PROPOSED
TOTAL MAXIMUM DAILY LOAD (TMDL)

for

E. Coli

in the

Stones River Watershed (HUC 05130203)

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

SUMMARY SHEET

Total Maximum Daily Load for E. coli in Stones River Watershed (HUC 05130203)

Impaired Waterbody Information

State: Tennessee
Counties: Cannon, Davidson, Rutherford, and Wilson
Watershed: Stones River (HUC 05130203)
Constituents of Concern: E. coli

Impaired Waterbodies Addressed in This Document:

Waterbody ID	Waterbody	Miles Impaired
TN05130203003T – 1000*	FINCH BRANCH	5.7
TN05130203018 – 0100	SINKING CREEK	5.5
TN05130203022 – 0100	UT TO LYTLE CREEK	1.0
TN05130203022 – 1000	LYTLE CREEK	8.9
TN05130203022 – 2000	LYTLE CREEK	10.1

*TMDL could not be developed for Finch Branch due to lack of monitoring data. Additional monitoring is recommended to allow for either development of a TMDL or delisting.

Designated Uses:

The designated use classifications for waterbodies in the Stones River Watershed include fish and aquatic life, irrigation, livestock watering & wildlife, and recreation.

Water Quality Targets:

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

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

TMDL Scope:

Waterbodies identified on the Final 2004 303(d) list as impaired due to E. coli. TMDLs were developed for impaired waterbodies on a HUC-12 subwatershed or waterbody drainage area basis.

Analysis/Methodology:

The TMDLs for impaired waterbodies in the Stones 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 Tier II waterbodies and 941 CFU/100 mL maximum water quality criteria for non-Tier II waterbodies. A duration curve is a cumulative frequency graph that represents the percentage of time during which the value of a given parameter is equaled or exceeded. Load duration curves are developed from flow duration curves and can illustrate existing water quality conditions (as represented by loads calculated from monitoring data), how these conditions compare to desired targets, and the region of the waterbody flow regime represented by these existing loads. Load duration curves were used to determine the load reductions required to meet desired maximum concentrations for E. coli. When sufficient data were available, load reductions were also determined based on geometric mean criteria.

Critical Conditions:

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

Seasonal Variation:

The 10-year period used for LSPC model simulation period 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 for Impaired Waterbodies

HUC-12 Subwatershed (05130203__) or Drainage Area	Impaired Waterbody Name	Impaired Waterbody ID	TMDL	WLAs				LAs	
				WWTFs [a]		CAFOs	MS4s [b]	Precipitation Induced Nonpoint Sources	Other Direct Sources [c]
				Monthly Avg.	Daily Max.				
			[% Red.]	[CFU/day]	[CFU/day]	[CFU/day]	[% Red.]	[% Red.]	[CFU/day]
DA	Sinking Creek	TN05130203018 – 0100	72.3	NA	NA	0	75.0	75.0	0
0204	UT to Lytle Creek	TN05130203022 – 0100	>79.7	NA	NA	0	>81.8	>81.8	0
	Lytle Creek	TN05130203022 – 1000							
	Lytle Creek	TN05130203022 – 2000							

Notes: NA = Not Applicable.

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

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

c. The objective for all "other direct sources" is a load allocation of zero. It is recognized, however, that for leaking septic systems a LA of 0 CFU/day may not be practical. For these sources, the LA is interpreted to mean a reduction in pathogen loading to the maximum extent practicable, consistent with the requirement that these sources not contribute to a violation of the water quality standard for E. coli.

PROPOSED E. COLI TOTAL MAXIMUM DAILY LOAD (TMDL) STONES RIVER WATERSHED (HUC 05130203)

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 Stones River Watershed, identified on the Final 2004 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.

3.0 WATERSHED DESCRIPTION

The Stones River Watershed (HUC 05130203) is located in Middle Tennessee (Figure 1), primarily in Rutherford County. The Stones River Watershed lies within one Level III ecoregion (Interior Plateau) and contains three Level IV ecoregions as shown in Figure 2 (USEPA, 1997):

- **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.

- **Inner Nashville Basin (71i)** is less hilly and lower than the Outer Nashville Basin. Outcrops of the Ordovician-age limestone are common, and the generally shallow soils are redder and lower in phosphorus than those of the Outer Basin. Streams are lower gradient than surrounding regions, often flowing over large expanses of limestone bedrock. The most characteristic hardwoods within the Inner Basin are a maple-oak-hickory-ash association. The limestone cedar glades of Tennessee, a unique mixed grassland/forest/cedar glades vegetation type with many endemic species, are located primarily on the limestone of the Inner Nashville Basin. The more xeric, open characteristics and shallow soils of the cedar glades also result in a distinct distribution of amphibian and reptile species.

The Stones River Watershed, located in Cannon, Davidson, Rutherford, and Wilson Counties, Tennessee, has a drainage area of approximately 921 square miles (mi^2). Watershed land use distribution is based on the Multi-Resolution Land Characteristic (MRLC) databases derived from Landsat Thematic Mapper digital images from the period 1990-1993. Although changes in the land use of the Stones River Watershed have occurred since 1993 as a result of development, this is the most current land use data available. Land use for the Stones River Watershed is summarized in Table 1 and shown in Figure 3. Predominant land use in the Stones River Watershed is forest (58.1%) followed by pasture (20.7%). Urban areas represent approximately 5.0% of the total drainage area of the watershed. Details of land use distribution of impaired subwatersheds in the Stones River Watershed are presented in Appendix A.

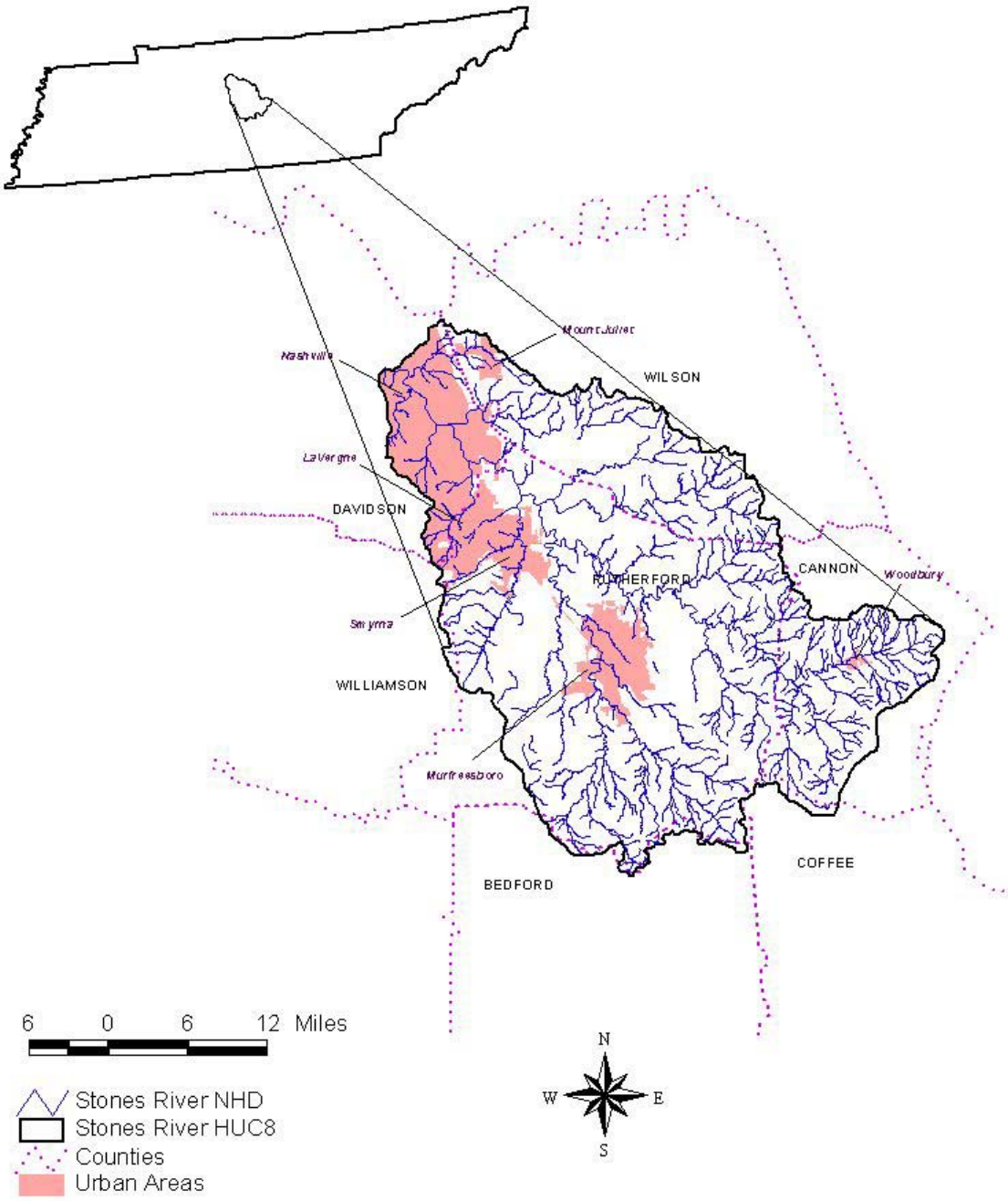

Figure 1. Location of the Stones River Watershed.

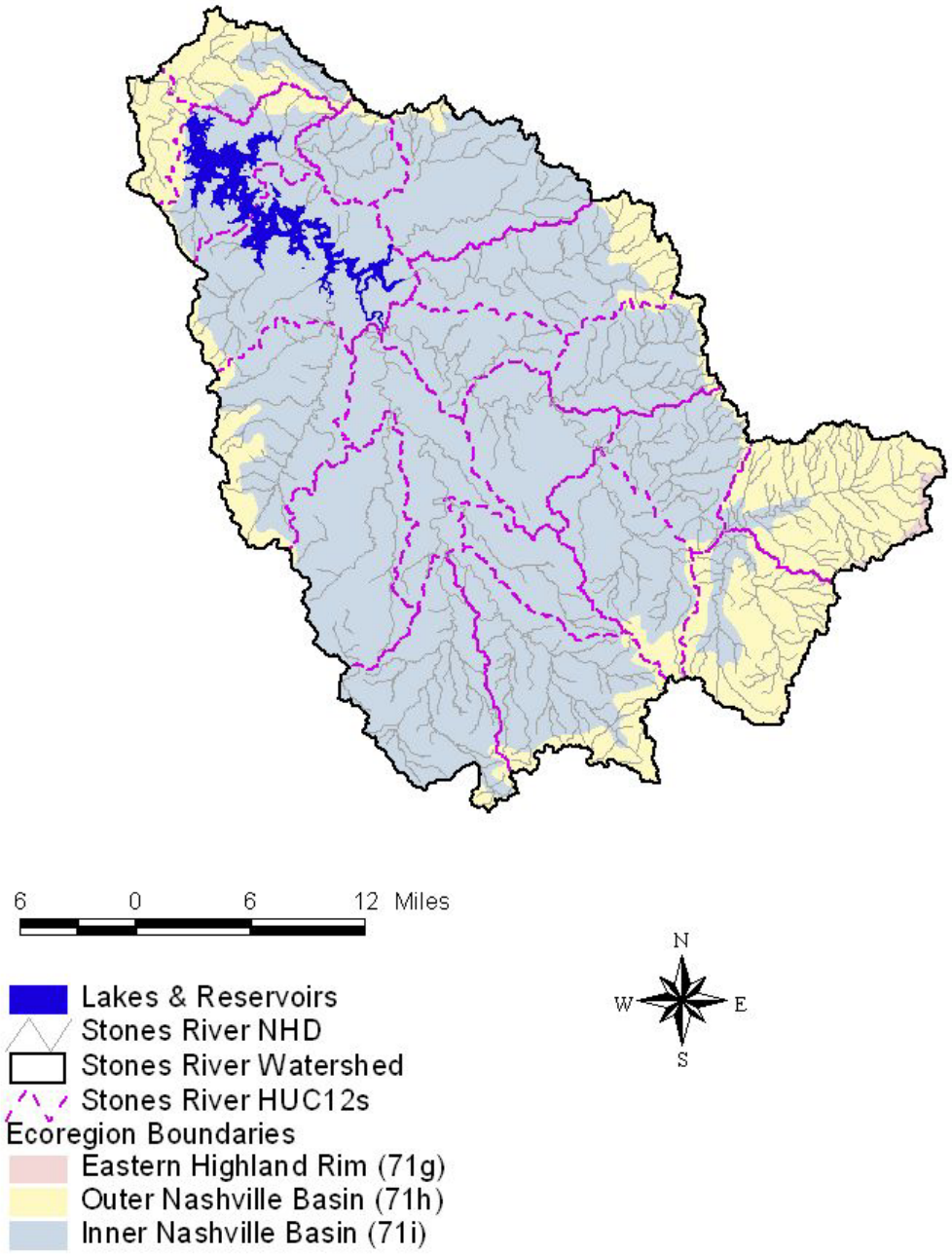

Figure 2. Level IV Ecoregions in the Stones River Watershed.

