TOTAL MAXIMUM DAILY LOAD (TMDL)

for

Pathogens

In

Floyd Creek and Cloyd Creek
Ft. Loudoun Lake Watershed (HUC 06010201)
Loudon and Blount 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
DEM	Digital Elevation Model
DMR	Discharge Monitoring Report
DWPC	Division of Water Pollution Control
E. coli	Escherichia coli
EPA	Environmental Protection Agency
FCLES	Fecal Coliform Load Estimation Spreadsheet
GIS	Geographic Information System
HSPF	Hydrological Simulation Program - Fortran
HUC	Hydrologic Unit Code
IPSI	Integrated Pollutant Source Identification
LA	Load Allocation
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
NHD	National Hydrography Dataset
NMP	Nutrient Management Plan
NOV	Notice of Violation
NPS	Nonpoint Source
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
PDFE	Percent of Days Flow Exceeded
Rf3	Reach File v.3
RILR	Required In-stream Load Reduction
RM	River Mile
SSO	Sanitary Sewer Overflow
STP	Sewage Treatment Plant
TDA	Tennessee Department of Agriculture
TDEC	Tennessee Department of Environment & Conservation
TDOT	Tennessee Department of Transportation
TMDL	Total Maximum Daily Load
TWRA	Tennessee Wildlife Resources Agency
USGS	United States Geological Survey
UCF	Unit Conversion Factor
WCS	Watershed Characterization System
WLA	Waste Load Allocation
WWTF	Wastewater Treatment Facility

SUMMARY SHEET

Total Maximum Daily Load for Pathogens in Floyd Creek and Cloyd Creek Ft. Loudoun Lake Watershed (HUC 06010201)

Impaired Waterbody Information

State: Tennessee
Counties: Loudon and Blount
Watershed: Ft. Loudoun Lake (HUC 06010201)
Constituents of Concern: Pathogens

Impaired Waterbodies Addressed in This Document:

Waterbody ID*	Waterbody	Miles Impaired
TN06010201083 – 1000	FLOYD CREEK	7.7
TN060102011015 – 1000	CLOYD CREEK	11.3

*Waterbody ID based on Final 2002 303(d) List

Designated Uses:

The designated use classifications for waterbodies in the Ft. Loudoun Lake 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. In addition, the concentration of the E. coli group in any individual sample taken from a lake, reservoir, State Scenic River, or Tier II or III stream (1200-4-3-.06) shall not exceed 487 colony forming units per 100 mL. The concentration of the E. coli group in any individual sample taken from any other waterbody shall not exceed 941 colony forming units per 100 mL.

Additionally, consistent with current TMDL methodology, standards from *State of Tennessee Water Quality Standards, Chapter 1200-4-3, General Water Quality Criteria, October 1999* for recreation use classification:

> The concentration of a fecal coliform group shall not exceed 200 per 100 mL nor shall the concentration of the *E. coli* group exceed 126 per 100 mL, as a geometric mean based on a minimum of 10 samples collected from a given sampling site over a period of not more than 30 consecutive days with individual samples being collected at intervals of not less than 12 hours. For the purposes of determining the geometric mean, individual samples having a fecal coliform group or *E. coli* concentration of less than 1 per 100 mL shall be considered as having a concentration of 1 per 100 mL. In addition, the concentration of the fecal coliform group in any individual sample shall not exceed 1,000 per 100 mL.

TMDL Scope:

Waterbodies identified on the EPA-approved 2002 303(d) list and on the Proposed Final 2004 303(d) list as impaired due to E. coli and/or fecal coliform. TMDLs are generally developed for impaired waterbodies on a HUC-12 basis.

