9LI	8/7/02	190
	9/10/02	180
	10/7/02	2400
	11/7/02	1200
	12/3/02	86
	1/6/03	40
	2/12/03	32
	3/10/03	20
	5/20/03	580
	6/16/03	100
	7/25/07	86

Table B-1 (cont'd). Monitoring Data for Upper Elk River Watershed

Monitoring Station	Date	E. Coli [cts./100 mL]
ELK093.9LI (cont'd)	10/21/09	75
	10/22/09	299
	10/29/09	122
	11/2/09	260
	11/5/09	107
ELK187.4FR	9/5/02	88
	10/29/02	2400
	11/12/02	870
	12/12/02	1100
	2/24/03	19
	3/12/03	96
	4/1/03	96
	5/20/03	690
	6/24/03	290
ELK195.3GY	10/20/09	248.1
	10/22/09	325.5
	10/29/09	360.9
	11/2/09	461.1
	11/9/09	186
GILLI1.3T1.8GY	7/12/07	133.4
	7/17/07	2419.2
	7/18/07	2419.2
	7/19/07	2419.2
	8/2/07	50.4
	8/7/07	20.1
	9/5/07	461.1
	10/1/07	1986.28
	12/3/07	325.5
	2/9/08	43.7
	2/11/08	29.2
	3/3/08	6.3
	5/14/08	40.4
	6/9/08	191.8

Table B-1 (cont'd). Monitoring Data for Upper Elk River Watershed

Monitoring Station	Date	E. Coli [cts./100 mL]
SWAN000.8LI	7/25/07	219
	11/3/09	613
	11/4/09	326
	11/5/09	365
	11/16/09	113
	11/19/09	137
SWAN008.2LI	8/7/02	2400
	10/7/02	2400
	11/7/02	1200
	12/3/02	150
	1/6/03	200
	2/12/03	20
	3/10/03	250
	4/16/03	290
	5/20/03	1100
	6/16/03	2400
	11/3/09	687
	11/4/09	488
	11/5/09	261
	11/16/09	770
	11/19/09	921
TRUSS1.7T0.7GY	7/18/07	106.7
	8/7/07	119.1
	9/5/07	29.8
	10/1/07	4.1
	11/7/07	387.3
	12/3/07	218.7
	1/7/08	8.4
	2/9/08	107.6
	2/11/08	52.9
	3/3/08	10.7
	6/9/08	2419.6
WAGNE001.4FR	10/29/02	2400
	11/12/02	1200
	12/12/02	730

Table B-1 (cont'd). Monitoring Data for Upper Elk River Watershed

Monitoring Station	Date	E. Coli [cts./100 mL]
WAGNE001.4FR (cont'd)	2/24/03	770
	3/12/03	870
	4/1/03	870
	5/20/03	1100
WAGNE001.9FR	10/20/09	387.3
	10/22/09	290.9
	11/2/09	980.4
WAGNE002.4FR	10/20/09	517.2
	10/22/09	325.5
	10/29/09	2419.6
	11/2/09	920.8
	11/9/09	2419.6
WFMUL001.4LI	8/14/02	39
	9/12/02	2000
	10/23/02	280
	11/13/02	690
	12/4/02	120
	1/14/03	39
	3/11/03	150
	4/8/03	1200
	5/22/03	1000
	6/25/03	390
	7/26/07	126
	10/21/09	201
	10/22/09	291
	10/29/09	435
	11/2/09	365
	11/5/09	150
YELLO000.8FR	10/20/09	298.7
	10/22/09	1299.7
	10/29/09	365.4
	11/2/09	325.5
	11/9/09	648.8

Table B-2. Monitoring Data for Lower Elk River Watershed

Monitoring Station	Date	E. Coli [cts./100 mL]
COFFE000.2ML	10/19/08	1120
	10/27/08	649
	11/4/08	921
	11/3/09	291
	11/4/09	261
	11/5/09	649
	11/16/09	687
	11/19/09	1120
CORN000.4ML	10/23/08	2420
	10/27/08	2420
	10/29/08	1733
	11/3/09	2420
	11/4/09	2420
	11/5/09	2420
	11/16/09	2420
	11/19/09	1986
ELK036.5GS	7/24/07	57
	10/20/09	166
	10/21/09	219
	10/22/09	108
	10/26/09	276
	10/28/09	308
PRUN000.1GS	10/9/07	649
	10/10/07	579
	10/17/07	225
	10/29/07	816
	10/22/08	107
	11/4/08	27
	11/5/08	78
	11/18/08	178
	11/19/08	13
RFORK005.5GS	7/30/02	730
	9/30/02	770
	10/22/02	650
	11/14/02	1100
	12/17/02	150

Table B-2 (cont'd). Monitoring Data for Lower Elk River Watershed

Monitoring Station	Date	E. Coli [cts./100 mL]
RFORK005.5GS (cont'd)	1/8/03	290
	2/20/03	520
	3/3/03	52
	4/2/03	440
	5/5/03	2400
	6/10/03	1600
	10/22/08	770
	10/27/08	980
	10/29/08	1203
RICHL018.3GS	10/2/02	200
	10/23/02	170
	11/20/02	190
	12/30/02	200
	1/27/03	4
	2/13/03	61
	3/12/03	46
	4/29/03	110
	5/22/03	2400
	6/25/03	310
RICHL025.7GS	10/22/08	20
	10/27/08	105
	10/29/08	99
	10/20/09	276
	10/21/09	126
	10/22/09	135
	10/26/09	103
	10/28/09	770
RICHL029.9GS	10/2/02	350
	10/23/02	170
	12/30/02	800
	1/27/03	10
	2/13/03	36
	3/12/03	57
	4/29/03	150
	5/22/03	2000
	7/24/07	199

Table B-2 (cont'd). Monitoring Data for Lower Elk River Watershed

Monitoring Station	Date	E. Coli [cts./100 mL]
RICHL029.9GS (cont'd)	10/20/09	248
	10/21/09	155
	10/22/09	219
	10/26/09	167
	10/28/09	488
RICHL055.5GS	7/30/02	490
	9/30/02	2000
	10/22/02	2400
	11/14/02	820
	12/17/02	1200
	1/8/03	440
	2/20/03	980
	4/2/03	920
	5/5/03	2400
	6/10/03	1200
	10/23/08	145
	10/27/08	345
	10/29/08	219
	11/3/09	1414
	11/4/09	613
	11/5/09	613
	11/16/09	517
	11/19/09	461
TOWN000.8ML	7/30/02	460
	9/30/02	730
	10/22/02	160
	11/14/02	1700
	12/17/02	140
	1/8/03	170
	2/20/03	280
	3/3/03	9
	5/5/03	2400
	6/10/03	440
	10/23/08	162
	10/27/08	138
	10/29/08	166

APPENDIX C

Load Duration Curve Development and Determination of Daily Loading

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

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

The objective of a TMDL is to allocate loads among all of the known pollutant sources throughout a watershed so that appropriate control measures can be implemented and water quality standards achieved. 40 CFR §130.2 (i) (http://www.epa.gov/epacfr40/chapt-I.info/chi-toc.htm) 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 and drainage areas in the Elk River Watershed using Load Duration Curves (LDCs). Daily loads for TMDLs, WLAs, and LAs are expressed as a function of daily mean in-stream flow (daily loading function).

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 an extended 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 (http://waterdata.usgs.gov/tn/nwis/sw) 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 Windows version of Hydrologic Simulation Program - Fortran (WinHSPF).

Flow duration curves for impaired waterbodies in the Elk River Watershed were derived from WinHSPF hydrologic simulations based on parameters derived from calibrations at several USGS gaging stations (see Appendix D for details of calibration). For example, a flow-duration curve for Richland Creek was constructed using simulated daily mean flow for the period from 1/1/01 through 12/31/10 (RM 29.9 corresponds to the location of monitoring stations RICHL029.9GS). 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 TMDLs

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 Elk 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 (Richland Creek at RM29.9 is shown as an example):

1. A target load-duration curve (LDC) was generated for Richland Creek 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 D.1) and plotting the results. The E. coli target maximum load corresponding to each ranked daily mean flow is:

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

   where: Target Load = TMDL (CFU/day)
   Q = daily instream mean flow
   UCF = the required unit conversion factor

   TMDL = (2.30×10^{10}) x (Q) CFU/day

2. Daily loads were calculated for each of the water quality samples collected at monitoring station RICHL029.9GS (ref.: Table B-1) by multiplying the sample concentration by the daily mean flow for the sampling date and the required unit conversion factor. RICHL029.9GS was selected for LDC analysis because it has a longer period of record 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 – 10/20/09 sampling event:
   Modelled Flow = 675.9 cfs
   Concentration = 248 CFU/100 mL
   Daily Load = 4.10×10^{12} CFU/day

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 is shown in Figure C-2.

LDCs of other impaired waterbodies were derived in a similar manner and are shown in Appendix E.

C.2 Development of WLAs & 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:

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

Expanding the terms:

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

For E. coli TMDLs in each impaired subwatershed or drainage area, WLA terms include:

- $[\sum WLAs]_{WWTP}$ is the allowable load associated with discharges of NPDES permitted WWTPs located in impaired subwatersheds or drainage areas. Since NPDES permits for these facilities specify that treated wastewater must meet in-stream water quality standards at the point of discharge, no additional load reduction is required. WLAs for WWTPs are calculated from the facility design flow and the Monthly Average permit limit.
- $[\sum WLAs]_{CAFO}$ is the allowable load for all CAFOs in an impaired subwatershed or drainage area. 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.
- $[\sum WLAs]_{MS4}$ is the allowable E. coli load for discharges from MS4s. E. coli loading from MS4s is the result of buildup/wash-off processes associated with storm events.

LA terms include:

- $[\sum LAs]_{DS}$ 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).
- $[\sum LAs]_{SW}$ represents the allowable 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 $[\sum WLAs]_{CAFO} = 0$ and $[\sum LAs]_{DS} = 0$, the expression relating TMDLs to precipitation-based point and nonpoint sources may be simplified to:

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

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 percent load reductions necessary to achieve and WLAs and LAs:

Instantaneous Maximum (lake, reservoir, State Scenic River, Exceptional Tennessee Waters):

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 Daily Load Calculation

Since WWTPs discharge must comply with instream water quality criteria (TMDL target) at the point of discharge, WLAs for WWTPs are expressed as a constant term. In addition, WLAs for MS4s and LAs for precipitation-based nonpoint sources are equal on a per unit area basis and may be expressed as the daily allowable load per unit area (acre) resulting from a decrease in in-stream E. coli concentrations to TMDL target values minus MOS:

$$WLA[MS4] = LA = \{TMDL - MOS - WLA[WWTPs]\} / DA$$

where: DA = waterbody drainage area (acres)

Using Richland Creek as an example:

$$TMDL_{Richland\ Creek} = (941\ CFU/100\ mL) \times (Q) \times (UCF)$$

$$= 2.30 \times 10^{10} \times Q$$

$MOS_{Richland\ Creek}$ = TMDL x 0.10 = 2.30×10^9 x Q

MOS = (2.30×10^9) x (Q) CFU/day

$WLA[MS4]_{Richland\ Creek}$ = $LA_{Richland\ Creek}$

= {TMDL – MOS – WLA[WWTPs]} / DA

= {(2.30×10^{10} x Q) – (2.30×10^9 x Q) – (1.466×10^{11})} / (3.005×10^5)

WLA[MS4] = LA = [6.889×10^4 x Q] – [4.879×10^5]

TMDLs, WLAs, & LAs for other impaired subwatersheds and drainage areas were derived in a similar manner and are summarized in Table C-1.

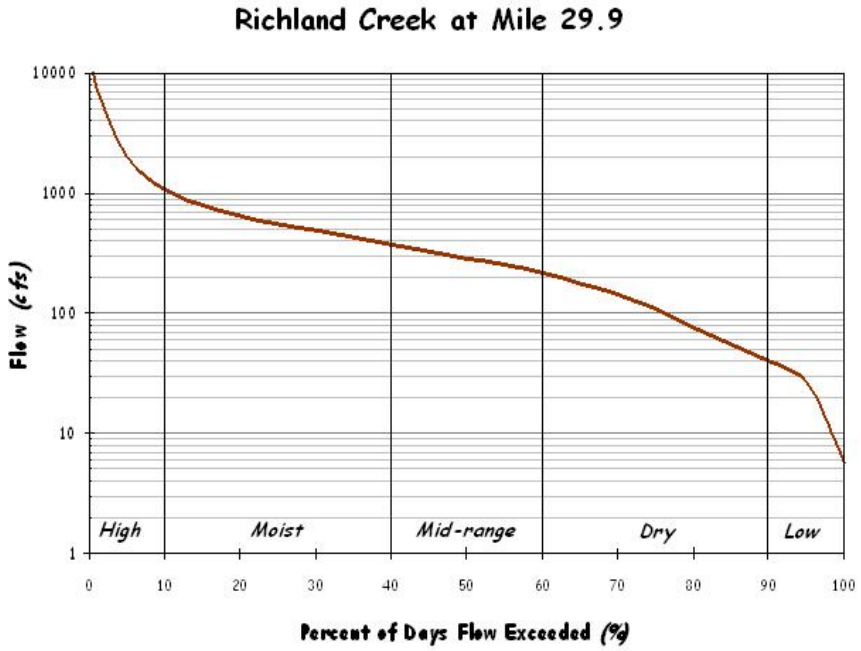

Figure C-1. Flow Duration Curve for Richland Creek at Mile 29.9

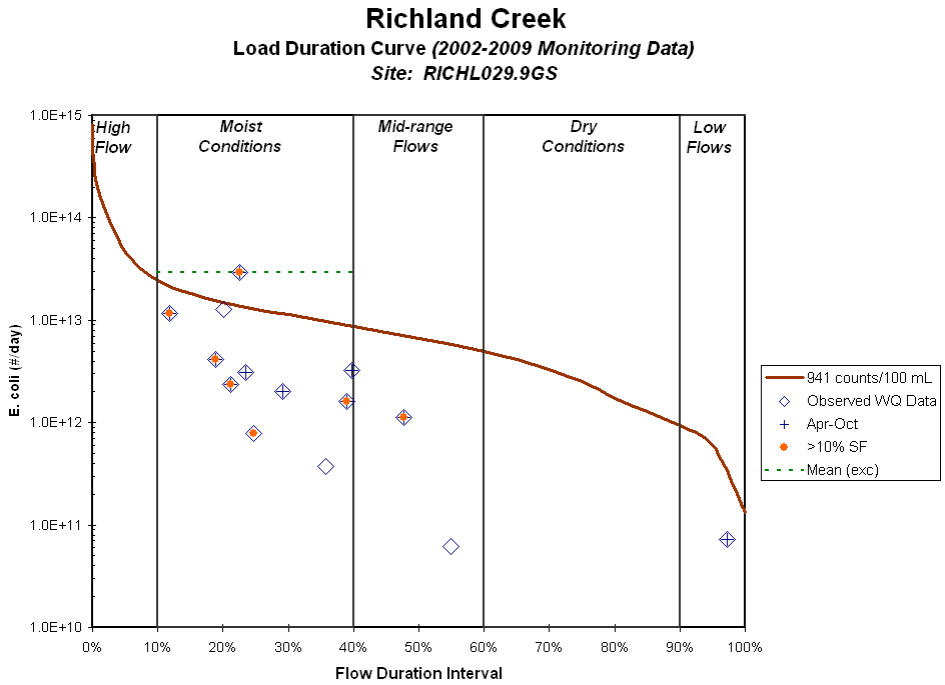

Figure C-2. E. Coli Load Duration Curve for Richland Creek at Mile 29.9

Table C-1. TMDLs, WLAs, & LAs for Impaired Waterbodies in the Elk River Watershed (HUC 06030003 & 06030004)

HUC-12 Subwatershed (06030003 & 06030004__) or Drainage Area (DA)	Impaired Waterbody Name	Impaired Waterbody ID	TMDL	MOS	WLAs			LAs [c]
					WWTPs [a]	Collection Systems	MS4s [b,c]	
			[CFU/day]	[CFU/day]	[CFU/day]	[CFU/day]	[CFU/d/ac]	[CFU/d/ac]
Elk River DA (Multiple HUC12s)	Elk River	TN06030003044 – 1000	$1.20 \times 10^{10} \times Q$	$1.20 \times 10^{9} \times Q$	1.888×10^{10}	0	NA	$(1.772 \times 10^{5} \times Q) - (3.098 \times 10^{5})$
Caldwell Creek DA	Caldwell Creek	TN06030003044 – 0700	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	1.781×10^{10}	0	NA	$(1.607 \times 10^{6} \times Q) - (1.383 \times 10^{6})$
	Gilliam Creek	TN06030003044 – 0720						
	Juanita Creek	TN06030003044 – 0721						
	Trussel Creek	TN06030003044 – 0730						
0202	Betsy Willis Creek	TN06030003044 – 0100	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	NA	$2.436 \times 10^{6} \times Q$
Yellow Branch DA	Yellow Branch	TN06030003041 – 0100	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	NA	$6.208 \times 10^{6} \times Q$
0302 DAs	Boiling Fork Creek	TN06030003030 – 1000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	1.425×10^{10}	0	NA	$(8.548 \times 10^{5} \times Q) - (5.885 \times 10^{5})$
	Wagner Creek	TN06030003032 – 1000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	4.769×10^{9}	0	NA	$(2.247 \times 10^{6} \times Q) - (5.177 \times 10^{5})$
Blue Creek DA	Blue Creek	TN06030003053 – 0100	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	0	$4.947 \times 10^{6} \times Q$	$4.947 \times 10^{6} \times Q$
0501	West Fork Mulberry Creek	TN06030003056 – 0100	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	0	NA	$7.399 \times 10^{5} \times Q$
East Fork Mulberry Creek DA	East Fork Mulberry Creek	TN06030003056 – 0250	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	1.069×10^{10}	0	NA	$(8.180 \times 10^{5} \times Q) - (4.224 \times 10^{5})$
Elk River DA (Multiple HUC12s)	Elk River	TN06030003010 – 1000	$1.20 \times 10^{10} \times Q$	$1.20 \times 10^{9} \times Q$	4.915×10^{11}	0	NA	$(2.057 \times 10^{4} \times Q) - (9.362 \times 10^{5})$
0801+0802	Cane Creek	TN06030003060 – 1000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	NA	$3.327 \times 10^{5} \times Q$
0902	Swan Creek	TN06030003063 – 1000 + TN06030003063 – 2000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	2.564×10^{8}	0	NA	$(6.598 \times 10^{5} \times Q) - (8.173 \times 10^{3})$
0201 DAs	Corn Creek	TN06030004043 – 0300	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	NA	$6.785 \times 10^{6} \times Q$
	Town Creek	TN06030004043 – 0400	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	3.562×10^{9}	0	NA	$(5.200 \times 10^{6} \times Q) - (8.948 \times 10^{5})$
	Coffey Branch	TN06030004043 – 0600	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	NA	$1.079 \times 10^{7} \times Q$
0202	Robertson Fork Creek	TN06030004023 – 1000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	5.699×10^{9}	0	NA	$(6.168 \times 10^{5} \times Q) - (1.698 \times 10^{4})$

Table C-1 (cont;d). TMDLs, WLAs, & LAs for Impaired Waterbodies in the Elk River Watershed (HUC 06030003 & 06030004)

HUC-12 Subwatershed (06030003 & 06030004__) or Drainage Area (DA)	Impaired Waterbody Name	Impaired Waterbody ID	TMDL	MOS	WLAs			LAs [c]
					WWTPs [a]	Collection Systems	MS4s [b,c]	
			[CFU/day]	[CFU/day]	[CFU/day]	[CFU/day]	[CFU/d/ac]	[CFU/d/ac]
Pleasant Run DA	Pleasant Run Creek	TN06030004017 – 0800	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	NA	$2.261 \times 10^{7} \times Q$
Richland Creek DA (Multiple HUC12s)	Richland Creek	TN06030004017 – 2000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	1.466×10^{11}	0	NA	$(6.889 \times 10^{4} \times Q) - (4.879 \times 10^{5})$
Richland Creek DA (Multiple HUC12s)	Richland Creek	TN06030004043 – 1000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	4.132×10^{9}	0	NA	$(1.101 \times 10^{5} \times Q) - (2.198 \times 10^{4})$
Weakley Creek DA	UT to Weakley Creek	TN06030004029 – 0410	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	NA	$5.986 \times 10^{7} \times Q$
Elk River DA (Multiple HUC12s)	Elk River	TN06030004013 – 1000	$1.20 \times 10^{10} \times Q$	$1.20 \times 10^{9} \times Q$	6.393×10^{11}	NA	NA	$(9.349 \times 10^{3} \times Q) - (5.534 \times 10^{5})$

Notes: NA = Not Applicable.
Q = Mean Daily In-stream Flow (cfs).

a. WLAs for WWTPs are expressed as E. coli loads (CFU/day). All current and future WWTPs must meet water quality standards as specified in their NPDES permit.

b. Applies to any MS4 discharge loading in the subwatershed. Future MS4s will be assigned waste load allocations (WLAs) consistent with load allocations (LAs) assigned to precipitation induced nonpoint sources.

c. WLAs and LAs expressed as a “per acre” load are calculated based on the drainage area at the pour point of the HUC-12 or drainage area (see Table A-1).

APPENDIX D

Hydrodynamic Modeling Methodology

HYDRODYNAMIC MODELING METHODOLOGY

D.1 Model Selection

The Windows version of Hydrologic Simulation Program - Fortran (HSPF) was selected for flow simulation of pathogen-impaired waters in the subwatersheds of the Elk River Watershed. HSPF is a watershed model capable of performing flow routing through stream reaches.

D.2 Model Set Up

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

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

An important factor influencing model results is the precipitation data used for the simulation. Weather data from multiple meteorological stations were available for the time period from January 1970 through December 2011. Meteorological data for a selected 11-year period were used for all simulations. The first year of this period was used for model stabilization with simulation data from the subsequent 10-year period (10/1/99 – 9/30/10) used for TMDL analysis. Meteorological data from the stations at Lawrenceburg, Lewisburg, and Monteagle, Tennessee was used for hydrologic calibration.

D.3 Model Calibration

Hydrologic calibration of the watershed model involves comparison of simulated streamflow to historic streamflow data from U. S. Geological Survey (USGS) stream gaging stations for the same period of time. Three USGS continuous record stations located in the Elk River watershed were selected as the basis of the hydrology calibration. Station 03578000 is located on the Elk River near Pelham, TN, within Level IV ecoregions 68A, 68C, and 71G and has a drainage area of 65.6 square miles. Calibration parameters determined for station 03578000 were used for impaired waterbodies lying in ecoregions other than 71H. Station 03584020 is located on Richland Creek at Hwy 64 near Pulaski, TN, within Level IV ecoregion 71H and has a drainage area of 366 square miles. Calibration parameters determined for station 03584020 were used for large impaired waterbodies lying in ecoregion 71H. Station 03578500 is located on Bradley Creek near Prairie Plains, TN, within Level IV ecoregion 71G and has a drainage area of 41.3 square miles. Calibration parameters determined for station 03578500 were used for smaller impaired waterbodies (drainage areas of less than 50 square miles) lying in ecoregion 71H. A gaging station with a drainage area less than 100 square miles could not be located in the ecoregion 71H portion of the Elk River Watershed.

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

The results of the hydrologic calibration for the Elk River near Pelham, USGS Station 03578000, are shown in Table D-1 and Figures D-1 and D-2. The results of the hydrologic calibration for Richland Creek at Hwy 64 near Pulaski, USGS Station 03584020, are shown in Table D-2 and Figures D-3 and D-4. The results of the hydrologic calibration for Bradley Creek near Prairie Plains, USGS Station 03578500, are shown in Table D-3 and Figures D-5 and D-6.