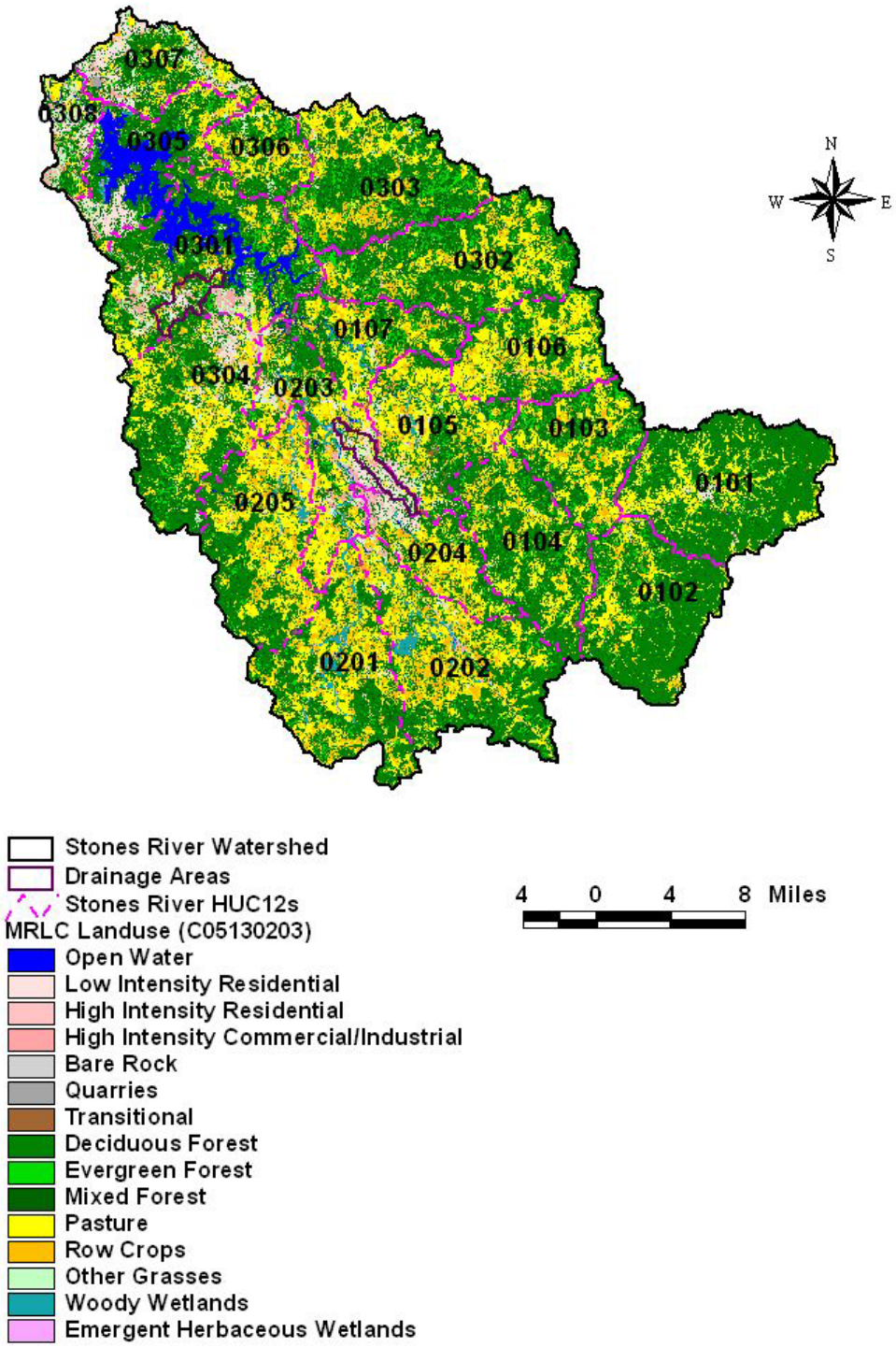

Figure 3. Land Use Characteristics of the Stones River Watershed.

Table 1. MRLC Land Use Distribution – Stones River Watershed

Land Use	Area	
	[acres]	[%]
Bare Rock/Sand/Clay	3	0.0
Deciduous Forest	212,530	35.5
Emergent Herbaceous Wetlands	661	0.1
Evergreen Forest	38,346	6.4
High Intensity Commercial/Industrial/ Transportation	8,570	1.4
High Intensity Residential	3,494	0.6
Low Intensity Residential	17,499	2.9
Mixed Forest	97,000	16.2
Open Water	14,662	2.4
Other Grasses (Urban/recreational)	9,662	1.6
Pasture/Hay	123,955	20.7
Quarries/Strip Mines/ Gravel Pits	210	0.0
Row Crops	64,841	10.8
Transitional	661	0.1
Woody Wetlands	6,821	1.1
Total	**598,914**	**100.0**

4.0 PROBLEM DEFINITION

The State of Tennessee's final 2004 303(d) list (TDEC, 2005) was approved by the U.S. Environmental Protection Agency (EPA), Region IV in August of 2005. This list identified portions of three waterbodies in the Stones River Watershed as not 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.

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

5.0 WATER QUALITY CRITERIA & TMDL TARGET

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

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

The portion of Finch Branch within the Percy Priest Wildlife Management Area (WMA) has been classified as a Tier II stream. Portions of Lytle Creek within the Lytle Creek WMA also have been classified as Tier II streams. The Sinking Creek referred to on the List of Known High Quality Waters in Tennessee available on the TDEC website is a small waterbody located north of Finch Branch. As of February 2, 2006, the Sinking Creek identified on the Final 2004 303(d) list has not been classified as a Tier II stream.

The geometric mean standard for the E. coli group of 126 colony forming units per 100 ml (CFU/100 ml) and the sample maximum of 487 CFU/100 ml have been selected as the appropriate numerical targets for TMDL development for impaired waterbodies classified as Tier II streams. The geometric mean standard for the E. coli group of 126 colony forming units per 100 ml (CFU/100 ml) and the sample maximum of 941 CFU/100 ml have been selected as the appropriate numerical targets for TMDL development for the other impaired waterbodies.

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

Waterbody ID	Impacted Waterbody	Miles/Acres Impaired	Cause (Pollutant)	Pollutant Source
TN05130203003T – 0100	FINCH BRANCH	5.7	Organic Enrichment Alteration in stream-side or littoral vegetative cover Escherichia coli	Land Development Collection System Failure
TN05130203018 – 0100	SINKING CREEK	5.5	Alterations of stream-side or littoral vegetative cover Escherichia coli	Land Development Discharges from MS4 Area
TN05130203022 – 0100	UNNAMED TRIB TO LYTLE CREEK	1.0	Low dissolved oxygen Escherichia coli	Undetermined Source
TN05130203022 – 1000	LYTLE CREEK	8.9	Alterations of stream-side or littoral vegetative cover Siltation Escherichia coli	Discharges from MS4 Area
TN05130203022 – 2000	LYTLE CREEK	10.1	Alterations of stream-side or littoral vegetative cover Siltation Escherichia coli	Pasture Grazing

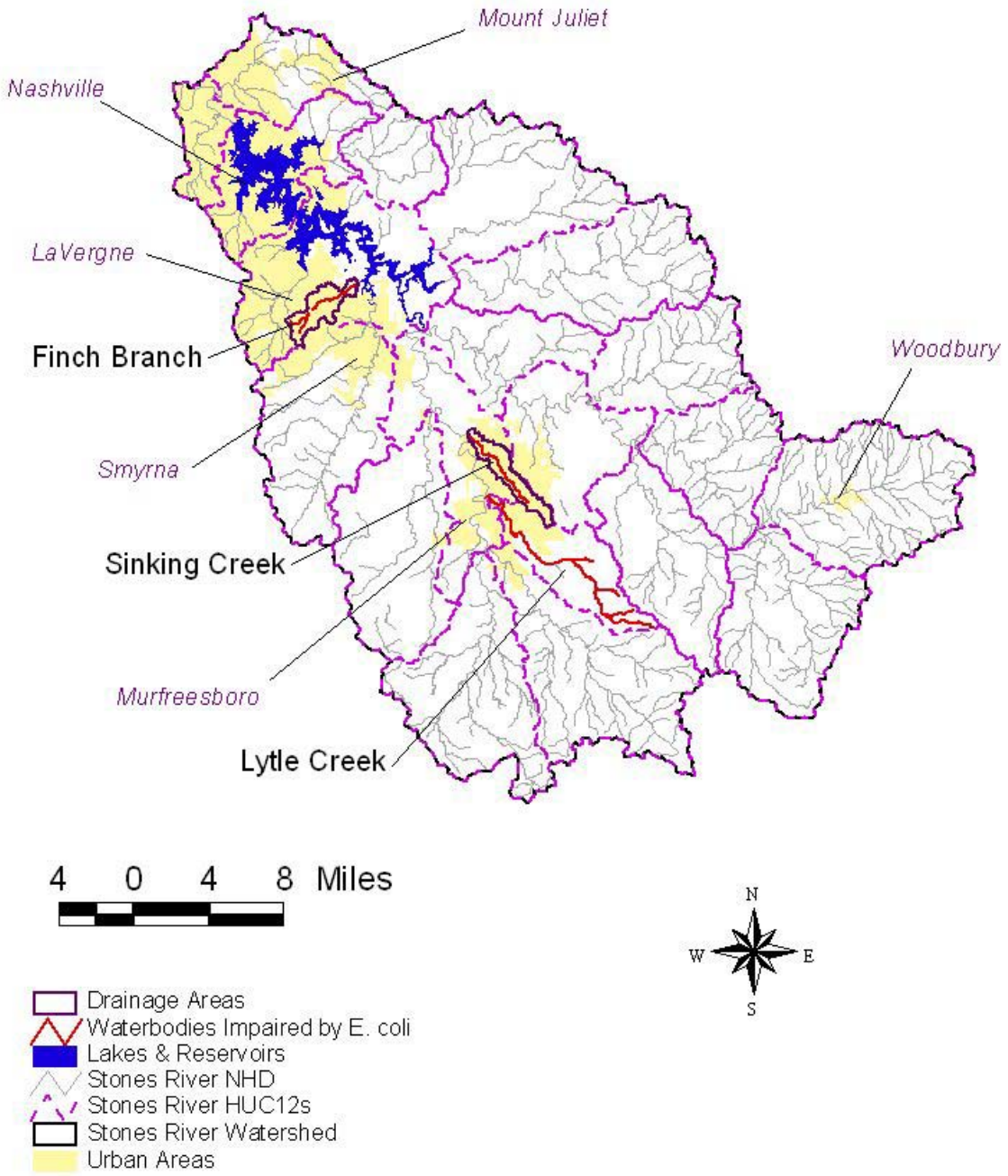

Figure 4. Waterbodies Impaired by E. Coli (as Documented on the Final 2004 303(d) List).

6.0 WATER QUALITY ASSESSMENT AND DEVIATION FROM TARGET

There are several water quality monitoring stations that provide data for waterbodies identified as impaired for E. coli in the Stones River Watershed. Monitoring stations located on Tier II waterboides have been italicized:

- Finch Branch Subwatershed:
  - *FINCH001.4RU – Finch Branch, at Jones Mill Rd.*
  - *FINCH001.9RU – Finch Branch, 500 feet d/s of Fergus Rd.*
- Sinking Creek Subwatershed:
  - SINKI000.2RU – Sinking Creek, at Thompson Lane, d/s of Murfreesboro
- Lytle Creek Subwatershed:
  - *LYTLE000.6RU – Lytle Creek, near Old Fort Park*
  - *LYTLE001.1RU – Lytle Creek, off West Main Street (@ Greenway)*
  - *LYTLE008.7RU – Lytle Creek, at Dilton Mankin Rd.*
  - *LYTLE1T0.1RU – unnamed trib to Lytle Creek, at Cannonsburg S Front St.*

The location of these monitoring stations is shown in Figure 5. Water quality monitoring results for these stations are tabulated in Appendix C. Examination of the data shows exceedances of the 487 CFU/100 mL (Tier II) and 941 CFU/100 mL (non-Tier II) maximum E. coli standard at many 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.

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

Insufficient monitoring data were available to develop a load reduction for Finch Branch (see Section 9.4 for discussion of monitoring requirements). All other waterbodies listed on the Final 2004 303(d) List are provided a TMDL for pathogen loading.

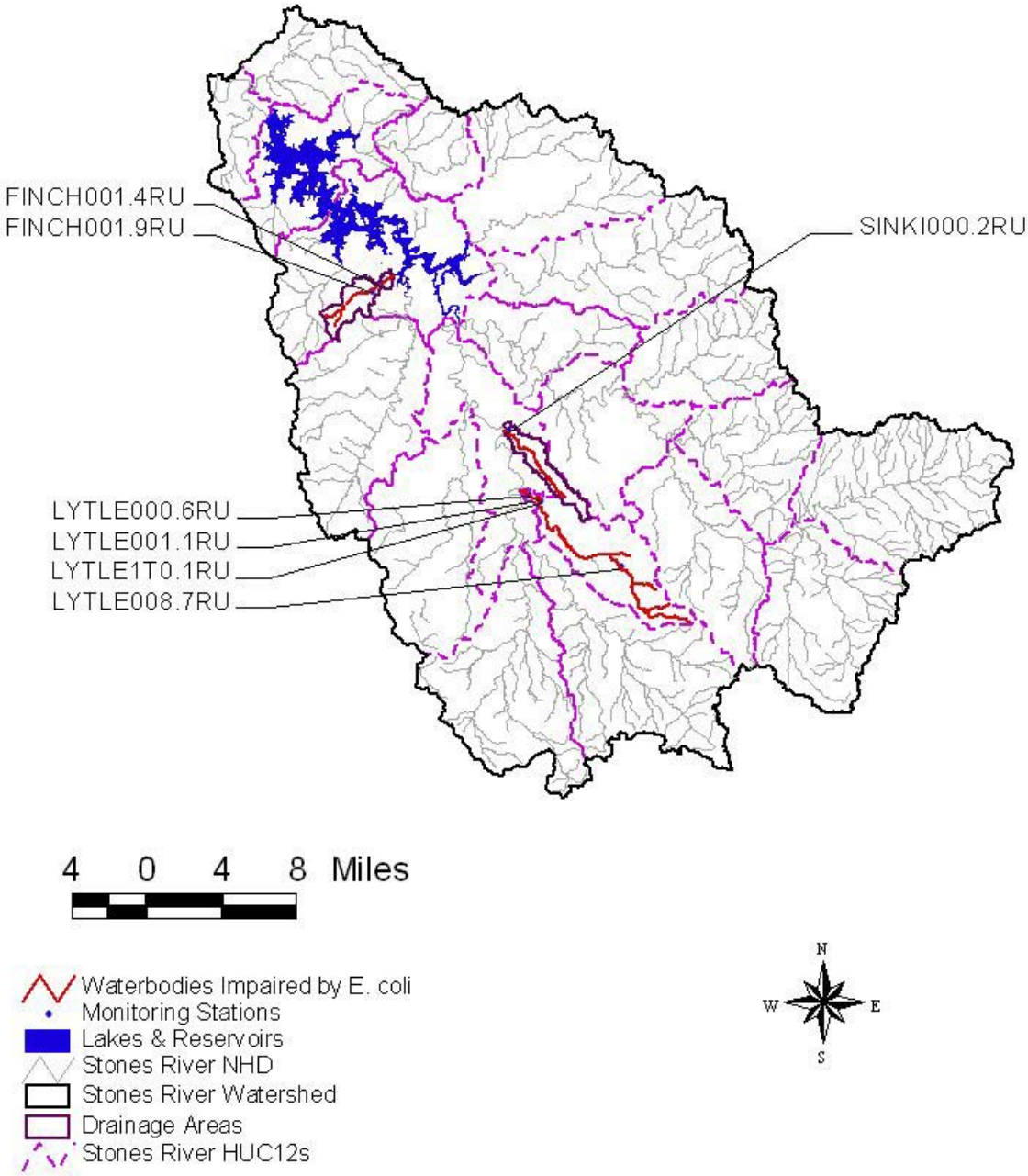

Figure 5. Water Quality Monitoring Stations in the Stones River Watershed

Table 3 Summary of TDEC Water Quality Monitoring Data

Monitoring Station	Date Range	E. Coli (Max WQ Target = 487 Counts/100 mL)**				
		Data Pts.	Min. [CFU/100 ml]	Avg. [CFU/100 ml]	Max. [CFU/100 ml]	No. Exceed. WQ Max. Target
LYTLE000.6RU	*2000 – 2001*	*5*	*16*	*685*	*>2,400*	*2*
LYTLE001.1RU	*2001 – 2002*	*9*	*32*	*824*	*>2,400*	*4*
LYTLE008.7RU	*2001 – 2002*	*7*	*91*	*822*	*2,000*	*4*
LYTLE1T0.1RU	*2001 – 2002*	*9*	*50*	*711*	*>2,400*	*3*
SINKI000.2RU	2001 – 2002	8	120	1,534	9,600	1

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

7.0 SOURCE ASSESSMENT

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

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

7.1 Point Sources

7.1.1 NPDES Regulated Municipal and Industrial Wastewater Treatment Facilities

Both treated and untreated sanitary wastewater contain coliform bacteria. There are 14 WWTFs in the Stones River Watershed that have NPDES permits authorizing the discharge of treated sanitary wastewater. None of these facilities are located in impaired subwatersheds or drainage areas; however, the Murfreesboro-Sinking Creek STP includes the Sinking Creek and Lytle Creek watersheds in its service area (see Table 4 & Figure 6). The permit limits for discharges from these WWTFs are in accordance with the coliform criteria specified in Tennessee Water Quality Standards for the protection of the recreation use classification.