Analysis/Methodology:

The TMDLs for impaired waterbodies in the Ft. Loudoun Lake watershed were developed using the load duration curve methodology to assure compliance with the E. Coli 126 counts/100 mL geometric mean and 941 counts/100 mL maximum standards while also incorporating the fecal coliform 200 counts/100 mL geometric mean and 1,000 counts/100 mL maximum concentration as surrogates. A duration curve is a cumulative frequency graph that represents the percentage of time during which the value of a given parameter is equaled or exceeded. Load duration curves are developed from flow duration curves and can illustrate existing water quality conditions (as represented by loads calculated from monitoring data), how these conditions compare to desired targets, and the portion of the waterbody flow regime represented by these existing loads. Load duration curves were used to determine the load reductions required to meet the target maximum concentrations for fecal coliform and E. coli (standard - MOS). When sufficient data were available, load reductions were also determined based on geometric mean criteria.

Critical Conditions:

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

Seasonal Variation:

The 10-year period used for LSPC model simulation period and for load duration curve analysis included all seasons and a full range of flow and meteorological conditions.

Margin of Safety (MOS):

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

Summary of TMDLs, WLAs, & LAs for Impaired Waterbodies

HUC-12 Subwatershed (06010201__) or Drainage Area	Impaired Waterbody	Impaired Waterbody ID	TMDL	WLAs		LAs	
				Leaking Collection Systems[a]	MS4s[b]	Precipitation Induced Nonpoint Sources	Other Direct Sources[c]
			[% Red.]	[cts./day]	[% Red.]	[% Red.]	[cts./day]
0301	FLOYD CREEK	TN06010201083 – 1000	***93.9***	**NA**	***93.9***	***93.9***	**0**
	CLOYD CREEK	TN060102011015 – 1000					

a. *The objective for leaking collection systems is a waste load allocation of zero. It is recognized, however, that a WLA of 0 counts/day may not be practical. For these sources, the WLA is interpreted to mean a reduction in coliform loading to the maximum extent practicable, consistent with the requirement that these sources not contribute to a violation of the water quality standard for fecal coliform and/or E. coli.*

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 fecal coliform and/or E. coli.*

PATHOGEN TOTAL MAXIMUM DAILY LOAD (TMDL)
FT. LOUDOUN LAKE WATERSHED (HUC 06010201)

1.0 INTRODUCTION

Section 303(d) of the Clean Water Act requires each state to list those waters within its boundaries for which technology based effluent limitations are not stringent enough to protect any water quality standard applicable to such waters. Listed waters are prioritized with respect to designated use classifications and the severity of pollution. In accordance with this prioritization, states are required to develop Total Maximum Daily Loads (TMDLs) for those waterbodies that are not attaining water quality standards. State water quality standards consist of designated uses for individual waterbodies, appropriate numeric and narrative water quality criteria protective of the designated uses, and an antidegradation statement. The TMDL process establishes the maximum allowable loadings of pollutants for a waterbody that will allow the waterbody to maintain water quality standards. The TMDL may then be used to develop controls for reducing pollution from both point and nonpoint sources in order to restore and maintain the quality of water resources (USEPA, 1991).

2.0 SCOPE OF DOCUMENT

This document presents details of TMDL development for waterbodies in the Ft. Loudoun Lake watershed, identified on the 2002 303(d) list or on the Proposed Final 2004 303(d) list as not supporting designated uses due to E. coli and/or fecal coliform. TMDL analyses are performed primarily on a 12-digit hydrologic unit area (HUC-12) basis.

3.0 WATERSHED DESCRIPTION

The Ft. Loudoun Lake watershed (HUC 06010201) is located in East Tennessee (Figure 1), primarily in Blount, Knox, Loudon, and Sevier Counties. The Ft. Loudoun Lake watershed lies within two Level III ecoregions (Blue Ridge Mountains, Ridge and Valley) and contains seven Level IV ecoregions as shown in Figure 2 (USEPA, 1997):

