TOTAL MAXIMUM DAILY LOAD (TMDL)

for

Pathogens

in the

Conasauga River Watershed (HUC 03150101)

Bradley and Polk Counties, Tennessee

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LIST OF ABBREVIATIONS

ADB	Assessment Database
AFO	Animal Feeding Operation
BMP	Best Management Practices
BST	Bacterial Source Tracking
CAFO	Concentrated Animal Feeding Operation
CFR	Code of Federal Regulations
CFS	Cubic Feet per Second
DEM	Digital Elevation Model
DWPC	Division of Water Pollution Control
E. coli	Escherichia coli
EPA	Environmental Protection Agency
GIS	Geographic Information System
HSPF	Hydrological Simulation Program - Fortran
HUC	Hydrologic Unit Code
LA	Load Allocation
LDC	Load Duration Curve
LSPC	Loading Simulation Program in C^{++}
MGD	Million Gallons per Day
MOS	Margin of Safety
MRLC	Multi-Resolution Land Characteristic
MS4	Municipal Separate Storm Sewer System
MST	Microbial Source Tracking
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
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
UCF	Unit Conversion Factor
USGS	United States Geological Survey
WCS	Watershed Characterization System
WLA	Waste Load Allocation
WQS	Water Quality Standard
WWTF	Wastewater Treatment Facility

SUMMARY SHEET

Total Maximum Daily Load for Pathogens in Selected Waterbodies of the Conasauga River Watershed (HUC 03150101)

Impaired Waterbody Information

State: Tennessee
County: Bradley and Polk
Watershed: Conasauga River (HUC 03150101)
Constituents of Concern: Pathogens

Impaired Waterbodies Addressed in This Document:

Waterbody ID	Waterbody	Miles Impaired
TN03150101012 – 0200*	MILL CREEK*	20.1
TN03150101012 – 0300	BALL PLAY CREEK	7.44

* Available data for Mill Creek suggest no reduction is required. However, there are insufficient data to make a delisting determination. Therefore, the TMDL, WLAs and LAs are not quantified for Mill Creek. Analytical results are included in Appendix C.

Designated Uses:

The designated use classifications for all impaired waterbodies in the Conasauga River watershed include fish and aquatic life, irrigation, livestock watering & wildlife, and recreation.

Water Quality Goal:

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

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

TMDL Scope:

Waterbodies identified on the Final 2004 303(d) list as impaired due to Escherichia coli. TMDLs are developed for impaired waterbodies on a HUC-12 or smaller subwatershed basis. For Mill Creek and Ball Play Creek, the analyses were conducted on a smaller subwatershed basis. The analytical results for Mill Creek are included in the TMDL document. However, the available data suggests no reduction is required for this waterbody segment, though there is insufficient data to make a delisting determination. Therefore, the TMDL, WLAs and LAs are not quantified for Mill Creek.

Analysis/Methodology:

The Conasauga watershed TMDLs were developed using the Load Duration Curve (LDC) methodology (below) to assure compliance with the E. Coli 941 counts/100 mL maximum standard.

Load Duration Curve Method
A duration curve is a cumulative frequency graph that represents the percentage of time during which the value of a given parameter is equaled or exceeded. Load duration curves are developed from flow duration curves and can illustrate existing water quality conditions (as represented by loads calculated from monitoring data), how these conditions compare to desired targets, and the portion of the waterbody flow regime represented by these existing loads. Load duration curves were used to determine the load reductions required to meet the target maximum concentrations for E. coli (standard - MOS).

Critical Conditions:

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

Margin of Safety (MOS):

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

TMDLs, WLAs, & LAs

Summary of TMDLs, WLAs, & LAs for Impaired Waterbodies

Drainage Area and/or HUC-12 Subwatershed (03150101__)	Impaired Waterbody Name	Impaired Waterbody ID	TMDL	WLAs			LAs	
				WWTFs[a] (Monthly Avg.) E. Coli	CAFOs	MS4s[b]	Precipitation Induced Nonpoint Sources	Other Direct Sources[c]
			[% Red.]	[cts./day]	[cts./day]	[% Red.]	[% Red.]	[cts./day]
BALL PLAY CREEK (0102)	BALL PLAY CREEK	TN03150101012 – 0300	**>41.2**	**NA[d]**	**NA**	**NA**	**>41.2**	**0**

Note: NA = Not applicable.

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

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 counts/day may not be practical. For these sources, the LA is interpreted to mean a reduction in coliform loading by the application of best management practices, consistent with the requirement that these sources not contribute to a violation of the water quality standard for E. coli.

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

PROPOSED PATHOGEN TOTAL MAXIMUM DAILY LOAD (TMDL)
CONASAUGA RIVER WATERSHED (HUC 03150101)

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 Conasauga River Watershed identified on the Final 2004 303(d) list as not supporting designated uses due to Escherichia coli (E. coli). Portions of the Conasauga River Watershed lie in Tennessee and Georgia. This document addresses only impaired waterbodies in Tennessee. The TMDL analyses were performed for the impaired waterbodies (Mill Creek and Ball Play Creek) drainage areas only.

The analytical results for Mill Creek are included in Appendix C. However, the available data suggest no reduction is required for this waterbody segment, though there are insufficient data to make a delisting determination. Therefore, the TMDL, WLAs and LAs are not quantified for Mill Creek.

3.0 WATERSHED DESCRIPTION

The Conasauga River watershed (HUC 03150101) is located in Southeast Tennessee (Figure 1) and lies within the Level III Ridge and Valley (67) and Blue Ridge Mountains (66) ecoregions. The impaired subwatersheds lie in the Level IV Southern Metasedimentary Mountains (66g), Southern Limestone/Dolomite Valleys and Low Rolling Hills (67f), Southern Shale Valleys (67g), and Southern Dissected Ridges and Knobs (67i) ecoregions as shown in Figure 2 (USEPA, 1997):

- Southern Metasedimentary Mountains (66g) is a region of low mountains, elevations 1000-6000 feet, with local relief 1000-3000 feet. The geology consists of metamorphic and sedimentary rocks and the surficial geology in the ecoregion consists of bouldery colluvium. The mountains support extremely complex and numerous plant communities.

- Southern Limestone/Dolomite Valleys and Low Rolling Hills (67f) is a heterogeneous ecoregion composed predominantly of limestone and cherty dolomite. Landforms include undulating valleys as well as low rolling hills and ridges, with elevations ranging from 700 feet in the south to 2000 feet on the highest hills in the north. The soils are

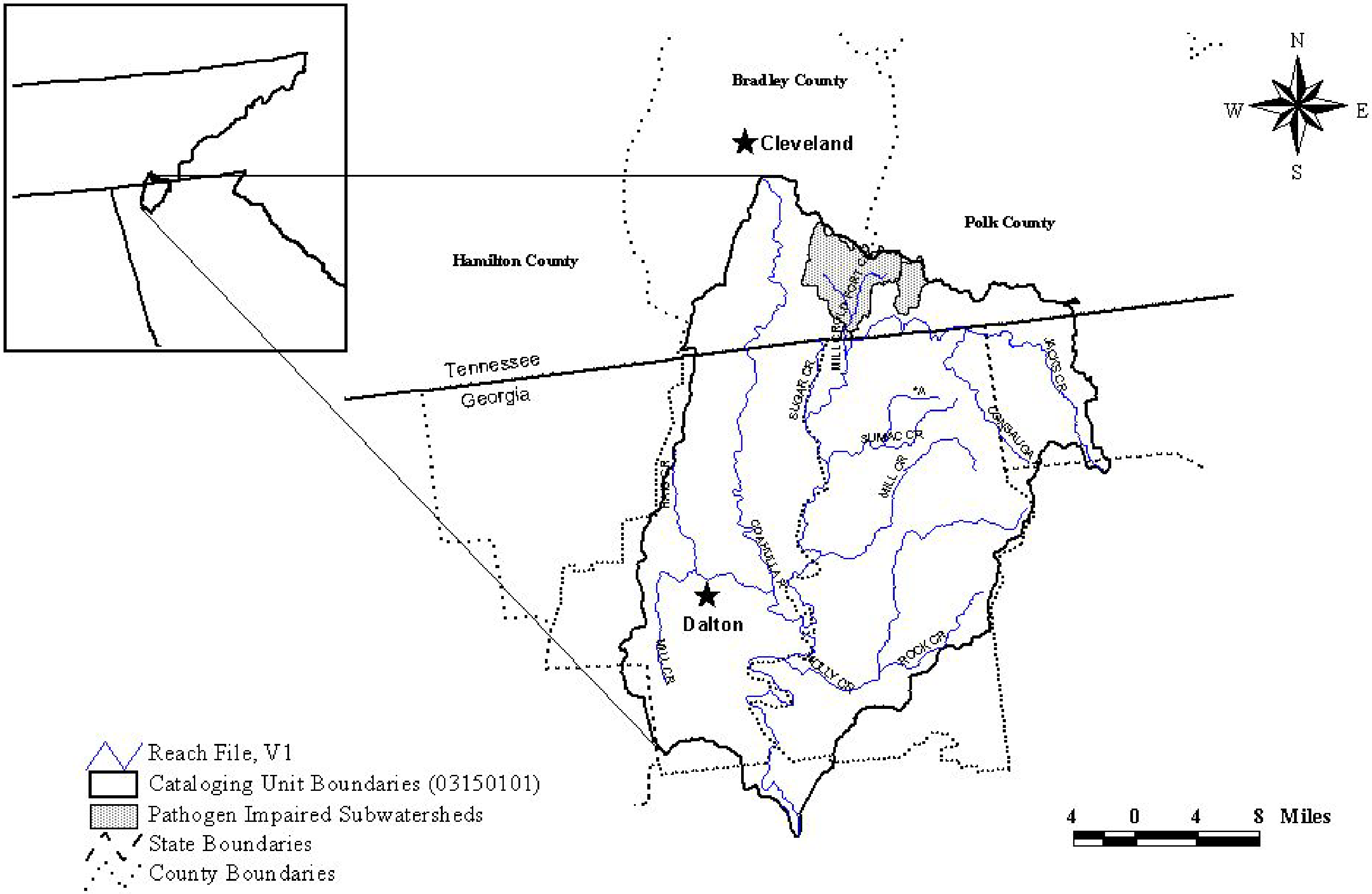

Figure 1. Location of the Conasauga River Watershed and E. coli Impaired Subwatersheds.