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 WWTFs in Impaired Subwatersheds or Drainage Areas

NPDES Permit No.	Facility	Design Flow [MGD]	Receiving Stream
TN0022586	Murfreesboro-Sinking Creek STP	16.0	West Fork Stones River at RM 10.5

A summary of effluent monitoring data, submitted on Discharge Monitoring Reports (DMRs) for the period from October 2001 to November 2005, for facilities that are located in HUC-12 subwatersheds or drainage areas containing waterbodies impaired for pathogens is presented in Table 5.

7.1.2 NPDES Regulated Municipal Separate Storm Sewer Systems (MS4s)

Municipal Separate Storm Sewer Systems (MS4s) are considered to be point sources of E. coli. Discharges from MS4s occur in response to storm events through road drainage systems, curb and gutter systems, ditches, and storm drains. Phase I of the EPA storm water program requires large and medium MS4s to obtain NPDES storm water permits. Large and medium MS4s are those located in incorporated places or counties serving populations greater than 100,000 people. At present, Metro Nashville/Davidson County is the only large or medium (Phase I) MS4 in the Stones River Watershed.

Table 5 Summary of DMRs for NPDES Permitted WWTFs in Impaired Subwatersheds or Drainage Areas

NPDES Permit No.	E. Coli (Permit Limit = 126 CFU/100 mL Avg.)					Fecal Coliform (Permit Limit = 200 CFU/100 mL Avg.)					Fecal Coliform (Permit Limit = 1000 CFU/100 mL Max.)					No. Bypass/ Overflow Events
	Data Pts.	Min. (CFU/100 mL)	Avg. (CFU/100 mL)	Max. (CFU/100 mL)	No. Exceed.	Data Pts.	Min. (CFU/100 mL)	Avg. (CFU/100 mL)	Max. (CFU/100 mL)	No. Exceed.	Data Pts.	Min. (CFU/100 mL)	Avg. (CFU/100 mL)	Max. (CFU/100 mL)	No. Exceed.	
TN0022856	50	1	21	240	1	50	1	16	74	0	50	5	111	398	0	126

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. Fecal coliform data are presented for informational purposes only.

According to a Compliance Sampling Inspection conducted in October 2004, the Sinking Creek STP was operating in very good compliance with permit effluent requirements. A vigorous collection system rehabilitation program is in place. Examination of Monthly Operating Reports (MORs) indicates that the average monthly flow has been in the range of 8.1 to 20.5 MGD and the daily peak flow has been in the range of 13.6 to 35.1 MGD. This could be a cause for concern given that the design flow of the plant is 16 MGD.

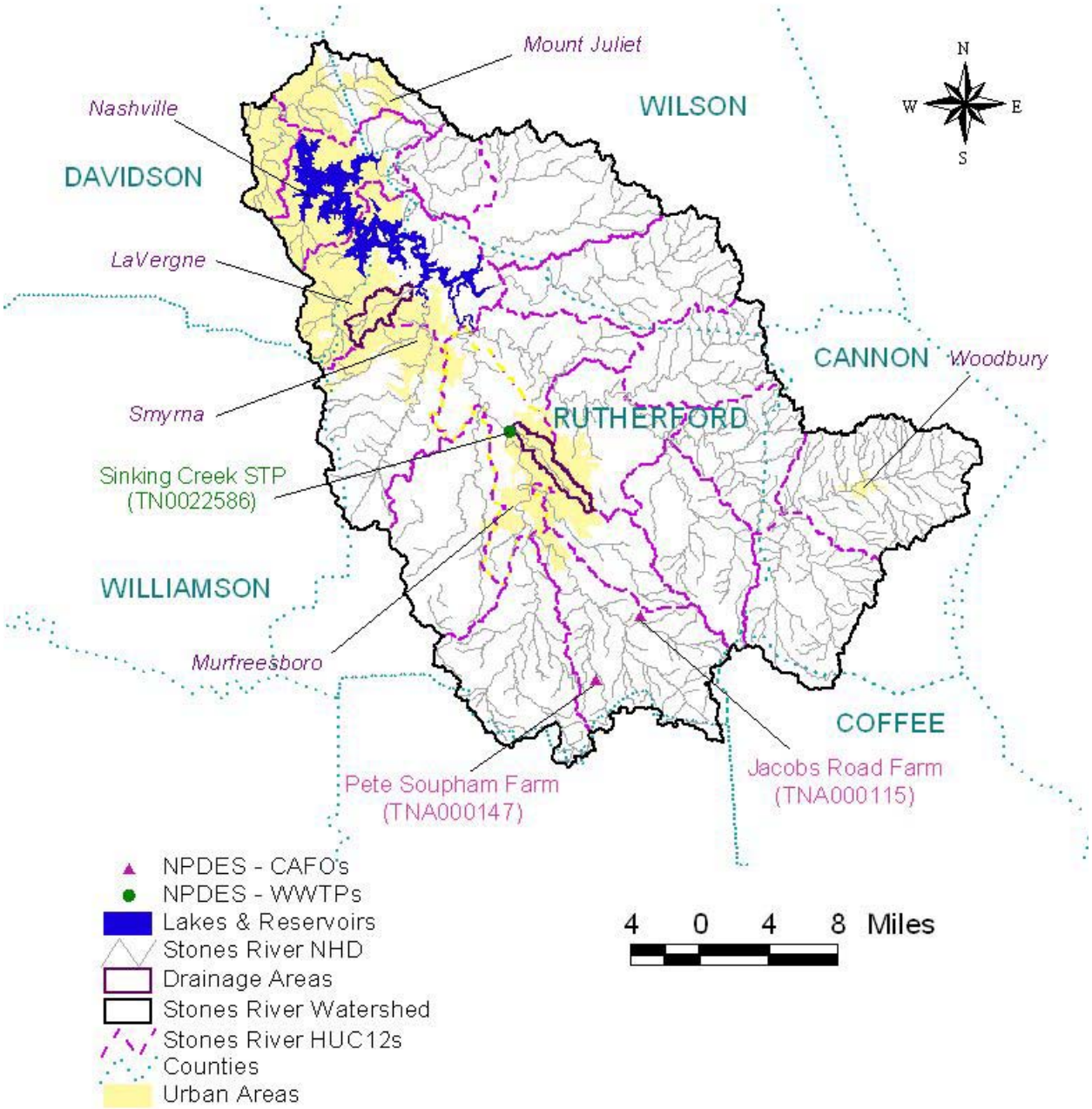

Figure 6. NPDES Regulated Point Sources in and near Impaired Subwatersheds and Drainage Areas of the Stones River Watershed.

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

The Tennessee Department of Transportation (TDOT) has been issued an individual MS4 permit 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.

Information regarding storm water permitting in Tennessee may be obtained from the Tennessee Department of Environment and Conservation (TDEC) website at:

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

7.1.3 NPDES Concentrated Animal Feeding Operations (CAFOs)

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

As of May 11, 2005, there are no Class I CAFOs individual permits located in the Stones River watershed. There are two Class II CAFOs in the watershed with coverage under the general NPDES permit. Jacobs Road Farm (TNA000115) is located outside Murfreesboro near Hurricane Creek. Pete Soupham Farm (TNA000147) is located outside Shelbyville near Little Creek. Neither Hurricane Creek nor Little Creek are impaired by E. coli.

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 majority of waterbodies identified on the Final 2004 303(d) list as impaired due to E. coli are attributed to nonpoint agricultural or urban sources.

7.2.1 Wildlife

Wildlife deposit coliform bacteria, with their feces, onto land surfaces where it can be transported during storm events to nearby streams. The overall deer density for Tennessee was estimated by the Tennessee Wildlife Resources Agency (TWRA) to be 23 animals per square mile.

7.2.2 Agricultural Animals

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

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

Data sources related to livestock operations include the 2002 Census of Agriculture, which was compiled for the Stones Watershed utilizing the Watershed Characterization System (WCS). WCS is an Arcview geographic information system (GIS) based program developed by USEPA Region IV to facilitate watershed characterization and TMDL development. Livestock information provided in WCS is based on the ratio of watershed pasture area to county pasture area applied to the livestock population within the county. Livestock data for E. coli-impaired watersheds are summarized in Table 6. Populations were rounded to the nearest 25 cows, 50 poultry, and 5 hogs, sheep, and horses.

7.2.3 Failing Septic Systems

Some coliform loading in the Stones 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

Stones River Watershed utilizing septic systems were compiled using the WCS and are summarized in Table 7. In middle and eastern Tennessee, it is estimated that there are approximately 2.37 people per household on septic systems, some of which can be reasonably assumed to be failing. As with livestock in streams, discharges of raw sewage provide a concentrated source of coliform bacteria directly to waterbodies.

Table 6 Livestock Distribution in the Stones River Watershed

HUC-12 Subwatershed (05130203__) or Drainage Area	Livestock Population (WCS)					
	Beef Cow	Milk Cow	Poultry	Hogs	Sheep	Horse
Finch Creek DA	175	25	350	10	0	15
Sinking Creek DA	175	25	400	10	5	25
0204 (Lytle Creek)	850	75	1,800	45	30	255

Table 7 Population on Septic Systems in the Stones River Watershed

HUC-12 Subwatershed (05130203__) or Drainage Area	Population on Septic Systems
Finch Creek DA	379
Sinking Creek DA	336
0204 (Lytle Creek)	2.221

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. Sinking Creek has the highest percentage of urban land area for impaired waterbodies in the Stones River watershed, with 46.4%. Land use for the Stones River impaired drainage areas is summarized in Figures 7 and 8 and tabulated in Appendix A.

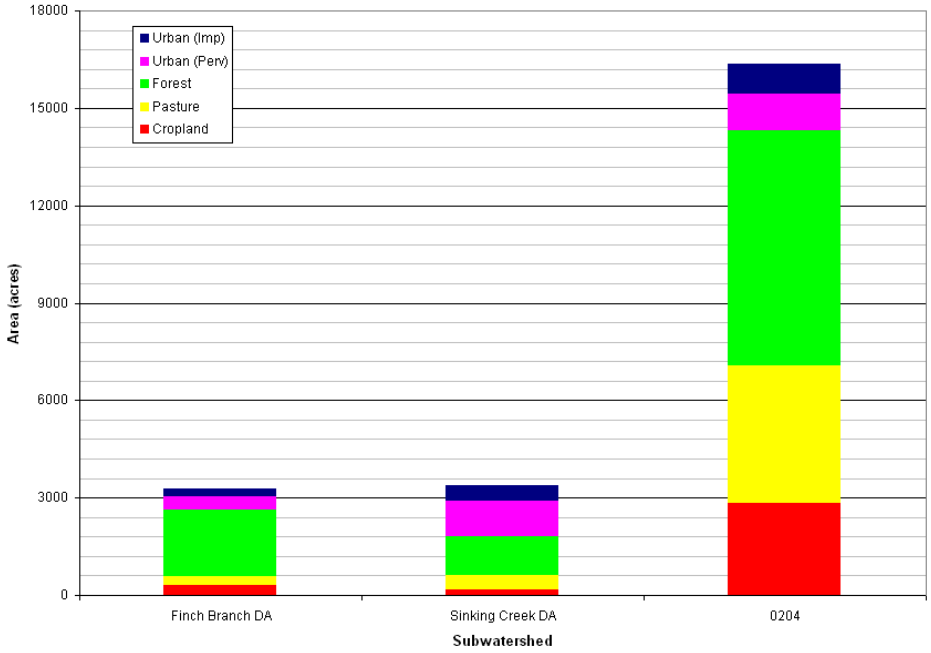

Figure 7. Land Use Area of Stones River Pathogen-Impaired Subwatersheds

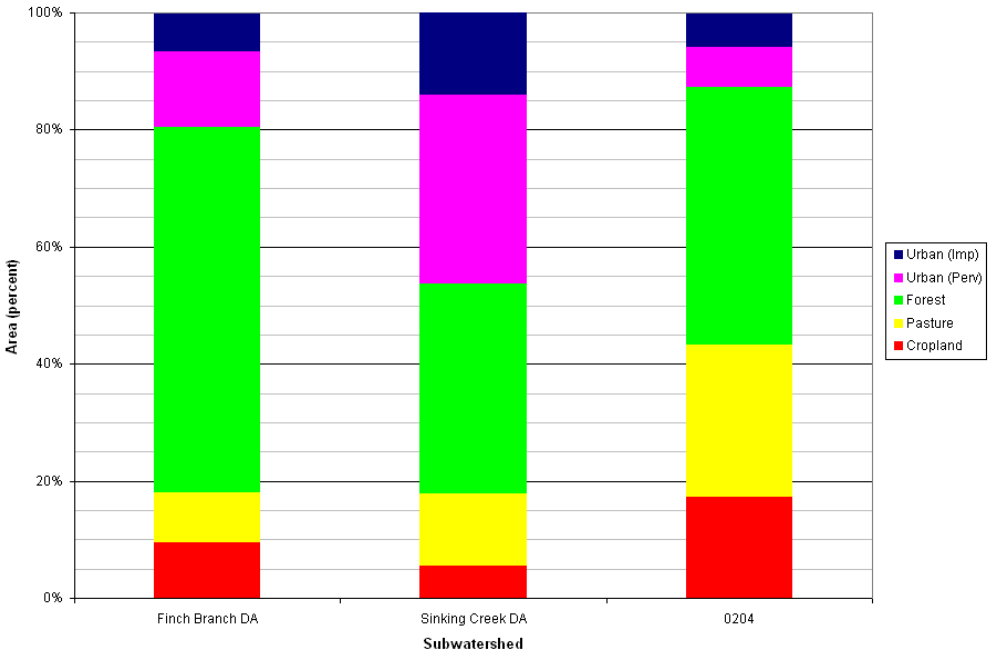

Figure 8. Land Use Percent of the Stones River Pathogen-Impaired Subwatersheds

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) states that TMDLs can be expressed in terms of mass per time, toxicity, or other appropriate measure.