- **The Southern Sedimentary Ridges (66e)** in Tennessee include some of the westernmost foothill areas of the Blue Ridges Mountains ecoregion, such as the Bean, Starr, Chilhowee, English, Stone, Bald, and Iron Mountain areas. Slopes are steep, and elevations are generally 1000-4500 feet. The rocks are primarily Cambrian-age sedimentary (shale, sandstone, siltstone, quartzite, conglomerate), although some lower stream reachs occur on limestone. Soils are predominantly friable loams and fine sandy loams with variable amounts of sandstone rock fragments, and support mostly mixed oak and oak-pine forests.
- **Limestone Valleys and Coves (66f)** are small but distinct lowland areas of the Blue Ridge, with elevations mostly between 1500 and 2500 feet. About 450 million years ago, older Blue Ridge rocks to the east were forced up and over younger rocks to the west. In places, the Precambrian rocks have eroded through to Cambrian or Ordovician-age limestones, as seen especially in isolated, deep cove areas that are surrounded by steep mountains. The main areas of limestone include the Mountain City lowland area and Shady Valley in the north; and Wear Cove, Tuckaleechee Cove, and Cades Cove of the Great Smoky Mountains in the south. Hay and pasture, with some tobacco patches on small farms, are typical land uses.

- **The Southern Metasedimentary Mountains (66g)** are steep, dissected, biologically-diverse mountains that include Clingmans Dome (6643 feet), the highest point in Tennessee. The Precambrian-age metamorphic and sedimentary geologic materials are generally older and more metamorphosed than the Southern Sedimentary Ridges (66e) to the west and north. The Appalachian oak forests and, at higher elevations, the northern hardwoods forests include a variety of oaks and pines, as well as silverbell, hemlock, yellow poplar, basswood, buckeye, yellow birch, and beech. Spruce-fir forests, found generally above 5500 feet, have been affected greatly over the past twenty-five years by the balsam woolly aphid. The Copper Basin, in the southeast corner of Tennessee, was the site of copper mining and smelting from the 1850's to 1987, and once left more than fifty square miles of eroded earth.
- **The Southern Limestone/Dolomite Valleys and Low Rolling Hills (67f)** form a heterogeneous region composed predominantly of limestone and cherty dolomite. Landforms are mostly low rolling ridges and valleys, and the solids vary in their productivity. Landcover includes intensive agriculture, urban and industrial, or areas of thick forest. White oak forests, bottomland oak forests, and sycamore-ash-elm riparian forests are the common forest types, and grassland barrens intermixed with cedar-pine glades also occur here.
- **The Southern Shale Valleys (67g)** consist of lowlands, rolling valleys, and slopes and hilly areas that are dominated by shale materials. The northern areas are associated with Ordovician-age calcareous shale, and the well-drained soils are often slightly acid to neutral. In the south, the shale valleys are associated with Cambrian-age shales that contain some narrow bands of limestone, but the soils tend to be strongly acid. Small farms and rural residences subdivide the land. The steeper slopes are used for pasture or have reverted to brush and forested land, while small fields of hay, corn , tobacco, and garden crops are grown on the foot slopes and bottomland.
- **The Southern Sandstone Ridges (67h)** ecoregion encompasses the major sandstone ridges, but these ridges also have areas of shale and siltstone. The steep, forested chemistry of streams flowing down the ridges can vary greatly depending on the geologic material. The higher elevation ridges are in the north, including Wallen Ridge, Powell Mountain, Clinch Mountain, and Bays Mountain. White Oak Mountain in the south has some sandstone on the west side, but abundant shale and limestone as well. Grindstone Mountain, capped by the Gizzard Group sandstone, is the only remnant of Pennsylvanian-age strata in the Ridge and Valley of Tennessee.
- **The Southern Dissected Ridges and Knobs (67i)** contain more crenulated, broken, or hummocky ridges, compared to smoother, more sharply pointed sandstone ridges. Although shale is common, there is a mixture and interbedding of geologic materials. The ridges on the east side of Tennessee's Ridge and Valley tend to be associated with the Ordovician-age Sevier shale, Athens shale, and Holston and Lenoir limestones. These can include calcareous shale, limestone, siltstone, sandstone, and conglomerate. In the central and western part of the ecoregion, the shale ridges are associated with the Cambrian-age Rome Formation: shale and siltstone with beds of sandstone. Chestnut oak forests and pine forests are typical for the higher elevations of the ridges, with areas of white oak, mixed mesophytic forest, and tulip poplar on the lower slopes, knobs, and draws.