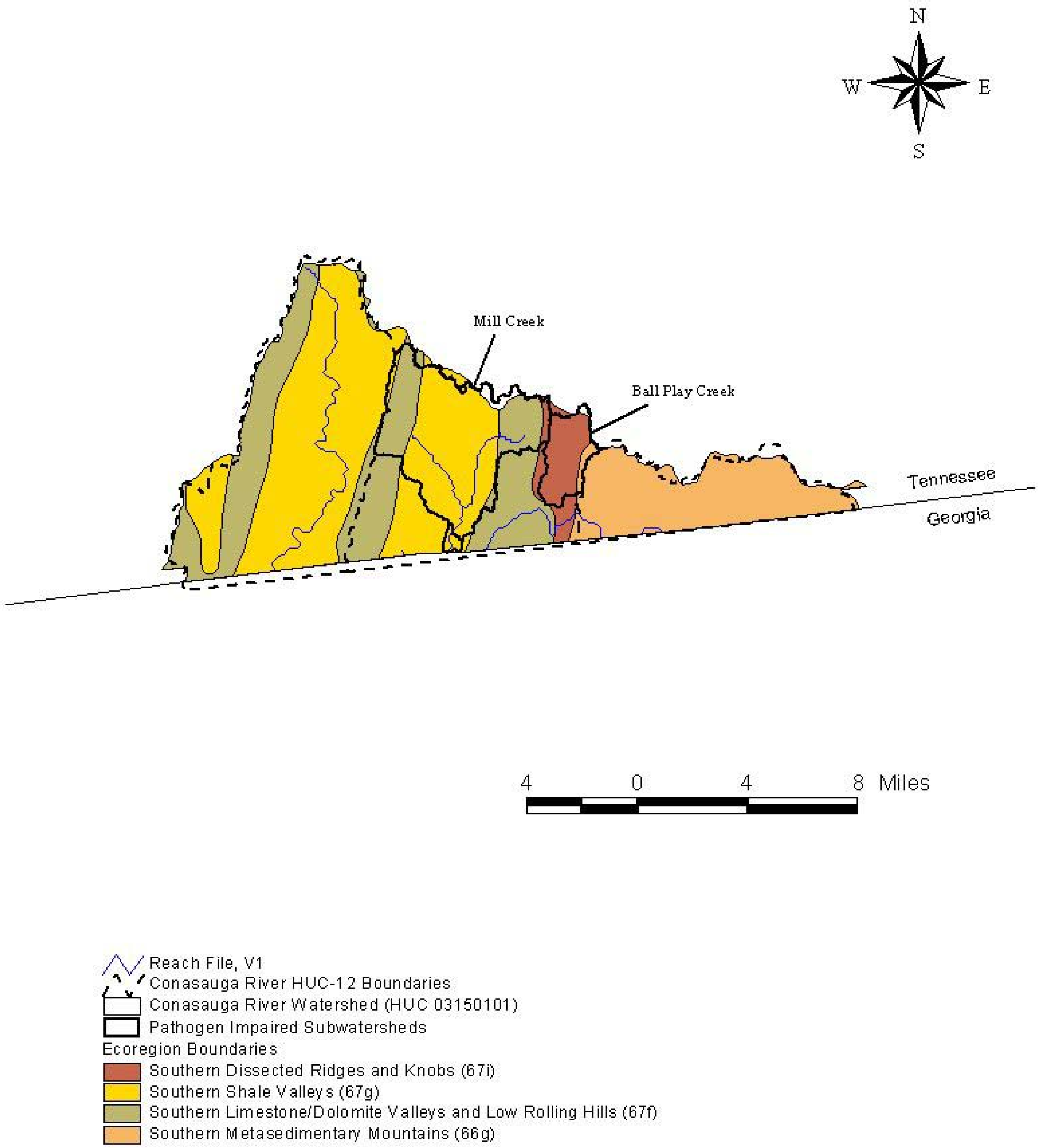

Figure 2. Level IV Ecoregions in the Conasauga River Watershed.

variable in productivity and landcover ranges from areas of intensive agriculture to thick forest. Most of the Ridge and Valley's urban areas are located in 67f.

- Southern Shale Valleys (67g) consists of lowlands, rolling valleys, and some slopes and hilly areas that are dominated by fine-grained rock, primarily shale. Local relief is generally 100-400 feet. Soils are slightly acidic or neutral, well drained or excessively drained. The steeper slopes in the ecoregion are used for pasture or have reverted to brush and forested land, while hay and crops are grown on the foot slopes and bottom land.

- The ridges of the Southern Dissected Ridges and Knobs (67i) are primarily those with abundant shale that have a prominent topographic expression. They are lower and more dissected than ridges of ecoregion 67h. In states to the north of Tennessee, streams of this ecoregion tend to less acidic than on the sandstone ridges (67h) and have storm hydrographs with higher peaks.

The Conasauga River watershed, located in Bradley and Polk Counties, Tennessee, has a drainage area of approximately 123.7 square miles (mi^2) in Tennessee. 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 minor changes in the land use of the Conasauga River watershed may have occurred since 1993, this is the most current land use data available. Land use for the Conasauga River watershed is summarized in Table 1 and shown in Figure 3. Predominate land use in the Conasauga River watershed is forest (66.0%) followed by agriculture (29.8%). Urban areas represent approximately 3.3% of the total drainage area of the watershed. Details of land use distribution of E. coli-impaired subwatersheds in the Conasauga River watershed are presented in Appendix A.

4.0 PROBLEM DEFINITION

The State of Tennessee's Final 2004 303(d) List (TDEC, 2005) was approved by the U.S. Environmental Protection Agency (EPA), Region IV in August of 2005. The list identified two waterbody segments in the Conasauga River watershed as not fully supporting designated use classifications due to E. coli, a pathogen indicator. The designated use classifications for these waterbodies include fish and aquatic life, irrigation, livestock watering & wildlife, and recreation. This TMDL document presents the analyses of the two E. coli-impaired waterbody segments (Table 2).

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 group is an indicator of the presence of pathogens in a stream.

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

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

Table 1. MRLC Land Use Distribution – Conasauga River Watershed

Land Use	Area	
	[acres]	[%]
Deciduous Forest	19,094.9	24.1
Emergent Herbaceous Wetlands	2.2	0.0*
Evergreen Forest	15,846.8	20.0
High Intensity Commercial/Industrial/ Transportation	213.9	0.3
High Intensity Residential	52.9	0.1
Low Intensity Residential	756.7	1.0
Mixed Forest	17,295.0	21.8
Open Water	101.9	0.1
Other Grasses (Urban/recreational)	378.1	0.5
Pasture/Hay	19,688.0	24.9
Quarries/Strip Mines/ Gravel Pits	205.5	0.3
Row Crops	3,841.1	4.9
Transitional	1,592.8	2.0
Woody Wetlands	119.9	0.2
Total	**79,199**	**100.0**

* < 0.05%

5.0 WATER QUALITY GOAL

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

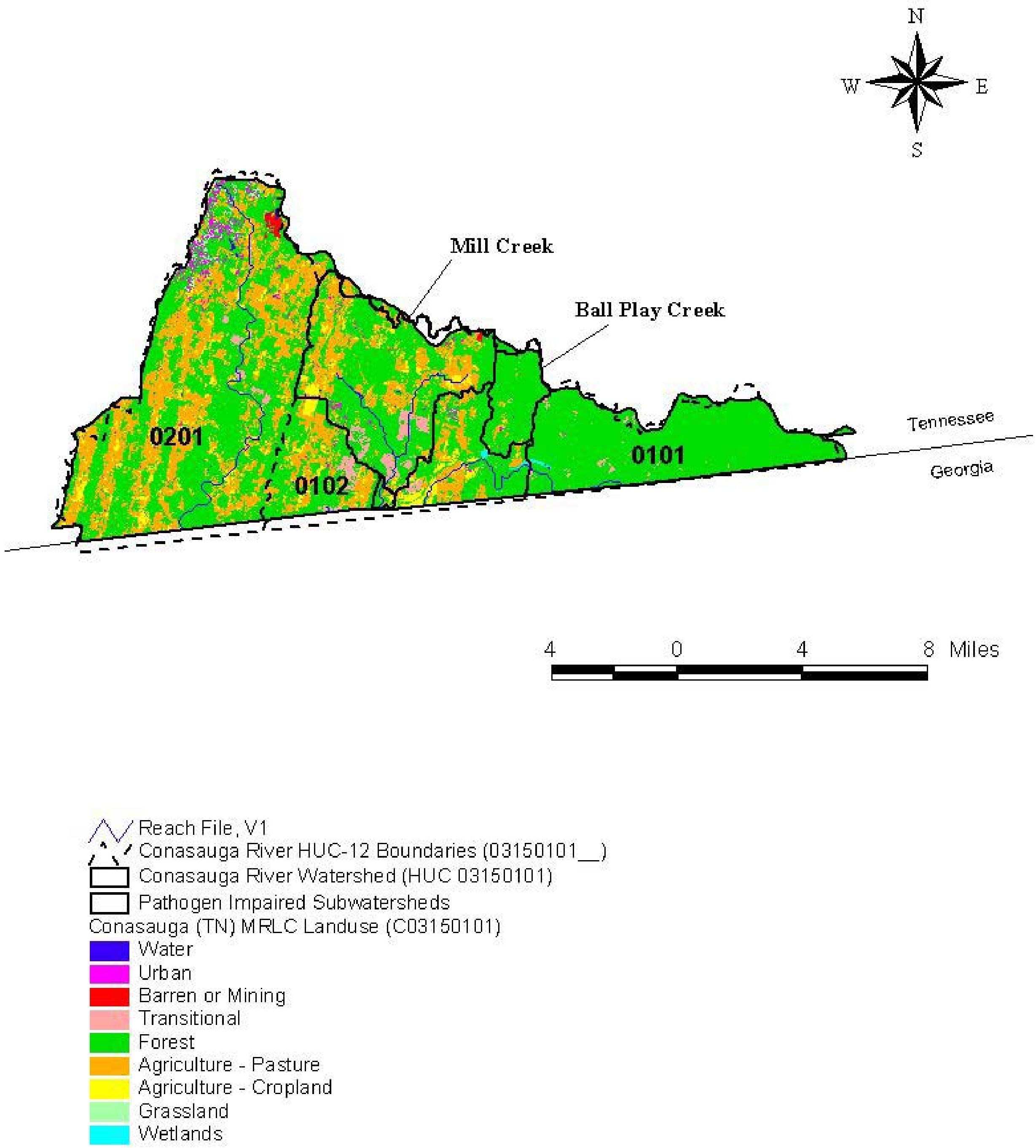

Figure 3. Land Use Characteristics of the Conasauga River Watershed.

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

Waterbody ID	Impacted Waterbody	Miles/Acres Impaired	CAUSE / TMDL Priority	Pollutant Source
TN03150101012 – 0200	MILL CREEK	20.1	Nitrate E. coli	Pasture Grazing
TN03150101012 – 0300	BALL PLAY CREEK	7.44	Siltation E. coli	Pasture Grazing Septic Tanks

Table 3. Water Quality Assessment of Waterbodies Impaired Due to E. coli - Conasauga River Watershed

Waterbody ID	Segment Name	Cause	Sources	Comments
TN03150101012 – 0200	MILL CREEK	Fecal Coliform	Grazing in Riparian or Shoreline Zones	1999 Conasauga Alliance sampling station at Highway 74. TDEC chemical station 2001-02 at mile 0.1 (Highway 74).
TN03150101012 – 0300	BALL PLAY CREEK	Fecal Coliform	Grazing in Riparian or Shoreline Zones On-Site Treatment Systems (Septic Systems and Similar Decentralized Systems)	1999 Conasauga Alliance sampling station at Ball Play Rd (10 yds from bridge). TDEC chemical station 2001-02 at river mile 0.3 (Springs Road).