This document describes TMDL, Waste Load Allocation (WLA), and Load Allocation (LA) development for waterbodies identified as impaired due to E. coli on the Final 2004 303(d) list.

8.1 Expression of TMDLs, WLAs, & LAs

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

8.2 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 2004 303(d) List). In some cases, however, TMDLs were 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.

Table 8 Determination of Analysis Areas for TMDL Development

HUC-12 Subwatershed (05130203____)	Impaired Waterbody	Area
0203	Sinking Creek	DA
0204	Lytle Creek Unnamed Trib to Lytle Creek	HUC-12

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

8.3 TMDL Analysis Methodology

TMDLs for the Stones River Watershed were developed using load duration curves for analysis of impaired HUC-12 subwatersheds or specific waterbody drainage areas. A load duration curve (LDC) is a cumulative frequency graph that illustrates existing water quality conditions (as represented by loads calculated from monitoring data), how these conditions compare to desired targets, and the portion of the waterbody flow regime represented by these existing loads. Load duration curves are considered to be well suited for analysis of periodic monitoring data collected by grab sample. LDCs were developed at monitoring site locations in impaired waterbodies and an overall load reduction calculated to meet E. coli targets according to the methods described in Appendix C.

8.4 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 analysis.

The ten-year period from October 1, 1994 to September 30, 2004 was used to simulate flow. This 10-year period contained a range of hydrologic conditions that included both low and high streamflows. Critical conditions are accounted for in the load duration curve analysis by using the entire period of flow and water quality data available for the impaired waterbodies. In all subwatersheds, water quality data have been collected during most flow ranges. Based on the location of the water quality exceedances on the load duration curves, no one delivery mode for E. oli appears to be dominant (see Section 9.3 and Table 9).

Seasonal variation was incorporated in the load duration curves by using the entire simulation period and all water quality data collected at the monitoring stations. The water quality data were not collected during all seasons.

8.5 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 Stones 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 (Tier II):	MOS = 49 CFU/100 ml
Instantaneous Maximum (non-Tier II):	MOS = 94 CFU/100 ml
30-Day Geometric Mean:	MOS = 13 CFU/100 ml

8.6 Determination of TMDLs

E. coli load reductions were calculated for impaired segments in the Stones Watershed using Load Duration Curves to evaluate compliance with the maximum target concentrations according to the procedure in Appendix C. When sufficient data were available, load reductions were also developed to achieve compliance with the 30-day geometric mean target concentrations. Both instream load reductions (where applicable) for a particular waterbody were compared and the largest required load reduction was selected as the TMDL. These TMDL load reductions for impaired segments are shown in Table 9 and are applied according to the areas specified in Table 8. In cases where the geometric mean could not be developed, it is assumed that achieving the load reduction based on the maximum target concentrations should result in attainment of the geometric mean criteria.

8.7 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 higher load reductions necessary to achieve instream targets <u>after application of the explicit MOS</u>. WLAs for existing WWTFs are equal to their existing NPDES permit limits. Since WWTF permit limits require that E. coli concentrations must comply with water quality criteria (TMDL targets) at the point of discharge and recognition that loading from these facilities 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 TMDLs, WLAs, & LAs for Impaired Subwatersheds and Drainage Areas in the Stones River Watershed

HUC-12 Subwatershed (05130203__) or Drainage Area	Impaired Waterbody Name	Impaired Waterbody ID	TMDL	WLAs				LAs	
				WWTFs [a]		CAFOs	MS4s [b]	Precipitation Induced Nonpoint Sources	Other Direct Sources [c]
				Monthly Avg.	Daily Max.				
			[% Red.]	[CFU/day]	[CFU/day]	[CFU/day]	[% Red.]	[% Red.]	[CFU/day]
DA	Sinking Creek	TN05130203018 – 0100	72.3	NA	NA	0	75.0	75.0	0
0204	UT to Lytle Creek	TN05130203022 – 0100	>79.7	NA	NA	0	>81.8	>81.8	0
	Lytle Creek	TN05130203022 – 1000							
	Lytle Creek	TN05130203022 – 2000							

Notes: NA = Not Applicable.

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

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

c. The objective for all "other direct sources" is a load allocation of zero. It is recognized, however, that for leaking septic systems a LA of 0 CFU/day may not be practical. For these sources, the LA is interpreted to mean a reduction in pathogen loading to the maximum extent practicable, consistent with the requirement that these sources not contribute to a violation of the water quality standard for E. coli.

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 Stones River Watershed through reduction of excessive pathogen loading. Adaptive management methods, within the context of the State's rotating watershed management approach, will be used to modify TMDLs, WLAs, and LAs as required to meet water quality goals.

9.1 Point Sources

9.1.1 NPDES Regulated Municipal and Industrial Wastewater Treatment Facilities

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

9.1.2 NPDES Regulated Municipal Separate Storm Sewer Systems (MS4s)

For existing and future regulated discharges from municipal separate storm sewer systems, WLAs will be implemented through Phase I & II MS4 permits. These permits will require the development and implementation of a Storm Water Management Program (SWMP) that will reduce the discharge of pollutants to the "maximum extent practicable" and not cause or contribute to violations of State water quality standards. The *NPDES General Permit for Discharges from Small Municipal Separate Storm Sewer Systems* (TDEC, 2003) and the TDOT individual MS4 permit (TNS077585) require SWMPs to include six minimum control measures:

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

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

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

- Effluent monitoring at selected outfalls that are representative of particular land uses or geographical areas that contribute to pollutant loading before and after implementation of pollutant control measures.
- Analytical monitoring of pollutants of concern in receiving waterbodies, both upstream and downstream of MS4 discharges, over an extended period of time.
- Instream biological monitoring at appropriate locations to demonstrate recovery of biological communities after implementation of storm water control measures.

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

9.1.3 NPDES Regulated Concentrated Animal Feeding Operations (CAFOs)

As of May 11, 2005, there are no Class I or Class II CAFOs within E. coli impaired drainage areas of the Stones River watershed with coverage under the general NPDES permit. WLAs and implementation requirements are provided for any future facilities.

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

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

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

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

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

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

9.2 Nonpoint Sources

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

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

Local citizen-led and implemented management measures offer the most efficient and comprehensive avenue for reduction of loading rates from nonpoint sources. One local stakeholder group, Stones River Watershed Association (SRWA), is dedicated to protecting, preserving, enhancing, and restoring the natural resources within the Stones River Watershed. The SRWA has recently received a grant to develop a watershed restoration plan for Lytle Creek. Participants include city and county governments and MTSU. Details regarding activities of the SRWA are available at their web site (http://stoneswatershed.org).

BMPs have been utilized in the Stones 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 the Stones River Watershed during the TMDL evaluation period. The TDA keeps a database of BMPs implemented in Tennessee. Those listed in the Stones River Watershed are shown in Figure 9. It is recommended that additional information (e.g., livestock access to streams, manure application practices, etc.) be provided and evaluated to better identify and quantify agricultural sources of coliform bacteria loading in order to minimize uncertainty in future modeling efforts.

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

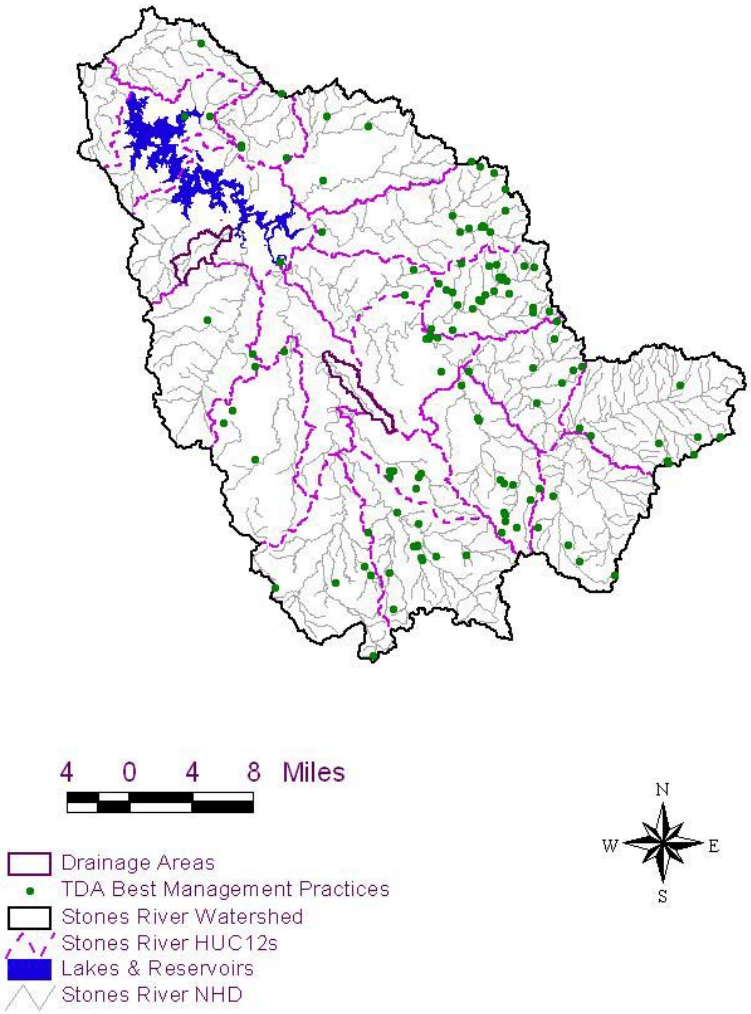

Figure 9. Tennessee Department of Agriculture Best Management Practices located in the Stones River Watershed.

9.3 Application of Load Duration Curves for Implementation Planning

The Load Duration Curve methodology (Appendix C) is a form of water quality analysis and presentation of data that aids in guiding implementation by targeting strategies to appropriate flow conditions. One of the strengths of this method is that it can be used to interpret possible delivery mechanisms of pathogens by differentiating between point and nonpoint problems. The E. coli load duration analysis was utilized for implementation planning. The E. coli load duration curve for each pathogen-impaired subwatershed (Figures C-2 through C-6) was analyzed to determine the frequency with which water quality monitoring data exceed the E. coli target maximum concentrations of 487 CFU/100 mL (Tier II) and 941 CFU/100 mL (non-Tier II) under five flow conditions (low, dry, mid- range, moist, and high). A sample E. coli load duration curve is presented in Figure 10.

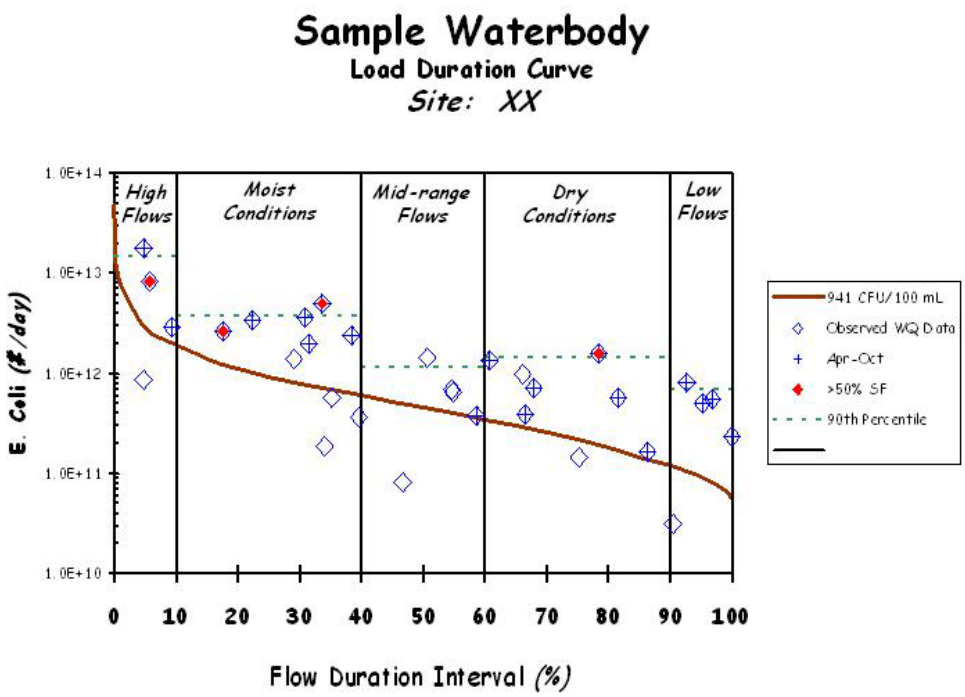

Figure 10. Sample E. Coli Load Duration Curve

Table 10 presents an example of Load Duration analysis statistics for E. coli. Table 11 presents targeted implementation strategies for each source category covering the entire range of flow (Stiles, 2003). Each implementation strategy addresses a range of flow conditions and targets point sources, nonpoint sources, or a combination of each. Results indicate the implementation strategy for all subwatersheds will require BMPs targeting a variety of sources. The implementation strategies listed in Table 11 are a subset of the categories of BMPs and implementation strategies available for application to the pathogen-impaired Stones River Watersheds for reduction of pathogen loading and mitigation of water quality impairment.