The Ft. Loudoun Lake watershed, located in Loudon, Blount, Knox, and Sevier Counties, Tennessee, has a drainage area of approximately 660 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 Ft. Loudoun Lake watershed have occurred since 1993 as a result of development, this is the most current land use data available. Land use for the Ft. Loudoun Lake watershed is summarized in Table 1 and shown in Figure 3. Predominant land use in the Ft. Loudoun Lake watershed is forest (63.6%) followed by agriculture (19.2%). Urban areas represent approximately 10.9% of the total drainage area of the watershed. Details of land use distribution of impaired subwatersheds in the Ft. Loudoun Lake watershed are presented in Appendix A.

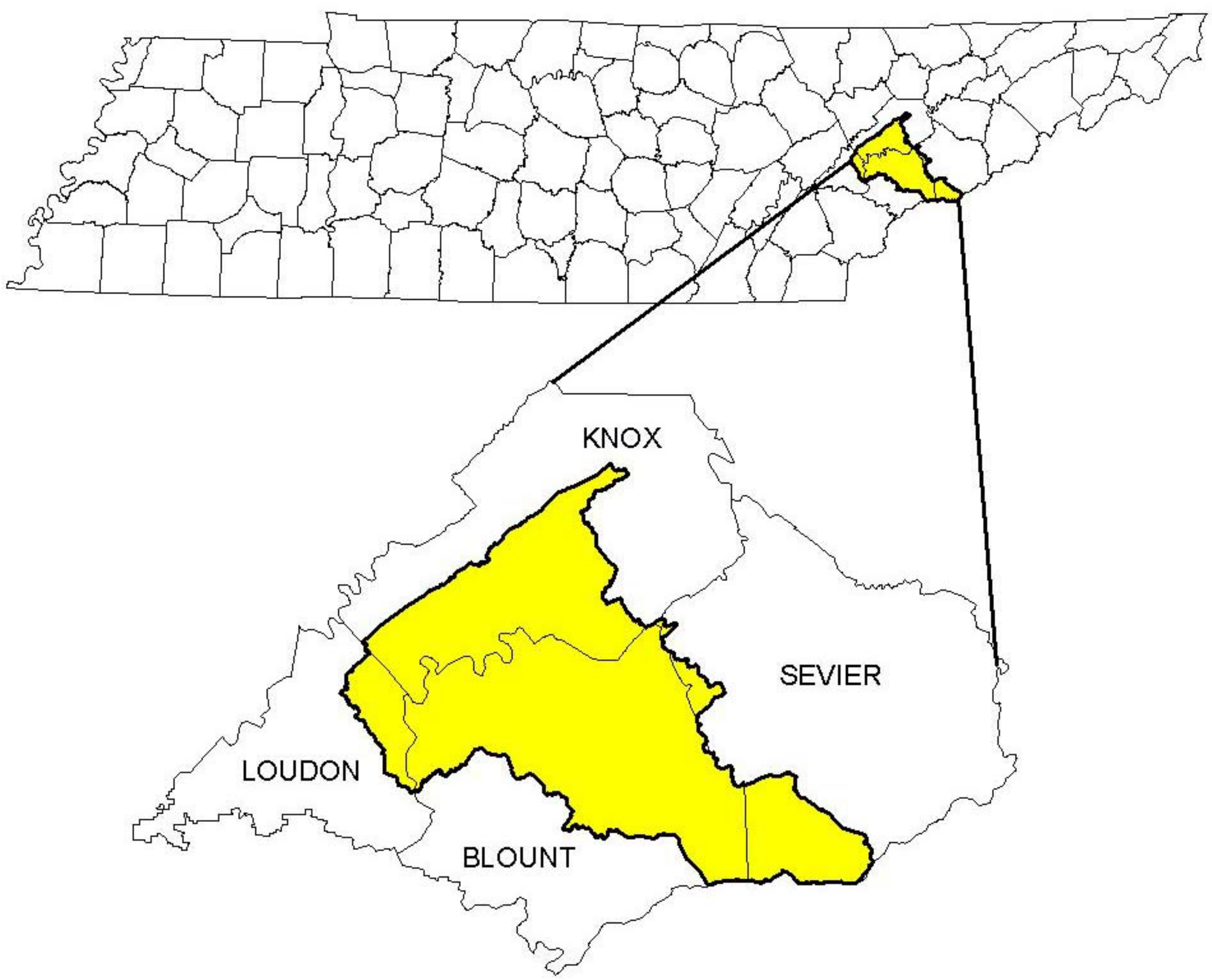

Figure 1. Location of the Ft. Loudoun Lake Watershed.