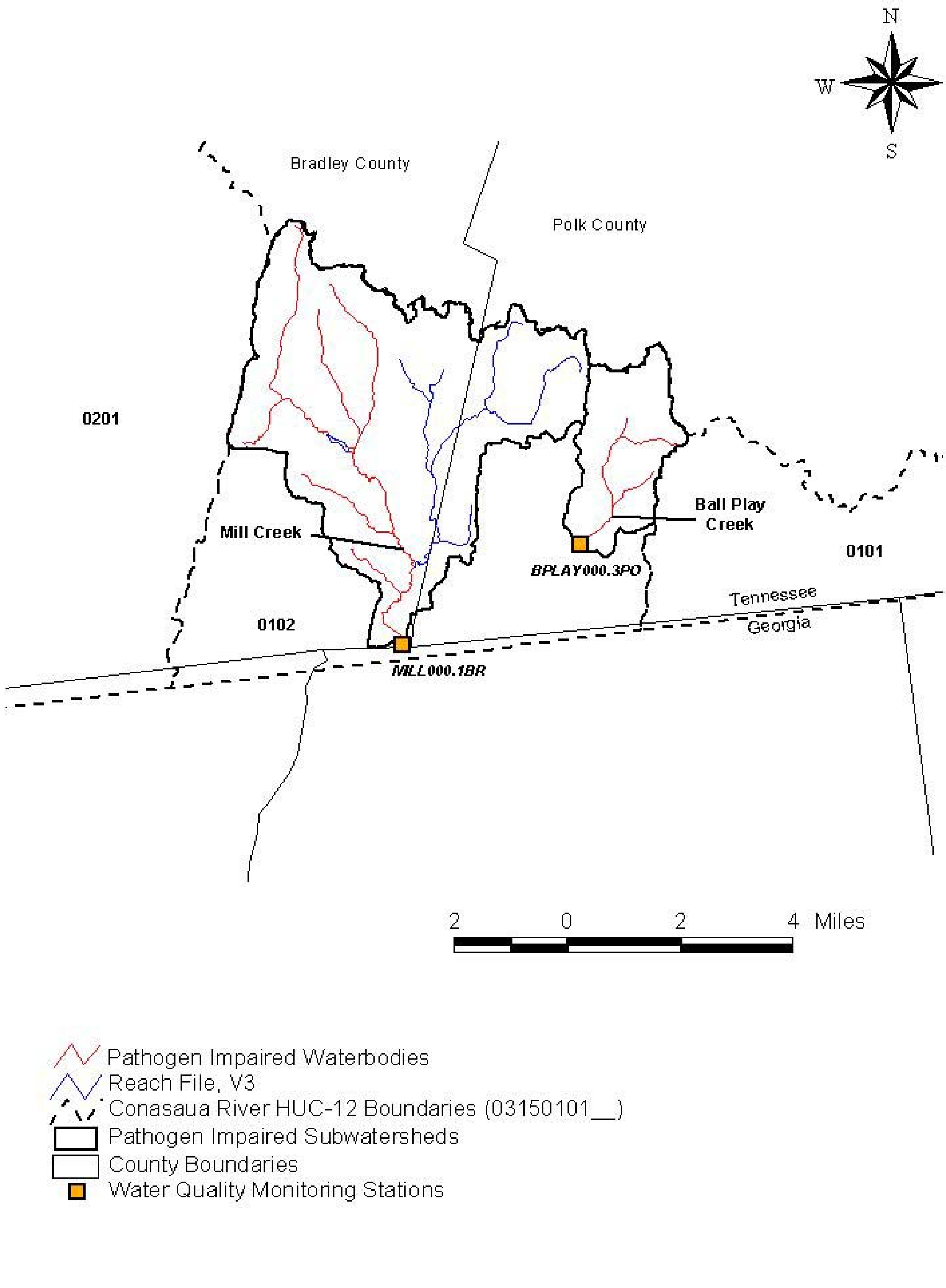

Figure 4. Water Quality Monitoring Stations and E. coli Impaired Waterbodies in the Mill Creek and Ball Play Creek Subwatersheds.

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. T he concentration of the E. coli group in any individual sample taken from any other waterbody shall not exceed 941 colony forming units per 100 mL.

None of the impaired waterbodies in the Conasauga River watershed have been classified as either Tier II or Tier III streams.

This TMDL employs the E. coli water quality standard by determining the results relative to the E. coli sample maximum of 941counts/100 mL to determine the percent reduction(s) required for impaired waterbodies.

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

6.0 WATER QUALITY ASSESSMENT AND DEVIATION FROM GOAL

There are two water quality monitoring stations that provide data for waterbodies identified as impaired for E. coli in the Conasauga River watershed. The locations of these monitoring stations are shown in Figure 4. Water quality monitoring results for these stations are tabulated in Appendix B and summarized in Table 4. Examination of the data shows a single violation of the 941 counts/100 mL maximum E. coli standard at Ball Play Creek at mile 0.3. At the Mill Creek (mile 0.1) monitoring station, there were no violations of the 941 counts/100 mL maximum E. coli standard. There were not enough data to determine compliance with the geometric mean standard for E. coli at either of the monitoring stations in the Conasauga River watershed.

Table 4. Summary of Water Quality Monitoring Data

Monitoring Station	E. Coli				
	Data Pts.	[Counts/100 mL]			No. Viol. WQ Std.
		Min.	Avg.	Max.	
MILL000.1BR	6	23	190	579	0
BPLAY000.3PO	6	118	>630	>2419	1

7.0 SOURCE ASSESSMENT

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

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

7.1 Point Sources

7.1.1 NPDES Regulated Municipal and Industrial Wastewater Treatment Facilities

Both treated and untreated sanitary wastewater contain coliform bacteria. There are no NPDES permitted WWTFs in the impaired subwatersheds of the Conasauga River watershed that are authorized to discharge treated sanitary wastewater. Future E. coli permit limits for discharges from WWTFs will be in accordance with the criteria specified in the 2004 State of Tennessee water quality standards (TDEC, 2004) (ref.: Section 5.0).

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. Large and medium MS4s serving populations greater than 100,000 people are required to obtain NPDES storm water permits. At present, there are no MS4s of this size in the Conasauga River watershed. As of March 2003, small MS4s serving urbanized areas, or having the potential to exceed instream water quality standards, are required to obtain a permit under the *NPDES General Permit for Discharges from Small Municipal Separate Storm Sewer Systems* (TDEC, 2002). An urbanized area is defined as an entity with a residential population of at least 50,000 people and an overall population density of at least 1,000 people per square mile. Bradley County is covered under Phase II of the NPDES Storm Water Program. The Tennessee Department of Transportation (TDOT) is also being issued MS4 permits for State roads in urban areas. Information regarding storm water permitting in Tennessee may be obtained from the TDEC website at http://www.state.tn.us/environment/wpc/stormh2o/.

7.1.3 NPDES Concentrated Animal Feeding Operations (CAFOs)

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

As of July 2, 2004, there are 4 Class II CAFOs in the Conasauga River watershed with coverage under the general NPDES permit. None of these CAFOs are located in E. coli-impaired subwatersheds. The locations of CAFOs in the Conasauga River watershed are shown in Figure 5. There are also no Class I CAFOs with individual permits located in the watershed.

7.2 Nonpoint Sources

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

7.2.1 Wildlife

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

7.2.2 Agricultural Animals

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

- Agricultural livestock grazing in pastures deposit manure containing coliform bacteria onto land surfaces. This material accumulates during periods of dry weather and is available for washoff and transport to surface waters during storm events. The number of animals in pasture and the time spent grazing are important factors in determining the loading contribution.

- Processed agricultural manure from confined feeding operations is often applied to land surfaces and can provide a significant source of coliform bacteria loading. Guidance for issues relating to manure application is available through the University of Tennessee Agricultural Extension Service and the Natural Resources Conservation Service (NRCS).

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

Potential data sources related to livestock operations include from the 2002 Census of Agriculture, compiled for the Mill Creek and Ball Play Creek subwatersheds 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 by WCS is based on the ratio of watershed pasture area to county pasture area applied to livestock population within the county. Livestock data for the E. coli-impaired subwatersheds of the Conasauga River watershed are summarized in Table 5. Populations were rounded to the nearest 50 poultry, 25 cows, 10 horses, and 5 hogs and sheep.

7.2.3 Failing Septic Systems

Some coliform loading in the Conasauga 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 E. coli-impaired subwatersheds of the Conasauga River watershed utilizing septic systems were compiled using the WCS and are summarized in Table 6. In 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.

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. Mill Creek has the highest percentage of urban land area for impaired waterbodies in the Conasauga River watershed, with 5.9%. Land use for the Conasauga River impaired drainage areas is summarized in Figures 6 and 7 and tabulated in Appendix A.