Table 10 Sample Load Duration Curve Summary

Flow Condition		High	Moist	Mid-range	Dry	Low
% Time Flow Exceeded		0-10	10-40	40-60	60-90	90-100
Sample Site	% Samples > 941 CFU/100 mL	75.0	90.0	40.0	87.5	80.0
	Reduction	>61.1	>61.1	>49.7	>61.1	>61.1

Table 11 Example Implementation Strategies

Flow Condition	High	Moist	Mid-range	Dry	Low
% Time Flow Exceeded	0-10	10-40	40-60	60-90	90-100
Municipal NPDES		**L**	**M**	**H**	**H**
Stormwater Management		**H**	**H**	**H**	
SSO Mitigation	**H**	**H**	**M**	**L**	
Collection System Repair		**L**	**M**	**H**	**H**
Septic System Repair		**L**	**M**	**H**	**M**
Livestock Exclusion[1]			**M**	**H**	**H**
Pasture Management/Land Application of Manure[1]	**H**	**H**	**M**	**L**	
Riparian Buffers[1]		**H**	**H**	**H**	
Potential for source area contribution under given hydrologic condition (H: High; M: Medium; L: Low)					

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

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

9.4 Additional Monitoring

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

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

Additional monitoring and assessment activities are recommended for the Finch Branch subwatershed to verify the assessment status of the stream reach identified on the Final 2004 303(d) list as impaired due to E. coli. If it is determined that this stream reach is still not fully supporting designated uses, then sufficient data to enable development of a TMDL must be acquired.

Additional monitoring and assessment activities are recommended for the Sinking Creek and Lytle Creek subwatersheds. Examination of monitoring data indicates that no sampling events have occurred during the summer (July, August, and September) and few sampling events have occurred during periods of high flow. Once additional monitoring representing all seasons and a full range of flow and meteorological conditions has been obtained, the required load reductions may be revised.

9.5 Source Identification

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

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

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

A multi-disciplinary group of researchers is developing and testing a series of different microbial assay methods based on real-time PCR to detect fecal bacterial concentrations and host sources in water samples (McKay, 2005). The assays have been used in a study of fecal contamination and have proven useful in identification of areas where cattle represent a significant fecal input and in development of BMPs. It is expected that these types of assays could have broad applications in monitoring fecal impacts from Animal Feeding Operations, as well as from wildlife and human

sources. Other BST projects have been conducted or are currently in progress throughout the state of Tennessee, as presented in sessions of the Thirteenth Tennessee Water Resources Symposium (Lawrence, 2003) and the Fifteenth Tennessee Water Resources Symposium (Bailey, 2005; Baldwin, 2005; Farmer, 2005).

A BST study was conducted in the Stones River watershed by researchers at MTSU (Bailey, 2004). Sampling was conducted in fall and spring at six sites along Stoner's Creek, Lytle Creek, McCrory Creek, and Finch Creek. All sites except Lytle Creek exceeded the recreational geometric mean standard of 126 counts/100 mL. The two sites along Stoner's Creek only exceeded the standard in the spring sampling period. According to Table 3 of the report (Source tracking results for combined Enterococcus/E. coli using CUP by date of sample), human pathogens contributed 32% of the fecal contamination in Finch Creek, while cow pathogens contributed 13%. The Final Report is included in Appendix E.

9.6 Evaluation of TMDL Implementation Effectiveness

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

10.0 PUBLIC PARTICIPATION

In accordance with 40 CFR §130.7, the proposed pathogen TMDLs for the Stones 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 WWTFs located in E. coli-impaired subwatersheds or drainage areas in the Stones 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:

   Murfreesboro-Sinking Creek STP (TN0022586)

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

   Metro Nashville/Davidson County (TNS068047)
   City of LaVergne, Tennessee (TNS075418)
   City of Mount Juliet, Tennessee (TNS075451)
   City of Murfreesboro, Tennessee (TNS075469)
   City of Smyrna, Tennessee (TNS075779)
   Rutherford County, Tennessee (TNS075647)
   Wilson County, Tennessee (TNS075809)
   Tennessee Dept. of Transportation (TNS077585)

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

   Stones River Watershed Association
   Friends of Murfreesboro Greenway

11.0 FURTHER INFORMATION

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

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

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

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APPENDIX A

Land Use Distribution in the Stones River Watershed

Table A-1. MRLC Land Use Distribution of Stones River Subwatersheds

Land Use	HUC-12 Subwatershed (05130203__) or Drainage Area					
	Finch Branch DA		Sinking Creek DA		0204	
	[acres]	[%]	[acres]	[%]	[acres]	[%]
Deciduous Forest	959.9	29.3	539.3	16.0	4,334.5	26.4
Emergent Herbaceous Wetlands	0	0.0	2.2	0.1	14.2	0.1
Evergreen Forest	212.6	6.5	35.6	1.1	555.5	3.4
High Intensity Commercial/Industrial/Transp.	155.0	4.7	157.0	4.7	646.3	3.9
High Intensity Residential	40.9	1.3	319.1	9.5	386.5	2.4
Low Intensity Residential	439.2	13.4	1,088.6	32.3	1,024.1	6.2
Mixed Forest	640.9	19.6	273.3	8.1	1,790.1	10.9
Open Water	4.4	0.1	0	0.0	27.1	0.2
Other Grasses (Urban/recreation; e.g. parks)	184.8	5.7	316.5	9.4	433.2	2.6
Pasture/Hay	285.3	8.7	411.9	12.2	4,261.8	26.0
Quarries/Strip Mines/Gravel Pits	307.6	9.4	187.5	5.6	0.0	0.0
Row Crops	40.5	1.2	0	0.0	2,825.1	17.2
Transitional	0	0.0	40.7	1.2	0.0	0.0
Woody Wetlands	3,271.2	100.0	3,371.7	100.0	94.7	0.6
Total	959.9	29.3	539.3	16.0	16,393.2	100.0

Note: Percent calculations were performed using a spreadsheet. Percentages and totals were rounded off and may differ slightly from values calculated by other means.

APPENDIX B

Water Quality Monitoring Data

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

Table B-1. TDEC Water Quality Monitoring Data – Stones River Subwatersheds

Monitoring Station	Date	E. Coli [cts./100 mL]
FINCH001.4RU	12/19/01	32
	5/8/02	130
LYTLE000.6RU	2/3/00	16
	4/3/00	>2400
	7/24/00	490
	10/16/00	190
	6/1/01	330
LYTLE001.1RU	10/11/01	>2400
	11/28/01	650
	12/4/01	200
	1/3/02	50
	2/12/02	32
	3/19/02	>2400
	4/18/02	140
	5/20/02	240
	6/25/02	1300
LYTLE008.7RU	11/28/01	2000
	12/4/01	1300
	1/3/02	1200
	2/12/02	120
	3/19/02	870
	4/18/02	91
	5/20/02	170
LYTLE1T0.1RU	10/11/01	>2400
	11/28/01	340
	12/4/01	170
	1/3/02	52
	2/12/02	50
	3/19/02	>2400
	4/18/02	200
	5/20/02	190
	6/25/02	600

Monitoring Station	Date	E. Coli [cts./100 mL]
SINKI000.2RU	10/24/01	180
	11/15/01	140
	12/6/01	200
	1/24/02	9600
	3/26/02	650
	4/23/02	120
	5/16/02	650
	6/19/02	730

APPENDIX C

Development of TMDLs, WLAs, & LAs

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

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

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

C.1 Development of TMDLs

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

C.1.1 Development of Flow Duration Curves

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

Flow duration curves for impaired waterbodies in the Stones River Watershed were derived from LSPC hydrologic simulations based on parameters derived from calibration at USGS Station No. 03426800, located on East Fork Stones River at Woodbury, in the Stones River watershed (see Appendix D for details of calibration). For example, a flow-duration curve for Sinking Creek at RM 0.2 was constructed using simulated daily mean flow for the period from 10/1/94 through 9/31/04 (RM 0.2 corresponds to the location of monitoring station SINKI000.2RU). This flow duration curve is shown in Figure C-1 and represents the cumulative distribution of daily discharges arranged to show percentage of time specific flows were exceeded during the period of record (the highest daily mean flow during this period is exceeded 0% of the time and the lowest daily mean flow is equaled or exceeded 100% of the time). Flow duration curves for other impaired waterbodies were derived using a similar procedure.

C.1.2 Development of Load Duration Curves and Determination of 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 Stones 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 (Sinking Creek is shown as an example):

1. A target load-duration curve (LDC) was generated for Sinking 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:

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

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

2. Daily loads were calculated for each of the water quality samples collected at monitoring station SINKI000.2RU (ref.: Table B-1) by multiplying the sample concentration by the daily mean flow for the sampling date and the required unit conversion factor. SINKI000.2RU was selected for LDC analysis because it was the monitoring station on Sinking Creek with the most exceedances of the target concentration.

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

   Example – 3/26/02 sampling event:
   Modelled Flow = 45.35 cfs
   Concentration = 650 CFU/100 mL
   Daily Load = 5.68×10^{11} 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.

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

   Example – 1/24/02 sampling event:
   Target Concentration = 941 CFU/100 mL
   Measured Concentration = 9600 CFU/100 mL
   Reduction to Target = 90.2%

5. The 90th percentile value for all of the E. coli sampling data at SINKI000.2RU monitoring site was determined. If the 90th percentile value exceeded the target maximum E. coli concentration, the reduction required to reduce the 90th percentile value to the target maximum concentration was calculated (Table C-1).

   Example: *Target Concentration = 941 CFU/100 mL*
   90th Percentile Concentration = 3391 CFU/100 mL
   Reduction to Target = 72.3%

6. For cases where five or more samples were collected over a period of not more than 30 consecutive days, the geometric mean E. coli concentration was determined and compared to the target geometric mean E. coli concentration of 126 CFU/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: Insufficient monitoring data was available for any monitoring station in the Stones River watershed

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

Load duration curves, required load reductions, and TMDLs of other impaired waterbodies were derived in a similar manner and are shown in Figures C-3 through C-6 and Tables C-2 through C-5.

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:

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

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

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

LA terms include:

- $[\sum LAs]_{DS}$ 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 practicable).
- $[\sum LAs]_{SW}$ represents the required reduction in E. coli loading from nonpoint sources indirectly going to surface waters from all land use areas (except areas covered by a MS4 permit) as a result of the buildup/wash-off processes associated with storm events.

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

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

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

Instantaneous Maximum (Tier II):

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

Target – MOS = 438 CFU/100 ml

Instantaneous Maximum (non-Tier II):

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 Determination of WLAs for MS4s & LAs for Precipitation-Based Nonpoint Sources

WLAs for MS4s and LAs for precipitation-based nonpoint sources were developed using methods similar to those described in C.1.2 (again, using Sinking Creek as an example):

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

   $(\text{Target Load - MOS})_{\text{Sinking Creek}}$ = (847 CFU/100 mL) x (Q) x (UCF)

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

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

   Example – 1/24/02 sampling event:
   Target Concentration -- MOS = 847 CFU/100 mL
   Measured Concentration = 650 CFU/100 mL
   Reduction to Target -- MOS = 91.2%

10. If the 90th percentile value for all of the E. coli sampling data at SINKI000.2RU monitoring site (calculated in Step 5) exceeded the "target maximum – MOS" E. coli concentration, the reduction required to reduce the 90th percentile value to the "target maximum – MOS" concentration was calculated (Table C-1).

    Example: *Target Concentration -- MOS = 847 CFU/100 mL*
    90th Percentile Concentration = 3391 CFU/100 mL
    Reduction to Target -- MOS = 75.0%

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

    Example: Insufficient monitoring data was available for any monitoring station in the Stones River watershed

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

Load duration curves, required load reductions, WLAs for MS4s, and LAs for precipitation-based nonpoint sources of other impaired waterbodies were derived in a similar manner and are shown in Figures C-3 through C-6 and Tables C-2 through C-5. TMDLs, WLAs, & LAs for impaired subwatersheds and drainage areas in the Stones River Watershed are summarized in Table C-6.