Table D-1. Hydrologic Calibration Summary: Elk River near Pelham (USGS 03578000)

			64.084174	
	Simulation Name:	USGS03578000	**Simulation Period:**	
			Watershed Area (ac):	41027.00
	Period for Flow Analysis			
	Begin Date:	01/01/01	**Baseflow PERCENTILE:**	2.5
	End Date:	01/01/11	*Usually 1%-5%*	
	Total Simulated In-stream Flow:	**276.52**	Total Observed In-stream Flow:	**280.32**
	Total of highest 10% flows:	**151.22**	Total of Observed highest 10% flows:	**155.51**
	Total of lowest 50% flows:	**20.34**	Total of Observed Lowest 50% flows:	**17.86**
	Simulated Summer Flow Volume (months 7-9):	**30.93**	Observed Summer Flow Volume (7-9):	**27.05**
	Simulated Fall Flow Volume (months 10-12):	**92.22**	Observed Fall Flow Volume (10-12):	**67.23**
	Simulated Winter Flow Volume (months 1-3):	**101.14**	Observed Winter Flow Volume (1-3):	**114.36**
	Simulated Spring Flow Volume (months 4-6):	**52.24**	Observed Spring Flow Volume (4-6):	**71.67**
	Total Simulated Storm Volume:	**274.49**	Total Observed Storm Volume:	**276.95**
	Simulated Summer Storm Volume (7-9):	**30.42**	Observed Summer Storm Volume (7-9):	**26.20**
	Errors (Simulated-Observed)		*Recommended Criteria*	Last run
	Error in total volume:	**-1.35**	10	
***	Error in 50% lowest flows:	**13.84**	10	
	Error in 10% highest flows:	**-2.76**	15	
	Seasonal volume error - Summer:	**14.33**	30	
***	Seasonal volume error - Fall:	**37.15**	30	
	Seasonal volume error - Winter:	**-11.56**	30	
	Seasonal volume error - Spring:	**-27.11**	30	
	Error in storm volumes:	**-0.89**	20	
	Error in summer storm volumes:	**16.10**	50	

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

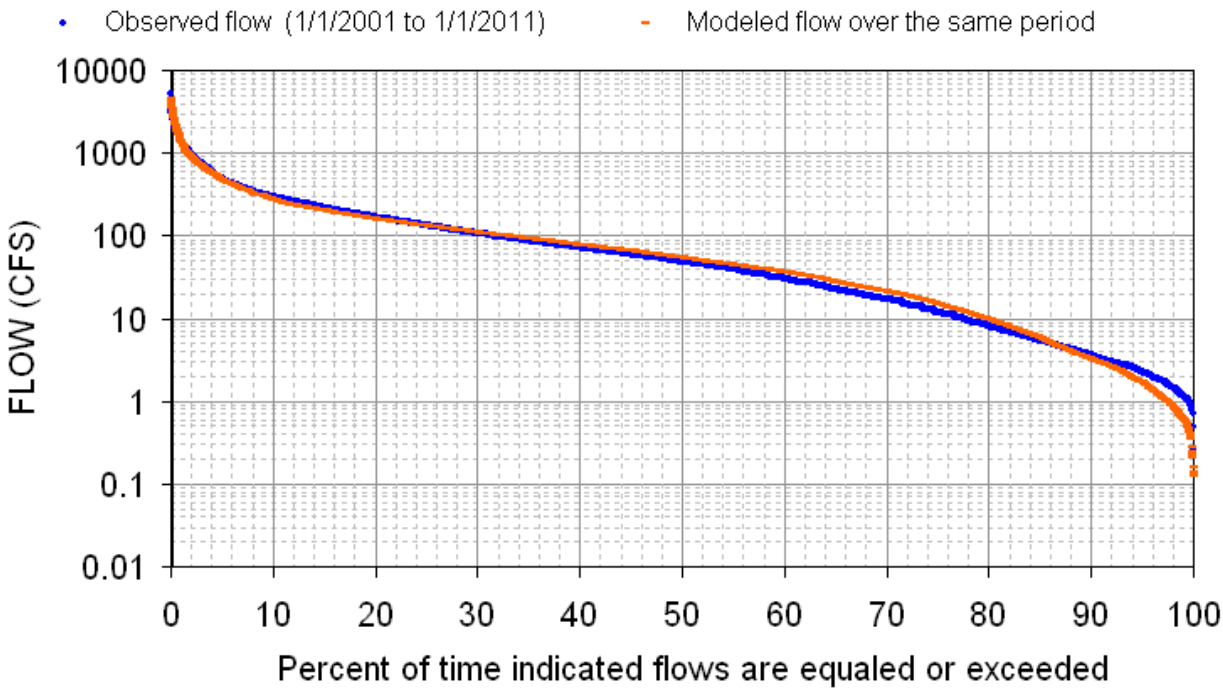

Figure D-1. Hydrologic Calibration: Elk River, USGS 03578000 (2001-2011)

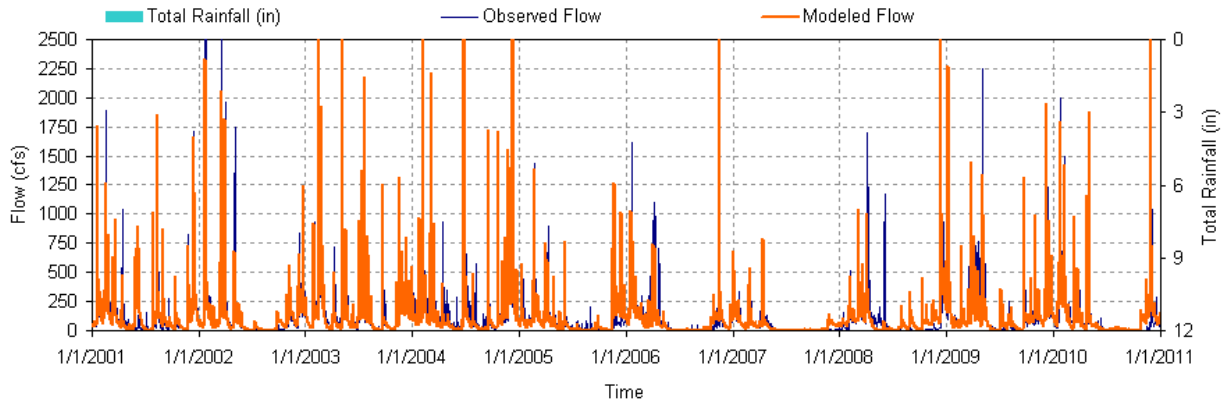

Figure D-2. 10-Year Hydrologic Comparison: Elk River, USGS 03578000

Table D-2. Hydrologic Calibration Summary: Richland Creek near Pulaski (USGS 03584020)

		361.828709	
Simulation Name:	USGS03584020	**Simulation Period:**	
		Watershed Area (ac):	231644.50
Period for Flow Analysis			
Begin Date:	**10/01/01**	**Baseflow PERCENTILE:**	2.5
End Date:	**09/30/09**	*Usually 1%-5%*	
Total Simulated In-stream Flow:	**184.16**	Total Observed In-stream Flow:	**198.87**
Total of highest 10% flows:	**105.83**	Total of Observed highest 10% flows:	**112.88**
Total of lowest 50% flows:	**16.84**	Total of Observed Lowest 50% flows:	**15.73**
Simulated Summer Flow Volume (months 7-9):	**15.96**	Observed Summer Flow Volume (7-9):	**15.41**
Simulated Fall Flow Volume (months 10-12):	**44.97**	Observed Fall Flow Volume (10-12):	**47.11**
Simulated Winter Flow Volume (months 1-3):	**75.49**	Observed Winter Flow Volume (1-3):	**83.84**
Simulated Spring Flow Volume (months 4-6):	**47.75**	Observed Spring Flow Volume (4-6):	**52.51**
Total Simulated Storm Volume:	**180.50**	Total Observed Storm Volume:	**191.70**
Simulated Summer Storm Volume (7-9):	**15.05**	Observed Summer Storm Volume (7-9):	**13.62**
Errors (Simulated-Observed)		*Recommended Criteria*	Last run
Error in total volume:	**-7.40**	10	
Error in 50% lowest flows:	**7.02**	10	
Error in 10% highest flows:	**-6.25**	15	
Seasonal volume error - Summer:	**3.55**	30	
Seasonal volume error - Fall:	**-4.55**	30	
Seasonal volume error - Winter:	**-9.95**	30	
Seasonal volume error - Spring:	**-9.07**	30	
Error in storm volumes:	**-5.84**	20	
Error in summer storm volumes:	**10.45**	50	

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

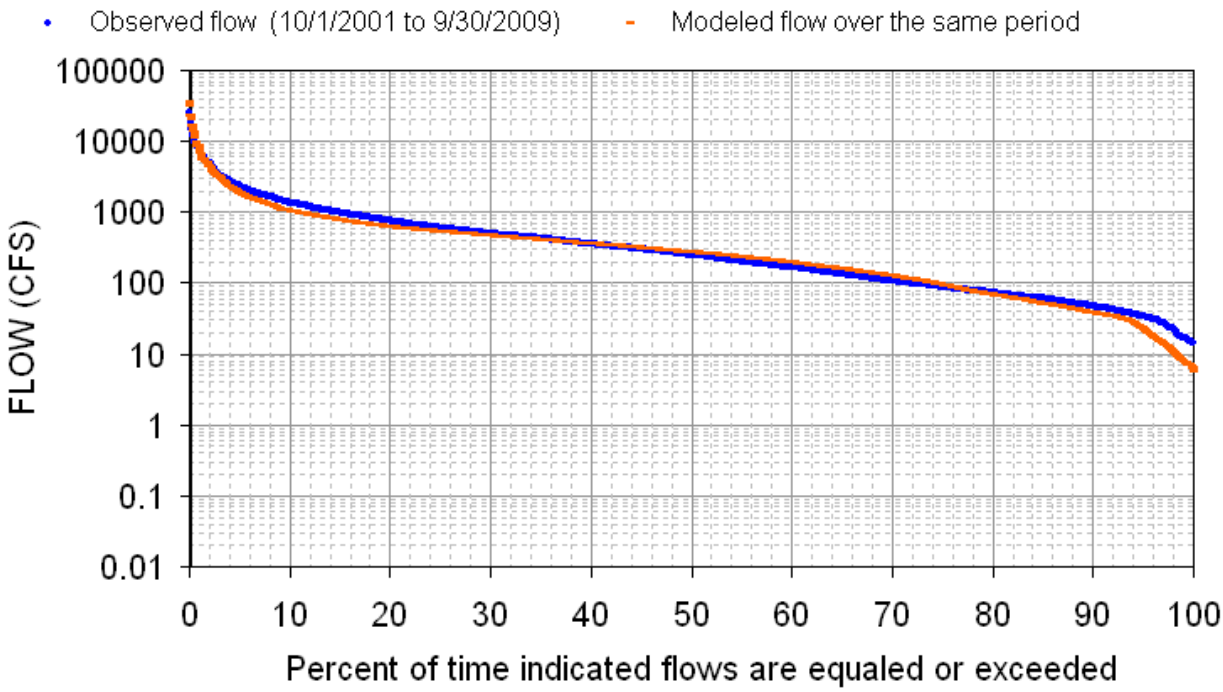

Figure D-3. Hydrologic Calibration: Richland Creek, USGS 03584020 (WYs 2002-2009)

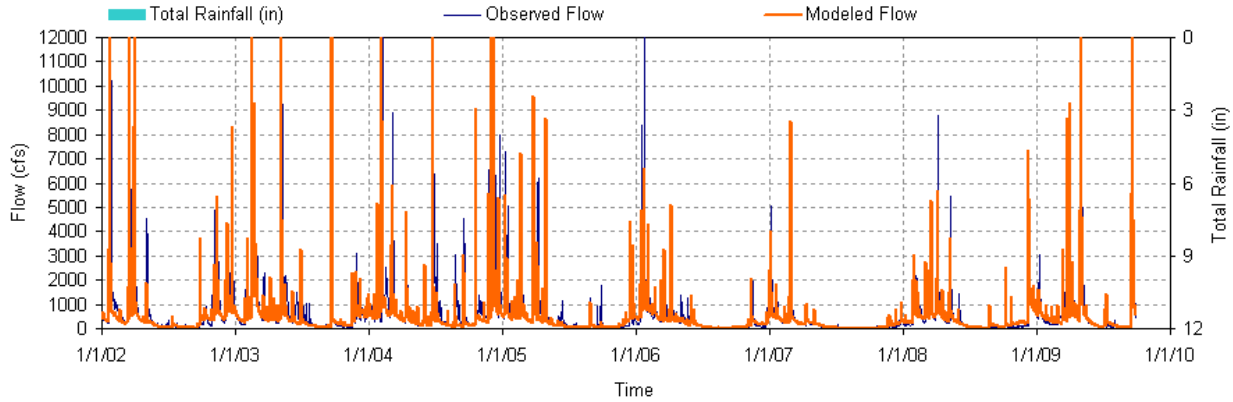

Figure D-4. 8-Year Hydrologic Comparison: Richland Creek, USGS 03584020

Table D-3. Hydrologic Calibration Summary: Bradley Creek near Prairie Plaines (USGS 03578500)

		36.6198404	
Simulation Name:	USGS03578500	**Simulation Period:**	
		Watershed Area (ac):	23444.20
Period for Flow Analysis			
Begin Date:	**01/02/04**	**Baseflow PERCENTILE:**	2.5
End Date:	**01/01/11**	*Usually 1%-5%*	
Total Simulated In-stream Flow:	**143.64**	Total Observed In-stream Flow:	**143.97**
Total of highest 10% flows:	**79.46**	Total of Observed highest 10% flows:	**76.45**
Total of lowest 50% flows:	**12.59**	Total of Observed Lowest 50% flows:	**11.75**
Simulated Summer Flow Volume (months 7-9):	**10.14**	Observed Summer Flow Volume (7-9):	**11.23**
Simulated Fall Flow Volume (months 10-12):	**51.01**	Observed Fall Flow Volume (10-12):	**32.23**
Simulated Winter Flow Volume (months 1-3):	**54.02**	Observed Winter Flow Volume (1-3):	**54.26**
Simulated Spring Flow Volume (months 4-6):	**28.46**	Observed Spring Flow Volume (4-6):	**46.25**
Total Simulated Storm Volume:	**142.29**	Total Observed Storm Volume:	**142.68**
Simulated Summer Storm Volume (7-9):	**9.81**	Observed Summer Storm Volume (7-9):	**10.90**
Errors (Simulated-Observed)		*Recommended Criteria*	Last run
Error in total volume:	**-0.23**	10	
Error in 50% lowest flows:	**7.14**	10	
Error in 10% highest flows:	**3.94**	15	
Seasonal volume error - Summer:	**-9.63**	30	
*** Seasonal volume error - Fall:	**58.28**	30	
Seasonal volume error - Winter:	**-0.45**	30	
*** Seasonal volume error - Spring:	**-38.47**	30	
Error in storm volumes:	**-0.27**	20	
Error in summer storm volumes:	**-10.01**	50	

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

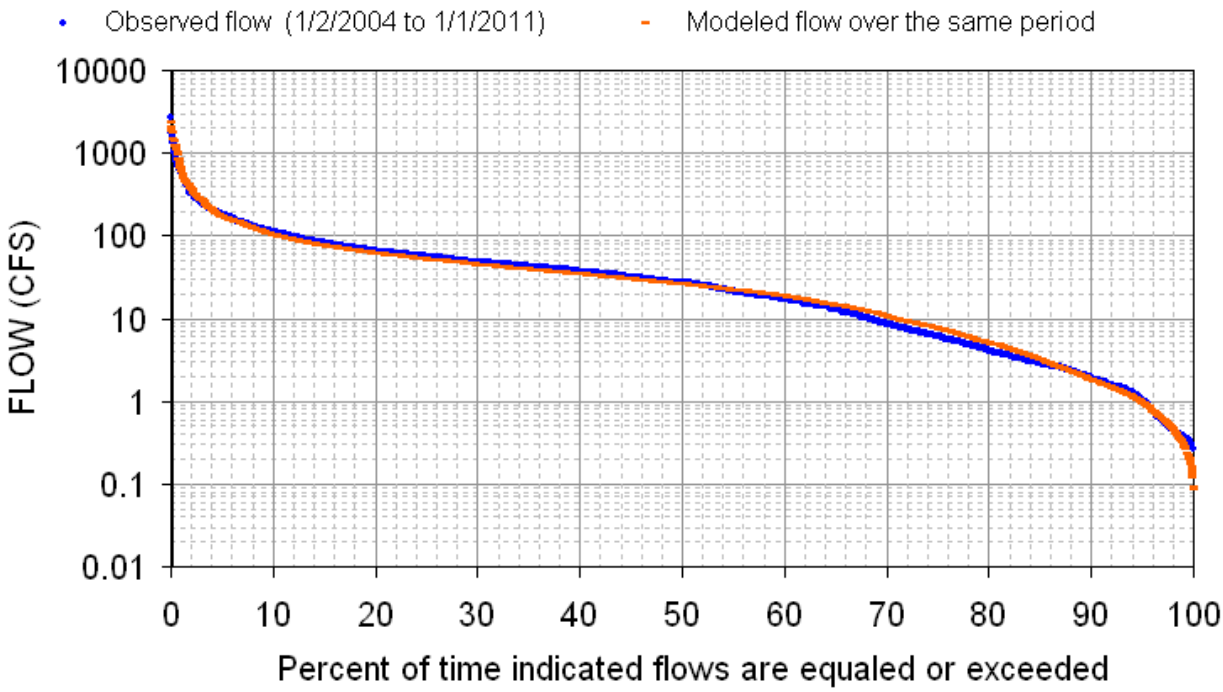

Figure D-5. Hydrologic Calibration: Bradley Creek, USGS 03578500 (2004-2011)

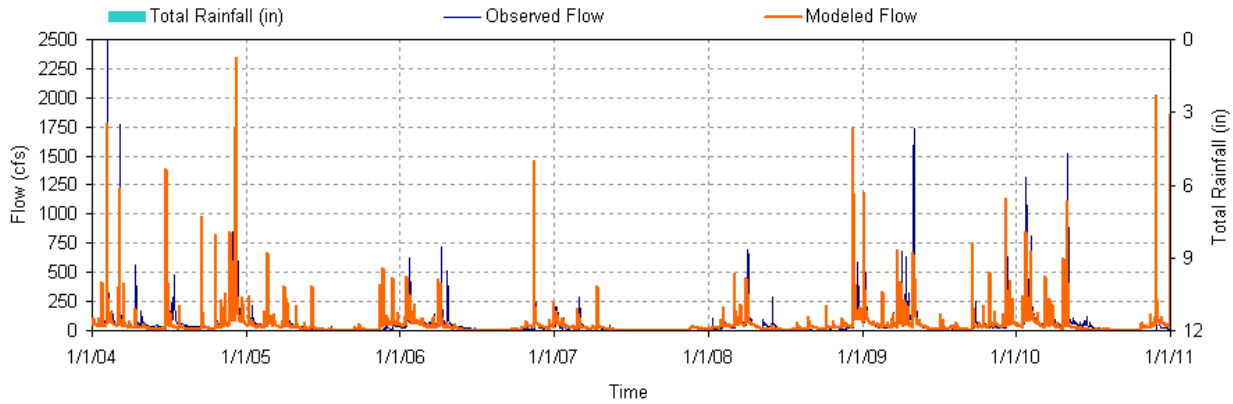

Figure D-6. 7-Year Hydrologic Comparison: Bradley Creek, USGS 03578500

APPENDIX E

Source Area Implementation Strategy

All impaired waterbodies and corresponding HUC-12 subwatersheds or drainage areas have been classified according to their respective source area types in Section 9.5, Table 10. The implementation for each area will be prioritized according to the guidance provided in Section 9.5.1 and 9.5.2, with examples provided in Section E.1 and E.2, below. For all impaired waterbodies, the determination of source area types serves to identify the predominant sources contributing to impairment (i.e., those that should be targeted initially for implementation). However, it is not intended to imply that sources in other landuse areas are not contributors to impairment and/or to grant an exemption from addressing other source area contributions with implementation strategies and corresponding load reduction. For mixed use areas, implementation will follow the guidance established for both urban and agricultural areas, at a minimum.

E.1 Urban Source Areas

For impaired waterbodies and corresponding HUC-12 subwatersheds or drainage areas identified as predominantly urban source area types, the following example for Blue Creek provides guidance for implementation analysis. Blue Creek was selected because it is the only drainage area with greater than 10 percent urban area.

The Blue Creek watershed, part of HUC-12 060300030402, lies in Tullahoma. The drainage area for Blue Creek is approximately 4,185 acres (6.5 mi^2); therefore, four flow zones were used for the duration curve analysis (see Sect. 9.1.1).

The flow duration curve for Blue Creek at mile 0.1 was constructed using simulated daily mean flow for the period from 1/1/01 through 12/31/10 (mile 0.1 corresponds to the location of monitoring station BLUE000.1FR). This flow duration curve is shown in Figure E-1 and represents the cumulative distribution of daily discharges arranged to show percentage of time specific flows were exceeded during the period of record. Flow duration curves for other impaired waterbodies were developed using a similar procedure (Appendix C).

The E. coli LDC for Blue Creek (Figure E-2) was analyzed to determine the frequency with which observed daily water quality loads exceed the E. coli target maximum daily loading (941 CFU/100 mL x flow [cfs] x conversion factor) under four flow conditions (low, mid-range, moist, and high). Observation of the plot illustrates that the only exceedance occured in the mid-range flow regime indicating the Blue Creek watershed may be impacted by a variety sources.

Critical conditions for the Blue Creek watershed occur during mid-range flow conditions, which may be indicative of a variety of source contributions (see Table E-3, Section E.4). According to hydrograph separation analysis, the exceedance did not occur during a stormflow event.

Figure E-1. Flow Duration Curve for Blue Creek at Mile 0.1

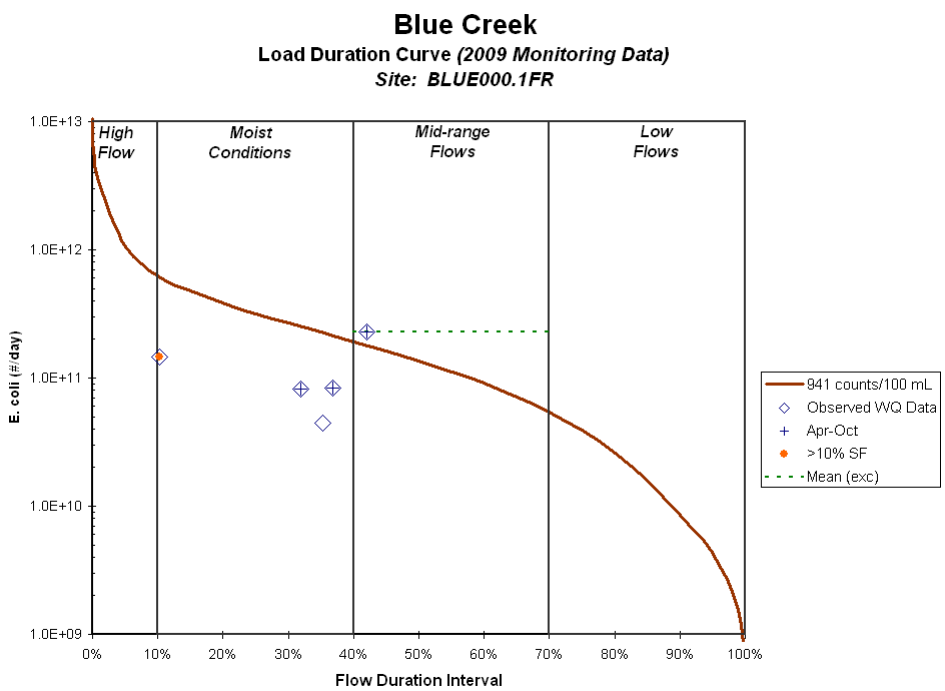

Figure E-2. E. Coli Load Duration Curve for Blue Creek

Table E-1. Load Duration Curve Summary for Implementation Strategies (Example: Blue Creek subwatershed, part of HUC-12 060300030402) (4 Flow Zones).

Hydrologic Condition		High	Moist	Mid-range*	Low
% Time Flow Exceeded		0-10	10-40	40-70	70-100
Blue Creek (060300030402)	Number of Samples	0	4	1	0
	% > 941 CFU/100 mL[1]	NA	0	100.0	NA
	Load Reduction[2]	NA	NR	21.8%	NA
TMDL (CFU/day)		1.052E+12	3.188E+11	1.111E+11	1.587E+10
Margin of Safety (CFU/day)		1.052E+11	3.188E+10	1.111E+10	1.587E+09
WLA (WWTPs) (CFU/day)		NA	NA	NA	NA
WLAs (MS4s) (CFU/day/acre)[3]		2.263E+08	6.856E+07	2.389E+07	3.413E+06
LA (CFU/day/acre)[3]		2.263E+08	6.856E+07	2.389E+07	3.413E+06
Implementation Strategies[4]					
Municipal NPDES			L	M	H
Stormwater Management			H	H	
SSO Mitigation		H	M	L	
Collection System Repair			H	M	
Septic System Repair			L	M	M
Potential for source area contribution under given flow condition (H: High; M: Medium; L: Low)					

* The Mid-range flow zone represents the critical condition for E. coli loading in the Blue Creek subwatershed.
[1] Tennessee Maximum daily water quality criterion for E. coli.
[2] Reductions (percent) based on mean of observed percent load reductions in range.
[3] LAs and MS4s are expressed as daily load per unit area in order to provide for future changes in the distribution of LAs and MS4s (WLAs).
[4] Watershed-specific Best Management Practices for Urban Source reduction. Actual BMPs applied may vary and should not be limited according to this grouping.