Table 5. Livestock Distribution in the Conasauga River Watershed

Subwatershed	Livestock Population (WCS)					
	Beef Cow	Milk Cow	Poultry	Hogs	Sheep	Horses
Mill Creek	1075	525	2,482,950	15	10	120
Ball Play Creek	25	25	87,100	0	0	30

Table 6. Population on Septic Systems in the Conasauga River Watershed

Subwatershed	Population on Septic Systems
Mill Creek	2672
Ball Play Creek	151

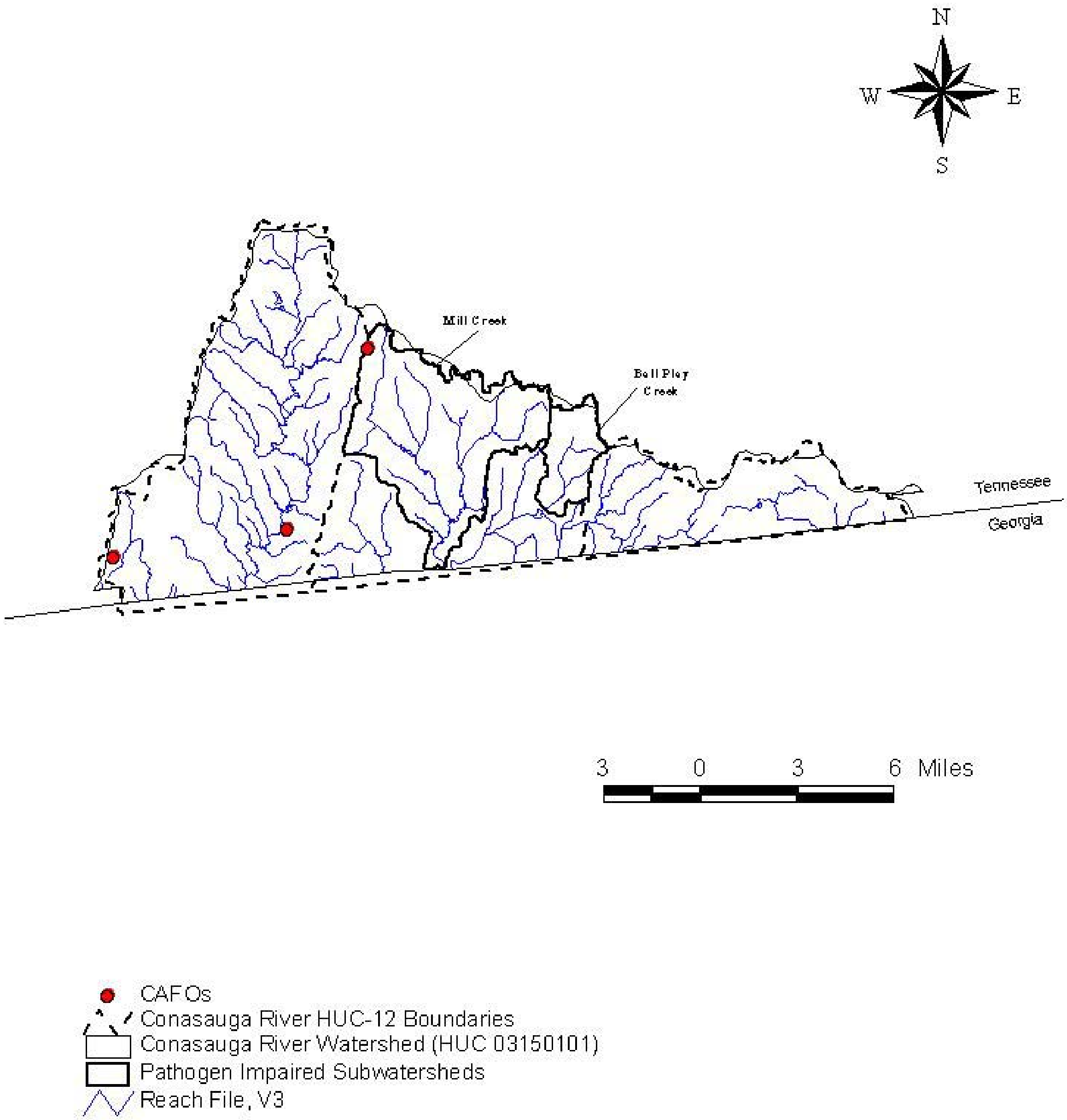

Figure 5. Location of CAFOs in the Conasauga River Watershed.

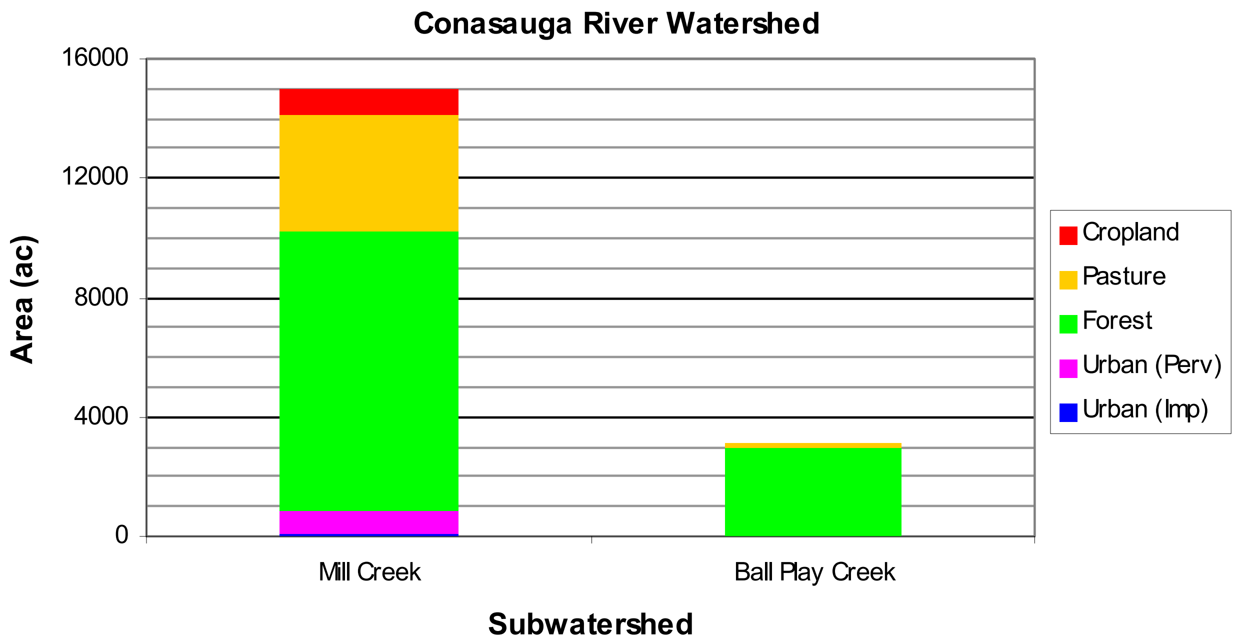

Figure 6. Land Use Area of the Mill Creek and Ball Play Creek Subwatersheds, Conasauga River Watershed.

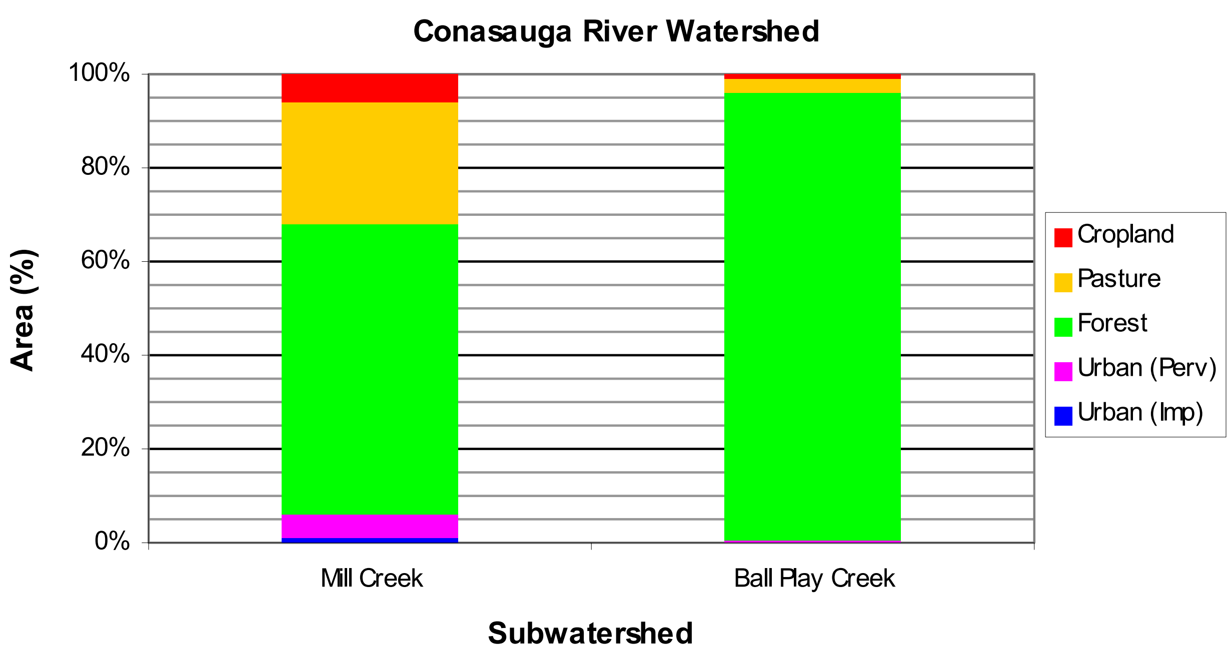

Figure 7. Land Use Percent of the Mill Creek and Ball Play Creek Subwatersheds, Conasauga River Watershed.

8.0 DEVELOPMENT OF TOTAL MAXIMUM DAILY LOAD

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

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

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

This document describes pathogen TMDL, Waste Load Allocation (WLA), and Load Allocation (LA) development for waterbodies identified as impaired due to E. coli on the Final 2004 303(d) list. TMDL analyses are performed on a subwatershed (drainage area) basis for waterbodies identified as impaired due to E. coli on the 303(d) list. The E. coli-impaired subwatersheds in the Conasauga River watershed are shown in Figures 1-5.

8.1 Expression of TMDLs, WLAs, & LAs

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

8.2 TMDL Analysis Methodology

Establishing the relationship between in-stream water quality and source loading is an important component of TMDL development. It allows the determination of the relative contribution of sources to total pollutant loading and the evaluation of potential changes to water quality resulting from implementation of various management options. This relationship can be developed using a variety of techniques ranging from qualitative assumptions based on scientific principles to numerical computer modeling. The TMDLs for the Conasauga River watershed were developed using the load duration curve (LDC) method to assure compliance with the maximum standard (ref.: Section 5.0) of 941 counts/100 mL for E. coli.

A 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. LDCs were considered to be well suited for analysis of periodic monitoring data collected by grab sample and determination of the load reductions required to meet the target maximum concentration (standard - MOS). Details of LDC development for Conasauga River E. coli-impaired waterbodies are presented in Appendix C.

8.3 Critical Conditions and Seasonal Variation

The critical condition for non-point source fecal bacteria loading is an extended dry period followed by a rainfall runoff event. During the dry weather period, fecal 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 July 1, 1994 to June 30, 2004 was used to simulate flow. This 10-year period contained a range of hydrologic conditions that included both low and high streamflows from which critical conditions were identified and used to derive the TMDL value. 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. Based on the location of the water quality exceedance on the Ball Play Creek load duration curve (between the 60% and 90% duration intervals), dry weather, low flow (point source-type) sources are the probable dominant delivery mode for pathogens (see Section 9.3).

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

8.4 Margin of Safety

There are two methods for incorporating an MOS in the analysis: a) implicitly incorporate the MOS using conservative model assumptions to develop allocations; or b) explicitly specify a portion of the TMDL as the MOS and use the remainder for allocations. In these TMDLs, an explicit MOS was utilized.

An explicit MOS, equal to 10% of the E. coli water quality goal (ref.: Section 5.0), was utilized for TMDL analysis. Application of the explicit MOS of 94 counts/100 mL to the E. coli maximum standard of 941 counts/100 mL results in an effective maximum target concentration of 847 counts/100 mL. Explicit MOS and the resulting target concentration are shown in Table 7.