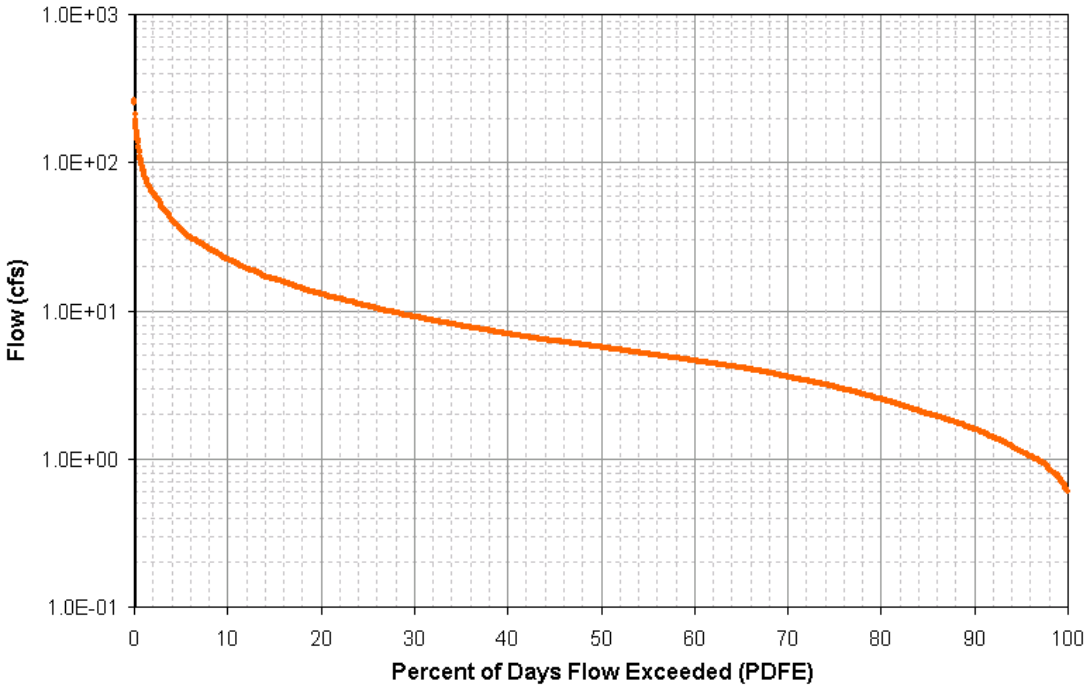

Figure C-1 Flow Duration Curve for Sinking Creek at SINKI000.2RU

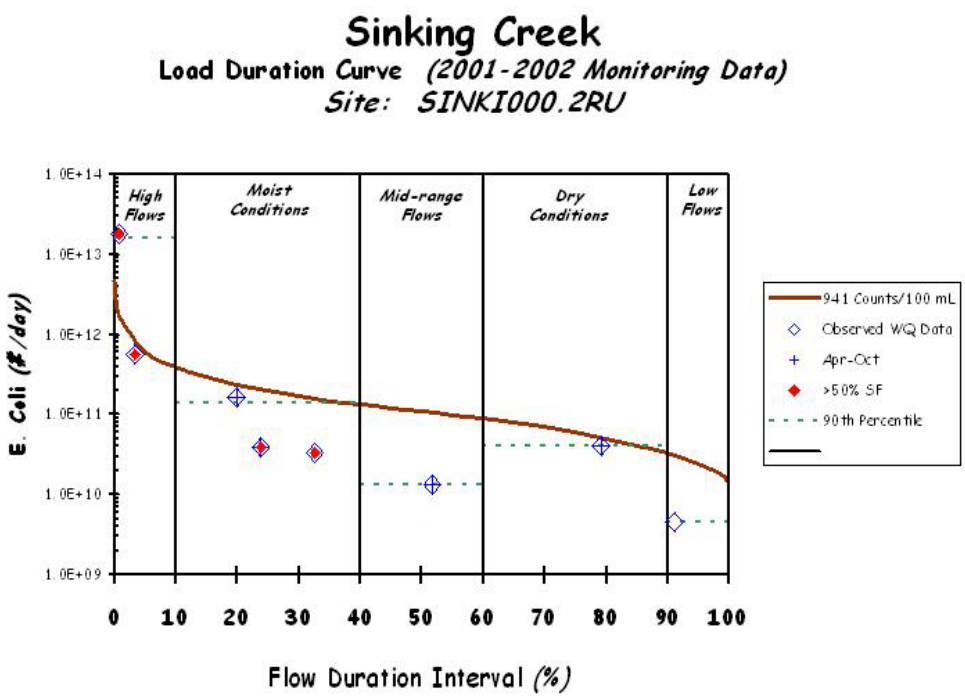

Figure C-2 E. Coli Load Duration Curve for Sinking Creek at SINKI000.2RU

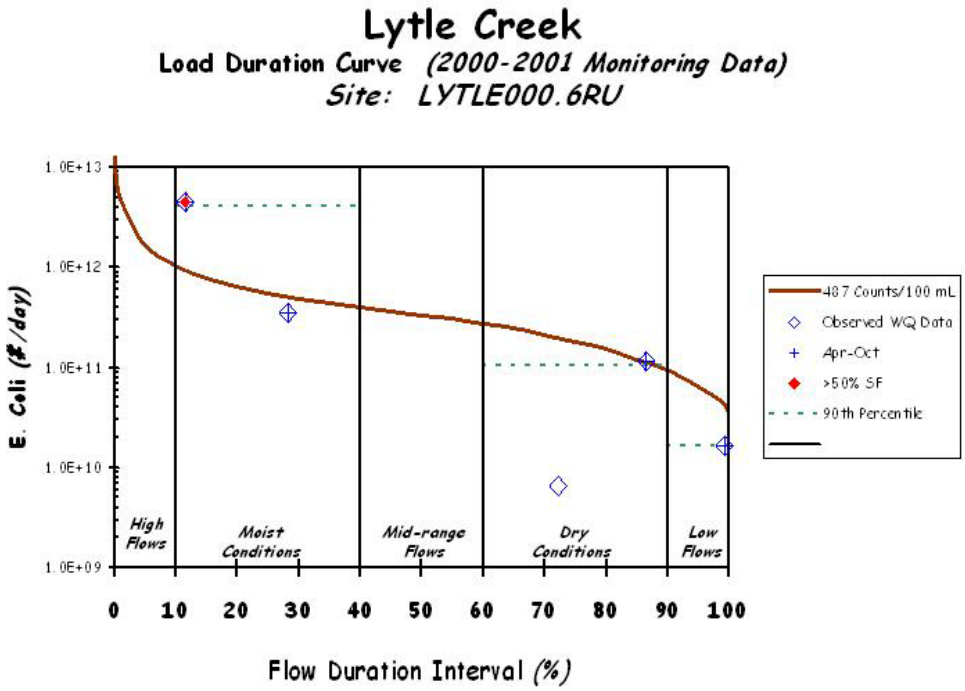

Figure C-3 E. Coli Load Duration Curve for Lytle Creek at LYTLE000.6RU

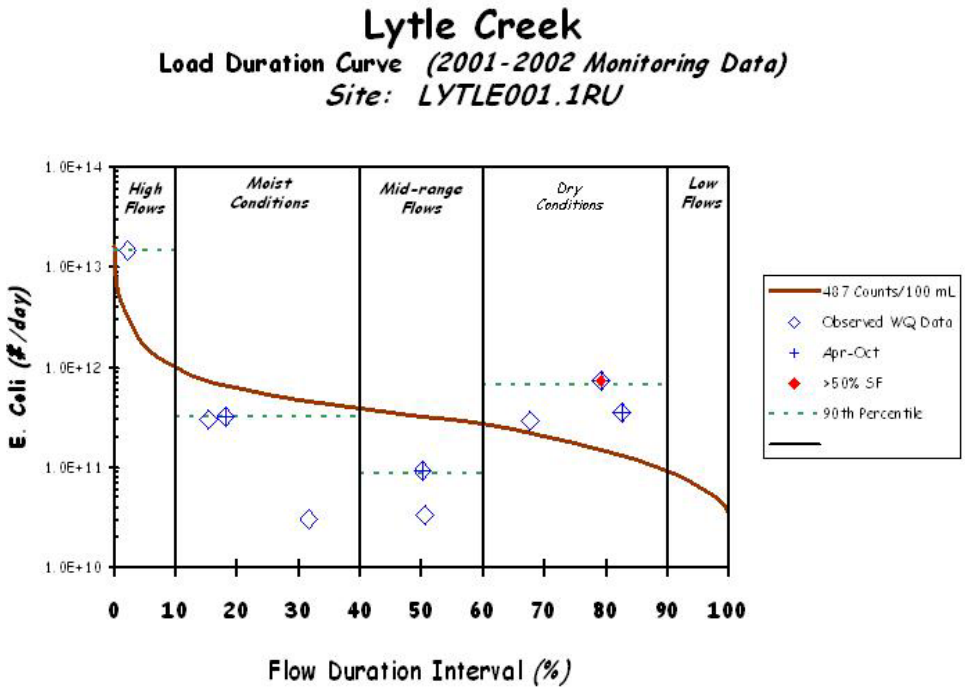

Figure C-4 E. Coli Load Duration Curve for Lytle Creek at LYTLE001.1RU

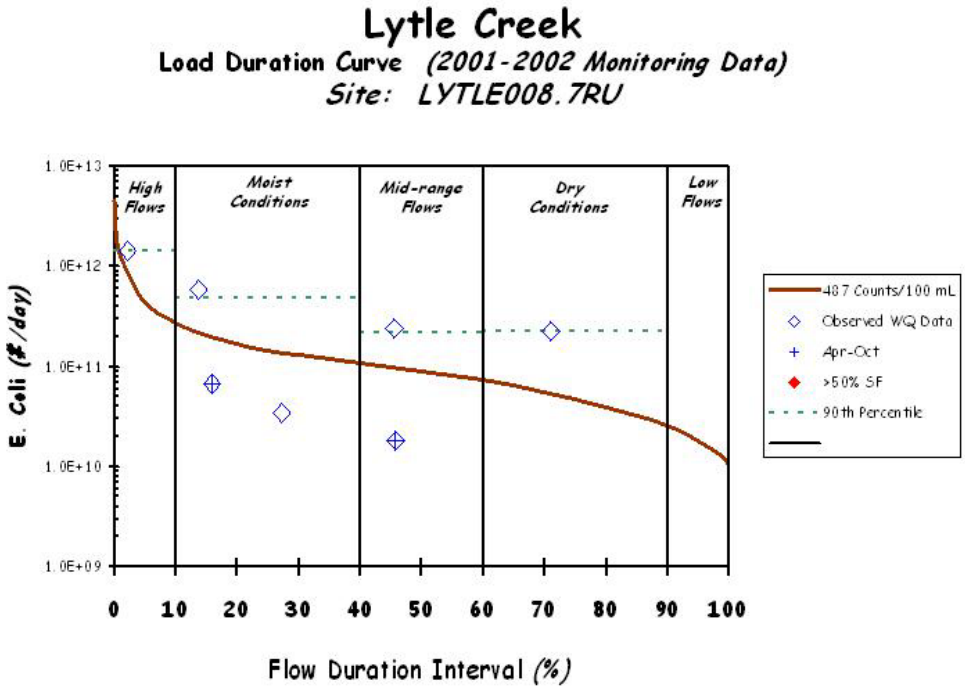

Figure C-5 E. Coli Load Duration Curve for Lytle Creek at LYTLE008.7RU

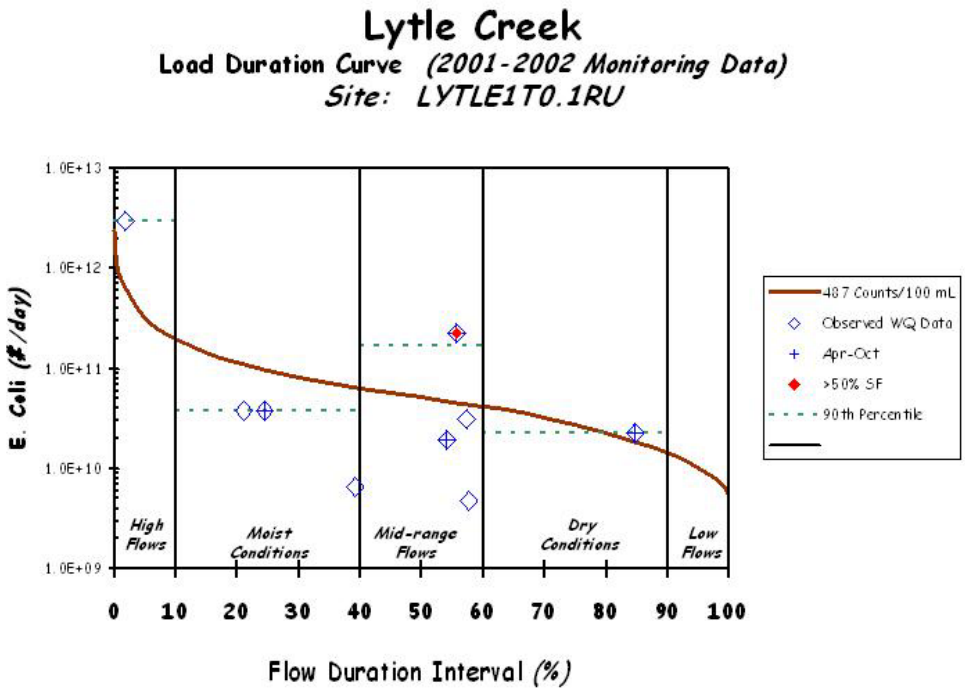

Figure C-6 E. Coli Load Duration Curve for Unnamed Trib to Lytle Creek

Table C-1 Required Load Reduction for Sinking Creek at SINKI000.2RU

Sample Date	Flow	PDFE	E. Coli Sample Concentration	Required Reduction	
				Sample to Target (941 CFU/100 ml)	Sample to Target - MOS (847 CFU/100 ml)
	[cfs]	[%]	[CFU/100 ml]	[%]	[%]
10/24/01	10.98	24.3%	180	**NR**	**NR**
11/15/01	1.61	89.7%	140	**NR**	**NR**
12/6/01	9.21	29.5%	200	**NR**	**NR**
1/24/02	109.63	0.7%	9600	90.2	91.2
3/26/02	45.35	3.6%	650	**NR**	**NR**
4/23/02	4.87	57.1%	120	**NR**	**NR**
5/16/02	12.39	21.1%	650	**NR**	**NR**
6/19/02	2.50	80.3%	730	**NR**	**NR**
90th Percentile Concentration			**3391**	**72.3**	**75.0**

Notes: 1. NR = No reduction required.
2. 30-day Geometric Mean could not be calculated due to insufficient data.
3. Reductions for individual samples (shaded area) is included for reference only.

Table C-2 Required Load Reduction for Lytle Creek at LYTLE000.6RU

Sample Date	Flow	PDFE	E. Coli Sample Concentration	Required Reduction	
				Sample to Target (487 CFU/100 ml)	Sample to Target - MOS (438 CFU/100 ml)
	[cfs]	[%]	[CFU/100 ml]	[%]	[%]
2/3/00	16.56	72.3%	16	**NR**	**NR**
4/3/00	77.60	11.6%	2400	79.7	81.8
7/24/00	9.56	86.7%	490	**0.6**	**10.6**
10/16/00	3.50	99.5%	190	**NR**	**NR**
6/1/01	43.04	28.2%	330	**NR**	**NR**
90th Percentile Concentration			**1636**	**70.2**	**73.2**

Notes: 1. NR = No reduction required.
2. 30-day Geometric Mean could not be calculated due to insufficient data.
3. Reductions for individual samples (shaded area) is included for reference only.

Table C-3 Required Load Reduction for Lytle Creek at LYTLE001.1RU

Sample Date	Flow	PDFE	E. Coli Sample Concentration	Required Reduction	
				Sample to Target (487 CFU/100 ml)	Sample to Target - MOS (438 CFU/100 ml)
	[cfs]	[%]	[CFU/100 ml]	[%]	[%]
10/11/01	12.71	79.3%	>2400	>79.7	>81.8
11/28/01	18.58	67.8%	650	**25.1**	**32.6**
12/4/01	62.09	15.4%	200	**NR**	**NR**
1/3/02	27.28	50.5%	50	**NR**	**NR**
2/12/02	38.94	31.6%	32	**NR**	**NR**
3/19/02	253.53	2.2%	>2400	>79.7	>81.8
4/18/02	27.38	50.2%	140	**NR**	**NR**
5/20/02	55.03	18.1%	240	**NR**	**NR**
6/25/02	11.18	82.7%	1300	62.5	66.3
90th Percentile Concentration			**>2400**	**>79.7**	**>81.8**

Notes: 1. NR = No reduction required.
2. 30-day Geometric Mean could not be calculated due to insufficient data.
3. Reductions for individual samples (shaded area) is included for reference only.