Results indicate the implementation strategy for the Blue Creek watershed will require BMPs targeting both point sources and nonpoint sources. Table E-1 presents an allocation table of LDC analysis statistics for Blue Creek E. coli and implementation strategies for each source category covering the entire range of flow (Stiles, 2003). The implementation strategies listed in Table E-1 are a subset of the categories of BMPs and implementation strategies available for application to the Elk River watershed for reduction of E. coli loading and mitigation of water quality impairment from urban sources. Targeted implementation strategies and LDC analysis statistics for other impaired waterbodies and corresponding HUC-12 subwatersheds and drainage areas identified as predominantly urban source area types can be derived from the information and results available in Tables 11 and E-56.

Table E-56 presents LDC analyses (TMDLs, WLAs, LAs, and MOS) and PLRGs for all flow zones for all E. coli impaired waterbodies in the Elk River watershed.

E.2 Agricultural Source Areas

For impaired waterbodies and corresponding HUC-12 subwatersheds or drainage areas identified as predominantly agricultural source area types, the following example for Wagner Creek provides guidance for implementation analysis.

The Wagner Creek subwatershed, HUC-12 060300030303, lies in a non-urbanized area of Franklin county. The drainage area for Wagner Creek is approximately 9,213 acres (14.4 mi^2); therefore, four flow zones were used for the duration curve analysis (see Sect. 9.1.1). The landuse for this portion of Wagner Creek is approximately 55.9% agricultural, with most of the remainder being forested. Urban areas make up approximately 8.4% of the total area. Therefore, the predominant landuse type and sources are agricultural, although urban sources may be a contributing factor.

The flow duration curve for Wagner Creek was constructed using simulated daily mean flow for the period from 1/1/01 through 12/31/10. This flow duration curve is shown in Figure E-3 and represents the cumulative distribution of daily discharges arranged to show percentage of time specific flows were exceeded during the period of record. Flow duration curves for other impaired waterbodies were developed using a similar procedure (see Appendix C).

The E. coli LDC for Wagner Creek (Figure E-4) was analyzed to determine the frequency with which observed daily water quality loads exceed the E. coli target maximum daily loading (941 CFU/100 mL x flow [cfs] x conversion factor) under four flow conditions (low, mid-range, moist, and high). Observation of the plot illustrates that exceedances occured in the moist conditions flow zone indicating that the Wagner Creek watershed may be impacted by nonpoint sources. LDCs for other impaired waterbodies were developed using a similar procedure (Appendix C) and are shown in Figures E-5 through E-29.

Critical conditions for the Wagner Creek watershed occur during moist conditions, typically indicative of nonpoint source contributions (see Table E-3, Section E.4). Exceedances of the E. coli water quality standard can occur under a variety of flow conditions. According to hydrograph separation analysis, exceedances occur during both storm (runoff) and non-storm (baseflow) periods. These factors indicate that nonpoint sources are significant contributors to impairment in the Wagner Creek watershed. However, it is possible that both point and nonpoint type sources contribute to exceedances of the E. coli standard in Wagner Creek.

Results indicate the implementation strategy for the Wagner Creek watershed will require BMPs targeting nonpoint sources (dominant under high flow/runoff conditions). Table E-2 presents an allocation table of Load Duration Curve analysis statistics for Wagner Creek E. coli and targeted implementation strategies for each source category covering the entire range of flow (Stiles, 2003). The implementation strategies listed in Table E-2 are a subset of the categories of BMPs and implementation strategies available for application to the Elk River watershed for reduction of E. coli loading and mitigation of water quality impairment from agricultural sources. Targeted implementation strategies and LDC analysis statistics for other impaired waterbodies and corresponding HUC-12 subwatersheds and drainage areas identified as predominantly agricultural source area types can be derived from the information and results available in Tables 12 and E-56.

Table E-56 presents LDC analyses (TMDLs, WLAs, LAs, and MOS) and PLRGs for all flow zones for all E. coli impaired waterbodies in the Elk River watershed.

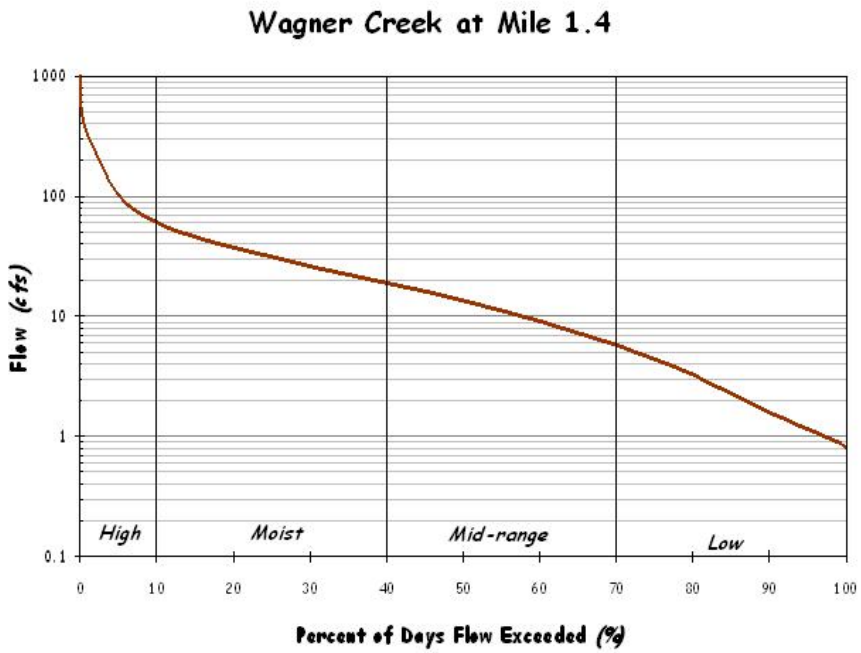

Figure E-3. Flow Duration Curve for Wagner Creek at Mile 1.4

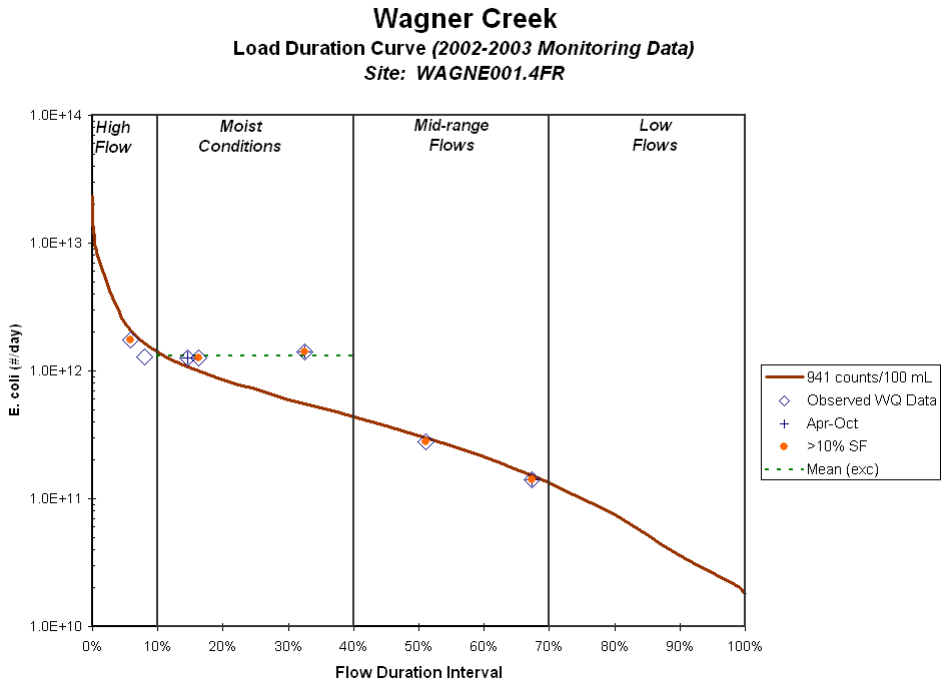

Figure E-4. E. Coli Load Duration Curve for Wagner Creek at Mile 1.4

Table E-2. Load Duration Curve Summary for Implementation Strategies (Example: Wagner Creek subwatershed, HUC-12 060300030303) (4 Flow Zones).

Hydrologic Condition		High	Moist*	Mid-range	Low
% Time Flow Exceeded		0-10	10-40	40-70	70-100
Wagner Creek (060300030303) RM1.4	Number of Samples	2	3	2	0
	% > 941 CFU/100 mL[1]	0.0	10.0	0.0	0.0
	Load Reduction[2]	NR	32.3%	NR	NA
TMDL (CFU/day)		2.341E+12	7.197E+11	2.583E+11	5.244E+10
Margin of Safety (CFU/day)		2.341E+11	7.197E+10	2.583E+10	5.244E+09
WLA (WWTPs) (CFU/day)		4.769E+09	4.769E+09	4.769E+09	4.769E+09
WLAs (MS4s) (CFU/day/acre)[3]		NA	NA	NA	NA
LA (CFU/day/acre)[3]		2.282E+08	6.979E+07	2.472E+07	4.606E+06
Implementation Strategies[4]					
Municipal NPDES			L	M	H
Stormwater Management			H	H	
SSO Mitigation		H	M	L	
Collection System Repair			H	M	
Septic System Repair			L	M	M
Potential for source area contribution under given flow condition (H: High; M: Medium; L: Low)					

* The moist conditions flow zone represents the critical conditions for E. coli loading in the Wagner Creek subwatershed.
[1] Tennessee Maximum daily water quality criterion for E. coli.
[2] Reductions (percent) based on mean of observed percent load reductions in range.
[3] LAs and MS4s are expressed as daily load per unit area in order to provide for future changes in the distribution of LAs and MS4s (WLAs).
[4] Example Best Management Practices for Agricultural Source reduction. Actual BMPs applied may vary and should not be limited according to this grouping.

E.3 Forestry Source Areas

There are no impaired waterbodies with corresponding HUC-12 subwatersheds or drainage areas classified as source area type predominantly forested, with the predominant source category being wildlife, in the Elk River watershed.

E.4 Calculation of Percent Load Reduction Goals and Determination of Critical Flow Zones

In order to facilitate implementation, corresponding percent reductions in loading required to decrease existing, in-stream E. coli loads to TMDL target levels (percent load reduction goals) were calculated. As a result, critical flow zones were determined and subsequently verified by secondary analyses. The following example is from Richland Creek (segment 043-1000).

1. For each flow zone, the mean of the percent exceedances of individual loads relative to their respective target maximum loads (at their respective PDFEs) was calculated. Each negative percent exceedance was assumed to be equal to zero.

Date	Sample Conc. (CFU/100 mL)	Flow (cfs)	Existing Load (CFU/Day)	Target (TMDL) Load (CFU/Day)	Percent Reduction
11/3/09	1,414	128.1	4.43E+12	2.95E+12	33.5
12/17/02	1,200	118.2	3.47E+12	2.72E+12	21.6
11/4/09	613	113.4	1.70E+12	2.61E+12	0 (-53.5)
11/5/09	613	104.1	1.56E+12	2.40E+12	0 (-53.5)
11/14/02	820	97.71	1.96E+12	2.25E+12	0 (-14.8)
1/8/03	440	76.29	8.21E+11	1.76E+12	0 (-113.9)
9/30/02	2,000	74.11	3.63E+12	1.71E+12	53.0
10/22/02	2,400	58.98	3.46E+12	1.36E+12	60.8
11/16/09	517	58.19	7.36E+11	1.34E+12	0 (-82.0)
11/19/09	461	56.05	6.32E+11	1.29E+12	0 (-104.1)
Percent Load Reduction Goal (PLRG) for Moist Conditions (Mean)					**16.9**

2. The PLRGs calculated for each of the flow zones, not including the high flow zone (see Section. 9.1.1), were compared and the PLRG of the greatest magnitude indicates the critical flow zone for prioritizing implementation actions for Richland Creek.

Example – *High Flow Zone Percent Load Reduction Goal = 32.4*
Moist Conditions Flow Zone Percent Load Reduction Goal = 16.9
Mid-Range Flow Zone Percent Load Reduction Goal = 5.4
Dry Conditions Flow Zone Percent Load Reduction Goal = NR
Low Flow Zone Percent Load Reduction Goal = NA

Therefore, the critical flow zone for prioritization of Richland Creek (segment 043-1000) implementation activities is the Moist Conditions Flow Zone and subsequently actions targeting nonpoint source controls.

3. Due to the frequently limited availability of sampling data and subsequent randomness of distribution of samples by flow zone, the determination of the critical flow zone by PLRG calculation often has a high degree of uncertainty. Therefore, secondary analyses were conducted to verify or supplement the determination of the critical flow zones. For each flow zone, the percent of samples that exceed the E. coli TMDL target levels was calculated. For Richland Creek:

Flow Zone	Number of Samples	Samples > 941 CFU/100 mL	% > 941 CFU/100 mL
High	2	1	50.0
Moist	**10**	**4**	**40.0**
Mid-Range	4	1	25.0
Dry	2	0	0.0
Low	0	NA	NA

The critical flow zone for prioritization of Richland Creek implementation activities is confirmed as the moist conditions flow zone.

4. Lastly, emphasis (priority) should be placed on recent data versus historical data. If data from multiple watershed cycles is available, analysis of recent data (current cycle) versus the entire period of record, or previous cycles, may identify different critical areas for implementation.

Zone	Period of Record (2002-2012)			Most Recent (2008-2012)		
	# of samples	% Red.	% Exc.	# of samples	% Red.	% Exc.
High	2	32.4	50.0	0	NA	NA
Moist	10	16.9	40.0	5	6.7	20
Mid-Range	4	5.4	25.0	2	NR	0
Dry	2	NR	0.0	1	NR	0
Low	0	NA	NA	0	NA	NA

The critical flow zone for prioritization of implementation activities for Richland Creek (segment 043-1000) is confirmed as the same zone (moist conditions flow zone) as initial analyses indicated. However, if a different flow zone, or zones, were identified, the flow zone(s) from analysis of recent data would have emphasis for implementation prioritization.

PLRGs and critical flow zones of the other impaired waterbodies were derived in a similar manner and are shown in Table E-56.

<u>Geometric Mean Data</u>

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/100 mL. 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: *Monitoring Location = Richland Creek Mile 55.5*
Sampling Period = 11/3/09 – 11/19/09
Geometric Mean Concentration = 661.5 CFU/100 mL
Target Concentration = 126 CFU/100 mL
Reduction to Target = 81.0%

For impaired waterbodies where monitoring data are limited to geometric mean data only, results can be utilized for general indication of relative impairment and, when plotted on a load duration curve, may indicate areas for prioritization of implementation efforts. For impaired waterbodies where both types of data are available, geometric mean data may be utilized to supplement the results of the individual flow zone calculations.

Table E-3. Summary of Critical Conditions for Impaired Waterbodies in the Elk River Watersheds.

Waterbody ID	Moist	Mid-range	Dry	Low	Monitoring Station	Drainage Area (ac)
Betsy Willis Creek [b]	✓				BWILL000.2CE	8,495
Blue Creek [b]		✓			BLUE000.1FR	4,183
Boiling Fork Creek [b]	✓				BFORK014.6FR	8,648
Caldwell Creek [c]					CALDW001.1GY	12,876
Cane Creek [c]					CANE008.1LI	49,707
E Fork Mulberry Creek [b]				✓	EFMUL010.2MR	25,316
Elk River (010-1000) [a]		✓			ELK093.9LI	524,984
Elk River (044-1000) [a]	✓				ELK187.4FR	60,951
Gilliam Creek [b]					None	1,263
Juanita Creek [b]				✓	GILLI1.3T1.8GY	767.2
Swan Creek (063-1000) [c]					SWAN000.8LI	3,1374
Swan Creek (063-2000) [b]				✓	SWAN008.1LI	13,359
Trussel Creek [b]				✓	TRUSS1.7T0.7GY	375.7
Wagner Creek [b]	✓				WAGNE002.4FR	9,212
W Fork Mulberry Creek [a]				✓	WFMUL001.4LI	27,978
Yellow Branch [b]		✓			YELLO000.8FR	3,343
Coffey Branch [b]		✓			COFFE000.2ML	1,918
Corn Creek [b]	✓			✓	CORN000.4ML	2,928
Elk River (013-1000) [c]					ELK036.5GS	1,155,200
Pleasant Run Creek [c]					PRUN000.1GS	915.4
Richland Creek (017-2000) [a]	✓				RICHL029.9GS	234,240
Richland Creek (043-1000) [a]	✓				RICHL055.5GS	37,804
Robertson Fork Creek [b]		✓			RFORK005.5GS	16,536
Town Creek [b]	✓				TOWN000.8ML	2,436
UT to Wet Weakley Creek [b]					None	3,730

[a] Waterbody(ies) with 5 flow zones.
[b] Waterbody(ies) with 4 flow zones.
[c] No exceedances of daily max criteria. Therefore, critical condition could not be determined.