Table 7. Explicit MOS and Target Concentration

Pollutant	WQ Goal Type	WQ Goal [counts/100 mL]	Explicit MOS [counts/100 mL]	Target [counts/100 mL]
E. coli	Maximum	941	94	847

8.5 Determination of TMDLs

E. coli load reductions were calculated for the impaired segments in the Conasauga River watershed using LDCs to evaluate compliance with the maximum target concentration (Appendix C). Sufficient data were not available to calculate load reductions to achieve compliance with the 30-day geometric mean target concentration. The TMDL load reduction for Ball Play Creek, Conasauga River watershed, is shown in Table 8 and is applied only to the drainage area of Ball Play Creek, and not to the entire HUC-12 in which it lies.

Table 8. Determination of TMDLs for Impaired Waterbodies, Conasauga River Watershed

Drainage Area and/or HUC-12 Subwatershed (03150101__)	Impaired Waterbody Name	Impaired Waterbody ID	Required Load Reduction	
			Load Duration Curve [%]	TMDL [%]
			E. Coli	
Ball Play Creek (0102)	Ball Play Creek	TN03150101012 - 0300	>41.2	**>41.2**

8.6 Determination of WLAs & LAs

WLAs & LAs are developed in Appendix E for point sources and nonpoint sources respectively. TMDLs, WLAs, & LAs for Conasauga River watershed impaired waterbodies are summarized in Table 9.

Table 9. WLAs & LAs for Conasauga River, Tennessee

Drainage Area and/or HUC-12 Subwatershed (03150101__)	Impaired Waterbody Name	Impaired Waterbody ID	WLAs			LAs	
			WWTFs[a] (Monthly Avg.) E. Coli	CAFOs	MS4s[b]	Precipitatio n Induced Nonpoint Sources	Other Direct Sources[c]
			[cts./day]	[cts./day]	[% Red.]	[% Red.]	[cts./day]
Ball Play Creek (0102)	Ball Play Creek	TN03150101012 – 0300	**NA[d]**	**NA**	**NA**	**>41.2**	**0**

Note: NA = Not Applicable.

a. WLAs for WWTFs expressed as E. coli loads (counts/day).
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 counts/day may not be practical. For these sources, the LA is interpreted to mean a reduction in coliform loading by the application of best management practices, consistent with the requirement that these sources not contribute to a violation of the water quality standard for E. coli.
d. Future WWTFs must meet instream water quality standards at the point of discharge as specified in their NPDES permit.

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

9.1 Point Sources

9.1.1 NPDES Regulated Municipal and Industrial Wastewater Treatment Facilities

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

9.1.2 NPDES Regulated Municipal Separate Storm Sewer Systems (MS4s)

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

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

For discharges into impaired waters, the Small MS4 General Permit (ref: http://www.state.tn.us/environment/wpc/stormh2o/MS4II.php) requires that SWMPs include a section describing how discharges of pollutants of concern will be controlled to ensure that they do not cause or contribute to instream exceedances of water quality standards. Specific measures and BMPs to control pollutants of concern must also be identified. In addition, MS4s must implement the WLA provisions of an applicable TMDL and describe methods to evaluate whether storm water controls are adequate to meet the WLA.

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

9.1.3 NPDES Regulated Concentrated Animal Feeding Operations (CAFOs)

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

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

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

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

- Requirements for the design, construction, operation, and maintenance of CAFO liquid waste management systems that are constructed, modified, repaired, or placed into operation after April 13, 2006. 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 E. coli loading from nonpoint sources (NPS) will be achieved using a phased approach. Voluntary, incentive-based mechanisms will be used to implement NPS management measures in order to assure that measurable reductions in pollutant loadings can be achieved for the targeted impaired waters. Cooperation and active participation by the general public and various industry, business, and environmental groups is critical to successful implementation of TMDLs. Local citizen-led and implemented management measures offer the most efficient and comprehensive avenue for reduction of loading rates from nonpoint sources. There are links to a number of publications and information resources on EPA's Nonpoint Source Pollution web page (http://www.epa.gov/owow/nps/pubs.html) relating to the implementation and evaluation of nonpoint source pollution control measures.

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

BMPs have been utilized in the Conasauga River watershed to reduce the amount of coliform bacteria transported to surface waters from agricultural sources. These BMPs (e.g., pasture and hayland planting, travel lanes, critical area treatment, heavy use area treatment, etc.) may have contributed to reductions in in-stream concentrations of coliform bacteria in one or more Conasauga River waterbodies during the TMDL evaluation period. The TDA keeps a database of BMPs implemented in Tennessee. Those listed in the Conasauga River watershed are shown in Figure 8. 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 analyses.

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. Coliform bacteria sampling and monitoring are recommended during low-flow (baseflow) and storm periods at sites with and without BMPs and/or before and after implementation of BMPs.

9.3 Example Application of Load Duration Curves for Implementation Planning

The Load Duration Curve methodology (Appendix C) is a form of water quality analysis and presentation of data that aids in guiding implementation by targeting strategies to appropriate flow conditions. One of the strengths of this method is that it can be used to interpret possible delivery mechanisms of E. coli by differentiating between point and non-point problems. The load duration curve analysis can be utilized for implementation planning. An example E. coli load duration curve (Figure 9) was analyzed to determine the frequency with which water quality monitoring data exceed the E. coli target maximum concentration of 847 counts/100 mL (standard – MOS) under five flow conditions (low, dry, mid- range, moist, and high). Observation of the plot suggests the example watershed is impacted primarily by point source-type inputs.

Table 10 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, non-point sources, or a combination of each. Results indicate the implementation strategy for all subwatersheds will require BMPs targeting a variety of sources. The implementation strategies listed in Table 10 are a subset of the categories of BMPs and implementation strategies available for application to the Conasauga River subwatersheds for reduction of E. coli loading and mitigation of water quality impairment.

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

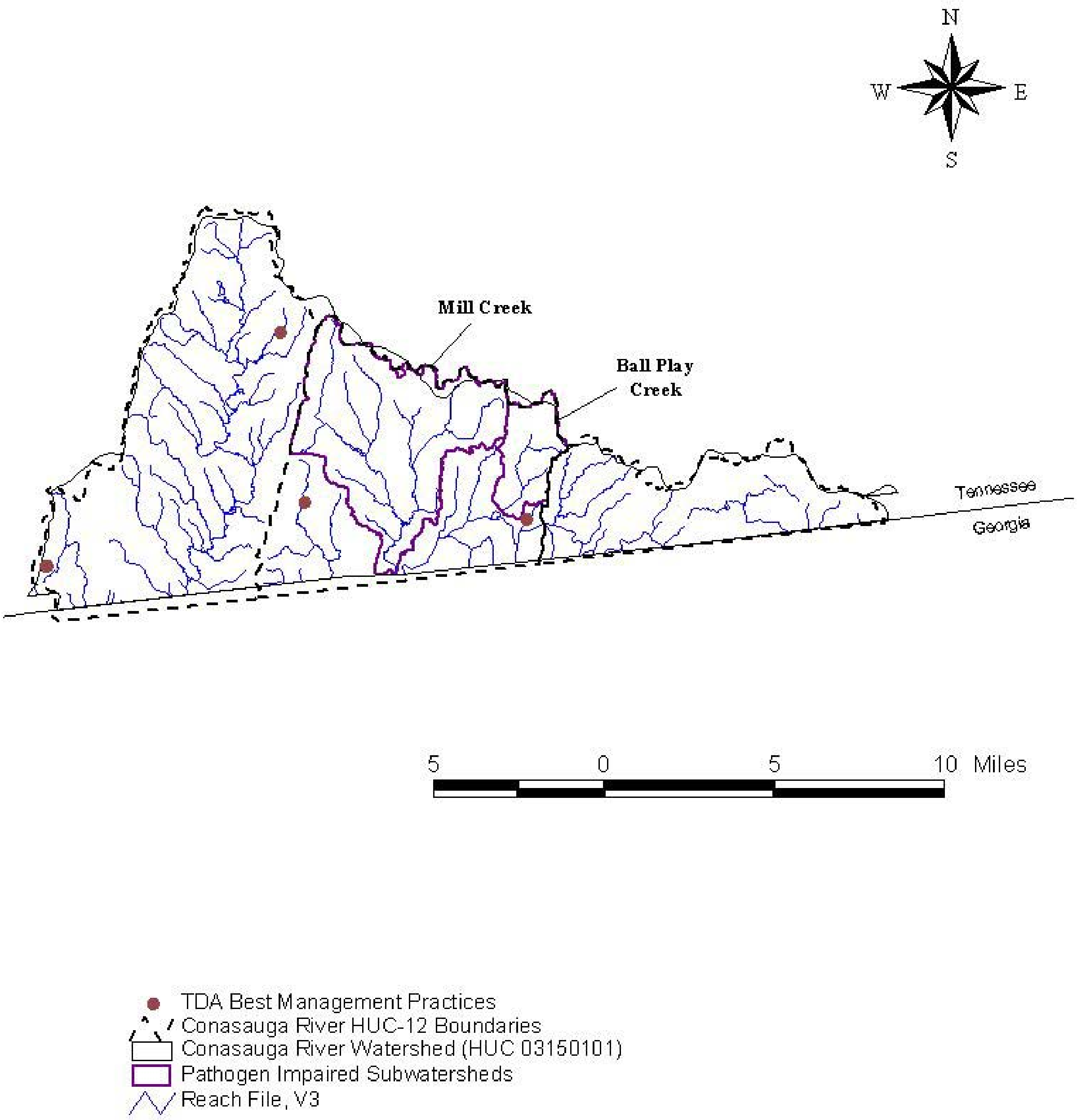

Figure 8. Tennessee Department of Agriculture Best Management Practices located in the Conasauga River Watershed.