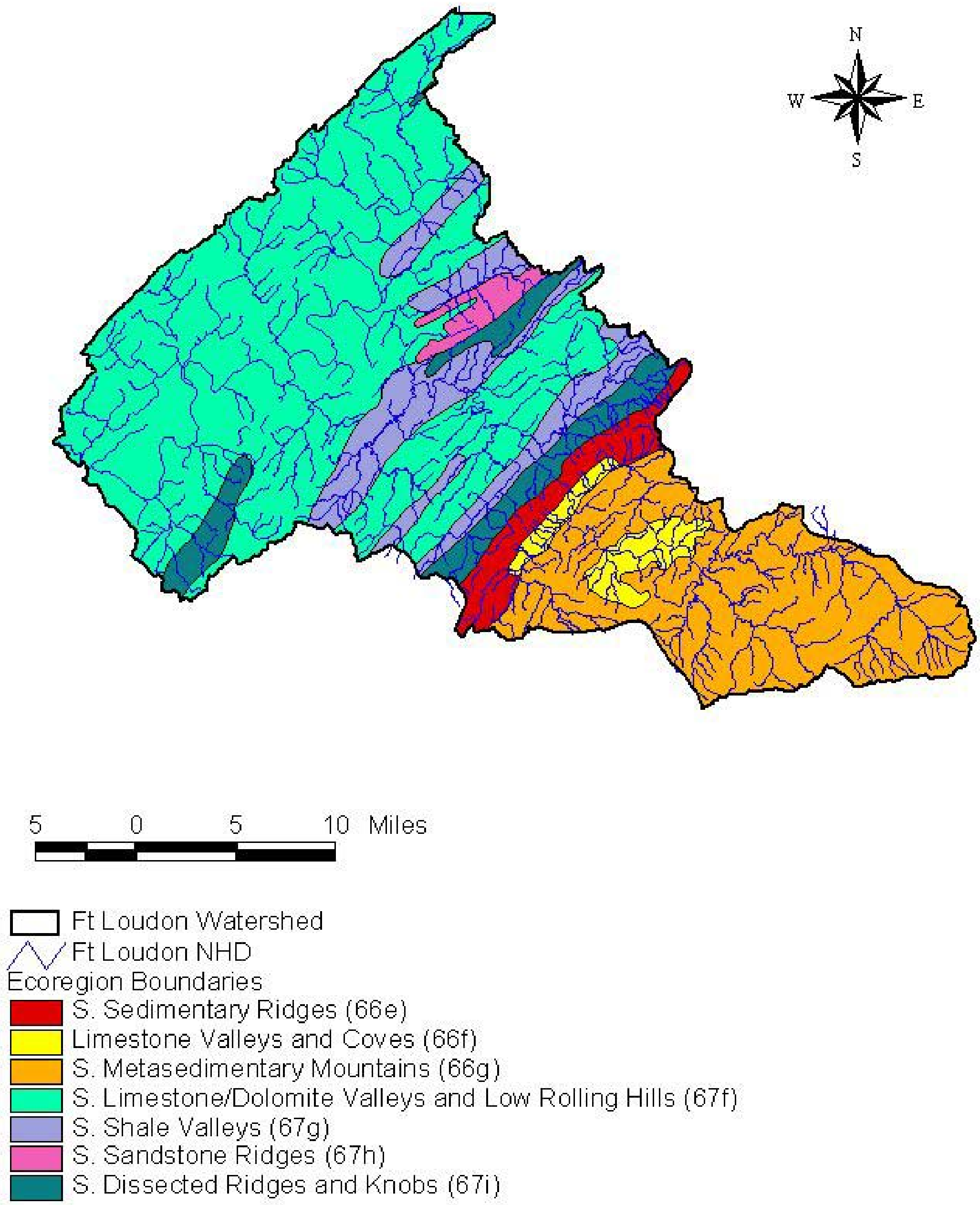

Figure 2. Level IV Ecoregions in the Ft. Loudoun Lake Watershed.