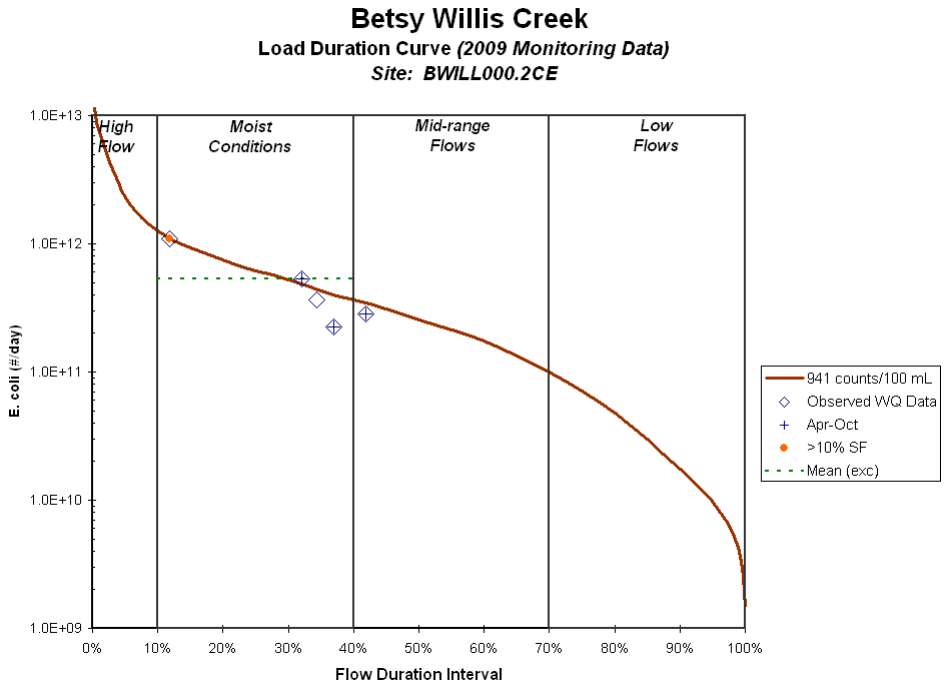

Figure E-5. E. Coli Load Duration Curve for Betsy Willis Creek – RM0.2

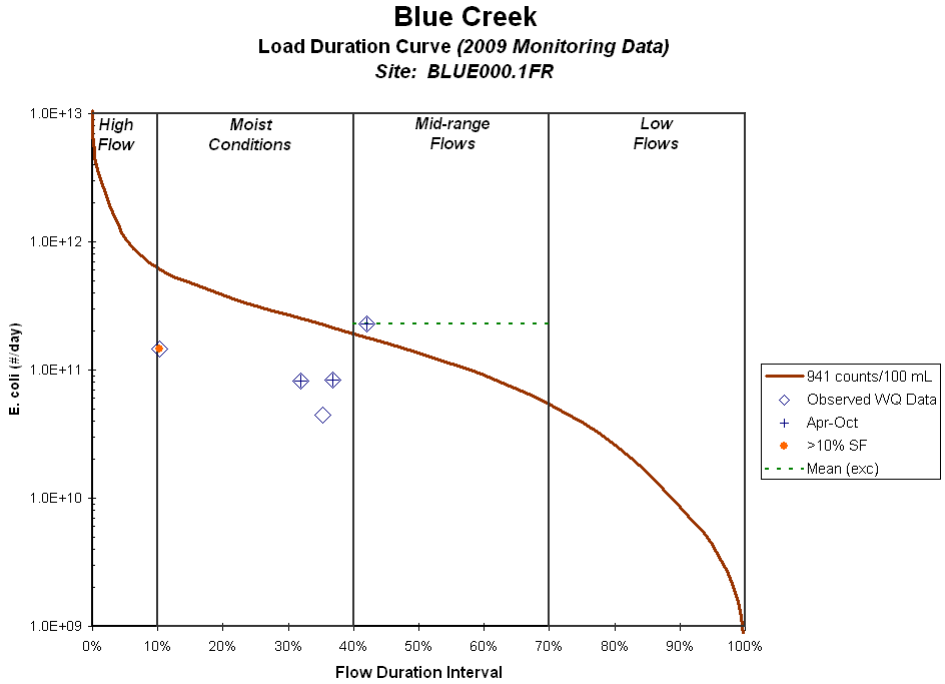

Figure E-6. E. Coli Load Duration Curve for Blue Creek – RM0.1

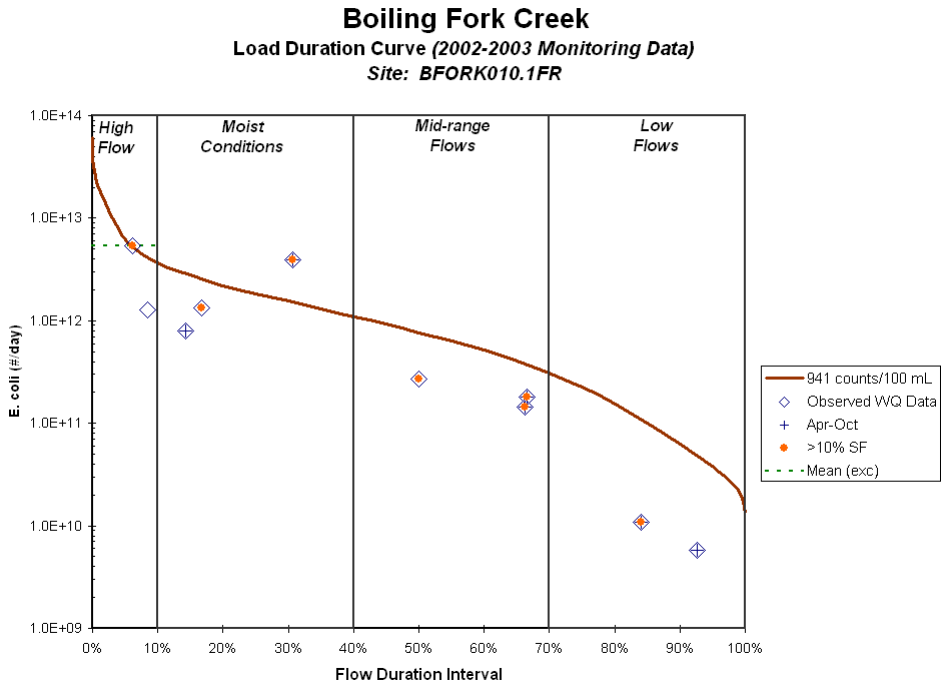

Figure E-7. E. Coli Load Duration Curve for Boiling Fork Creek – RM10.1

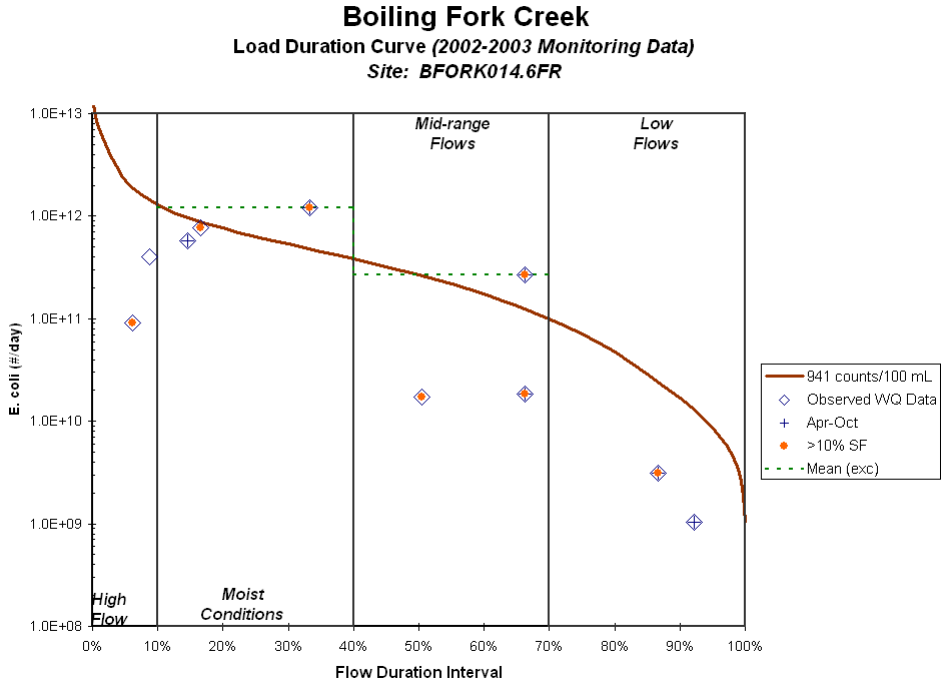

Figure E-8. E. Coli Load Duration Curve for Boiling Fork Creek – RM14.6

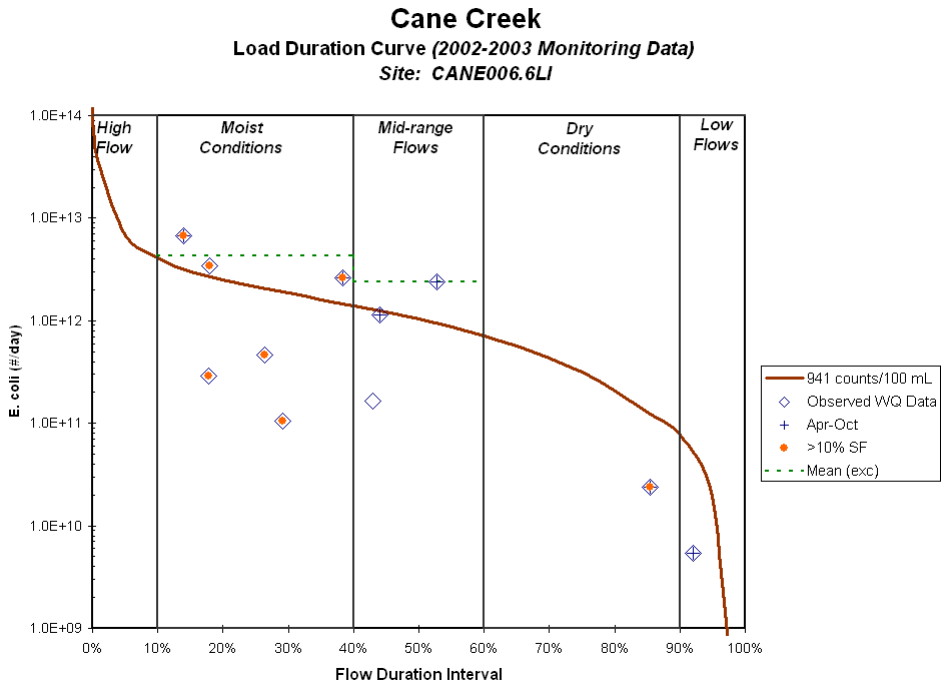

Figure E-9. E. Coli Load Duration Curve for Cane Creek – RM6.6

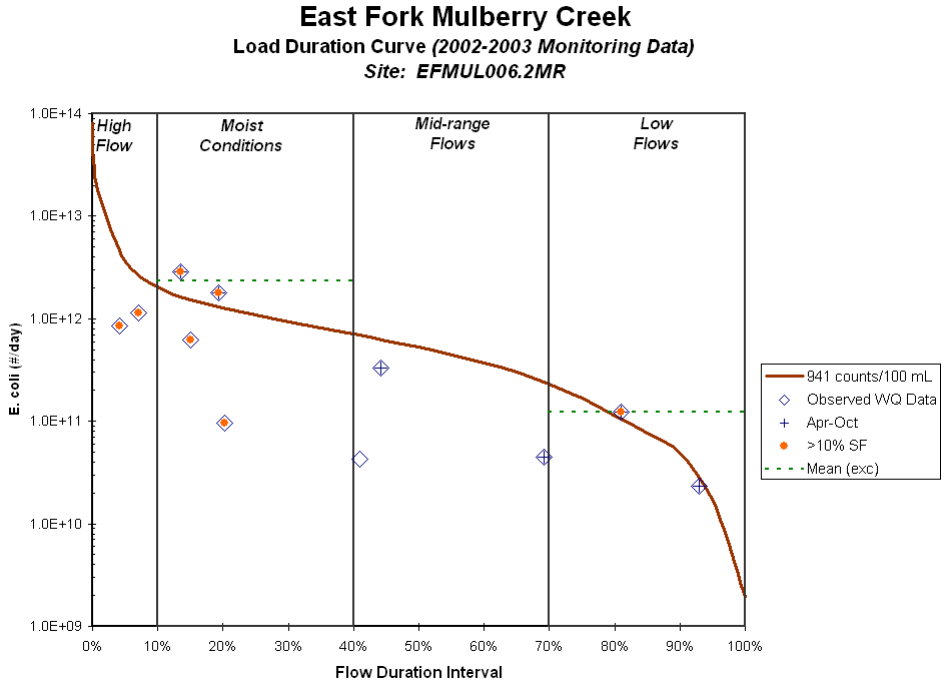

Figure E-10. E. Coli Load Duration Curve for East Fork Mulberry Creek – RM6.2

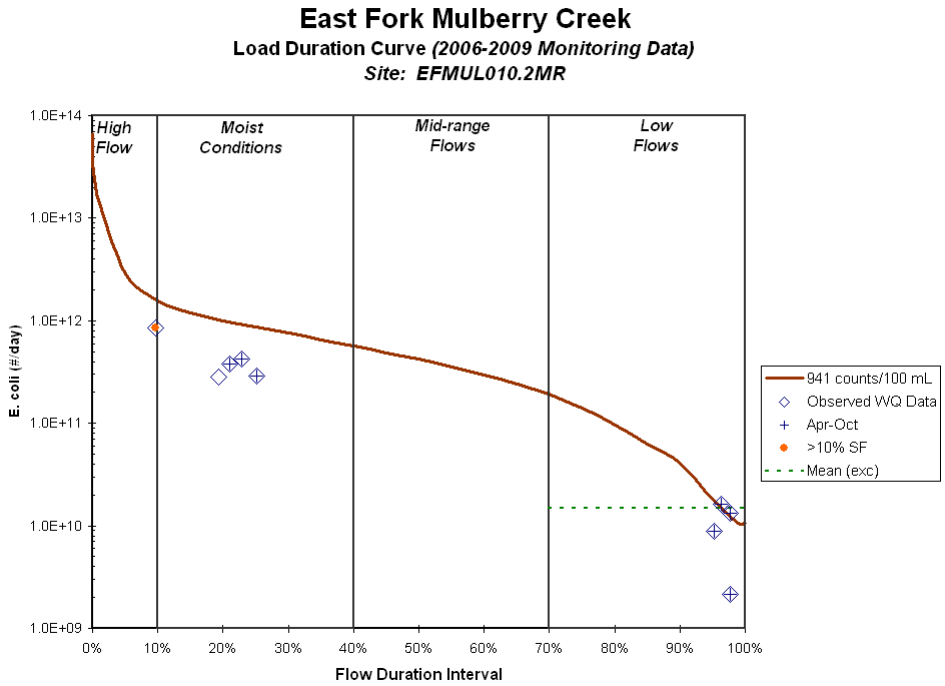

Figure E-11. E. Coli Load Duration Curve for East Fork Mulberry Creek – RM10.2

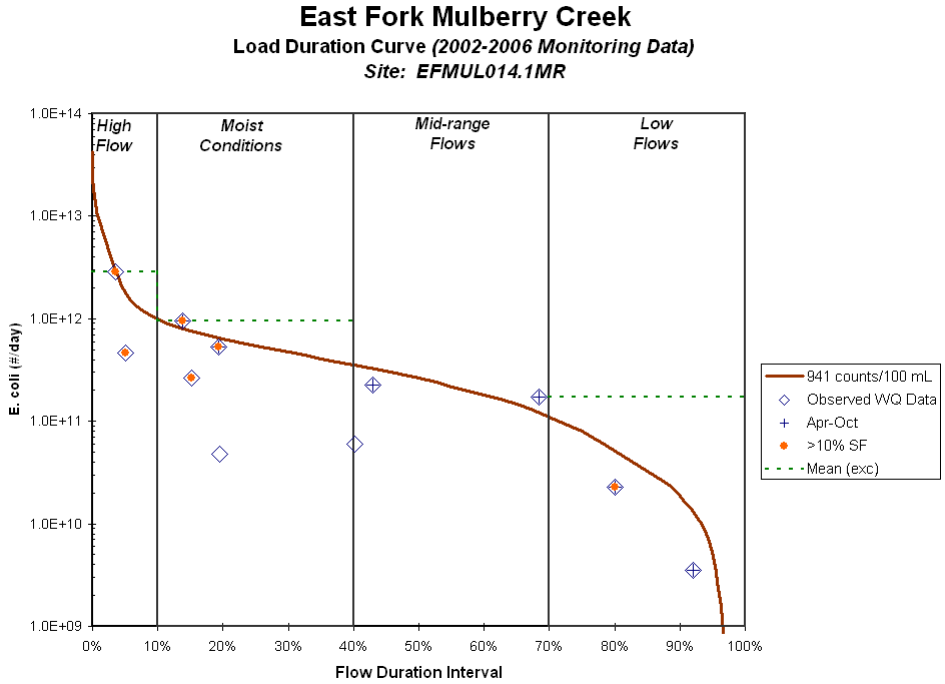

Figure E-12. E. Coli Load Duration Curve for East Fork Mulberry Creek – RM14.1

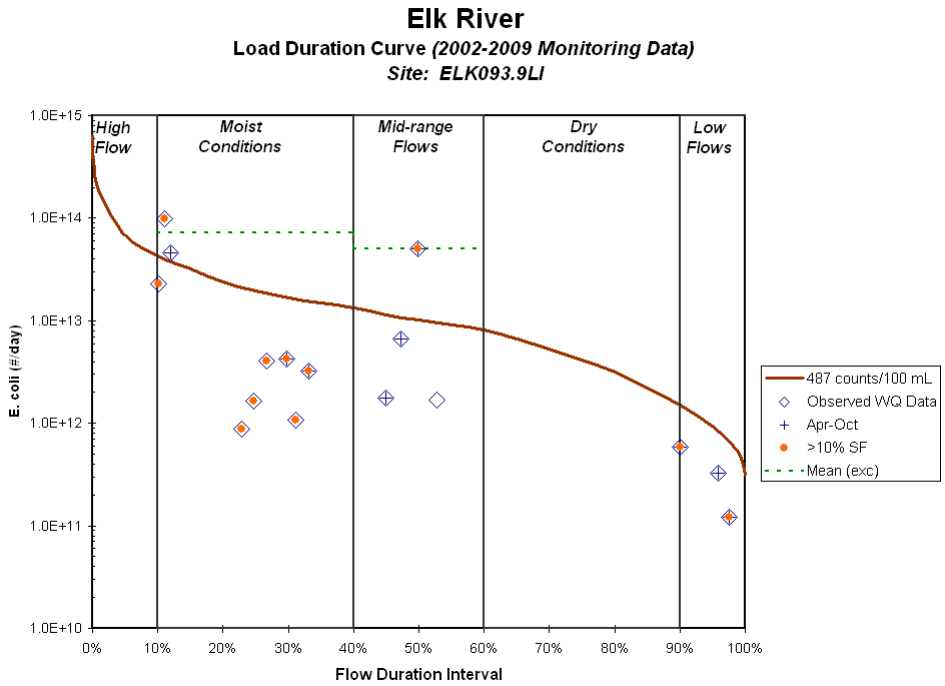

Figure E-13. E. Coli Load Duration Curve for Elk River – RM93.9

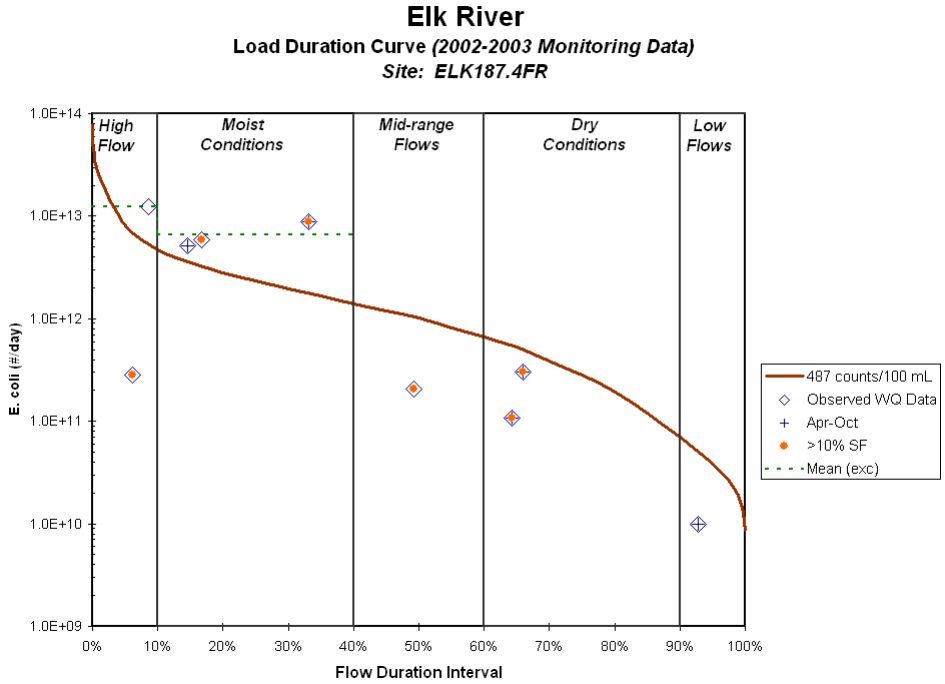

Figure E-14. E. Coli Load Duration Curve for Elk River – RM187.4

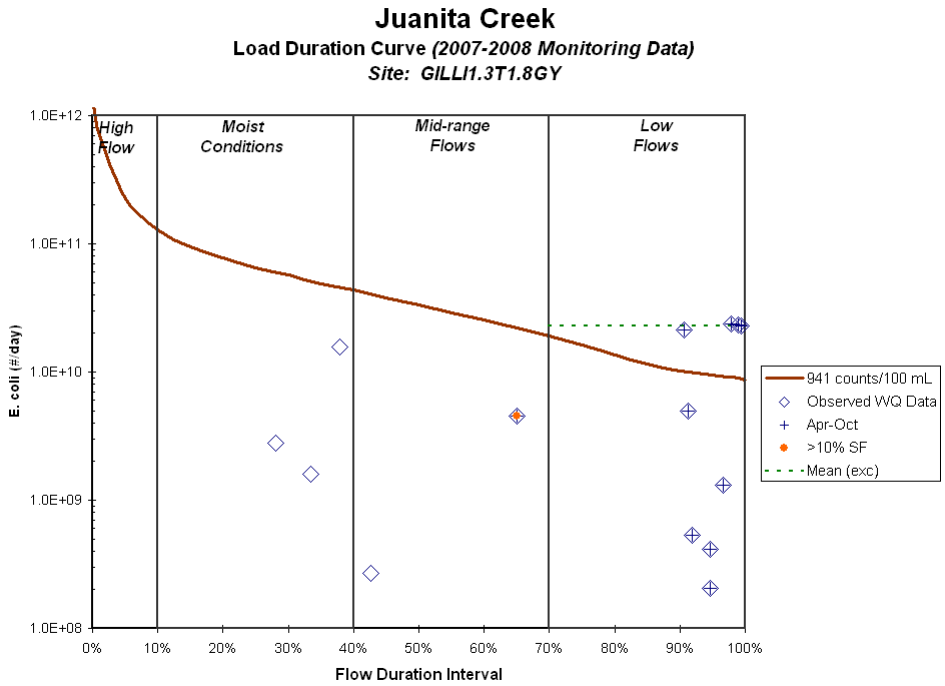

Figure E-15. E. Coli Load Duration Curve for Juanita Creek – RM1.8

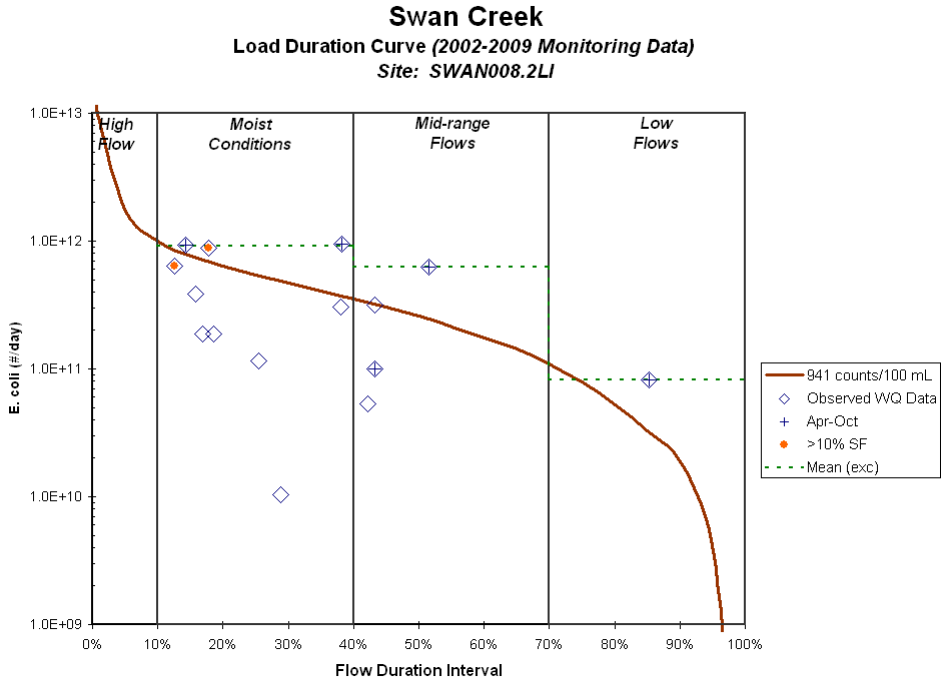

Figure E-16. E. Coli Load Duration Curve for Swan Creek – RM8.2

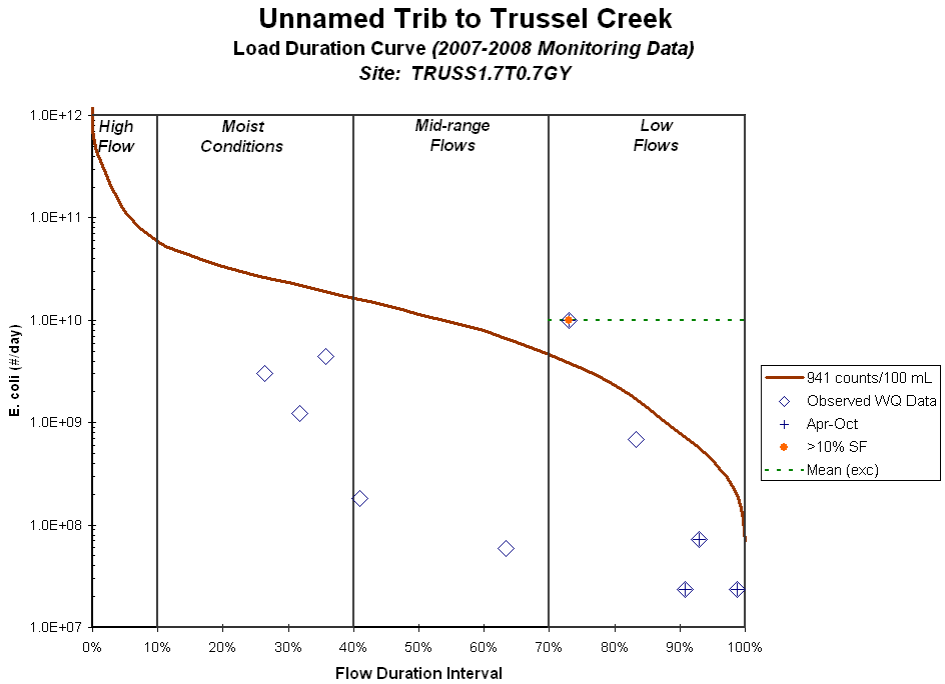

Figure E-17. E. Coli Load Duration Curve for Unnamed Trib to Trussel Creek – RM0.7