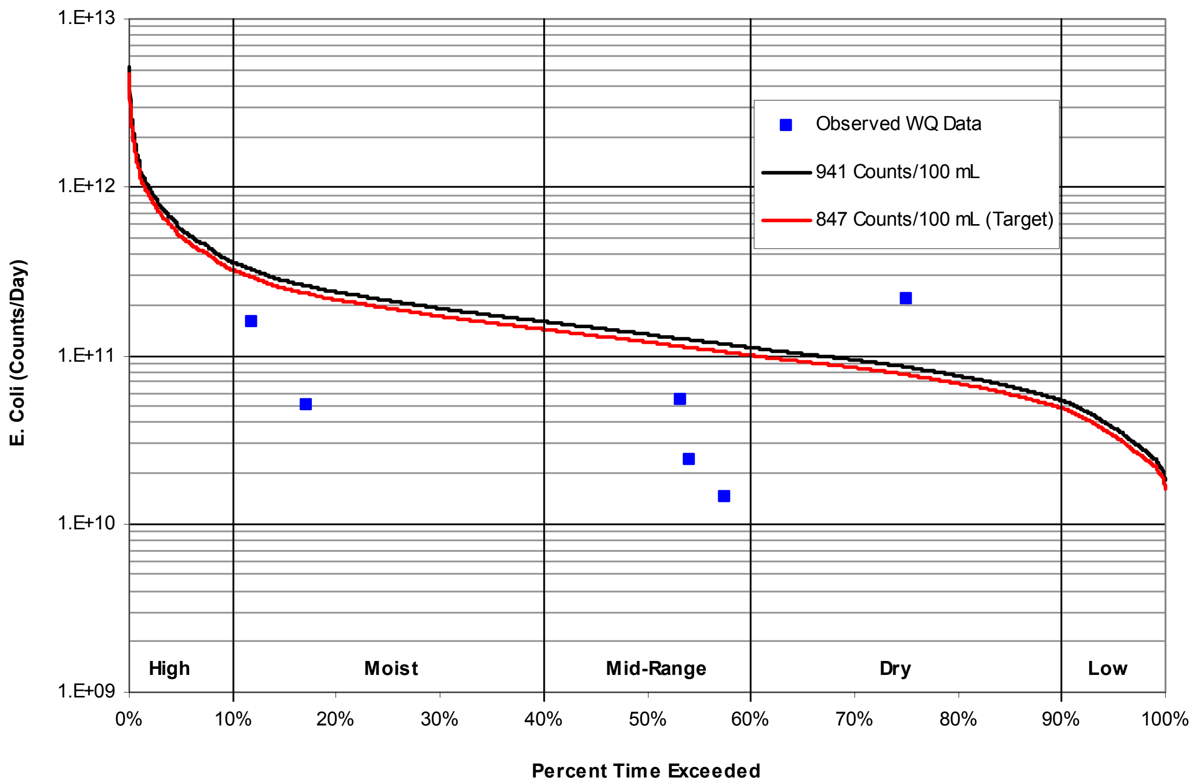

Figure 9. Example Load Duration Curve for Implementation Planning.

9.4 Additional Monitoring

Documenting progress in reducing the quantity of E. coli entering the Conasauga 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 standards for E. coli.

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 Conasauga River watershed E. coli-impaired subwatersheds to verify the assessment status of the stream reaches identified on the Final 2004 303(d) list as impaired due to E. coli. If it is determined that these stream reaches are still not fully supporting designated uses, then sufficient data to enable development of a TMDL must be acquired. In addition, collection of E. coli data at sufficient frequency to support calculation of the geometric mean, as described in Tennessee's General Water Quality Criteria (TDEC, 2004), is encouraged.

Table 10. 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.

Both Ball Play Creek and Mill Creek have limited available sampling data (6 samples), collected during a one-year period, and not representative of the full range of flow conditions. Samples were collected at flows in the moist, mid-range, and dry flow ranges, excluding the highest and lowest flow regimes. Therefore, these waterbodies do not have adequate data to establish conditions during these flow regimes. Additional monitoring must be completed before a reliable assessment of impairment can be conducted, thereby identifying source response under varying flow conditions.

9.5 Source Identification

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

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

The USEPA has published a fact sheet that discusses BST methods and presents examples of

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

A multi-disciplinary group of researchers at the University of Tennessee is developing and testing a series of microbial assay methods based on real-time PCR to detect fecal bacteria concentrations and host sources in water samples (McKay, 2004). The assays have been utilized in a study of fecal contamination and have proven useful in identification of areas where cattle represent significant fecal input and for development of BMPs. It is expected that these types of BST 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 Thirteen Annual Tennessee Water Resources Symposium (Lawrence, 2003) and Fifteenth Tennessee Water Resources Symposium (Bailey, 2005; Farmer, 2005; McKay, 2005).

9.6 Evaluation of TMDL Implementation Effectiveness

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

10.0 PUBLIC PARTICIPATION

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

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 was sent to approximately 90 interested persons or groups who have requested this information.

3) Draft copies of the proposed TMDLs were sent to Bradley County and the Tennessee Department of Transportation.

No written comments were received during the proposed TMDL public comment period. No requests to hold public meetings were received regarding the proposed TMDLs as of close of business on July 25, 2005.

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 Conasauga River Watershed

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

Land Use	Conasauga River Subwatersheds			
	Mill Creek		Ball Play Creek	
	[acres]	[%]	[acres]	[%]
Deciduous Forest	2,656	17.7	865	27.8
Evergreen Forest	3,374	22.5	1,339	43.0
High Intensity Commercial/Industrial/Transp.	26	0.2	3	0.1
High Intensity Residential	2	0.0*	0	0.0
Low Intensity Residential	101	0.7	7	0.2
Mixed Forest	3,218	21.4	757	24.3
Open Water	31	0.2	1	0.0*
Other Grasses (Urban/recreation; e.g. parks)	0	0.0	4	0.1
Pasture/Hay	3,948	26.3	104	3.3
Quarries/Strip Mines/Gravel Pits	28	0.2	0	0.0
Row Crops	888	5.9	24	0.8
Transitional	750	5.0	13	0.4
Woody Wetlands	0	0.0	1	0.0*
Total	15,022	100.0	3,118	100.0

* < 0.05%

APPENDIX B

Water Quality Monitoring Data

There are two water quality monitoring stations that provide data for waterbodies identified as impaired for E. coli in the Conasauga River watershed. The location of these monitoring stations is shown in Figure 4. Monitoring data recorded at these stations for E. Coli are tabulated in Table B-1.

Table B-1. Water Quality Monitoring Data – Conasauga River Watershed

Monitoring Station	Date	E. Coli
		[cts./100 mL]
MILL000.1BR	7/9/01	147
	8/7/01	579
	1/14/02	23
	2/12/02	119
	3/19/02	186
	6/19/02	86
BPLAY000.3PO	7/9/01	411
	8/7/01	185
	1/14/02	118
	2/12/02	188
	3/19/02	461
	6/19/02	**>2419**

APPENDIX C

Load Duration Curve Methodology

LOAD DURATION CURVE METHOD

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

C.1 Development of Flow Duration Curves

Flow duration curves are developed for a waterbody from daily discharges of flow over a period of record. In general, there is a higher level of confidence that curves derived from data over a long period of record correctly represent the entire range of flow. The preferred method of flow duration curve computation uses daily mean data from a USGS continuous-record station 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 Mill Creek and Ball Play Creek were derived from LSPC hydrologic simulations based on parameters derived from calibration at USGS Station No. 03565500, located at mile 5.7 on Oostanaula Creek near Sanford, TN, in the Hiwassee River watershed. The data used, in each case, included the simulated period from 7/1/94 – 6/30/04. The flow duration curves for Mill Creek at mile 0.1 and Ball Play Creek at mile 0.3 are shown in Figures C-1 and C-2, respectively, and each 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).

C.2 Development of Load Duration Curves

E. coli load duration curves for the Conasauga River E. coli-impaired subwatersheds were developed from the flow duration curves developed in Section C.1 and available water quality monitoring data. Load duration curves were developed using the following procedure:

1. Target LDCs were generated for Mill Creek at mile 0.1 and Ball Play Creek at mile 0.3 by applying the E. coli target concentration of 847 cts./100 mL (941 cts./100mL - MOS) to each of the ranked flows used to generate the flow duration curves (ref.: Section C.1) and plotting the results. The E. coli target maximum load corresponding to each ranked daily mean flow is:

   (Target Load) = (847 cts./100 mL) x (Q) x (UCF)

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

2. Daily loads were calculated for each of the water quality samples collected at monitoring stations MILL000.1BR and BPLAY000.3PO (ref.: Table B-1) by multiplying the sample concentration by the derived daily mean flow for the sampling date and the required unit conversion factor.

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

3. Using the flow duration curves developed in Step 1, the "percent of days the flow was exceeded" (PDFE) was determined for each sampling event. Each sample load was then plotted on the LDCs developed in Step 2 according to the PDFE. The resulting E. coli LDCs for Mill Creek at mile 0.1 and Ball Play Creek at mile 0.3 are shown in Figures C-3 and C-4, respectively.

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

5. The 90^{th} percentiles of all sample data (E. coli) were calculated for each waterbody sampling location and load reductions determined for each (see Tables C-1 and C-2).