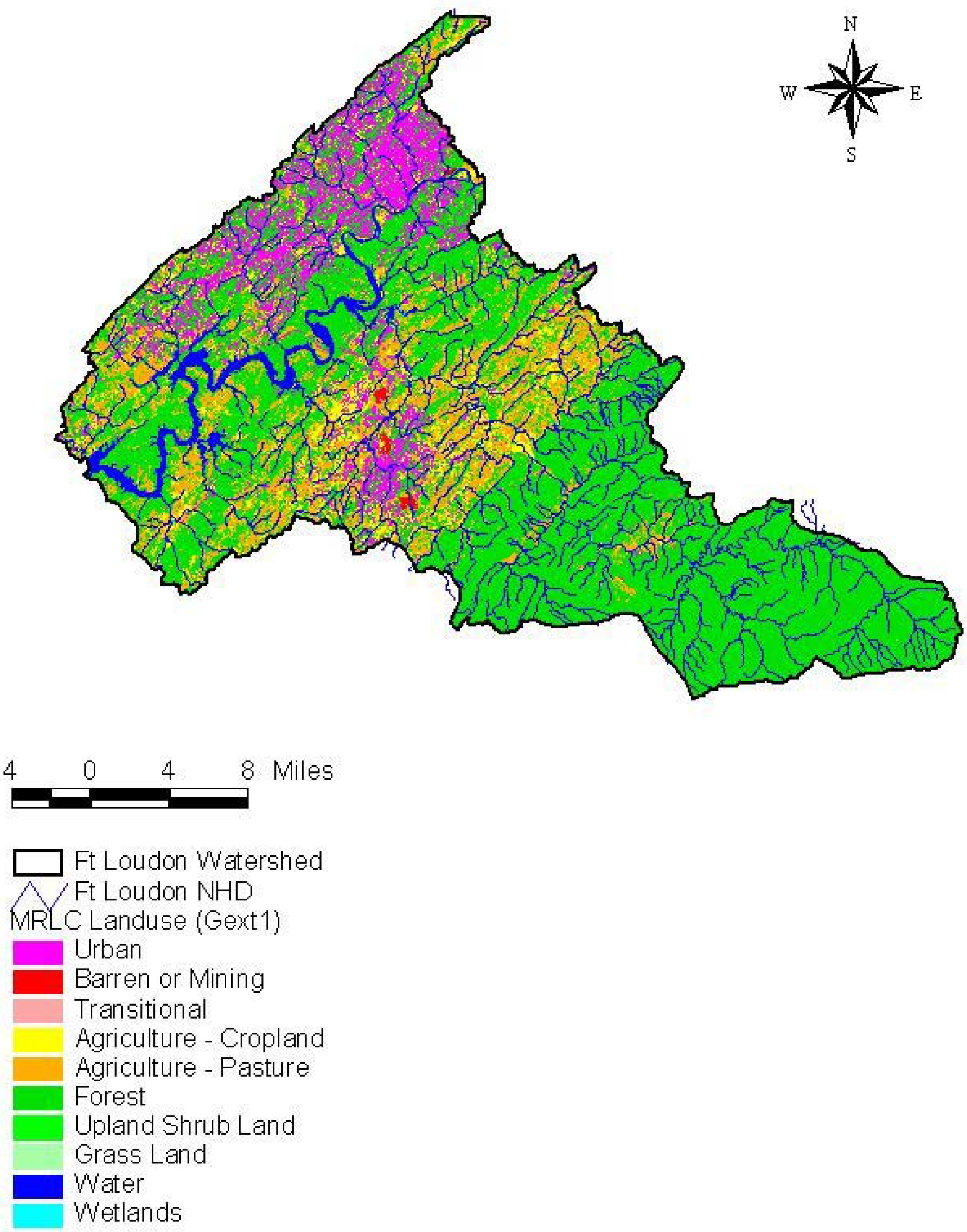

Figure 3. Land Use Characteristics of the Ft. Loudoun Lake Watershed.

Table 1. MRLC Land Use Distribution – Ft. Loudoun Lake Watershed

Land Use	Area	
	[acres]	[%]
Bare Rock/Sand/Clay	2	0.0
Deciduous Forest	9,659	22.1
Emergent Herbaceous Wetlands	37	0.0
Evergreen Forest	89,205	21.1
High Intensity Commercial/Industrial/ Transportation	11,444	2.7
High Intensity Residential	6,796	1.6
Low Intensity Residential	27,772	6.6
Mixed Forest	86,454	20.4
Open Water	13,152	3.1
Other Grasses (Urban/recreational)	11,646	2.8
Pasture/Hay	66,954	15.8
Quarries/Strip Mines/ Gravel Pits	819	0.2
Row Crops	14,360	3.4
Transitional	237	0.1
Woody Wetlands	427	0.1
Total	**422,964**	**100.0**

4.0 PROBLEM DEFINITION

The State of Tennessee's final 2002 303(d) list (TDEC, 2004a) was approved by the U.S. Environmental Protection Agency (EPA), Region IV in January of 2004. The list identified the waterbody segments shown in Table 2 as not fully supporting designated use classifications due to E. coli and/or fecal coliform. The designated use classifications for these waterbodies include fish and aquatic life, irrigation, livestock watering & wildlife, and recreation.

Waterbodies in the Ft. Loudoun Lake watershed were reassessed by the State in 2004 using more recent data. In September 2004, the State of Tennessee submitted to the USEPA the Proposed Final 2004 303(d) List. Since the 2004 303(d) list, based on the latest field data (2003-2004), indicated no significant change from the 2002 303(d) list, the TMDL analysis will be based on the 2002 303(d) list.

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

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