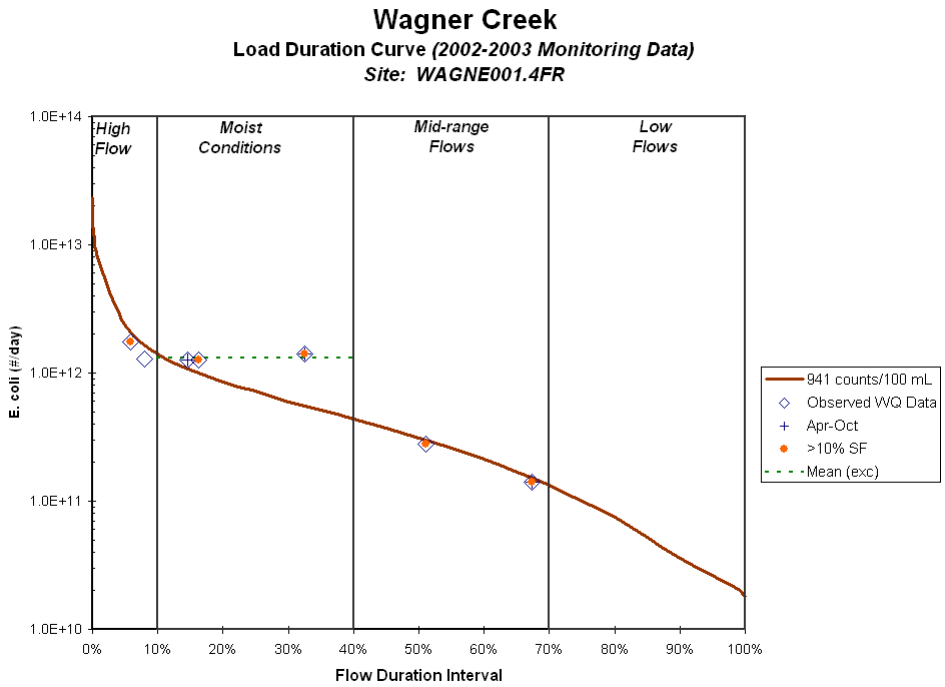

Figure E-18. E. Coli Load Duration Curve for Wagner Creek – RM1.4

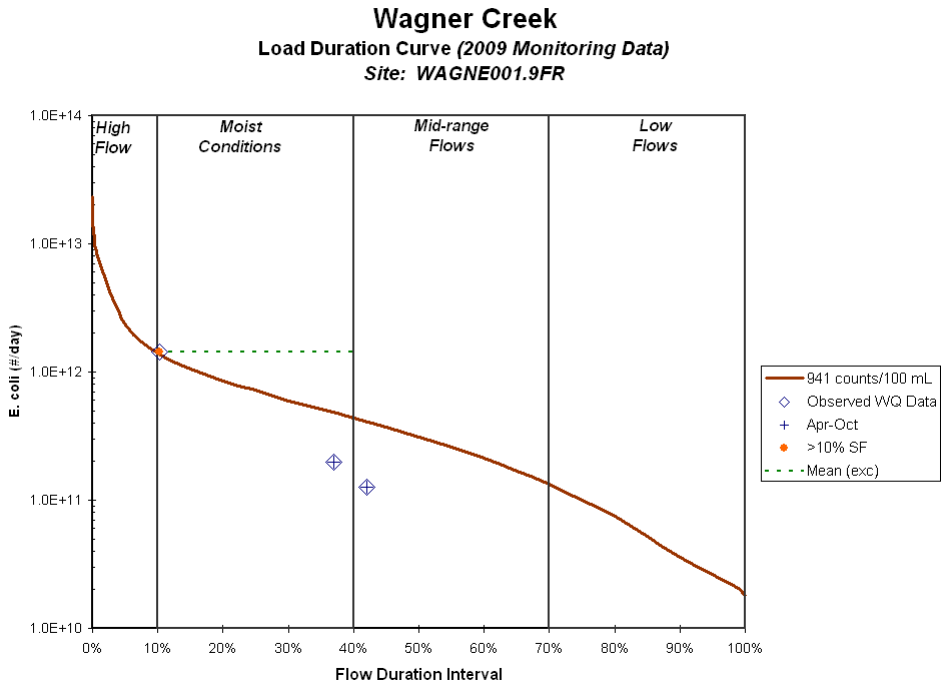

Figure E-19. E. Coli Load Duration Curve for Wagner Creek – RM1.9

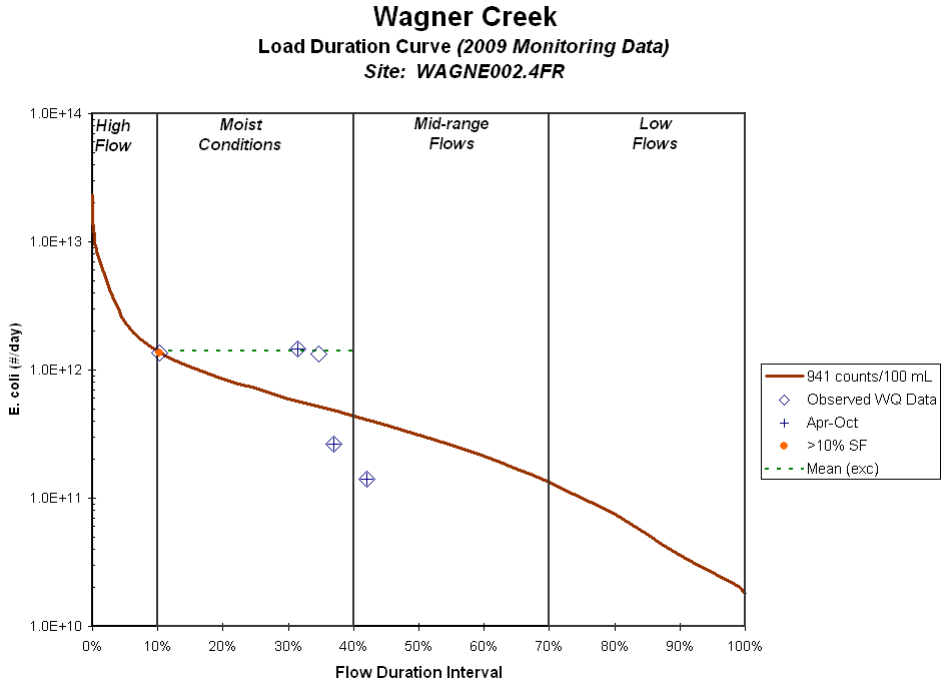

Figure E20. E. Coli Load Duration Curve for Wagner Creek – RM2.4

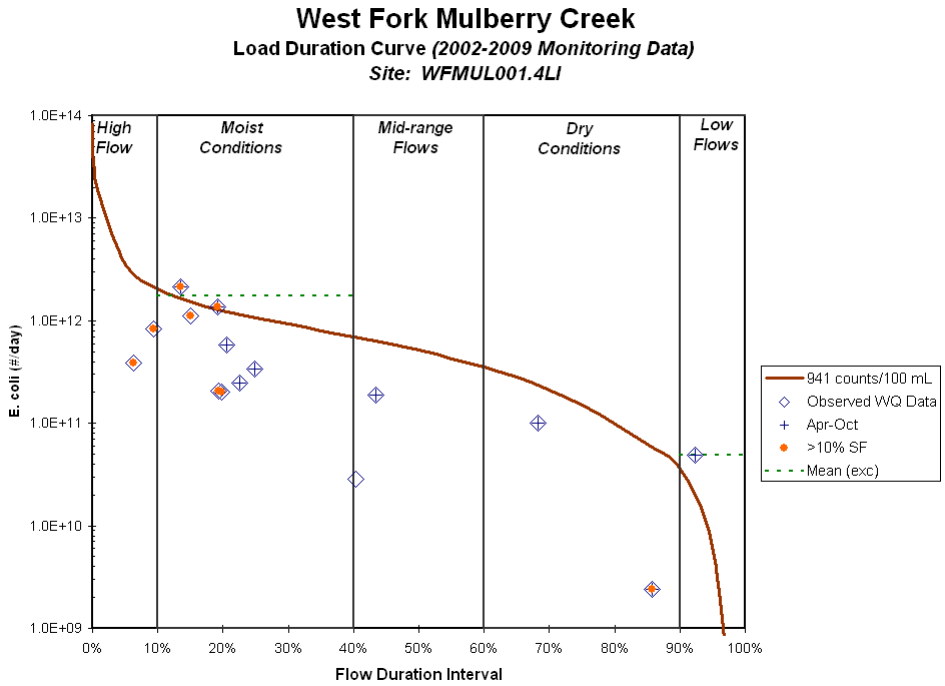

Figure E-21. E. Coli Load Duration Curve for West Fork Mulberry Creek – RM1.4

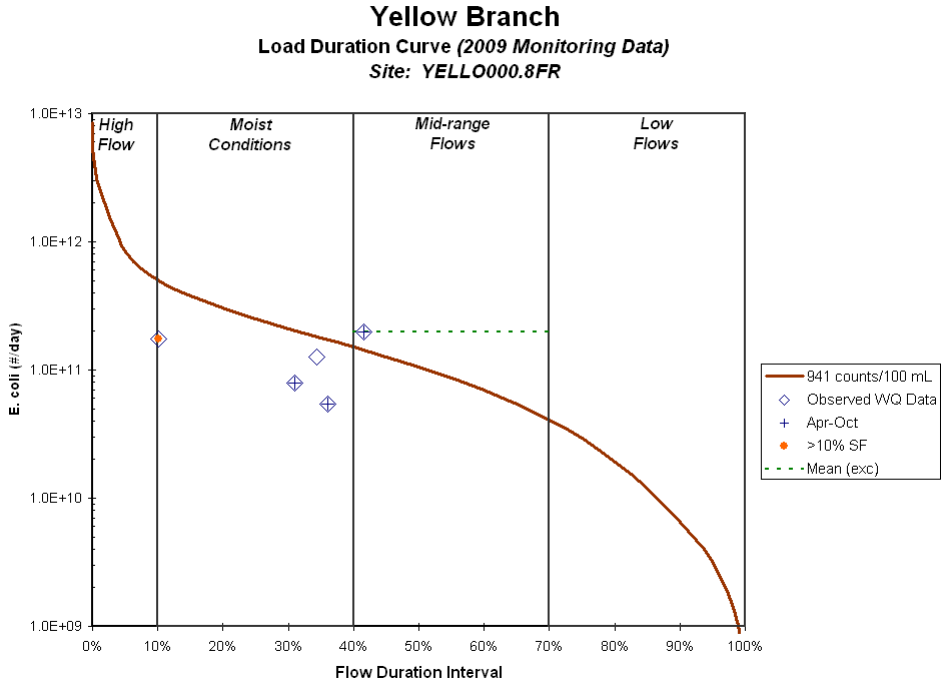

Figure E-22. E. Coli Load Duration Curve for Yellow Branch – RM0.8

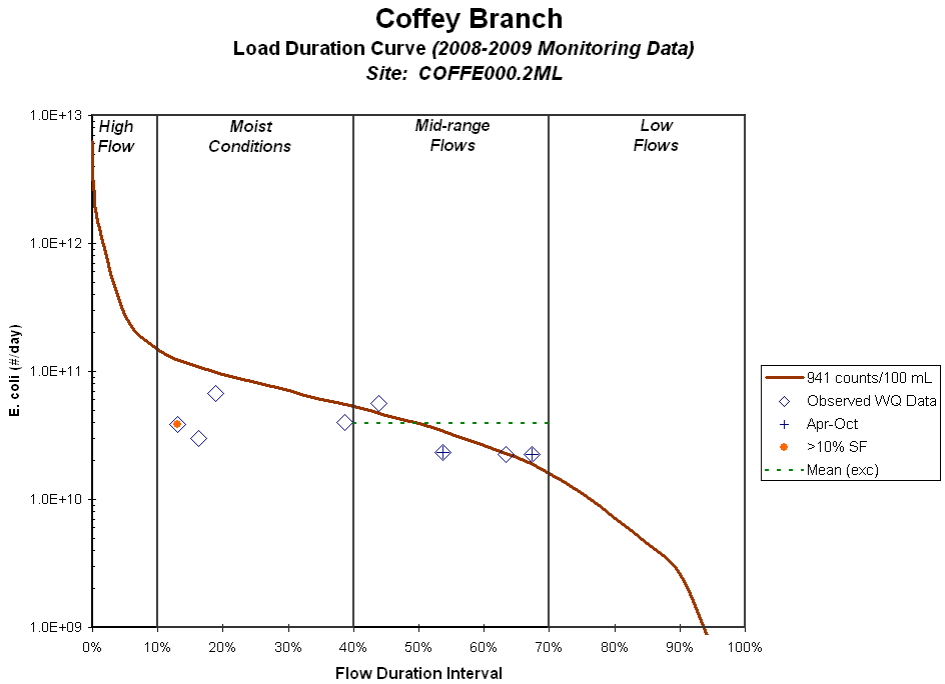

Figure E-23. E. Coli Load Duration Curve for Coffey Branch – RM0.2

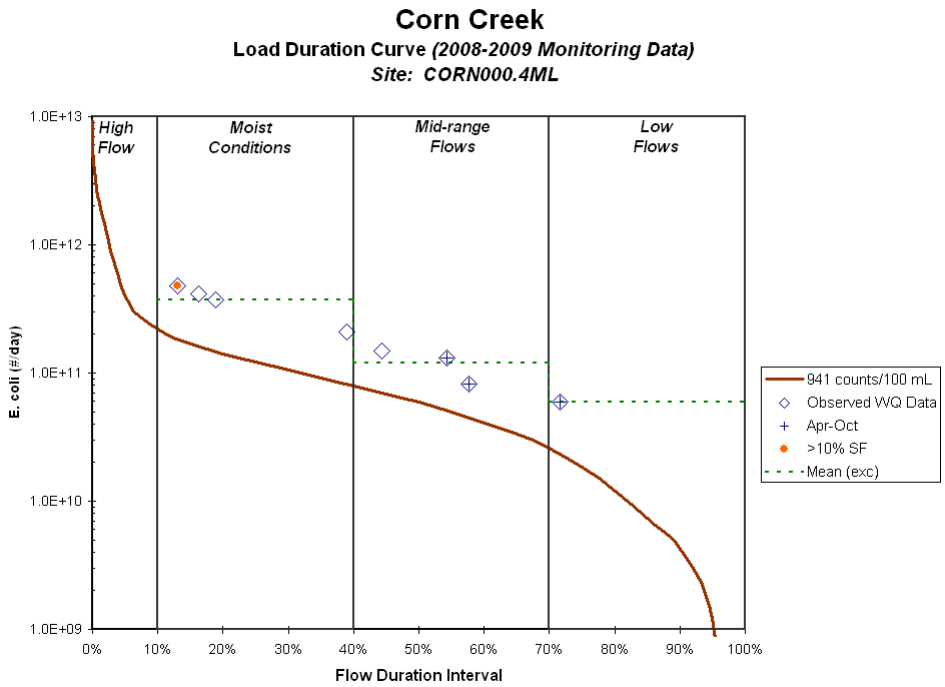

Figure E-24. E. Coli Load Duration Curve for Corn Creek – RM0.4

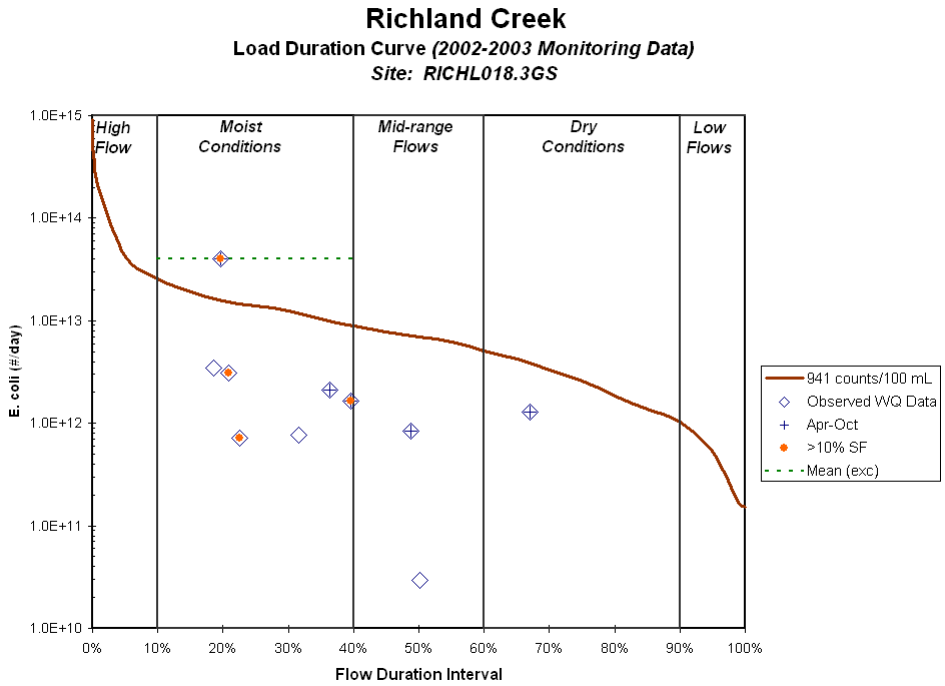

Figure E-25. E. Coli Load Duration Curve for Richland Creek – RM18.3

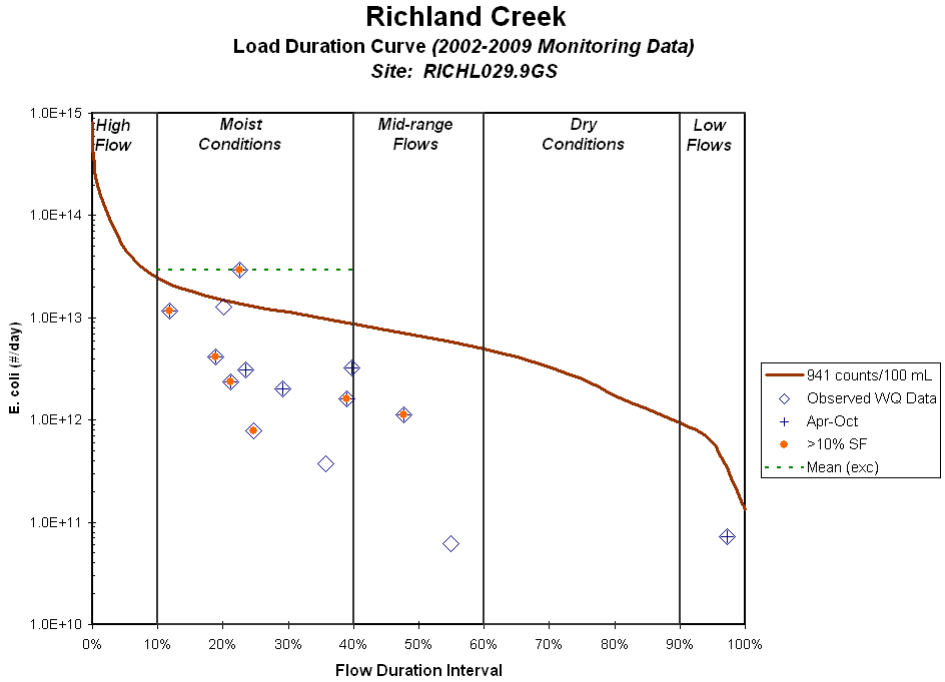

Figure E-26. E. Coli Load Duration Curve for Richland Creek – RM29.9

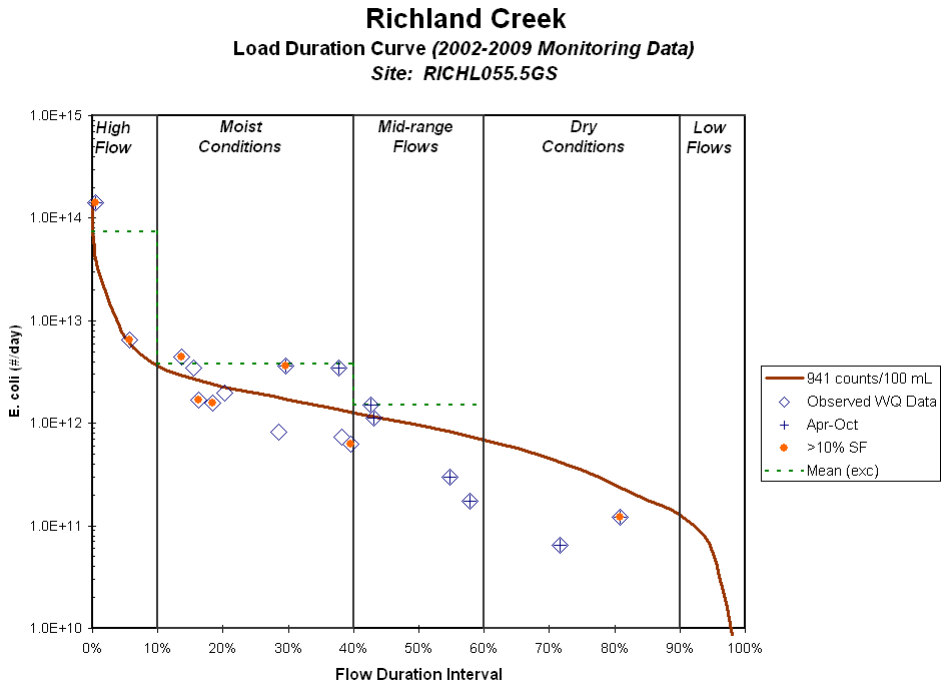

Figure E-27. E. Coli Load Duration Curve for Richland Creek – RM55.5

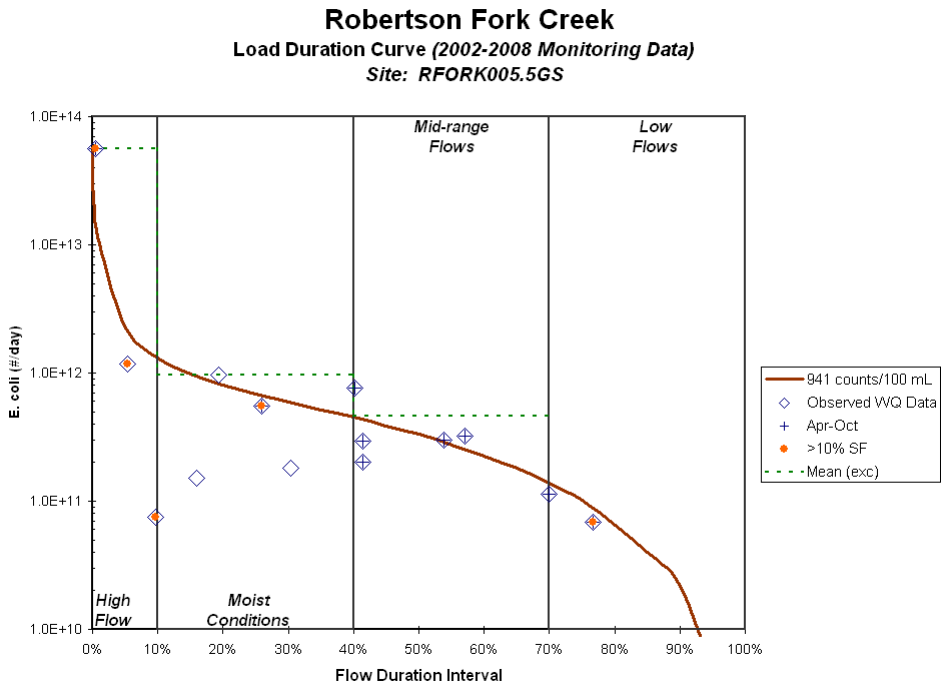

Figure E-28. E. Coli Load Duration Curve for Robertson Fork Creek – RM5.5

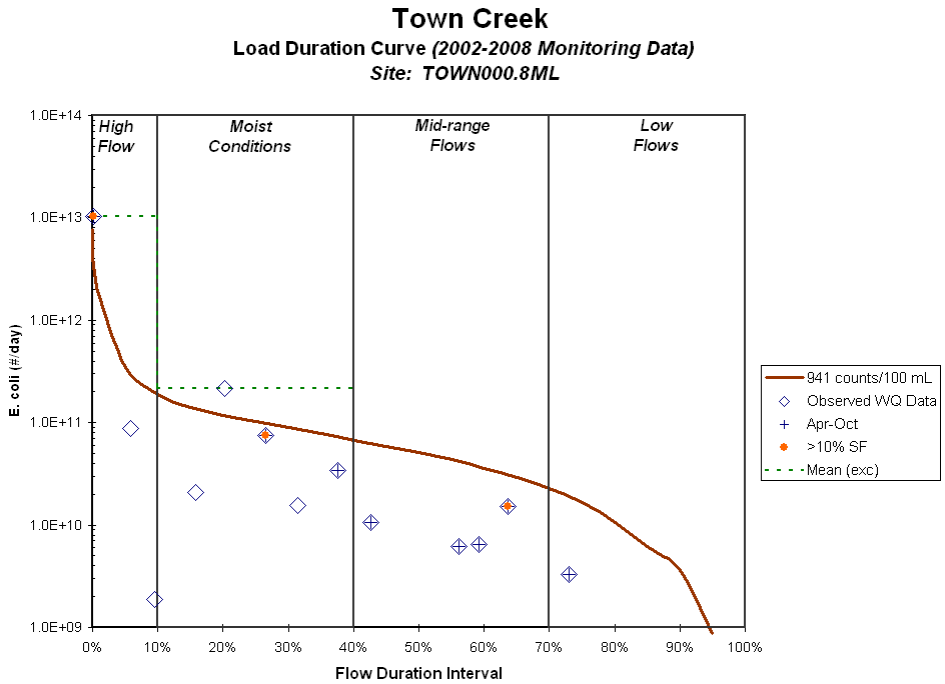

Figure E-29. E. Coli Load Duration Curve for Town Branch – RM0.8

Table E-4. Calculated Load Reduction Based on Daily Loading – Betsy Willis Creek – RM0.2

Sample Date	Flow Regime	Flow	PDFE	Concentration	Load	% Reduction to Achieve TMDL	Average of Load Reductions	% Reduction to TMDL – MOS
		[cfs]	[%]	[CFU/100 ml]	[CFU/day]	[%]	[%]	[%]
11/2/09	Moist Conditions	48.95	11.8%	920.8	1.10E+12	NR	**2.5**	**4.8**
10/29/09		20.87	32.0%	1046.2	5.34E+11	**10.1**		
11/9/09		19.36	34.3%	770.1	3.65E+11	NR		
10/20/09		17.62	37.0%	517.2	2.23E+11	NR		
10/22/09	Mid-Range Flows	15.05	41.8%	770.1	2.84E+11	NR	**NR**	**NR**

Note: NR = No reduction required
NA = Not applicable

Table E-5. Calculated Load Reduction Based on Geomean Data – Betsy Willis Creek – RM0.2

Sample Date	Flow	PDFE	Concentration	Geometric Mean	Calculated Reduction to Target GM (126 CFU/100 ml)	Calculated Reduction to Target – MOS (113 CFU/100 ml)
	[cfs]	[%]	[CFU/100 ml]	[CFU/100 ml]	[%]	[%]
10/20/09	17.62	37.0%	517.2			
10/22/09	15.05	41.8%	770.1			
10/29/09	20.87	32.0%	1046.2			
11/2/09	48.95	11.8%	920.8			
11/9/09	19.36	34.3%	770.1	**783.6**	**83.9**	**85.6**

Note: Geometric Mean is calculated whenever 5 or more samples are collected over a period of not more than 30 consecutive days.

Table E-6. Calculated Load Reduction Based on Daily Loading – Blue Creek – RM0.1

Sample Date	Flow Regime	Flow	PDFE	Concentration	Load	% Reduction to Achieve TMDL	Average of Load Reductions	% Reduction to TMDL – MOS
		[cfs]	[%]	[CFU/100 ml]	[CFU/day]	[%]	[%]	[%]
11/2/09	Moist Conditions	27.12	10.2%	218.7	1.45E+11	NR	**NR**	**NR**
10/29/09		10.99	31.9%	307.6	8.27E+10	NR		
11/9/09		9.90	35.2%	185	4.48E+10	NR		
10/20/09		9.28	36.8%	365.4	8.30E+10	NR		
10/22/09	Mid-Range Flows	7.82	42.0%	1203.3	2.30E+11	**21.8**	**21.8**	**29.6**

Note: NR = No reduction required
NA = Not applicable

Table E-7. Calculated Load Reduction Based on Geomean Data – Blue Creek – RM0.1

Sample Date	Flow	PDFE	Concentration	Geometric Mean	Calculated Reduction to Target GM (126 CFU/100 ml)	Calculated Reduction to Target – MOS (113 CFU/100 ml)
	[cfs]	[%]	[CFU/100 ml]	[CFU/100 ml]	[%]	[%]
10/20/09	9.28	36.8%	365.4			
10/22/09	7.82	42.0%	1203.3			
10/29/09	10.99	31.9%	307.6			
11/2/09	27.12	10.2%	218.7			
11/9/09	9.90	35.2%	185	**352.9**	**64.3**	**68.0**

Note: Geometric Mean is calculated whenever 5 or more samples are collected over a period of not more than 30 consecutive days.