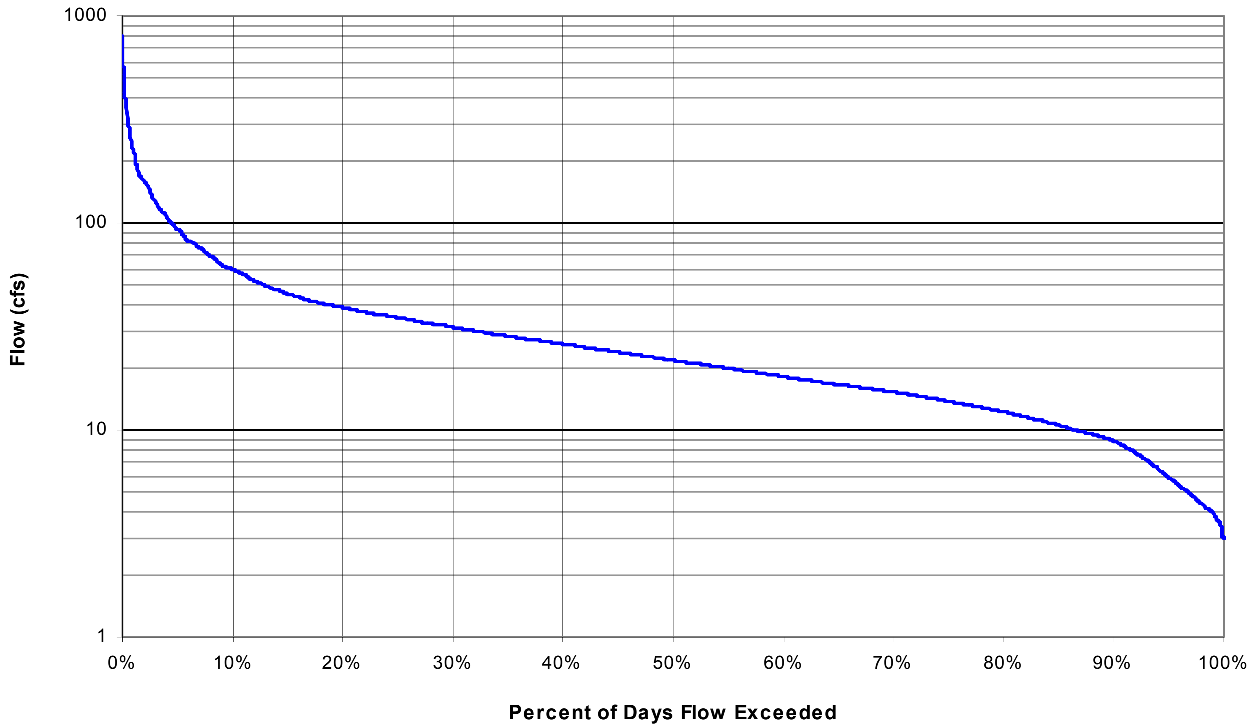

Figure C-1. Flow Duration Curve for Mill Creek at Mile 0.1

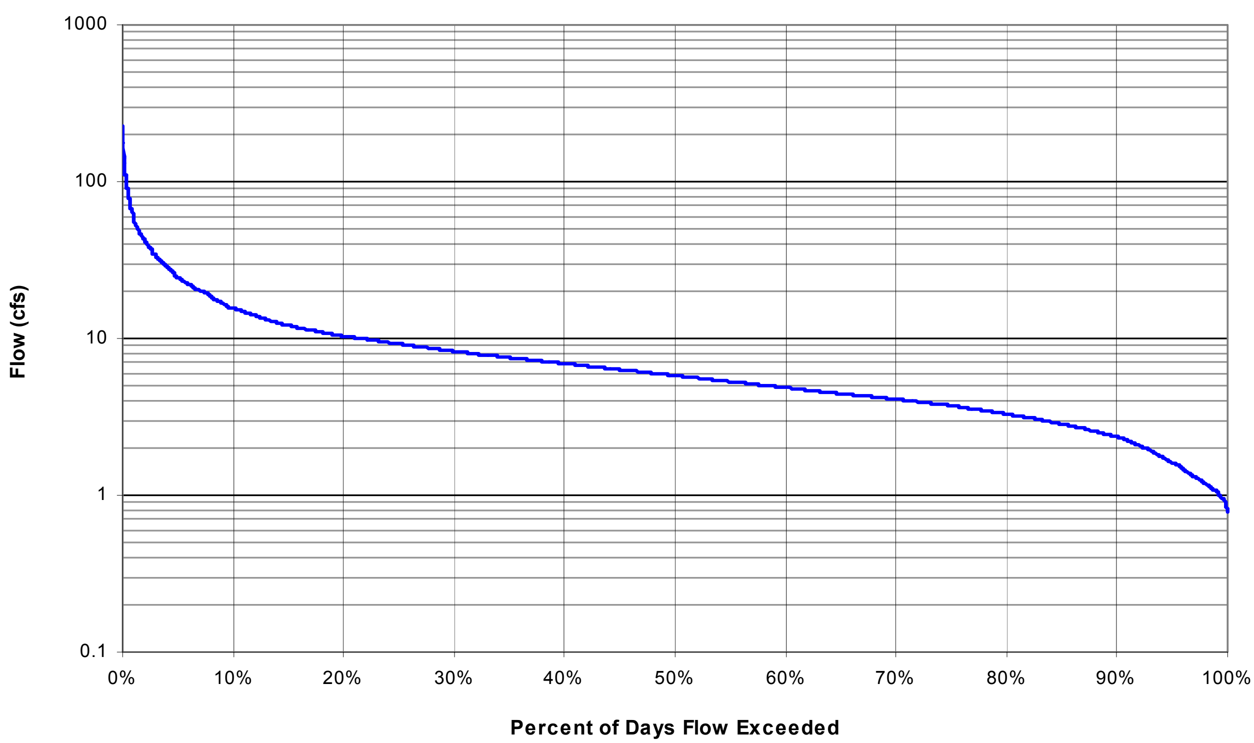

Figure C-2. Flow Duration Curve for Ball Play Creek at Mile 0.3

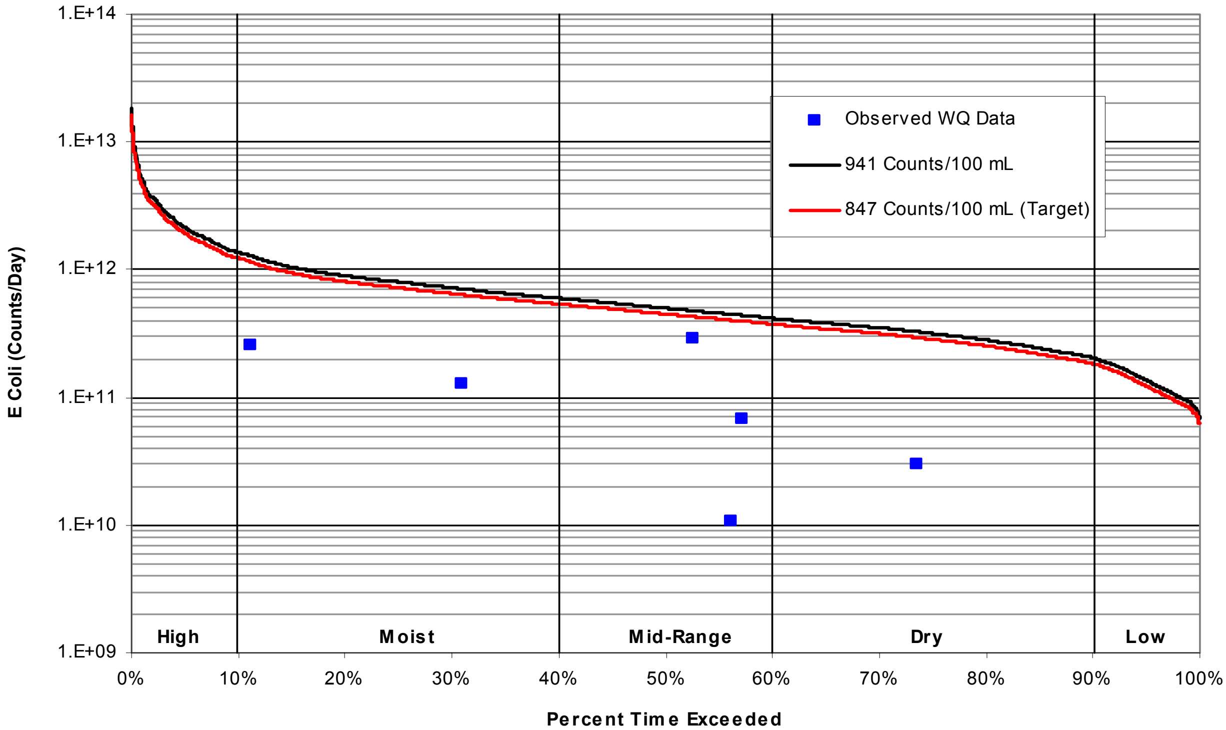

Figure C-3. E. Coli Load Duration Curve for Mill Creek at Mile 0.1

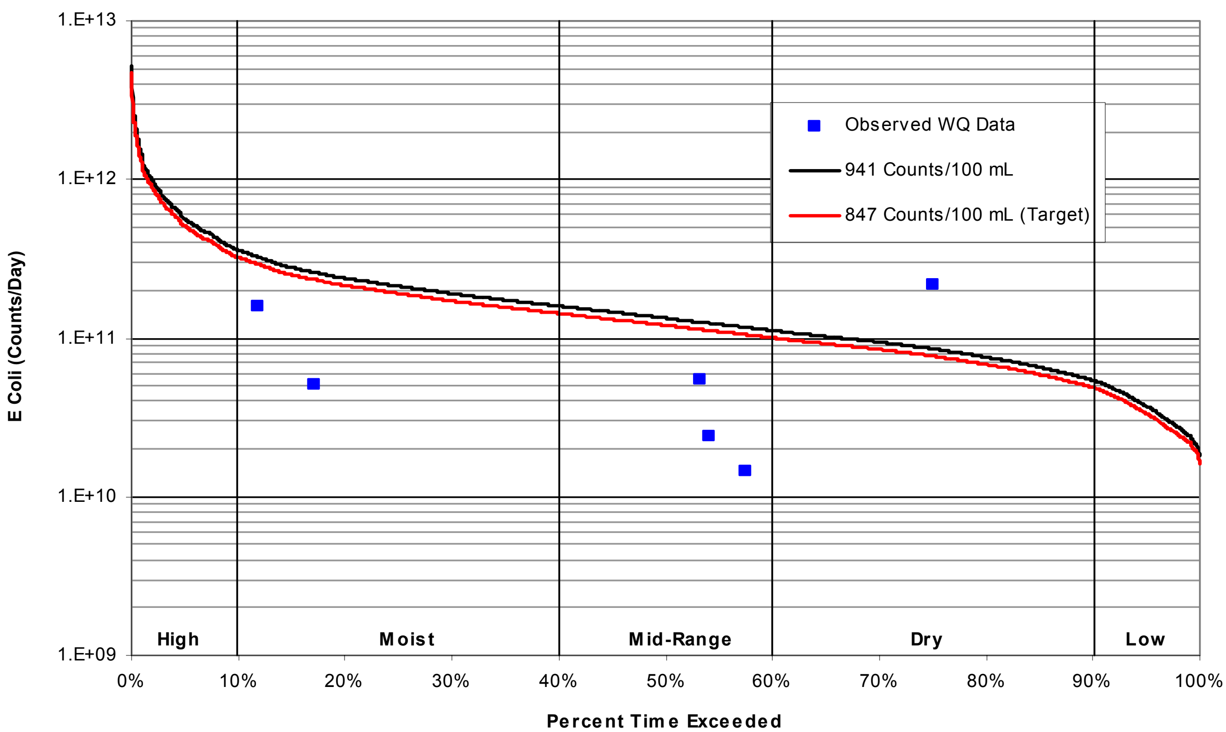

Figure C-4. E. Coli Load Duration Curve for Ball Play Creek at Mile 0.3

Table C-1. Required Load Reduction for Mill Creek at Mile 0.1 – E. Coli Analysis

PDFE	Flow	Sample Date	E. Coli	
			Sample Conc.	Required Load Reduction
[%]	[cfs]		[cts/100 ml]	[%]
11.005%	56.6188	3/19/02	186	**NR**
30.824%	30.8142	2/12/02	119	**NR**
52.532%	20.8033	8/7/01	579	**NR**
56.064%	19.4858	1/14/02	23	**NR**
56.994%	19.1715	7/9/01	147	**NR**
73.474%	14.2488	6/19/02	86	**NR**
	90th Percentile (all)		383	0.0

Table C-2. Required Load Reduction for Ball Play Creek at Mile 0.3 – E. Coli Analysis

PDFE	Flow	Sample Date	E. Coli	
			Sample Conc.	Required Load Reduction
[%]	[cfs]		[cts/100 ml]	[%]
11.278%	11.3937	3/19/02	461	**NR**
30.851%	6.38208	2/12/02	188	**NR**
52.560%	4.30325	8/7/01	185	**NR**
55.927%	4.03809	1/14/02	118	**NR**
56.721%	3.98011	7/9/01	411	**NR**
73.392%	2.9529	6/19/02	**>2419**	**>65.0**
	90th Percentile (all)		**>1440**	**>41.2**

APPENDIX D

Hydrodynamic Modeling Methodology

HYDRODYNAMIC MODELING METHOD

D.1 Model Selection

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

D.2 Model Set Up

The Conasauga River watershed was delineated into subwatersheds in order to facilitate model hydrologic calibration. Boundaries were constructed so that subwatershed "pour points" coincided with the 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 hydrologic 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 (7/1/94 – 6/30/04) 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 on Oostanaula Creek (Hiwassee 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 ecoregions, 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 Oostanaula Creek near Sanford, USGS Station 03565500, are shown in Table D-1 and Figure D-1.