Table C-4 Required Load Reduction for Lytle Creek at LYTLE008.7RU

Sample Date	Flow	PDFE	E. Coli Sample Concentration	Required Reduction	
				Sample to Target (487 CFU/100 ml)	Sample to Target - MOS (438 CFU/100 ml)
	[cfs]	[%]	[CFU/100 ml]	[%]	[%]
11/28/01	4.54	71.1%	2000	75.7	78.1
12/4/01	18.24	13.7%	1300	62.5	66.3
1/3/02	8.23	45.6%	1200	59.4	63.5
2/12/02	11.71	27.2%	120	**NR**	**NR**
3/19/02	67.85	2.2%	870	**44.0**	**49.7**
4/18/02	8.21	45.8%	91	**NR**	**NR**
5/20/02	16.30	16.0%	170	**NR**	**NR**
90th Percentile Concentration			**1580**	**69.2**	**72.3**

Notes: 1. NR = No reduction required.
2. 30-day Geometric Mean could not be calculated due to insufficient data.
3. Reductions for individual samples (shaded area) is included for reference only.

Table C-5 Required Load Reduction for Unnamed Trib to Lytle Creek

Sample Date	Flow	PDFE	E. Coli Sample Concentration	Required Reduction	
				Sample to Target (487 CFU/100 ml)	Sample to Target - MOS (438 CFU/100 ml)
	[cfs]	[%]	[CFU/100 ml]	[%]	[%]
10/11/01	3.86	55.7%	>2400	>79.7	>81.8
11/28/01	3.73	57.3%	340	**NR**	**NR**
12/4/01	9.24	21.2%	170	**NR**	**NR**
1/3/02	3.70	57.7%	52	**NR**	**NR**
2/12/02	5.40	39.2%	50	**NR**	**NR**
3/19/02	51.45	1.7%	>2400	>79.7	>81.8
4/18/02	3.96	54.1%	200	**NR**	**NR**
5/20/02	8.25	24.5%	190	**NR**	**NR**
6/25/02	1.57	84.8%	600	**18.8**	**27.0**
90th Percentile Concentration			**>2400**	**>79.7**	**>81.8**

Notes: 1. NR = No reduction required.
2. 30-day Geometric Mean could not be calculated due to insufficient data.
3. Reductions for individual samples (shaded area) is included for reference only.

Table C-6 TMDLs, WLAs, & LAs for Stones River Watershed

HUC-12 Subwatershed (05130203__) or Drainage Area	Impaired Waterbody Name	Impaired Waterbody ID	TMDL	WLAs				LAs	
				WWTFs [a]		CAFOs	MS4s [b]	Precipitation Induced Nonpoint Sources	Other Direct Sources [c]
				Monthly Avg.	Daily Max.				
			[% Red.]	[CFU/day]	[CFU/day]	[CFU/day]	[% Red.]	[% Red.]	[CFU/day]
DA	Sinking Creek	TN05130203018 – 0100	72.3	NA	NA	0	75.0	75.0	0
0204	Unnamed Trib to Lytle Creek	TN05130203022 – 0100	>79.7	NA	NA	0	>81.8	>81.8	0
	Lytle Creek	TN05130203022 – 1000							
	Lytle Creek	TN05130203002 – 2000							

Notes: NA = Not Applicable.

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

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

c. The objective for all “other direct sources” is a load allocation of zero. It is recognized, however, that for leaking septic systems a LA of 0 CFU/day may not be practical. For these sources, the LA is interpreted to mean a reduction in pathogen loading to the maximum extent practicable, consistent with the requirement that these sources not contribute to a violation of the water quality standard for E. coli.

APPENDIX D

Hydrodynamic Modeling Methodology

HYDRODYNAMIC MODELING METHOD

D.1 Model Selection

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

D.2 Model Set Up

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

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

D.3 Model Calibration

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

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

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

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

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

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

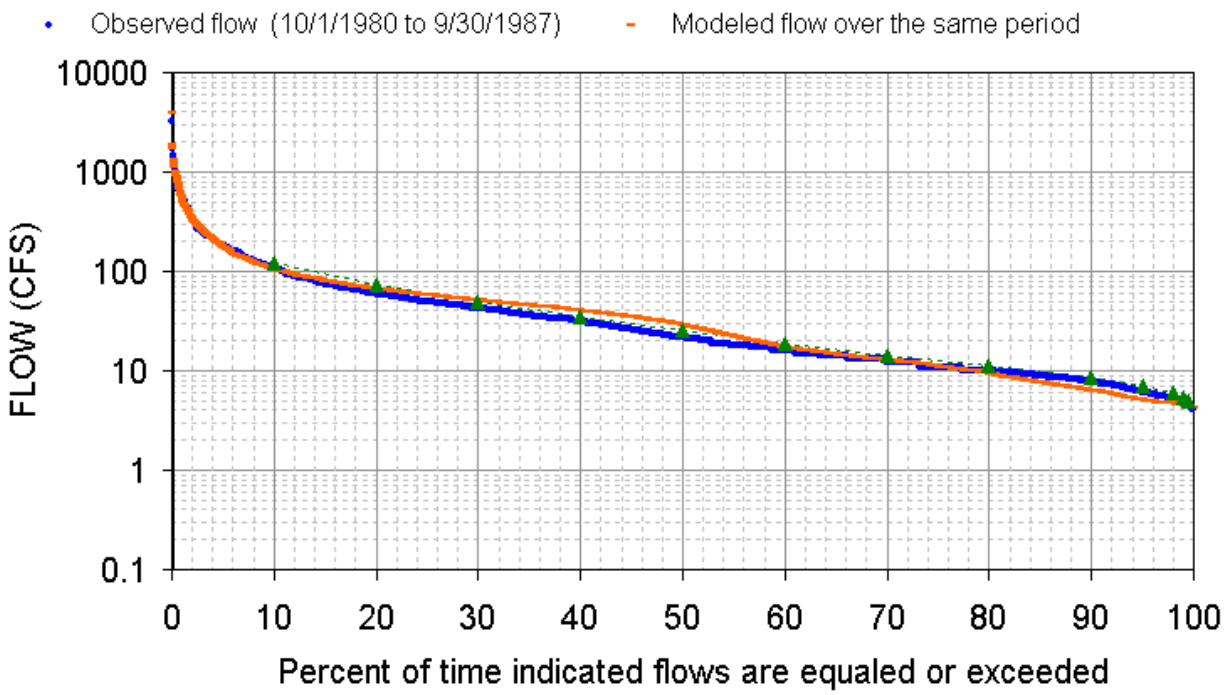

Figure D-1. Hydrologic Calibration: East Fork Stones River, USGS 03426800 (WYs1981-87)

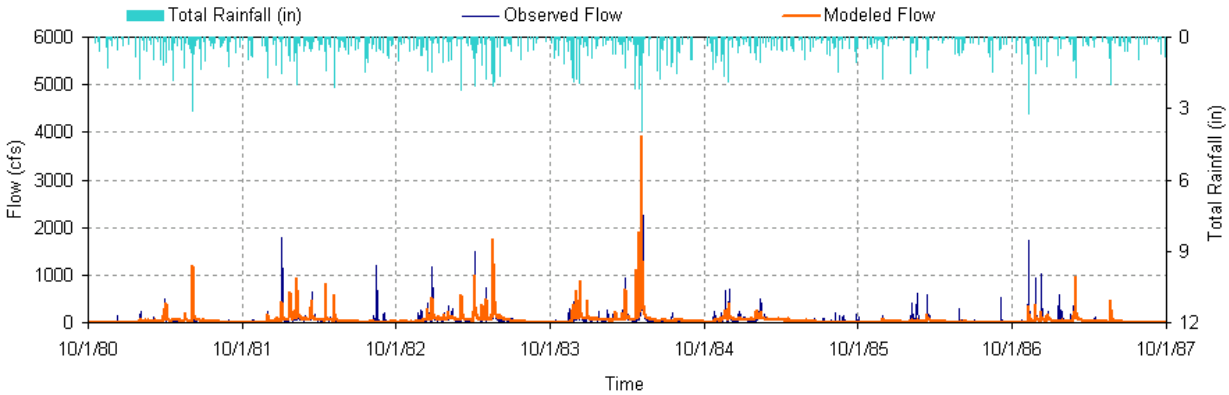

Figure D-2. 10-Year Hydrologic Comparison: East Fork Stones River at Woodbury, USGS 03426800

APPENDIX E

Final Report
2004
Frank Bailey, MTSU

TITLE: Identifying Streams with Potentially High Pathogen Levels by Bacterial Counts and Determining the Source of Bacterial Contamination by Bacterial Source Tracking in the Stones River Watershed in Middle Tennessee

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PROJECT AREA

Stones River Watershed (USGS Hydrologic Unit Code 05130203)

INTRODUCTION

Fecal contamination of surface and ground waters remains a serious health problem in the U.S. and the world. This problem cannot be adequately addressed until specific sources are identified. Determining the source of a contaminant in these water systems requires an interdisciplinary approach involving hydrology, geology, biology, and chemistry. This study addresses the biological aspect of fecal bacterial source tracking (BST).

Previously, the biological approach to identifying the source of fecal contamination was often derived through speculation using the ratio of fecal coliform to fecal streptococci (known today as *enterococci*). However, use of this ratio is no longer considered to be a reliable discriminator between humans and other animals (Standard Methods, 1995). No standard biological technique is presently available that will allow determination of the source of bacterial contamination. Several molecular techniques that are based on genetic sequences and have been perfected for clinical use show promise for sub-classifying bacteria into strains. These techniques include: *In situ* hybridization with rRNA probes (Amann, 1995; DeLong, 1989); ribotyping (Covadonga et al., 1998; Hoi et al., 1997; Vogel et al., 1997; Dalsgaard et al., 1994; Moyer *et.al.,* 1992; Garaizar *et.al.,* 1991); pulsed-field gel electrophoresis [PFGE] (Kodjo, et al., 1999; Kariuki et al., 1999; Castro et al., 1997; Chetoui et al., 1997; Krause et al., 1996; Skov et al., 1995; Anderson et al., 1991); polymerase chain reaction [PCR] (Marcos et al., 1999; Dombeck, et al., 2000) and terminal restriction fragment length polymorphisms (Bernard and Field, 2000). In addition, antibiotic resistance patterns have been reported to be effective in differentiating between strains of bacteria (Kariuki et al., 1999; Wiggins, 1996; Kaspar and Burgess, 1990). These patterns of resistance show some promise as a method of separating *E. coli* and fecal *enterococci* associated with other animals from humans (Wiggins, 1996; Kaspar and Burgess, 1990). Pulsed-field gel electrophoresis has been reported to be the most promising method for differentiating strains of bacteria (Kodjo, et al., 1999; Castro et al., 1997; Chetoui et al., 1997). When PFGE was used in conjunction with antibiotic resistance patterns, differentiation of strains was enhanced (Kariuki et al., 1999). Carbon utilization profiles (CUP) also show promise as a means of categorizing bacteria associated with different fecal host sources (*Simpson et al*., 2002).

Carbon utilization profiles (CUP) are generated by inoculating a Biolog® microtiter plate that contains 96 different carbon sources (Biolog, 1999). This plate is then incubated and the use of particular carbon sources is indicated by a colorimetric change. The pattern generated by the use or non-use of the 96 carbon sources is compared to a computer database to identify the organism. This same pattern can be recorded and used a biochemical "*fingerprint"* for the organism. The Environmental Protection Agency has recognized the potential of this method for bacterial source tracking (*Simpson et al*., 2002). For BST, the CUP "fingerprints" of bacteria from known sources are used to determine the host sources of bacteria from stream water samples (unknowns) utilizing discriminant analysis.

Discriminant analysis is multivariate statistical method that is used to classify unknowns against groups of knowns. In BST, the knowns are the fingerprints of bacteria from known fecal sources and the unknowns are fingerprints of bacteria from the streams. The analysis is designed to minimize the difference **within** the known groups and maximize the difference **among** the known groups. The average rate of correct classification (ARCC) is used as an indicator of the accuracy of the classification by discriminant analysis. The ARCC is calculated by removing each fingerprint of known source bacteria from the database and reclassifying it against the database. The percentage of the fingerprints that are reclassified correctly is the ARCC. Published studies have shown a range ARCCs from 60% to over 90%.

The objectives of the current study were:

1. To establish a fecal bacteria library for the Stones River Watershed.
2. To utilize CUP to determine sources of fecal bacteria at selected sites in the Stones River Watershed.
3. To perform geometric mean bacterial counts and loads for *E.coli* and *Enterococcus* group D (fecal strep.) at these same sites.

METHODS

Fecal Sample collection:

Fecal samples were collected from cow, goose, duck, dog, human and deer sources within the watershed and five to ten *Escherichia coli* and *Enterococci* were isolated from each sample. A septic tank pumping company was utilized to collect samples from septic tanks in the area and samples were also collected from the influent to Murfreesboro wastewater treatment plant.

After collection, fecal samples were placed on ice and returned to the laboratory at Middle Tennessee State University (MTSU). Two grams of fecal material from each sample were weighed into individual sterile 50 ml centrifuge tubes and 25 ml of phosphate buffer solution plus twenty percent glycerol was added and mixed thoroughly. Five 4.5 ml aliquots of the mixture were placed into cryovials and stored at –80°C. Aliquots of septic and sewage were mixed with twenty percent glycerol to a final volume 4.5 ml and stored at –80°C.

For processing, the fecal and sewage samples were thawed and serial dilutions were plated on mTec and *Enterococcus* agar for selection of thermo-tolerant lactose fermenting bacteria and Group D Enterococci (fecal strep), respectively. Colonies taken from the selective agars were plated onto tripticase soy (TSoy) agar for isolation. Isolates were identified and biochemically fingerprinted using the Biolog® Microlog System at Tennessee State University. Aloquots of the isolated bacteria were stored frozen in TSoy broth plus twenty percent glycerol for preservation.