Table E-8. Calculated Load Reduction Based on Daily Loading – Boiling Fork Creek – RM10.1

Sample Date	Flow Regime	Flow	PDFE	Concentration	Load	% Reduction to Achieve TMDL	Average of Load Reductions	% Reduction to TMDL – MOS
		[cfs]	[%]	[CFU/100 ml]	[CFU/day]	[%]	[%]	[%]
2/24/03	High Flows	238.80	6.1%	920	5.38E+12	NR		
12/12/02		181.00	8.5%	290	1.28E+12	NR	**NR**	**NR**
5/20/03	Moist Conditions	125.30	14.3%	260	7.97E+11	NR		
11/12/02		110.40	16.7%	490	1.32E+12	NR		
10/29/02		66.20	30.7%	2400	3.89E+12	**60.8**	**20.3**	**21.6**
3/12/03	Mid-Range Flows	33.44	50.0%	330	2.70E+11	NR		
4/1/03		16.45	66.3%	360	1.45E+11	NR		
6/24/03		16.110	66.6%	460	1.81E+11	NR	**NR**	**NR**
8/29/02	Low Flows	4.83	84.1%	91	1.07E+10	NR		
9/5/02		2.15	92.7%	110	5.78E+09	NR	**NR**	**NR**

Note: NR = No reduction required
NA = Not applicable

Table E-9. Calculated Load Reduction Based on Daily Loading – Boiling Fork Creek – RM13.4

Sample Date	Flow Regime	Flow	PDFE	Concentration	Load	% Reduction to Achieve TMDL	Average of Load Reductions	% Reduction to TMDL – MOS
		[cfs]	[%]	[CFU/100 ml]	[CFU/day]	[%]	[%]	[%]
11/2/09	Moist Conditions	88.83	10.5%	307.6	6.69E+11	NR		
10/29/09		36.45	30.7%	461.1	4.11E+11	NR		
10/20/09		30.41	36.6%	579.4	4.31E+11	NR	**NR**	**NR**
10/22/09	Mid-Range Flows	25.90	41.6%	145	9.19E+10	NR	**NR**	**NR**

Note: NR = No reduction required
NA = Not applicable

Table E-10. Calculated Load Reduction Based on Daily Loading – Boiling Fork Creek – RM14.6

Sample Date	Flow Regime	Flow	PDFE	Concentration	Load	% Reduction to Achieve TMDL	Average of Load Reductions	% Reduction to TMDL – MOS
		[cfs]	[%]	[CFU/100 ml]	[CFU/day]	[%]	[%]	[%]
2/24/03	High Flows	84.23	6.1%	44	9.07E+10	NR		
12/12/02		63.64	8.7%	260	4.05E+11	NR	**NR**	**NR**
5/20/03	Moist Conditions	42.39	14.6%	550	5.70E+11	NR		
11/12/02		38.72	16.5%	820	7.77E+11	NR		
10/29/02		20.67	33.3%	2400	1.21E+12	**60.8**	**20.3**	**21.6**
3/12/03	Mid-Range Flows	11.35	50.4%	62	1.72E+10	NR		
4/1/03		5.44	66.3%	140	1.86E+10	NR		
6/24/03		5.45	66.3%	2000	2.67E+11	**53.0**	**17.7**	**19.2**
8/29/02	Low Flows	1.05	86.7%	120	3.09E+09	NR		
9/5/02		0.58	92.2%	72	1.03E+09	NR	**NR**	**NR**

Note: NR = No reduction required
NA = Not applicable

Table E-11. Calculated Load Reduction Based on Daily Loading – Caldwell Creek – RM1.1

Sample Date	Flow Regime	Flow	PDFE	Concentration	Load	% Reduction to Achieve TMDL	Average of Load Reductions	% Reduction to TMDL – MOS
		[cfs]	[%]	[CFU/100 ml]	[CFU/day]	[%]	[%]	[%]
11/2/09	Moist Conditions	76.75	11.3%	435.2	8.17E+11	NR	**NR**	**NR**
10/29/09		33.08	31.5%	307.6	2.49E+11	NR		
11/9/09		29.90	34.6%	185	1.35E+11	NR		
10/20/09		27.86	36.6%	270	1.84E+11	NR		
10/22/09	Mid-Range Flows	23.75	41.4%	387.3	2.25E+11	NR	**NR**	**NR**

Note: NR = No reduction required
NA = Not applicable

Table E-12. Calculated Load Reduction Based on Geomean Data – Caldwell Creek – RM1.1

Sample Date	Flow	PDFE	Concentration	Geometric Mean	Calculated Reduction to Target GM (126 CFU/100 ml)	Calculated Reduction to Target – MOS (113 CFU/100 ml)
	[cfs]	[%]	[CFU/100 ml]	[CFU/100 ml]	[%]	[%]
10/20/09	27.86	36.6%	270			
10/22/09	23.75	41.4%	387.3			
10/29/09	33.08	31.5%	307.6			
11/2/09	76.75	11.3%	435.2			
11/9/09	29.90	34.6%	185	**303.8**	**58.5**	**62.8**

Note: Geometric Mean is calculated whenever 5 or more samples are collected over a period of not more than 30 consecutive days.

Table E-13. Calculated Load Reduction Based on Daily Loading – Cane Creek – RM6.6

Sample Date	Flow Regime	Flow	PDFE	Concentration	Load	% Reduction to Achieve TMDL	Average of Load Reductions	% Reduction to TMDL – MOS
		[cfs]	[%]	[CFU/100 ml]	[CFU/day]	[%]	[%]	[%]
5/20/03	Moist Conditions	138.70	14.0%	2000	6.79E+12	**53.0**		
3/10/03		117.30	17.8%	100	2.87E+11	NR		
11/7/02		116.60	18.0%	1200	3.42E+12	**21.6**		
1/6/03		89.84	26.4%	210	4.62E+11	NR		
2/12/03		82.87	29.1%	52	1.05E+11	NR		
10/7/02		63.26	38.4%	1700	2.63E+12	**44.6**	**19.9**	**22.9**
12/3/02	Mid-Range Flows	55.77	42.9%	120	1.64E+11	NR		
4/16/03		53.91	44.0%	870	1.15E+12	NR		
6/16/03		40.81	52.7%	2400	2.40E+12	**60.8**	**20.3**	**22.5**
8/7/02	Dry Conditions	5.44	85.5%	180	2.39E+10	NR	**NR**	**NR**
9/10/02	Low Flows	2.42	92.0%	91	5.39E+09	NR	**NR**	**NR**

Note: NR = No reduction required
NA = Not applicable

Table E-14. Calculated Load Reduction Based on Daily Loading – Cane Creek – RM8.1

Sample Date	Flow Regime	Flow	PDFE	Concentration	Load	% Reduction to Achieve TMDL	Average of Load Reductions	% Reduction to TMDL – MOS
		[cfs]	[%]	[CFU/100 ml]	[CFU/day]	[%]	[%]	[%]
11/2/09	High Flow	192.60	8.5%	687	3.24E+12	NR	**NR**	**NR**
11/5/09	Moist Conditions	109.60	19.2%	228	6.11E+11	NR		
10/29/09		106.60	20.1%	218	5.69E+11	NR		
10/21/09		97.64	22.8%	102	2.44E+11	NR		
10/22/09		91.89	24.9%	105	2.36E+11	NR	**NR**	**NR**
7/25/07	Low Flow	0.03	97.7%	199	1.51E+08	NR	**NR**	**NR**

Note: NR = No reduction required
NA = Not applicable

Table E-15. Calculated Load Reduction Based on Geomean Data – Cane Creek – RM8.1

Sample Date	Flow	PDFE	Concentration	Geometric Mean	Calculated Reduction to Target GM (126 CFU/100 ml)	Calculated Reduction to Target – MOS (113 CFU/100 ml)
	[cfs]	[%]	[CFU/100 ml]	[CFU/100 ml]	[%]	[%]
10/21/09	97.64	22.8%	102			
10/22/09	91.89	24.9%	105			
10/29/09	106.60	20.1%	218			
11/2/09	192.60	8.5%	687			
11/5/09	109.60	19.2%	228	**205.4**	**38.7**	**45.0**

Note: Geometric Mean is calculated whenever 5 or more samples are collected over a period of not more than 30 consecutive days.

Table E-16. Calculated Load Reduction Based on Daily Loading – East Fork Mulberry Creek – RM6.2

Sample Date	Flow Regime	Flow	PDFE	Concentration	Load	% Reduction to Achieve TMDL	Average of Load Reductions	% Reduction to TMDL – MOS
		[cfs]	[%]	[CFU/100 ml]	[CFU/day]	[%]	[%]	[%]
2/26/03	High Flow	184.50	4.2%	190	8.58E+11	NR		
12/4/02		122.10	7.0%	380	1.14E+12	NR	**NR**	**NR**
4/8/03	Moist Conditions	73.42	13.5%	1600	2.87E+12	**41.2**		
11/13/02		66.39	15.0%	380	6.17E+11	NR		
5/22/03		56.24	19.3%	1300	1.79E+12	**27.6**		
3/11/03		54.69	20.3%	72	9.63E+10	NR	**17.2**	**20.5**
1/14/03	Mid-Range Flows	29.82	40.9%	59	4.30E+10	NR		
10/23/02		27.57	44.1%	490	3.31E+11	NR		
6/25/03		10.70	69.2%	170	4.45E+10	NR	**NR**	**NR**
8/14/02	Low Flows	4.55	81.0%	1100	1.22E+11	**14.5**		
9/12/02		1.48	92.9%	650	2.35E+10	NR	**7.2**	**11.5**

Note: NR = No reduction required
NA = Not applicable

Table E-17. Calculated Load Reduction Based on Daily Loading – East Fork Mulberry Creek – RM10.2

Sample Date	Flow Regime	Flow	PDFE	Concentration	Load	% Reduction to Achieve TMDL	Average of Load Reductions	% Reduction to TMDL – MOS
		[cfs]	[%]	[CFU/100 ml]	[CFU/day]	[%]	[%]	[%]
11/2/09	High Flow	71.19	9.6%	488	8.50E+11	NR	**NR**	**NR**
11/5/09	Moist Conditions	43.97	19.3%	261	2.81E+11	NR		
10/29/09		42.39	21.0%	365	3.79E+11	NR		
10/21/09		39.81	22.8%	435	4.24E+11	NR		
10/22/09		37.57	25.1%	313	2.88E+11	NR	**NR**	**NR**
8/8/06	Low Flows	0.77	95.2%	470	8.84E+09	NR		
8/24/06		0.61	96.3%	1100	1.63E+10	**14.5**		
7/26/07		0.49	97.7%	1120	1.34E+10	**16.0**	**10.1**	**15.8**

Note: NR = No reduction required
NA = Not applicable

Table E-18. Calculated Load Reduction Based on Geomean Data – East Fork Mulberry Creek – RM10.2

Sample Date	Flow	PDFE	Concentration	Geometric Mean	Calculated Reduction	
					to Target GM (126 CFU/100 ml)	to Target – MOS (113 CFU/100 ml)
	[cfs]	[%]	[CFU/100 ml]	[CFU/100 ml]	[%]	[%]
10/21/09	39.81	22.8%	435			
10/22/09	37.57	25.1%	313			
10/29/09	42.39	21.0%	365			
11/2/09	71.19	9.6%	488			
11/5/09	43.973	19.3%	261	**363.3**	**65.3**	**68.9**

Note: Geometric Mean is calculated whenever 5 or more samples are collected over a period of not more than 30 consecutive days.

Table E-19. Calculated Load Reduction Based on Daily Loading – East Fork Mulberry Creek – RM14.1

Sample Date	Flow Regime	Flow	PDFE	Concentration	Load	% Reduction to Achieve TMDL	Average of Load Reductions	% Reduction to TMDL – MOS
		[cfs]	[%]	[CFU/100 ml]	[CFU/day]	[%]	[%]	[%]
2/26/03	High Flow	105.82	3.6%	1100	2.85E+12	**14.5**		
12/4/02		78.37	5.0%	240	4.60E+11	NR	**7.2**	**11.5**
4/8/03	Moist Conditions	35.14	13.8%	1100	9.46E+11	**14.5**		
11/13/02		32.87	15.2%	330	2.65E+11	NR		
5/22/03		28.08	19.3%	770	5.29E+11	NR		
3/11/03		28.04	19.5%	70	4.80E+10	NR	**3.6**	**5.8**
1/14/03	Mid-Range Flows	15.24	40.2%	160	5.97E+10	NR		
10/23/02		14.12	43.0%	650	2.25E+11	NR		
6/25/03		5.38	68.4%	1300	1.71E+11	**27.6**	**9.2**	**11.6**
8/14/02	Low Flows	2.23	80.0%	420	2.29E+10	NR		
9/12/02		0.58	92.1%	250	3.55E+09	NR		
8/24/06		0.10	96.4%	270	6.34E+08	NR	**NR**	**NR**

Note: NR = No reduction required
NA = Not applicable

Table E-20. Calculated Load Reduction Based on Daily Loading – Elk River – RM93.9

Sample Date	Flow Regime	Flow	PDFE	Concentration	Load	% Reduction to Achieve TMDL	Average of Load Reductions	% Reduction to TMDL – MOS
		[cfs]	[%]	[CFU/100 ml]	[CFU/day]	[%]	[%]	[%]
11/2/09	Moist Conditions	3613.0	10.1%	260	2.30E+13	NR		
11/7/02		3369.0	11.1%	1200	9.89E+13	**59.4**		
5/20/03		3246.0	12.0%	580	4.61E+13	**16.0**		
3/10/03		1798.0	22.8%	20	8.80E+11	NR		
1/6/03		1667.0	24.7%	40	1.63E+12	NR		
11/5/09		1546.0	26.7%	107	4.05E+12	NR		
10/29/09		1430.0	29.7%	122	4.27E+12	NR		
2/12/03		1379.0	31.1%	32	1.08E+12	NR		
6/16/03		1316.0	33.1%	100	3.22E+12	NR	**8.4**	**9.8**
10/21/09	Mid-Range Flows	966.90	45.0%	75	1.77E+12	NR		
10/22/09		916.30	47.2%	299	6.70E+12	NR		
10/7/02		859.30	49.9%	2400	5.05E+13	79.7		
12/3/02		796.50	52.7%	86	1.68E+12	NR	**19.9**	**20.4**
8/7/02	Low Flows	125.80	90.0%	190	5.85E+11	NR		
9/10/02		73.58	95.8%	180	3.24E+11	NR		
7/25/07		58.12	97.6%	86	1.22E+11	NR	**NR**	**NR**

Note: NR = No reduction required
NA = Not applicable

Table E-21. Calculated Load Reduction Based on Geomean Data – Elk River – RM93.9

Sample Date	Flow	PDFE	Concentration	Geometric Mean	Calculated Reduction	
					to Target GM (126 CFU/100 ml)	to Target – MOS (113 CFU/100 ml)
	[cfs]	[%]	[CFU/100 ml]	[CFU/100 ml]	[%]	[%]
10/21/09	966.90	45.0%	75			
10/22/09	916.30	47.2%	299			
10/29/09	1430.0	29.7%	122			
11/2/09	3613.0	10.1%	260			
11/5/09	1546.0	26.7%	107	**150.1**	**16.0**	**24.7**

Note: Geometric Mean is calculated whenever 5 or more samples are collected over a period of not more than 30 consecutive days.

Table E-22. Calculated Load Reduction Based on Daily Loading – Elk River – RM187.4

Sample Date	Flow Regime	Flow	PDFE	Concentration	Load	% Reduction to Achieve TMDL	Average of Load Reductions	% Reduction to TMDL – MOS
		[cfs]	[%]	[CFU/100 ml]	[CFU/day]	[%]	[%]	[%]
2/24/03	High Flow	605.50	6.1%	19	2.81E+11	NR		
12/12/02		457.40	8.6%	1100	1.23E+13	**55.7**	**27.9**	**30.1**
5/20/03	Moist Conditions	303.80	14.5%	690	5.13E+12	**29.4**		
11/12/02		275.50	16.7%	870	5.86E+12	**44.0**		
10/29/02		149.60	33.2%	2400	8.78E+12	**79.7**	**51.1**	**56.0**
3/12/03	Mid-Range Flows	88.03	49.2%	96	2.07E+11	NR	**NR**	**NR**
4/1/03	Dry Conditions	46.17	64.3%	96	1.08E+11	NR		
6/24/03		42.19	65.9%	290	2.99E+11	NR	**NR**	**NR**
9/5/02	Low Flows	4.57	92.8%	88	9.84E+09	NR	**NR**	**NR**

Note: NR = No reduction required
NA = Not applicable

Table E-23. Calculated Load Reduction Based on Daily Loading – Elk River – RM195.3

Sample Date	Flow Regime	Flow	PDFE	Concentration	Load	% Reduction to Achieve TMDL	Average of Load Reductions	% Reduction to TMDL – MOS
		[cfs]	[%]	[CFU/100 ml]	[CFU/day]	[%]	[%]	[%]
11/2/09	Moist Conditions	259.10	10.5%	461.1	2.92E+12	NR	**NR**	**NR**
10/29/09		110.80	30.3%	360.9	9.78E+11	NR		
11/9/09		99.46	33.8%	186	4.53E+11	NR		
10/20/09		91.91	36.2%	248.1	5.58E+11	NR		
10/22/09	Mid-Range Flows	77.88	41.1%	325.5	6.20E+11	NR	**NR**	**NR**

Note: NR = No reduction required
NA = Not applicable

Table E-24. Calculated Load Reduction Based on Geomean Data – Elk River – RM195.3

Sample Date	Flow	PDFE	Concentration	Geometric Mean	Calculated Reduction	
					to Target GM (126 CFU/100 ml)	to Target – MOS (113 CFU/100 ml)
	[cfs]	[%]	[CFU/100 ml]	[CFU/100 ml]	[%]	[%]
10/20/09	91.91	36.2%	248.1			
10/22/09	77.88	41.1%	325.5			
10/29/09	110.80	30.3%	360.9			
11/2/09	259.10	10.5%	461.1			
11/9/09	99.46	33.8%	186	**301.7**	**58.2**	**62.5**

Note: Geometric Mean is calculated whenever 5 or more samples are collected over a period of not more than 30 consecutive days.

Table E-25. Calculated Load Reduction Based on Daily Loading – Juanita Creek – RM1.8

Sample Date	Flow Regime	Flow	PDFE	Concentration	Load	% Reduction to Achieve TMDL	Average of Load Reductions	% Reduction to TMDL – MOS
		[cfs]	[%]	[CFU/100 ml]	[CFU/day]	[%]	[%]	[%]
2/9/08	Moist Conditions	2.63	28.0%	43.7	2.81E+09	NR		
2/11/08		2.23	33.5%	29.2	1.59E+09	NR		
12/3/07		1.98	37.9%	325.5	1.58E+10	NR	**NR**	**NR**
3/3/08	Mid-Range Flows	1.74	42.7%	6.3	2.69E+08	NR		
6/9/08		0.96	65.0%	191.8	4.50E+09	NR	**NR**	**NR**
10/1/07	Low Flows	0.44	90.7%	1986.28	2.15E+10	**52.6**		
9/5/07		0.44	91.3%	461.1	4.94E+09	NR		
8/2/07		0.44	91.8%	50.4	5.36E+08	NR		
8/7/07		0.42	94.6%	20.1	2.05E+08	NR		
5/14/08		0.42	94.7%	40.4	4.11E+08	NR		
7/12/07		0.40	96.7%	133.4	1.32E+09	NR		
7/18/07		0.40	97.9%	2419.2	2.36E+10	**61.1**		
7/17/07		0.39	98.9%	2419.2	2.32E+10	**61.1**		
7/19/07		0.39	99.4%	2419.2	2.30E+10	**61.1**	**26.2**	**28.0**

Note: NR = No reduction required
NA = Not applicable

Table E-26. Calculated Load Reduction Based on Geomean Data – Juanita Creek – RM1.8

Sample Date	Flow	PDFE	Concentration	Geometric Mean	Calculated Reduction to Target GM (126 CFU/100 ml)	Calculated Reduction to Target – MOS (113 CFU/100 ml)
	[cfs]	[%]	[CFU/100 ml]	[CFU/100 ml]	[%]	[%]
7/12/07	0.40	96.7%	133.4			
7/17/07	0.39	98.9%	2419.2			
7/18/07	0.40	97.9%	2419.2			
7/19/07	0.39	99.4%	2419.2			
8/2/07	0.44	91.8%	50.4	919.1	86.3	87.7
8/7/07	0.42	94.6%	20.1	427.9	**70.6**	**73.6**

Note: Geometric Mean is calculated whenever 5 or more samples are collected over a period of not more than 30 consecutive days.

Table E-27. Calculated Load Reduction Based on Daily Loading – Swan Creek – RM0.8

Sample Date	Flow Regime	Flow	PDFE	Concentration	Load	% Reduction to Achieve TMDL	Average of Load Reductions	% Reduction to TMDL – MOS
		[cfs]	[%]	[CFU/100 ml]	[CFU/day]	[%]	[%]	[%]
11/3/09	Moist Conditions	89.98	12.8%	613	1.35E+12	NR	**NR**	**NR**
11/4/09		76.81	15.9%	326	6.13E+11	NR		
11/5/09		69.75	19.1%	365	6.23E+11	NR		
11/16/09		38.66	39.0%	113	1.07E+11	NR		
11/19/09	Mid-Range Flows	33.40	44.2%	137	1.12E+11	NR	**NR**	**NR**
7/25/07	Low Flows	0.02	97.6%	219	1.23E+08	NR	**NR**	**NR**

Note: NR = No reduction required
NA = Not applicable

Table E-28. Calculated Load Reduction Based on Geomean Data – Swan Creek – RM0.8

Sample Date	Flow	PDFE	Concentration	Geometric Mean	Calculated Reduction to Target GM (126 CFU/100 ml)	Calculated Reduction to Target – MOS (113 CFU/100 ml)
	[cfs]	[%]	[CFU/100 ml]	[CFU/100 ml]	[%]	[%]
11/3/09	89.98	12.8%	613			
11/4/09	76.81	15.9%	326			
11/5/09	69.75	19.1%	365			
11/16/09	38.66	39.0%	113			
11/19/09	33.40	44.2%	137	257.4	**51.0**	**56.1**

Note: Geometric Mean is calculated whenever 5 or more samples are collected over a period of not more than 30 consecutive days.

Table E-29. Calculated Load Reduction Based on Daily Loading – Swan Creek – RM8.2

Sample Date	Flow Regime	Flow	PDFE	Concentration	Load	% Reduction to Achieve TMDL	Average of Load Reductions	% Reduction to TMDL – MOS
		[cfs]	[%]	[CFU/100 ml]	[CFU/day]	[%]	[%]	[%]
11/3/09	Moist Conditions	37.79	12.6%	687	6.35E+11	NR		
5/20/03		34.52	14.2%	1100	9.29E+11	**14.5**		
11/4/09		32.31	15.8%	488	3.86E+11	NR		
3/10/03		30.83	16.8%	250	1.89E+11	NR		
11/7/02		29.78	17.8%	1200	8.74E+11	**21.6**		
3/28/00		29.65	18.1%	440	3.19E+11	NR		
11/5/09		29.14	18.5%	261	1.86E+11	NR		
1/6/03		23.47	25.4%	200	1.15E+11	NR		
2/12/03		21.35	28.8%	20	1.04E+10	NR		
11/16/09		16.30	38.0%	770	3.07E+11	NR		
10/7/02		16.22	38.2%	2400	9.52E+11	**60.8**	**8.8**	**10.6**
12/3/02	Mid-Range Flows	14.48	42.2%	150	5.31E+10	NR		
4/16/03		14.05	43.3%	290	9.97E+10	NR		
11/19/09		14.04	43.3%	921	3.16E+11	NR		
6/16/03		10.69	51.6%	2400	6.28E+11	**60.8**	**15.2**	**18.2**
8/7/02	Low Flows	1.40	85.3%	2400	8.21E+10	**60.8**	**60.8**	**64.7**

Note: NR = No reduction required
NA = Not applicable

Table E-30. Calculated Load Reduction Based on Geomean Data – Swan Creek – RM8.2

Sample Date	Flow	PDFE	Concentration	Geometric Mean	Calculated Reduction to Target GM (126 CFU/100 ml)	Calculated Reduction to Target – MOS (113 CFU/100 ml)
	[cfs]	[%]	[CFU/100 ml]	[CFU/100 ml]	[%]	[%]
11/3/09	37.79	12.6%	687			
11/4/09	32.31	15.8%	488			
11/5/09	29.14	18.5%	261			
11/16/09	16.30	38.0%	770			
11/19/09	14.04	43.3%	921	573.5	**78.0**	**80.3**

Note: Geometric Mean is calculated whenever 5 or more samples are collected over a period of not more than 30 consecutive days.