Table D-1. Hydrologic Calibration Summary: Oostanaula Cr. near Sanford (USGS 03565500)

Simulation Name:	OosCAP05		
(Chattanooga Airport Raingage)	Oostanaula Cr. near Sanford (USGS 03565500)	**Watershed Area (ac):**	36480.00
Period for Flow Analysis			
Begin Date:	**01/01/80**	**Baseflow PERCENTILE:**	2.5
End Date:	**12/31/89**	*Usually 1%-5%*	
Total Simulated In-stream Flow:	**163.22**	Total Observed In-stream Flow:	**157.99**
Total of highest 10% flows:	**68.93**	Total of Observed highest 10% flows:	**71.81**
Total of lowest 50% flows:	**28.96**	Total of Observed Lowest 50% flows:	**27.01**
Simulated Summer Flow Volume (months 7-9):	**16.63**	Observed Summer Flow Volume (7-9):	**15.35**
Simulated Fall Flow Volume (months 10-12):	**30.75**	Observed Fall Flow Volume (10-12):	**25.59**
Simulated Winter Flow Volume (months 1-3):	**74.61**	Observed Winter Flow Volume (1-3):	**68.62**
Simulated Spring Flow Volume (months 4-6):	**41.23**	Observed Spring Flow Volume (4-6):	**48.43**
Total Simulated Storm Volume:	**130.47**	Total Observed Storm Volume:	**124.96**
Simulated Summer Storm Volume (7-9):	**8.64**	Observed Summer Storm Volume (7-9):	**7.28**
Errors (Simulated-Observed)		*Recommended Criteria*	Last run
Error in total volume:	**3.31**	10	
Error in 50% lowest flows:	**7.23**	10	
Error in 10% highest flows:	**-4.01**	15	
Seasonal volume error - Summer:	**8.33**	30	
Seasonal volume error - Fall:	**20.16**	30	
Seasonal volume error - Winter:	**8.73**	30	
Seasonal volume error - Spring:	**-14.86**	30	
Error in storm volumes:	**4.41**	20	

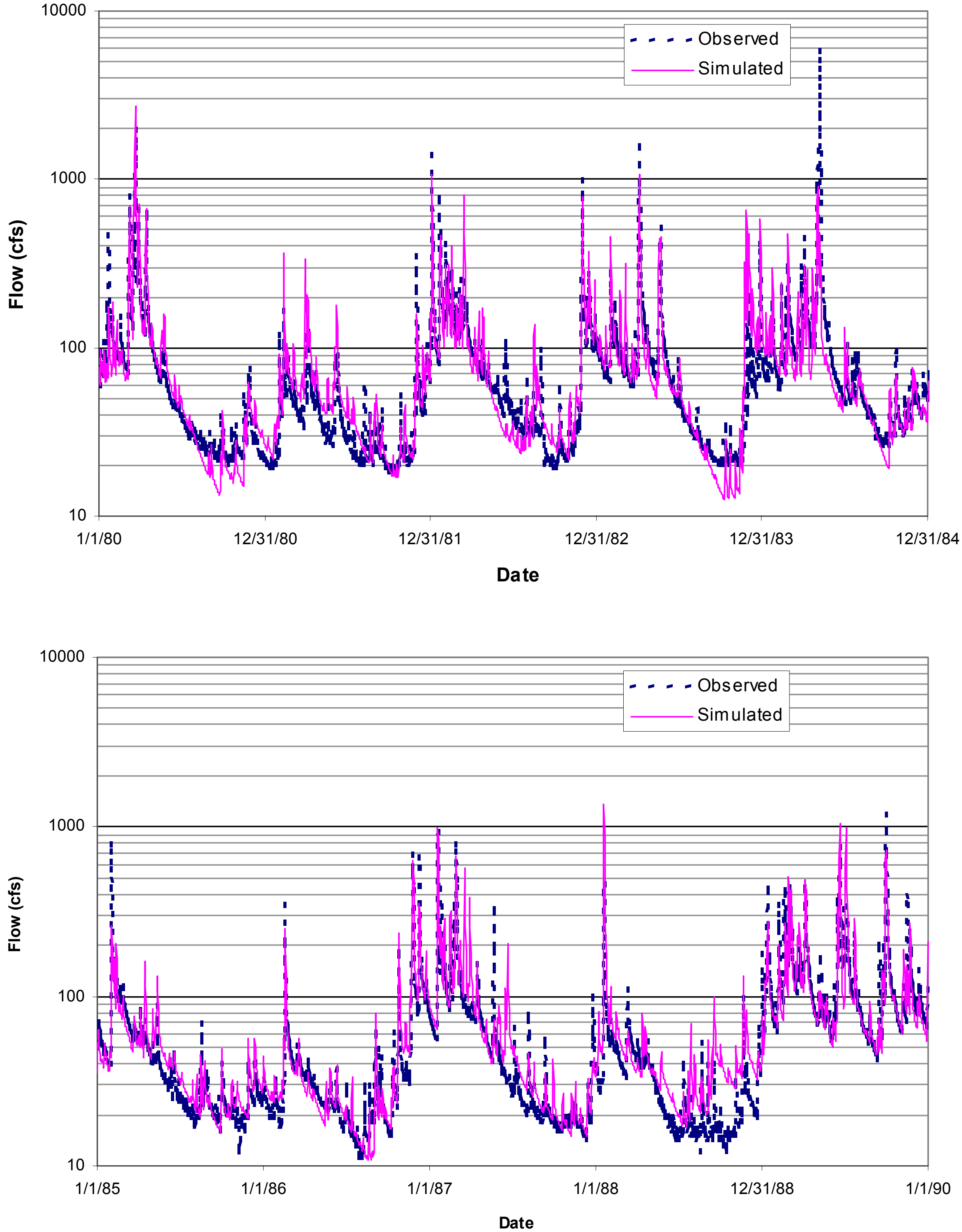

Figure D-1. Hydrologic Calibration: Oostanaula Cr. near Sanford, USGS 03565500 (1980-1989)

APPENDIX E

Determination of WLAs & LAs

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

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

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

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

- $[\Sigma WLAs]_{WWTF}$ is the allowable load associated with discharges of NPDES permitted WWTFs located in impaired subwatersheds. Since NPDES permits for these facilities specify that treated wastewater must meet instream water quality standards at the point of discharge, no additional load reduction is required. WLAs for WWTFs are calculated from the facility design flow and the Monthly Average permit limit.

- $[\Sigma WLAs]_{CAFO}$ is the allowable load for all CAFOs in an impaired subwatershed. All wastewater discharges from a CAFO to waters of the state of Tennessee are prohibited, except when either chronic or catastrophic rainfall events cause an overflow of process wastewater from a facility properly designed, constructed, maintained, and operated to contain:
    - All process wastewater resulting from the operation of the CAFO (such as wash water, parlor water, watering system overflow, etc.); plus,
    - All runoff from a 25-year, 24-hour rainfall event for the existing CAFO or new dairy or cattle CAFOs; or all runoff from a 100-year, 24-hour rainfall event for a new swine or poultry CAFO.

  Therefore, a WLA of zero has been assigned to this class of facilities.

- $[\Sigma WLAs]_{MS4}$ is the required load reduction for discharges from MS4s. E. coli loading from MS4s is the result of buildup/wash-off processes associated with storm events. The percent load reductions for MS4s are considered to be equal to the load reductions developed for TMDLs.

LA terms include:

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

- $[\Sigma LAs]_{SW}$ represents the required reduction in E. coli loading from nonpoint sources indirectly going to surface waters from all land use areas (except areas covered by a MS4 permit) as a result of the buildup/wash-off processes associated with storm events. The percent load reductions for precipitation-induced nonpoint sources are considered to be equal to the load reductions developed for TMDLs (and specified for MS4s).

Explicit MOS has already been incorporated into TMDL development as stated in Appendix C. TMDLs, WLAs, & LAs are applied to the entire subwatershed. WLAs & LAs for the Conasauga River waterbody (Ball Play Creek) are summarized in Table E-1.

Table E-1. WLAs & LAs for Conasauga River, Tennessee

Drainage Area and/or HUC-12 Subwatershed (03150101__)	Impaired Waterbody Name	Impaired Waterbody ID	WLAs			LAs	
			WWTFs[a] (Monthly Avg.) E. Coli	CAFOs	MS4s[b]	Precipitatio n Induced Nonpoint Sources	Other Direct Sources[c]
			[cts./day]	[cts./day]	[% Red.]	[% Red.]	[cts./day]
Ball Play Creek (0102)	Ball Play Creek	TN03150101012 – 0300	**NA**[d]	**NA**	**NA**	**>41.2**	**0**

Note: NA = Not Applicable.
a. WLAs for WWTFs expressed as E. coli loads (counts/day).
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 counts/day may not be practical. For these sources, the LA is interpreted to mean a reduction in coliform loading by the application of best management practices, consistent with the requirement that these sources not contribute to a violation of the water quality standard for E. coli.
d. Future WWTFs must meet instream water quality standards at the point of discharge as specified in their NPDES permit.

APPENDIX F

Public Notice of Proposed Maximum Daily Load (TMDL) for Pathogens in the Conasauga River Watershed (HUC 03150101)

DIVISION OF WATER POLLUTION CONTROL

PUBLIC NOTICE OF AVAILABILITY OF PROPOSED TOTAL MAXIMUM DAILY LOAD (TMDL) FOR PATHOGENS IN THE CONASAUGA RIVER WATERSHED (HUC 03150101), TENNESSEE

Announcement is hereby given of the availability of Tennessee's proposed total maximum daily load (TMDL) for pathogens in the Conasauga River watershed, located in southeastern 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.

Mill Creek and Ball Play Creek are listed on Tennessee's Proposed Final Version Year 2004 303(d) list as not supporting designated use classifications due, in part, to discharge of E. coli from pasture grazing and septic tanks. The TMDL utilizes Tennessee's general water quality criteria, recently collected site specific water quality data, continuous flow data from a USGS discharge monitoring station located in proximity to the watershed, a calibrated hydrologic model, and load duration curves to establish allowable loadings of E. coli which will result in reduced in-stream concentrations and attainment of water quality standards. The TMDL requires a reduction on the order of 41.2% for Ball Play Creek.

The proposed Conasauga River pathogen TMDL document can be downloaded from the following website:

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

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

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

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

Persons wishing to comment on the proposed TMDL are invited to submit their comments in writing no later than July 25, 2005 to:

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

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

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