Stones River Watershed Site selection:

The following sites were selected for sampling in the watershed based on suggestions from TDEC WPC: Stoner's Creek at Old Lebanon Dirt Road (Site 1); Stoner's Creek at Central Pike (Site 2); Cannonsburg Tributary of Lytle Creek (Site 3); McCrory Creek at Ironwood Road (Site 4); McCrory Creek at Stewarts Ferry Pike (Site 5); Finch Creek at Furgus Road (Site 6)

CUP Fingerprinting and Identification:

The CUP fingerprints for known and unknown bacteria were generated from the Biolog® identification system as outlined in the Introduction section of this report.

Geometric mean bacteria counts and flow (discharge) measurements:

At selected sites on the above mentioned streams, *E.coli* and *Enterococcus* counts were made on samples collected 5 times over a 30 day period with samples not less than 12 hours apart. The counts were performed using the filter membrane method (Standard Methods, 1995) with appropriate dilutions. *E. coli* were enumerated using mTec agar and Group D *Enterococcus* using *Enterococcus* agar. Flow rates (discharge) were measured by the method of Carter and Davidian (1968).

Environmental Sample Collection:

Water samples collected from the above listed streams were diluted and filtered onto mTec and *Enterococcus* agars using the filter membrane technique for the isolation of *E. coli* and *Enterococcus* respectively. Colonies were isolated onto Tsoy agar and processed and identified/fingerprinted as previously described in the Fecal Sample Selection section of this report.

Analysis:

Discriminant analysis was used to determine the source(s) of fecal bacteria in water samples.

RESULTS/DISCUSSION

Fecal Source Library Development

There are presently 2,449 total bacteria in the library. Of these, 406 are *Enterococcus sp.* and 528 are *E. coli.*

Geometric Means and Loads for Fecal Bacteria in Streams

The bacterial counts, geometric means and calculated loads are listed below for *E. coli* and *Enterococcus* for each site (Tables 1 and 2). All sites except site 3 (Cannonsburg Tributary of Lytle Creek) exceeded the recreational limit of 126 colony forming units per 100 ml (as a geometric mean). However, sites 1 (Stoner's Creek at Old Lebanon Dirt Road) and 2 (Stoner's Creek at Central Pike) only exceeded the limit in the spring sample but not the fall sample. Note that site 6 (Finch Creek at Furgus Road) was only sampled 4 times (over a 37 day period) due to its intermittent nature. A geometric mean calculation was made for this site anyway for comparison purposes. Also note that there were some extremely high counts during high flow (04/22/04) at several sites. The load duration curve for site 1 (Figure 1) was generated by the method of Cleland (2002). Source tracking information will be added to this figure in the near future. The load duration curves for the other sites will also be added soon.

Table 1. Bacterial counts by date and geometric means for each site.

Site	Date	*E. coli* (CFU/100mL)	*Enterococcus* (CFU/100mL)
1 Stoner's Creek at Old Lebanon Dirt Road	10/18/2003	66	113
	10/24/2003	77	99
	10/31/2003	66	98
	11/02/2003	188	130
	11/04/2003	41	85
	Geometric mean	76	104
1 Stoner's Creek at Old Lebanon Dirt Road	04/07/2004	61	80
	04/14/2004	330	410
	04/21/2004	160	109
	04/22/2004	13000	12800
	5/7/2004	128	344
	Geometric mean	351	436
2 Stoner's Creek at Central Pike	10/18/2003	80	136
	10/24/2003	50	101
	10/31/2002	90	87
	11/02/2003	132	81
	11/04/2003	71	64
	Geometric mean	80	91
2 Stoner's Creek at Central Pike	04/07/2004	30	24
	04/14/2004	327	388
	04/21/2004	109	223
	04/22/2004	12500	40000
	5/7/2004	295	240
	Geometric mean	330	457
3 Cannonsburg Tributary of Lytle Creek	10/18/2003	59	75
	10/24/2003	61	100
	10/31/2002	79	47
	11/02/2003	700	62
	11/04/2003	76	17
	Geometric mean	109	52
4 McCrory Creek at Ironwood Road	03/24/2004	61	32
	03/31/2004	70	84
	04/07/2004	66	76
	04/14/2004	129	158
	04/21/2004	256	233
	04/22/2004	5100	32500
	Geometric mean	190	250

5 McCrory Creek at Stewarts Ferry Pike	03/24/2004	57	16
	03/31/2004	108	114
	04/07/2004	105	61
	04/14/2004	190	8100
	04/21/2004	319	363
	04/22/2004	15400	34000
	Geometric mean	291	472
6 Finch Creek at Furgus Road	03/24/2004		
	03/31/2004	150	175
	04/07/2004		
	04/14/2004	444	850
	04/21/2004		
	04/22/2004	17600	23600
	05/07/2004	62	430
	Geometric mean	519	1108

Table 2. Loads for fecal bacteria by site and date.

Site	Date	*E. coli* (CFU/day)	*Enterococcus* (CFU/day)
1	10/18/2003	5.69E+09	9.74E+09
2	10/18/2003	2.07E+10	3.53E+10
3	10/18/2003	3.10E+09	3.95E+09
4	03/24/2004	7.91E+09	4.15E+09
4	03/31/2004	1.75E+10	9.33E+09
4	04/07/2004	7.11E+09	8.18E+09
5	03/31/2004	3.54E+10	3.67E+10
5	04/14/2004	2.81E+11	7.39E+12
6	04/14/2004	5.00E+10	9.57E+10

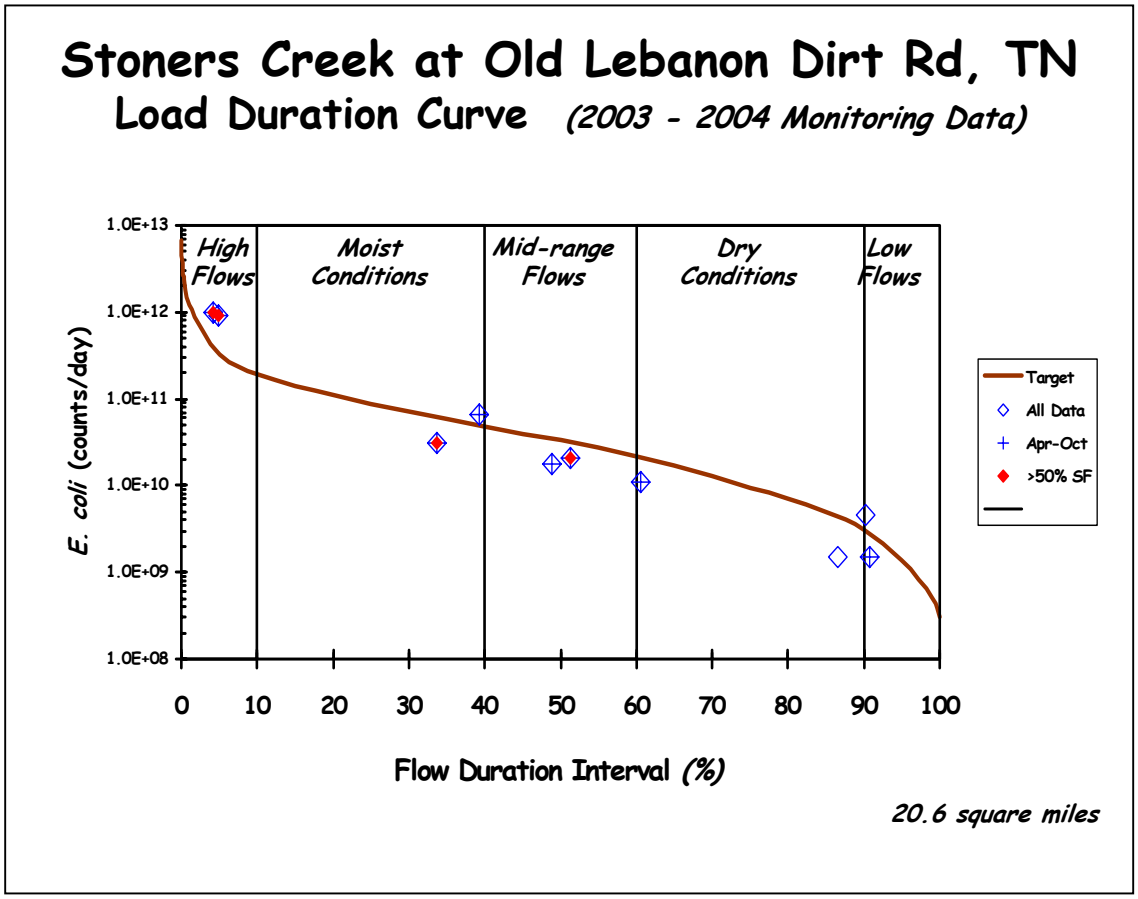

Figure 1. Load duration curve for site 1. The line represents the target load based on a geometric mean of 126 CFU/100ml. Each point represents the load calculated based on an individual sample.

Fecal Source Determination (Fecal Source Tracking)

There were 272 *Enterococcus* isolated from the Stones River Watershed Sites and 206 of these have been identified and fingerprinted with Biolog®. There were 348 fecal coliforms isolated from the Stones River Watershed Sites and 220 have been identified and fingerprinted with Biolog®. Of these 220, 179 are *E. coli*. Source tracking (BST) results are presented below in Table 3. Notice that the data for *E. coli* and *Enterococcus* has been combined to generate this table. The results are shown by site and date and an average is given for each site across dates. The ARCC's for the CUP data were 94% for *Enterococcus* and 97% for *E. coli*, indicating a very high rate of correct classification. *Escherichia coli* and *Enterococci* from cow, goose, duck, dog, human and deer sources only are included in the analysis. If an isolate from a water sample did not fit into one of these categories with a 75% probability, it is listed in Table 3 as "unknown". There may be other as yet undetermined sources contributing to the fecal load in these cases.

Table 3. Source tracking results for combined *Enterococcus*/*E. coli* using CUP by date of sample.

			% By Fecal Host Source						
Site	Date	Flow Condition	Cow	Goose	Duck	Deer	Dog	Human	Unknown
1 Stoner's Creek at Old Lebanon Dirt Road	10/24/03	Low	38	13	0	12	0	12	25
	10/31/03	Low	20	20	0	30	10	10	10
	11/02/03	Low	0	22	34	11	0	0	33
	11/04/03	Low	50	30	0	10	0	10	0
	04/07/04	Low	0	0	25	13	0	0	62
	04/14/04	High	0	20	0	20	20	30	10
	04/21/04	Low	20	0	20	0	10	20	30
	04/22/04	High	33	11	0	0	0	34	22
	05/05/04	High	22	11	0	33	11	0	22
	Average		21	14	8	15	6	13	23
2 Stoner's Creek at Central Pike	10/18/04	Low	43	0	29	0	0	0	28
	10/24/03	Low	57	0	0	29	0	14	0
	10/31/03	Low	0	14	0	58	0	14	14
	11/02/03	Low	33	11	0	11	0	11	33
	11/04/03	Low	11	44	0	11	11	0	23
	04/07/04	Low	22	22	0	33	0	0	23
	04/14/04	Low	40	0	0	20	0	20	20
	04/21/04	Low	20	0	10	0	30	0	40
	04/22/04	High	38	12	13	0	0	12	25
	05/05/04	High	17	33	0	0	17	0	33
	Average		27	14	5	16	6	7	25
3 Cannonsburg Tributary of Lytle Creek	10/18/04	Low	23	8	23	15	0	8	23
	10/24/03	Low	18	27	0	36	19	0	0
	10/31/03	Low	11	0	22	22	0	45	0
	11/02/03	Low	20	40	40	0	0	0	0
	11/04/03	Low	33	33	17	17	0	0	0
	02/10/04	High	0	75	0	13	0	0	12
	04/07/04	Low	0	40	0	40	0	0	20
	05/05/04	High	28	29	0	29	0	14	0
	Average		17	29	15	20	3	9	7
4 McCrory Creek at Ironwood Road	03/24/04	Low	8	54	0	15	8	0	15
	03/31/04	High	11	22	22	11	0	0	34
	04/07/04	Low	30	30	10	0	20	0	10
	04/14/04	High	80	0	0	0	20	0	0
	04/21/04	Low	12	13	13	0	37	0	25
	04/22/04	High	20	20	20	0	0	0	40
	Average		22	27	11	5	13	0	22

5 McCrory Creek at Stewarts Ferry Pike	03/24/04	Low	0	40	13	7	20	0	20
	03/31/04	High	40	10	20	0	10	0	20
	04/07/04	Low	30	0	0	30	0	10	30
	04/14/04	High	0	40	0	20	0	40	0
	04/21/04	Low	10	40	10	0	30	0	10
	04/22/04	High	44	0	0	22	0	11	23
	Average		20	22	8	12	12	7	19
6 Finch Creek at Furgus Road	03/31/04	High	20	0	10	20	10	20	20
	04/14/04	High	10	0	10	40	0	20	20
	04/22/04	High	25	12	0	13	0	50	0
	Average		13	3	11	19	3	32	19

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APPENDIX F

Public Notice Announcement

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

PUBLIC NOTICE OF AVAILABILITY OF PROPOSED TOTAL MAXIMUM DAILY LOAD (TMDL) FOR E. COLI IN STONES RIVER WATERSHED (HUC 05130203), TENNESSEE

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

A number of waterbodies in the Stones River watershed are listed on Tennessee's Final 2004 303(d) list as not supporting designated use classifications due, in part, to discharge of pathogens from pasture land and MS4 areas. The TMDL utilizes Tennessee's general water quality criteria, continuous flow data from a USGS discharge monitoring station located in proximity to the watershed, site specific water quality monitoring data, a calibrated hydrologic model, load duration curves, and an appropriate Margin of Safety (MOS) to establish allowable loadings of pathogens which will result in the reduced in-stream concentrations and attainment of water quality standards. The TMDL requires reductions of pathogen loading on the order of 72-80% in the listed waterbodies.

The proposed Stones River E. coli TMDL may be downloaded from the Department of Environment and Conservation website:

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

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

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

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

Persons wishing to comment on the proposed TMDLs are invited to submit their comments in writing no later than May 8, 2006 to:

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

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

The TMDL and supporting information are on file at the Division of Water Pollution Control, 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.