Table E-31. Calculated Load Reduction Based on Daily Loading – Unnamed Trib to Trussel Creek – RM0.7

Sample Date	Flow Regime	Flow	PDFE	Concentration	Load	% Reduction to Achieve TMDL	Average of Load Reductions	% Reduction to TMDL – MOS
		[cfs]	[%]	[CFU/100 ml]	[CFU/day]	[%]	[%]	[%]
2/9/08	Moist Conditions	1.15	26.4%	107.6	3.03E+09	NR		
2/11/08		0.94	31.7%	52.9	1.22E+09	NR		
12/3/07		0.82	35.7%	218.7	4.40E+09	NR	**NR**	**NR**
3/3/08	Mid-Range Flows	0.70	40.9%	10.7	1.82E+08	NR		
1/7/08		0.29	63.4%	8.4	5.92E+07	NR	**NR**	**NR**
6/9/08	Low Flows	0.17	73.0%	2419.6	1.00E+10	**61.1**		
11/7/07		0.07	83.3%	387.3	6.82E+08	NR		
9/5/07		0.03	90.8%	29.8	2.33E+07	NR		
10/1/07		0.03	90.8%	4.1	3.21E+06	**61.1**		
8/7/07		0.03	93.0%	119.1	7.28E+07	**61.1**		
7/18/07		0.01	98.8%	106.7	2.35E+07	**61.1**	**10.2**	**10.8**

Note: NR = No reduction required
NA = Not applicable

Table E-32. Calculated Load Reduction Based on Daily Loading – Wagner Creek – RM1.4

Sample Date	Flow Regime	Flow	PDFE	Concentration	Load	% Reduction to Achieve TMDL	Average of Load Reductions	% Reduction to TMDL – MOS
		[cfs]	[%]	[CFU/100 ml]	[CFU/day]	[%]	[%]	[%]
2/24/03	High Flow	92.80	5.9%	770	1.75E+12	NR		
12/12/02		72.37	7.9%	730	1.29E+12	NR	**NR**	**NR**
5/20/03	Moist Conditions	46.94	14.6%	1100	1.26E+12	**14.5**		
11/12/02		43.22	16.2%	1200	1.27E+12	**21.5**		
10/29/02		24.09	32.5%	2400	1.41E+12	**60.8**	**32.3**	**39.0**
3/12/03	Mid-Range Flows	13.00	51.0%	870	2.77E+11	NR		
4/1/03		6.60	67.3%	870	1.40E+11	NR	**NR**	**NR**

Note: NR = No reduction required
NA = Not applicable

Table E-33. Calculated Load Reduction Based on Daily Loading – Wagner Creek – RM1.9

Sample Date	Flow Regime	Flow	PDFE	Concentration	Load	% Reduction to Achieve TMDL	Average of Load Reductions	% Reduction to TMDL – MOS
		[cfs]	[%]	[CFU/100 ml]	[CFU/day]	[%]	[%]	[%]
11/2/09	Moist Conditions	59.96	10.3%	980.4	1.44E+12	4.0		
10/20/09		20.77	37.0%	387.3	1.97E+11	NR	**2.0**	**6.8**
10/22/09	Mid-Range Flows	17.72	42.0%	290.9	1.26E+11	NR	**NR**	**NR**

Note: NR = No reduction required
NA = Not applicable

Table E-34. Calculated Load Reduction Based on Daily Loading – Wagner Creek – RM2.4

Sample Date	Flow Regime	Flow	PDFE	Concentration	Load	% Reduction to Achieve TMDL	Average of Load Reductions	% Reduction to TMDL – MOS
		[cfs]	[%]	[CFU/100 ml]	[CFU/day]	[%]	[%]	[%]
11/2/09	Moist Conditions	59.96	10.3%	920.8	1.35E+12	NR		
10/29/09		24.84	31.4%	2419.6	1.47E+12	**61.1**		
11/9/09		22.57	34.7%	2419.6	1.34E+12	**61.1**		
10/20/09		20.77	37.0%	517.2	2.63E+11	NR	**30.6**	**34.5**
10/22/09	Mid-Range Flows	17.72	42.0%	325.5	1.41E+11	NR	**NR**	**NR**

Note: NR = No reduction required
NA = Not applicable

Table E-35. Calculated Load Reduction Based on Geomean Data – Wagner Creek – RM2.4

Sample Date	Flow	PDFE	Concentration	Geometric Mean	Calculated Reduction	
					to Target GM (126 CFU/100 ml)	to Target – MOS (113 CFU/100 ml)
	[cfs]	[%]	[CFU/100 ml]	[CFU/100 ml]	[%]	[%]
10/20/09	20.77	37.0%	517.2			
10/22/09	17.72	42.0%	325.5			
10/29/09	24.84	31.4%	2419.6			
11/2/09	59.96	10.3%	920.8			
11/9/09	22.57	34.7%	2419.6	980.8	**87.2**	**88.5**

Note: Geometric Mean is calculated whenever 5 or more samples are collected over a period of not more than 30 consecutive days.

Table E-36. Calculated Load Reduction Based on Daily Loading – West Fork Mulberry Creek – RM1.4

Sample Date	Flow Regime	Flow	PDFE	Concentration	Load	% Reduction to Achieve TMDL	Average of Load Reductions	% Reduction to TMDL – MOS
		[cfs]	[%]	[CFU/100 ml]	[CFU/day]	[%]	[%]	[%]
12/4/02	High Flow	130.52	6.3%	120	3.83E+11	NR		
11/2/09		92.87	9.4%	365	8.29E+11	NR	**NR**	**NR**
4/8/03	Moist Conditions	72.09	13.5%	1200	2.12E+12	**21.6**		
11/13/02		66.17	15.0%	690	1.12E+12	NR		
5/22/03		56.08	19.2%	1000	1.37E+12	**5.9**		
11/5/09		55.91	19.3%	150	2.05E+11	NR		
3/11/03		55.22	19.8%	150	2.03E+11	NR		
10/29/09		54.01	20.6%	435	5.75E+11	NR		
10/21/09		49.96	22.6%	201	2.46E+11	NR		
10/22/09		47.03	24.8%	291	3.35E+11	NR	**3.4**	**5.6**
1/14/03	Mid-Range Flows	30.04	40.4%	39	2.87E+10	NR		
10/23/02		27.73	43.4%	280	1.90E+11	NR	**NR**	**NR**
6/25/03	Dry Conditions	10.42	68.3%	390	9.95E+10	NR		
8/14/02		2.52	85.8%	39	2.41E+09	NR	**NR**	**NR**
9/12/02	Low Flows	0.99	92.4%	2000	4.84E+10	53.0		
7/26/07		0.02	97.7%	126	6.47E+07	NR	**26.5**	**28.8**

Note: NR = No reduction required
NA = Not applicable

Table E-37. Calculated Load Reduction Based on Geomean Data – West Fork Mulberry Creek – RM1.4

Sample Date	Flow	PDFE	Concentration	Geometric Mean	Calculated Reduction	
					to Target GM (126 CFU/100 ml)	to Target – MOS (113 CFU/100 ml)
	[cfs]	[%]	[CFU/100 ml]	[CFU/100 ml]	[%]	[%]
10/21/09	49.96	22.6%	201			
10/22/09	47.03	24.8%	291			
10/29/09	54.01	20.6%	435			
11/2/09	92.87	9.4%	365			
11/5/09	55.91	19.3%	150	268.4	**53.1**	**57.9**

Note: Geometric Mean is calculated whenever 5 or more samples are collected over a period of not more than 30 consecutive days.

Table E-38. Calculated Load Reduction Based on Daily Loading – Yellow Branch – RM0.8

Sample Date	Flow Regime	Flow	PDFE	Concentration	Load	% Reduction to Achieve TMDL	Average of Load Reductions	% Reduction to TMDL – MOS
		[cfs]	[%]	[CFU/100 ml]	[CFU/day]	[%]	[%]	[%]
11/2/09	Moist Conditions	21.78	10.1%	325.5	1.73E+11	NR		
10/29/09		8.87	31.0%	365.4	7.93E+10	NR		
11/9/09		7.98	34.4%	648.8	1.27E+11	NR		
10/20/09		7.44	36.1%	298.7	5.43E+10	NR	**NR**	**NR**
10/22/09	Mid-Range Flows	6.27	41.5%	1299.7	1.99E+11	**27.6**	**27.6**	**34.8**

Note: NR = No reduction required
NA = Not applicable

Table E-39. Calculated Load Reduction Based on Geomean Data – Yellow Branch – RM0.8

Sample Date	Flow	PDFE	Concentration	Geometric Mean	Calculated Reduction	
					to Target GM (126 CFU/100 ml)	to Target – MOS (113 CFU/100 ml)
	[cfs]	[%]	[CFU/100 ml]	[CFU/100 ml]	[%]	[%]
10/20/09	7.44	36.1%	298.7			
10/22/09	6.27	41.5%	1299.7			
10/29/09	8.87	31.0%	365.4			
11/2/09	21.78	10.1%	325.5			
11/9/09	7.98	34.4%	648.8	495.8	**74.6**	**77.2**

Note: Geometric Mean is calculated whenever 5 or more samples are collected over a period of not more than 30 consecutive days.

Table E-40. Calculated Load Reduction Based on Daily Loading – Coffey Branch – RM0.2

Sample Date	Flow Regime	Flow	PDFE	Concentration	Load	% Reduction to Achieve TMDL	Average of Load Reductions	% Reduction to TMDL – MOS
		[cfs]	[%]	[CFU/100 ml]	[CFU/day]	[%]	[%]	[%]
11/3/09	Moist Conditions	5.46	13.1%	291	3.89E+10	NR		
11/4/09		4.69	16.3%	261	2.99E+10	NR		
11/5/09		4.24	18.9%	649	6.73E+10	NR		
11/16/09		2.38	38.7%	687	4.00E+10	NR	**NR**	**NR**
11/19/09	Mid-Range Flows	2.05	43.9%	1120	5.61E+10	**16.0**		
10/27/08		1.48	53.7%	649	2.34E+10	NR		
11/4/08		1.00	63.4%	921	2.25E+10	NR		
10/19/08		0.83	67.4%	1120	2.26E+10	**16.0**	**8.0**	**14.2**

Note: NR = No reduction required
NA = Not applicable

Table E-41. Calculated Load Reduction Based on Geomean Data – Coffey Branch – RM0.2

Sample Date	Flow	PDFE	Concentration	Geometric Mean	Calculated Reduction	
					to Target GM (126 CFU/100 ml)	to Target – MOS (113 CFU/100 ml)
	[cfs]	[%]	[CFU/100 ml]	[CFU/100 ml]	[%]	[%]
11/3/09	5.46	13.1%	291			
11/4/09	4.69	16.3%	261			
11/5/09	4.24	18.9%	649			
11/16/09	2.38	38.7%	687			
11/19/09	2.05	43.9%	1120	519.7	**75.8**	**78.3**

Note: Geometric Mean is calculated whenever 5 or more samples are collected over a period of not more than 30 consecutive days.

Table E-42. Calculated Load Reduction Based on Daily Loading – Corn Creek – RM0.4

Sample Date	Flow Regime	Flow	PDFE	Concentration	Load	% Reduction to Achieve TMDL	Average of Load Reductions	% Reduction to TMDL – MOS
		[cfs]	[%]	[CFU/100 ml]	[CFU/day]	[%]	[%]	[%]
11/3/09	Moist Conditions	8.14	13.1%	2420	4.82E+11	61.1		
11/4/09		6.99	16.3%	2420	4.14E+11	61.1		
11/5/09		6.32	18.8%	2420	3.74E+11	61.1		
11/16/09		3.55	39.0%	2420	2.10E+11	61.1	**61.1**	**65.0**
11/19/09	Mid-Range Flows	3.06	44.4%	1986	1.48E+11	**52.6**		
10/27/08		2.22	54.3%	2420	1.31E+11	61.1		
10/29/08		1.94	57.7%	1733	8.24E+10	**45.7**	**53.1**	**57.8**
10/23/08	Low Flows	1.01	71.7%	2420	5.99E+10	**61.1**	**61.1**	**65.0**

Note: NR = No reduction required
NA = Not applicable

Table E-43. Calculated Load Reduction Based on Geomean Data – Corn Creek – RM0.4

Sample Date	Flow	PDFE	Concentration	Geometric Mean	Calculated Reduction	
					to Target GM (126 CFU/100 ml)	to Target – MOS (113 CFU/100 ml)
	[cfs]	[%]	[CFU/100 ml]	[CFU/100 ml]	[%]	[%]
11/3/09	8.14	13.1%	2420			
11/4/09	6.99	16.3%	2420			
11/5/09	6.32	18.8%	2420			
11/16/09	3.55	39.0%	2420			
11/19/09	3.06	44.4%	1986	2326.2	**94.6**	**95.1**

Note: Geometric Mean is calculated whenever 5 or more samples are collected over a period of not more than 30 consecutive days.

Table E-44. Calculated Load Reduction Based on Daily Loading – Elk River – RM36.5

Sample Date	Flow Regime	Flow	PDFE	Concentration	Load	% Reduction to Achieve TMDL	Average of Load Reductions	% Reduction to TMDL – MOS
		[cfs]	[%]	[CFU/100 ml]	[CFU/day]	[%]	[%]	[%]
10/28/09	Moist Conditions	5330	12.7%	308	4.02E+13	NR	**NR**	**NR**
10/20/09		2860	26.7%	166	1.16E+13	NR		
10/21/09		2550	29.8%	219	1.37E+13	NR		
10/26/09		2490	30.5%	276	1.68E+13	NR		
10/22/09		2360	32.0%	108	6.24E+12	NR		
7/24/07	Low Flows	288.0	93.0%	57	4.02E+11	NR	**NR**	**NR**

Note: NR = No reduction required
NA = Not applicable

Table E-45. Calculated Load Reduction Based on Geomean Data – Elk River – RM36.5

Sample Date	Flow	PDFE	Concentration	Geometric Mean	Calculated Reduction	
					to Target GM (126 CFU/100 ml)	to Target – MOS (113 CFU/100 ml)
	[cfs]	[%]	[CFU/100 ml]	[CFU/100 ml]	[%]	[%]
10/20/09	2860	26.7%	166			
10/21/09	2550	29.8%	219			
10/22/09	2360	32.0%	108			
10/26/09	2490	30.5%	276			
10/28/09	5330	12.7%	308	201.7	**37.5**	**44.0**

Note: Geometric Mean is calculated whenever 5 or more samples are collected over a period of not more than 30 consecutive days.

Table E-46. Calculated Load Reduction Based on Daily Loading – Pleasant Run Creek – RM0.1

Sample Date	Flow Regime	Flow	PDFE	Concentration	Load	% Reduction to Achieve TMDL	Average of Load Reductions	% Reduction to TMDL – MOS
		[cfs]	[%]	[CFU/100 ml]	[CFU/day]	[%]	[%]	[%]
10/10/07	Moist Conditions	1.90	23.0%	579	2.69E+10	NR	**NR**	**NR**
10/29/07	Mid-Range Flows	0.57	58.8%	816	1.13E+10	NR		
11/18/08		0.47	62.9%	178	2.06E+09	NR		
11/19/08		0.44	64.0%	13	1.41E+08	NR	**NR**	**NR**
11/4/08	Low Flows	0.19	77.5%	27	1.26E+08	NR		
11/5/08		0.18	78.1%	78	3.47E+08	NR		
10/22/08		0.16	79.5%	107	4.27E+08	NR		
10/9/07		0.01	97.2%	649	2.22E+08	NR		
10/17/07		0.01	97.6%	225	6.06E+07	NR	**NR**	**NR**

Note: NR = No reduction required
NA = Not applicable

Table E-47. Calculated Load Reduction Based on Daily Loading – Richland Creek – RM18.3

Sample Date	Flow Regime	Flow	PDFE	Concentration	Load	% Reduction to Achieve TMDL	Average of Load Reductions	% Reduction to TMDL – MOS
		[cfs]	[%]	[CFU/100 ml]	[CFU/day]	[%]	[%]	[%]
12/30/02	Moist Conditions	714.0	18.6%	200	3.49E+12	NR	**8.7**	**9.2**
5/22/03		683.7	19.7%	2400	4.01E+13	**60.8**		
11/20/02		665.4	20.8%	190	3.09E+12	NR		
3/12/03		638.8	22.6%	46	7.19E+11	NR		
2/13/03		511.7	31.6%	61	7.64E+11	NR		
10/2/02		434.9	36.4%	200	2.13E+12	NR		
10/23/02		395.2	39.6%	170	1.64E+12	NR		
4/29/03	Mid-Range Flows	312.1	48.7%	110	8.40E+11	NR	**NR**	**NR**
1/27/03		302.5	50.1%	4	2.96E+10	NR		
6/25/03	Dry Conditions	168.5	67.0%	310	1.28E+12	NR	**NR**	**NR**

Note: NR = No reduction required
NA = Not applicable

Table E-48. Calculated Load Reduction Based on Daily Loading – Richland Creek – RM25.7

Sample Date	Flow Regime	Flow	PDFE	Concentration	Load	% Reduction to Achieve TMDL	Average of Load Reductions	% Reduction to TMDL – MOS
		[cfs]	[%]	[CFU/100 ml]	[CFU/day]	[%]	[%]	[%]
10/28/09	Moist Conditions	1056	10.1%	770	1.99E+13	NR	**NR**	**NR**
10/20/09		657.1	19.3%	276	4.44E+12	NR		
10/21/09		625.0	21.1%	126	1.93E+12	NR		
10/22/09		600.3	22.7%	135	1.98E+12	NR		
10/26/09		590.0	23.4%	103	1.49E+12	NR		
10/27/08	Mid-Range Flows	292.8	49.9%	105	7.52E+11	NR	**NR**	**NR**
10/29/08		246.2	57.2%	99	5.96E+11	NR		
10/22/08	Dry Conditions	128.6	72.2%	20	6.29E+10	NR	**NR**	**NR**

Note: NR = No reduction required
NA = Not applicable

Table E-49. Calculated Load Reduction Based on Geomean Data – Richland Creek – RM25.7

Sample Date	Flow	PDFE	Concentration	Geometric Mean	Calculated Reduction to Target GM (126 CFU/100 ml)	Calculated Reduction to Target – MOS (113 CFU/100 ml)
	[cfs]	[%]	[CFU/100 ml]	[CFU/100 ml]	[%]	[%]
10/20/09	657.1	19.3%	276			
10/21/09	625.0	21.1%	126			
10/22/09	600.3	22.7%	135			
10/26/09	590.0	23.4%	103			
10/28/09	1056	10.1%	770	206.2	**38.9**	**45.2**

Note: Geometric Mean is calculated whenever 5 or more samples are collected over a period of not more than 30 consecutive days.

Table E-50. Calculated Load Reduction Based on Daily Loading – Richland Creek – RM29.9

Sample Date	Flow Regime	Flow	PDFE	Concentration	Load	% Reduction to Achieve TMDL	Average of Load Reductions	% Reduction to TMDL – MOS
		[cfs]	[%]	[CFU/100 ml]	[CFU/day]	[%]	[%]	[%]
10/28/09	Moist Conditions	974.1	11.8%	488	1.16E+13	NR		
10/20/09		675.9	18.9%	248	4.10E+12	NR		
12/30/02		646.1	20.1%	800	1.26E+13	NR		
10/21/09		619.2	21.2%	155	2.35E+12	NR		
5/22/03		592.8	22.6%	2000	2.90E+13	**60.8**		
10/22/09		575.2	23.5%	219	3.08E+12	NR		
3/12/03		561.1	24.7%	57	7.82E+11	NR		
10/26/09		499.1	29.2%	167	2.04E+12	NR		
2/13/03		420.3	35.8%	36	3.70E+11	NR		
10/23/02		386.0	39.0%	170	1.61E+12	NR		
10/2/02		378.6	39.8%	350	3.24E+12	NR	**4.8**	**5.2**
4/29/03	Mid-Range Flows	306.9	47.7%	150	1.13E+12	NR		
1/27/03		252.9	54.9%	10	6.19E+10	NR	**NR**	**NR**
7/24/07	Low Flows	14.76	97.3%	199	7.19E+10	NR	**NR**	**NR**

Note: NR = No reduction required
NA = Not applicable

Table E-51. Calculated Load Reduction Based on Geomean Data – Richland Creek – RM29.9

Sample Date	Flow	PDFE	Concentration	Geometric Mean	Calculated Reduction	
					to Target GM (126 CFU/100 ml)	to Target – MOS (113 CFU/100 ml)
	[cfs]	[%]	[CFU/100 ml]	[CFU/100 ml]	[%]	[%]
10/20/09	675.9	18.9%	248			
10/21/09	619.2	21.2%	155			
10/22/09	575.2	23.5%	219			
10/26/09	499.1	29.2%	167			
10/28/09	974.1	11.8%	488	233.0	**45.9**	**51.5**

Note: Geometric Mean is calculated whenever 5 or more samples are collected over a period of not more than 30 consecutive days.

Table E-52. Calculated Load Reduction Based on Daily Loading – Richland Creek – RM55.5

Sample Date	Flow Regime	Flow	PDFE	Concentration	Load	% Reduction to Achieve TMDL	Average of Load Reductions	% Reduction to TMDL – MOS
		[cfs]	[%]	[CFU/100 ml]	[CFU/day]	[%]	[%]	[%]
5/5/03	High Flows	2404	0.4%	2400	1.41E+14	**60.8**		
2/20/03		269.0	5.6%	980	6.45E+12	**4.0**	**32.4**	**39.1**
11/3/09	Moist Conditions	128.1	13.6%	1414	4.43E+12	33.5		
12/17/02		118.2	15.5%	1200	3.47E+12	21.6		
11/4/09		113.4	16.3%	613	1.70E+12	NR		
11/5/09		104.1	18.4%	613	1.56E+12	NR		
11/14/02		97.71	20.3%	820	1.96E+12	NR		
1/8/03		76.29	28.6%	440	8.21E+11	NR		
9/30/02		74.11	29.6%	2000	3.63E+12	**53.0**		
10/22/02		58.98	37.7%	2400	3.46E+12	**60.8**		
11/16/09		58.19	38.2%	517	7.36E+11	NR		
11/19/09		56.05	39.5%	461	6.32E+11	NR	**16.9**	**19.2**
6/10/03	Mid-Range Flows	51.19	42.7%	1200	1.50E+12	**21.6**		
4/2/03		50.47	43.1%	920	1.14E+12	NR		
10/27/08		35.56	54.8%	345	3.00E+11	NR		
10/29/08		32.23	57.8%	219	1.73E+11	NR	**5.4**	**9.3**
10/23/08	Dry Conditions	18.38	71.7%	145	6.52E+10	NR		
7/30/02		10.18	80.9%	490	1.22E+11	NR	**NR**	**NR**

Note: NR = No reduction required
NA = Not applicable

Table E-53. Calculated Load Reduction Based on Geomean Data – Richland Creek – RM55.5

Sample Date	Flow	PDFE	Concentration	Geometric Mean	Calculated Reduction	
					to Target GM (126 CFU/100 ml)	to Target – MOS (113 CFU/100 ml)
	[cfs]	[%]	[CFU/100 ml]	[CFU/100 ml]	[%]	[%]
11/3/09	128.10	13.6%	1414			
11/4/09	113.40	16.3%	613			
11/5/09	104.10	18.4%	613			
11/16/09	58.19	38.2%	517			
11/19/09	56.05	39.5%	461	661.5	**81.0**	**82.9**

Note: Geometric Mean is calculated whenever 5 or more samples are collected over a period of not more than 30 consecutive days.

Table E-54. Calculated Load Reduction Based on Daily Loading – Robertson Fork Creek – RM5.5

Sample Date	Flow Regime	Flow	PDFE	Concentration	Load	% Reduction to Achieve TMDL	Average of Load Reductions	% Reduction to TMDL – MOS
		[cfs]	[%]	[CFU/100 ml]	[CFU/day]	[%]	[%]	[%]
5/5/03	High Flow	963.0	0.4%	2400	5.65E+13	**60.8**		
2/20/03		91.68	5.4%	520	1.17E+12	NR		
3/3/03		59.20	9.6%	52	7.53E+10	NR	**20.3**	**21.6**
12/17/02	Moist Conditions	41.32	15.9%	150	1.52E+11	NR		
11/14/02		35.88	19.4%	1100	9.66E+11	**14.5**		
9/30/02		29.24	25.9%	770	5.51E+11	NR		
1/8/03		25.68	30.4%	290	1.82E+11	NR	**3.6**	**5.8**
6/10/03	Mid-Range Flows	19.47	40.2%	1600	7.62E+11	**41..2**		
10/22/02		18.66	41.4%	650	2.97E+11	NR		
4/2/03		18.67	41.4%	440	2.01E+11	NR		
10/27/08		12.51	53.8%	980	3.00E+11	**4.0**		
10/29/08		10.93	57.1%	1203	3.22E+11	**21.8**	**13.4**	**18.0**
10/22/08	Low Flows	6.04	70.0%	770	1.14E+11	NR		
7/30/02		3.82	76.7%	730	6.82E+10	NR	**NR**	**NR**

Note: NR = No reduction required
NA = Not applicable

Table E-55. Calculated Load Reduction Based on Daily Loading – Town Creek – RM0.8

Sample Date	Flow Regime	Flow	PDFE	Concentration	Load	% Reduction to Achieve TMDL	Average of Load Reductions	% Reduction to TMDL – MOS
		[cfs]	[%]	[CFU/100 ml]	[CFU/day]	[%]	[%]	[%]
5/5/03	High Flow	174.5	0.2%	2400	1.02E+13	**60.8**		
2/20/03		12.83	5.8%	280	8.79E+10	NR		
3/3/03		8.55	9.5%	9	1.88E+09	NR	**20.3**	**21.6**
12/17/02	Moist Conditions	6.01	15.8%	140	2.06E+10	NR		
11/14/02		5.15	20.2%	1700	2.14E+11	**44.6**		
9/30/02		4.23	26.6%	730	7.55E+10	NR		
1/8/03		3.73	31.5%	170	1.55E+10	NR		
6/10/03		3.14	37.6%	440	3.38E+10	NR	**8.9**	**10.0**
10/22/02	Mid-Range Flows	2.71	42.7%	160	1.06E+10	NR		
10/27/08		1.82	56.1%	138	6.13E+09	NR		
10/29/08		1.59	59.2%	166	6.47E+09	NR		
7/30/02		1.34	63.7%	460	1.51E+10	NR	**NR**	**NR**
10/23/08	Low Flows	0.83	73.0%	162	3.29E+09	NR	**NR**	**NR**

Note: NR = No reduction required
NA = Not applicable

Table E-56 Summary of TMDLs, WLAs, & LAs by Flow Regime for Impaired Waterbodies in the Elk River Watershed (HUC 06030003 & 06030004)

Waterbody Description (TN06030003 & 06030004__)	Hydrologic Condition			Flow[a]	PLRG	TMDL	MOS	WLAs			LAs [d]
	Flow Regime	PDFE Range	Flow Range					WWTPs [c]	CS	MS4s [d]	
		[%]	[cfs]	[cfs]	[%]	[CFU/d]	[CFU/d]	[CFU/d]		[CFU/d/ac]	[CFU/d/ac]
Betsy Willis Crk Waterbody ID: **044 – 0100** HUC-12: 0202	High Flows	0 – 10	55.2 – 555	100	83.9[b]	2.303×10^{12}	2.303×10^{11}	NA	NA	NA	2.439×10^{8}
	Moist	10 – 40	15.9 – 55.2	26.7		6.141×10^{11}	6.141×10^{10}				6.504×10^{7}
	Mid-Range	40 – 70	4.36 – 15.9	9.24		2.125×10^{11}	2.125×10^{10}				2.251×10^{7}
	Low Flows	70 – 100	0.07 – 4.36	1.29		2.296×10^{10}	2.296×10^{9}				3.142×10^{6}
Blue Creek Waterbody ID: **053 – 0100** HUC-12: 0402	High Flows	0 – 10	27.4 – 257	45.8	64.3[b]	1.052×10^{12}	1.052×10^{11}	NA	0	2.263×10^{8}	2.263×10^{8}
	Moist	10 – 40	8.37 – 27.4	13.9		3.188×10^{11}	3.188×10^{10}			6.856×10^{7}	6.856×10^{7}
	Mid-Range	40 – 70	2.36 – 8.37	4.83		1.111×10^{11}	1.111×10^{10}			2.389×10^{7}	2.389×10^{7}
	Low Flows	70 – 100	0.02 – 2.36	0.69		1.587×10^{10}	1.587×10^{9}			3.413×10^{6}	3.413×10^{6}
Boiling Fork Crk Waterbody ID: **030 – 1000** HUC-12: 0302	High Flows	0 – 10	55.9 – 538	96.5	NR	2.220×10^{12}	2.220×10^{11}	NA	0	NA	2.310×10^{8}
	Moist	10 – 40	16.5 – 55.9	27.5	20.3	6.332×10^{11}	6.332×10^{10}				6.590×10^{7}
	Mid-Range	40 – 70	4.35 – 16.5	9.50	17.7	2.185×10^{11}	2.185×10^{10}				2.274×10^{7}
	Low Flows	70 – 100	0.05 – 4.35	1.27	NR	2.921×10^{10}	2.921×10^{9}				3.040×10^{6}
Caldwell Creek Waterbody ID: **044 – 0700** HUC-12: 0103	High Flows	0 – 10	84.1 – 774	147	58.8[b]	3.379×10^{12}	3.379×10^{11}	1.781×10^{10}	0	NA	2.347×10^{8}
	Moist	10 – 40	24.8 – 84.1	41.5		9.550×10^{11}	9.550×10^{10}				6.535×10^{7}
	Mid-Range	40 – 70	7.20 – 24.8	14.5		3.330×10^{11}	3.330×10^{10}				2.189×10^{7}
	Low Flows	70 – 100	0.39 – 7.20	2.38		5.474×10^{10}	5.474×10^{9}				2.442×10^{6}
Cane Creek Waterbody ID: **044 – 0730** HUC-12: 0801 + 0802	High Flows	0 – 10	175 – 2,919	287	38.7[b]	6.597×10^{12}	6.599×10^{11}	NA	NA	NA	1.194×10^{8}
	Moist	10 – 40	59.2 – 175	91.5		2.105×10^{11}	2.105×10^{10}				3.811×10^{7}
	Mid-Range	40 – 60	30.2 – 59.2	36.8		8.453×10^{11}	8.453×10^{10}				1.530×10^{7}
	Dry	60 – 90	3.23 – 30.2	13.3		3.057×10^{10}	3.057×10^{9}				5.534×10^{6}
	Low Flows	90 – 100	0.21 – 3.23	0.41		9.430×10^{9}	9.430×10^{8}				1.707×10^{5}
East Fork Mulberry Creek Waterbody ID: **044 – 0700** HUC-12: 0502	High Flows	0 – 10	68.5 – 1,236	123	65.3[b]	2.837×10^{12}	2.837×10^{11}	1.069×10^{10}	0	NA	1.363×10^{8}
	Moist	10 – 40	24.4 – 68.5	37.6		8.646×10^{11}	8.646×10^{10}				3.778×10^{7}
	Mid-Range	40 – 70	8.31 – 24.4	15.5		3.572×10^{11}	3.572×10^{10}				1.530×10^{7}
	Low Flows	70 – 100	0.46 – 8.31	2.75		6.325×10^{10}	6.325×10^{9}				2.276×10^{6}
Elk River Waterbody ID: **010 – 1000** HUC-12: 0706	High Flows	0 – 10	3,632 – 30,167	5,673	NA	6.809×10^{13}	6.809×10^{12}	4.915×10^{11}	0	NA	1.158×10^{8}
	Moist	10 – 40	1,113 – 3,632	1,648	8.4	1.978×10^{13}	1.978×10^{12}				3.297×10^{7}
	Mid-Range	40 – 60	681 – 1,113	856	19.9	1.027×10^{13}	1.027×10^{12}				1.667×10^{7}
	Dry	60 – 90	125 – 681	350	NA	4.202×10^{12}	4.202×10^{11}				6.268×10^{6}
	Low Flows	90 – 100	26.0 – 125	79.7	NR	9.560×10^{11}	9.560×10^{10}				7.028×10^{5}

Table E-56 (cont'd) Summary of TMDLs, WLAs, & LAs by Flow Regime for Impaired Waterbodies in the Elk River Watershed (HUC 06030003 & 06030004)

Waterbody Description (TN06030003 & 06030004__)	Hydrologic Condition			Flow[a]	PLRG	TMDL	MOS	WLAs			LAs [d]
	Flow Regime	PDFE Range	Flow Range					WWTPs [c]	CS	MS4s [d]	
		[%]	[cfs]	[cfs]	[%]	[CFU/d]	[CFU/d]	[CFU/d]		[CFU/d/ac]	[CFU/d/ac]
Elk River Waterbody ID: **044 – 1000** HUC-12: multiple	High Flows	0 – 10	269 – 2,595	467	58.2[b]	5.602×10^{12}	5.602×10^{11}	NA	0	NA	1.208×10^{8}
	Moist	10 – 40	80.8 – 269	134		1.608×10^{12}	1.608×10^{11}				3.466×10^{7}
	Mid-Range	40 – 60	36.6 – 80.8	58.0		6.961×10^{11}	6.961×10^{10}				1.501×10^{7}
	Dry	60 – 90	3.35 – 36.6	15.1		1.806×10^{11}	1.806×10^{10}				3.893×10^{6}
	Low Flows	90 – 100	0.09 – 3.35	1.65		1.980×10^{10}	1.980×10^{9}				4.268×10^{5}
Juanita Creek Waterbody ID: **044 – 0721** HUC-12: 0103	High Flows	0 – 10	5.55 – 52.6	9.79	86.3[b]	2.252×10^{11}	2.252×10^{10}	1.781×10^{10}	0	NA	2.409×10^{8}
	Moist	10 – 40	1.89 – 5.55	2.84		6.532×10^{10}	6.532×10^{9}				5.341×10^{7}
	Mid-Range	40 – 70	0.83 – 1.89	1.27		2.921×10^{10}	2.921×10^{9}				1.105×10^{7}
	Low Flows	70 – 100	0.38 – 0.83	0.51		1.173×10^{10}	1.173×10^{9}				0
Swan Creek Waterbody ID: **063 – 1000** HUC-12: 0902	High Flows	0 – 10	104 – 1,874	173	51.0[b]	3.981×10^{12}	3.981×10^{11}	2.564×10^{8}	0	NA	1.142×10^{8}
	Moist	10 – 40	37.2 – 104	58.3		1.342×10^{12}	1.342×10^{11}				3.848×10^{7}
	Mid-Range	40 – 60	18.9 – 37.5	27.9		6.412×10^{11}	6.412×10^{10}				1.839×10^{7}
	Dry	60 – 90	1.95 – 18.9	8.47		1.948×10^{11}	1.948×10^{10}				5.580×10^{6}
	Low Flows	90 – 100	0.001 – 1.95	0.48		1.104×10^{10}	1.104×10^{9}				3.085×10^{5}
Swan Creek Waterbody ID: **063 – 2000** HUC-12: 0902	High Flows	0 – 10	43.8 – 791	74.3	78.4[b]	1.709×10^{12}	1.709×10^{11}	2.564×10^{8}	0	NA	1.151×10^{8}
	Moist	10 – 40	15.3 – 43.8	23.8		5.465×10^{11}	5.465×10^{10}				3.680×10^{7}
	Mid-Range	40 – 70	4.77 – 15.3	9.31		2.141×10^{11}	2.141×10^{10}				1.441×10^{6}
	Low Flows	70 – 100	0.002 – 4.77	1.42		3.266×10^{10}	3.266×10^{9}				2.181×10^{6}
Trussel Creek Waterbody ID: **044 – 0730** HUC-12: 0103	High Flows	0 – 10	2.53 – 26.8	4.90	NA	1.127×10^{11}	1.127×10^{10}	1.781×10^{10}	0	NA	2.226×10^{8}
	Moist	10 – 40	0.72 – 2.53	1.20	NR	2.760×10^{10}	2.760×10^{9}				1.871×10^{7}
	Mid-Range	40 – 70	0.20 – 0.72	0.42	NR	9.660×10^{9}	9.660×10^{8}				0
	Low Flows	70 – 100	0.003 – 0.20	0.06	10.2	1.380×10^{9}	1.380×10^{8}				0
Wagner Creek Waterbody ID: **032 – 1000** HUC-12: 0302	High Flows	0 – 10	61.1 – 548	102	87.2[b]	2.341×10^{12}	2.341×10^{11}	4.769×10^{9}	0	NA	2.282×10^{8}
	Moist	10 – 40	18.9 – 61.1	31.3		7.197×10^{11}	7.197×10^{10}				6.979×10^{7}
	Mid-Range	40 – 70	5.83 – 18.9	11.2		2.583×10^{11}	2.583×10^{10}				2.472×10^{6}
	Low Flows	70 – 100	0.79 – 5.83	2.28		5.244×10^{10}	5.244×10^{9}				4.606×10^{6}
West Fork Mulberry Creek Waterbody ID: **044 – 0700** HUC-12: 0501	High Flows	0 – 10	88.0 – 1,521	154	53.1[b]	3.531×10^{12}	3.531×10^{11}	NA	0	NA	1.235×10^{8}
	Moist	10 – 40	30.4 – 88.0	46.7		1.074×10^{12}	1.074×10^{11}				3.755×10^{7}
	Mid-Range	40 – 60	15.3 – 30.4	22.6		5.187×10^{11}	5.187×10^{10}				1.814×10^{7}
	Dry	60 – 90	1.54 – 15.3	6.57		1.511×10^{11}	1.511×10^{10}				5.284×10^{6}
	Low Flows	90 – 100	0.002 – 1.54	0.27		6.210×10^{9}	6.210×10^{8}				2.171×10^{5}

Table E-56 (cont'd) Summary of TMDLs, WLAs, & LAs by Flow Regime for Impaired Waterbodies in the Elk River Watershed (HUC 06030003 & 06030004)

Waterbody Description (TN06030003 & 06030004__)	Hydrologic Condition			Flow[a]	PLRG	TMDL	MOS	WLAs			LAs [d]
	Flow Regime	PDFE Range	Flow Range					WWTPs [c]	CS	MS4s [d]	
		[%]	[cfs]	[cfs]	[%]	[CFU/d]	[CFU/d]	[CFU/d]		[CFU/d/ac]	[CFU/d/ac]
Yellow Branch Waterbody ID: **041 – 0100** HUC-12: 0205	High Flows	0 – 10	21.9 – 202	36.2	74.6[b]	8.317×10^{11}	8.317×10^{10}	NA	NA	NA	2.245×10^{8}
	Moist	10 – 40	6.60 – 21.9	11.0		2.523×10^{11}	2.523×10^{10}				6.811×10^{7}
	Mid-Range	40 – 70	1.77 – 6.60	3.74		8.602×10^{10}	8.602×10^{9}				2.322×10^{7}
	Low Flows	70 – 100	0.01 – 1.77	0.52		1.196×10^{10}	1.196×10^{9}				3.228×10^{6}
Coffey Branch Waterbody ID: **043 – 0600** HUC-12: 0201	High Flows	0 – 10	6.51 – 123	11.6	75.8[b]	2.666×10^{11}	2.666×10^{11}	NA	NA	NA	1.251×10^{8}
	Moist	10 – 40	2.30 – 6.51	3.54		8.142×10^{10}	8.142×10^{9}				3.821×10^{7}
	Mid-Range	40 – 70	0.70 – 2.30	1.39		3.197×10^{10}	3.197×10^{9}				1.500×10^{7}
	Low Flows	70 – 100	0.03 – 0.70	0.20		4.600×10^{9}	4.600×10^{8}				2.159×10^{6}
Corn Creek Waterbody ID: **043 – 0300** HUC-12: 0201	High Flows	0 – 10	9.60 – 194	17.09	94.6[b]	3.931×10^{11}	3.931×10^{10}	NA	NA	NA	1.208×10^{8}
	Moist	10 – 40	3.44 – 9.60	5.29		1.217×10^{11}	1.217×10^{10}				3.740×10^{7}
	Mid-Range	40 – 70	1.12 – 3.44	2.15		4.945×10^{10}	4.945×10^{9}				1.520×10^{7}
	Low Flows	70 – 100	0.05 – 1.12	0.32		7.360×10^{9}	7.360×10^{8}				2.262×10^{6}
Elk River Waterbody ID: **013 – 1000** HUC-12: 0402	High Flows	0 – 10	6,050 – 29,157	8,369	37.5[b]	1.004×10^{14}	1.004×10^{13}	3.562×10^{9}	NA	NA	7.768×10^{7}
	Moist	10 – 40	1,740 – 6,050	3,110		3.732×10^{13}	3.732×10^{12}				2.852×10^{7}
	Mid-Range	40 – 60	865 – 1,740	1,225		1.470×10^{13}	1.470×10^{12}				1.090×10^{7}
	Dry	60 – 90	319 – 865	549		6.588×10^{12}	6.588×10^{11}				4.579×10^{6}
	Low Flows	90 – 100	142 – 319	258		3.097×10^{12}	3.097×10^{11}				1.859×10^{6}
Pleasant Run Creek Waterbody ID: **017 – 0800** HUC-12: 0207	High Flows	0 – 10	4.23 – 61.7	9.37	NA	2.155×10^{11}	2.155×10^{10}	NA	NA	NA	2.119×10^{8}
	Moist	10 – 40	1.08 – 4.23	1.76	NR	4.048×10^{10}	4.048×10^{9}				3.980×10^{7}
	Mid-Range	40 – 70	0.31 – 1.08	0.65	NR	1.495×10^{10}	1.495×10^{9}				1.470×10^{7}
	Low Flows	70 – 100	0.008 – 0.31	0.10	NR	2.300×10^{9}	2.300×10^{8}				2.261×10^{6}
Richland Creek Waterbody ID: **017 – 2000** HUC-12: multiple	High Flows	0 – 10	1,067 – 16,341	2,006	45.9[b]	4.613×10^{13}	4.613×10^{12}	3.562×10^{9}	0	NA	1.772×10^{8}
	Moist	10 – 40	376 – 1,067	556		1.278×10^{13}	1.278×10^{12}				4.909×10^{7}
	Mid-Range	40 – 60	215 – 376	288		6.615×10^{12}	6.615×10^{11}				2.540×10^{7}
	Dry	60 – 90	40.4 – 215	110		2.537×10^{12}	2.537×10^{11}				9.730×10^{6}
	Low Flows	90 – 100	5.72 – 40.4	26.6		6.127×10^{11}	6.127×10^{10}				2.337×10^{6}
Richland Creek Waterbody ID: **043 – 1000** HUC-12: multiple	High Flows	0 – 10	159 – 2,683	298	81.0[b]	6.862×10^{12}	6.862×10^{11}	3.562×10^{9}	0	NA	1.633×10^{8}
	Moist	10 – 40	55.3 – 159	85.0		1.955×10^{12}	1.955×10^{11}				4.645×10^{7}
	Mid-Range	40 – 60	30.1 – 55.3	41.4		9.522×10^{11}	9.522×10^{10}				2.257×10^{7}
	Dry	60 – 90	5.56 – 30.1	15.1		3.462×10^{11}	3.462×10^{10}				8.147×10^{6}
	Low Flows	90 – 100	0.10 – 5.56	2.44		5.612×10^{10}	5.612×10^{9}				1.242×10^{6}

Table E-56 (cont'd) Summary of TMDLs, WLAs, & LAs by Flow Regime for Impaired Waterbodies in the Elk River Watershed (HUC 06030003 & 06030004)

Waterbody Description (TN06030003 & 06030004__)	Hydrologic Condition			Flow[a]	PLRG	TMDL	MOS	WLAs			LAs [d]
	Flow Regime	PDFE Range	Flow Range					WWTPs [c]	CS	MS4s [d]	
		[%]	[cfs]	[cfs]	[%]	[CFU/d]	[CFU/d]	[CFU/d]		[CFU/d/ac]	[CFU/d/ac]
Robertson Fork Creek Waterbody ID: **023 – 1000** HUC-12: 0202	High Flows	0 – 10	56.9 – 969	98.3	20.3	2.261×10^{12}	2.261×10^{11}	3.562×10^{9}	0	NA	1.230×10^{8}
	Moist	10 – 40	19.5 – 56.9	30.0	3.6	6.909×10^{11}	6.909×10^{10}				3.761×10^{7}
	Mid-Range	40 – 70	6.02 – 19.5	11.9	13.4	2.732×10^{11}	2.732×10^{10}				1.487×10^{7}
	Low Flows	70 – 100	0.002 – 6.02	1.74	NR	4.002×10^{10}	4.002×10^{9}				2.178×10^{7}
Town Creek Waterbody ID: **043 – 0400** HUC-12: 0201	High Flows	0 – 10	8.18 – 149	14.9	20.3	3.434×10^{11}	3.434×10^{10}	3.562×10^{9}	0	NA	1.254×10^{8}
	Moist	10 – 40	2.94 – 8.18	4.44	8.9	1.021×10^{11}	1.021×10^{10}				3.627×10^{7}
	Mid-Range	40 – 70	0.99 – 2.94	1.89	NR	4.347×10^{10}	4.347×10^{9}				1.460×10^{7}
	Low Flows	70 – 100	0.04 – 0.99	0.27	NR	6.210×10^{9}	6.210×10^{8}				8.323×10^{5}
UT to Wet Weakley Creek Waterbody ID: **029 – 0410** HUC-12: 0204	High Flows	0 – 10	1.18 – 22.9	2.24	NA	5.152×10^{10}	5.152×10^{9}	NA	NA	NA	1.341×10^{8}
	Moist	10 – 40	0.39 – 1.18	0.61		1.403×10^{10}	1.403×10^{9}				3.652×10^{7}
	Mid-Range	40 – 70	0.12 – 0.39	0.24		5.520×10^{9}	5.520×10^{8}				1.437×10^{7}
	Low Flows	70 – 100	0.001 – 0.12	0.04		9.200×10^{8}	9.200×10^{7}				2.394×10^{6}

Notes: NA = Not Applicable.
NR = No Reduction Required.
PLRG = Percent Load Reduction Goal to achieve TMDL.
CS = Collection Systems
Shaded Flow Zone for each waterbody represents the critical flow zone.

a. Flow applied to TMDL, MOS, and allocation (WLA[MS4] and LA) calculations. Flows represent the midpoint value in the respective hydrologic flow regime.
b. PLRG based on geomean data.
c. WLAs for WWTPs are expressed as E. coli loads (CFU/day). All current and future WWTPs must meet water quality standards as specified in their NPDES permit.
d. WLAs and LAs expressed on a "per acre" basis are calculated based on the drainage area at the specific monitoring point (see Table E-3).

APPENDIX F

Public Notice Announcement

STATE OF TENNESSEE
DEPARTMENT OF ENVIRONMENT AND CONSERVATION
DIVISION OF WATER REOURCES

PUBLIC NOTICE OF AVAILABILITY OF PROPOSED TOTAL MAXIMUM DAILY LOAD (TMDL) FOR E. COLI IN ELK RIVER WATERSHEDS (HUCs 06030003&06030004), TENNESSEE

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

A number of waterbodies in the Elk River watersheds are listed on Tennessee's Draft 2012 303(d) list as not supporting designated use classifications due, in part, to municipal urbanized areas and pasture grazing. The TMDL utilizes Tennessee's general water quality criteria, continuous flow data from a USGS discharge monitoring station located in proximity to the watershed, site specific water quality monitoring data, a calibrated hydrologic model, load duration curves, and an appropriate Margin of Safety (MOS) to establish allowable loadings of pathogens which will result in the reduced in-stream concentrations and attainment of water quality standards. The TMDL requires reductions of e. coli loading on the order of 3.6-94.6% in the listed waterbodies.

The Elk River E. Coli TMDL may be downloaded from the Department of Environment and Conservation website:

http://www.tn.gov/environment/wpc/tmdl/

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

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

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

Persons wishing to comment on the proposed TMDLs are invited to submit their comments in writing no later than June 24, 2013 to:

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