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

5.0 WATER QUALITY GOAL

As previously stated, the designated use classifications for the Ft. Loudoun Lake 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, 2004b). Section 1200-4-3-.03 (4) (f) states:

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

None of the impaired waterbodies in the Ft. Loudoun Lake watershed have been classified as either Tier II or Tier III streams.

Prior to January 2004, the coliform water quality criteria, for protection of the recreation use classification, established by *State of Tennessee Water Quality Standards, Chapter 1200-4-3, General Water Quality Criteria, October 1999* (TDEC, 1999), Section 1200-4-3-.03 (4) (f) states:

> The concentration of a fecal coliform group shall not exceed 200 per 100 mL, nor shall the concentration of the *E. coli* group exceed 126 per 100 mL, as a geometric mean based on a minimum of 10 samples collected from a given sampling site over a period of not more than 30 consecutive days with individual samples being collected at intervals of not less than 12 hours. For the purposes of determining the geometric mean, individual samples having a fecal coliform group or *E. coli* concentration of less than 1 per 100 mL shall be considered as having a concentration of 1 per 100 mL. In addition, the concentration of the fecal coliform group in any individual sample shall not exceed 1,000 per 100 mL.

In addition to utilizing the E. coli water quality standards (with MOS) as the target, this TMDL utilizes a fecal coliform target as a surrogate for determining the attainment of the E. coli standard because of the demonstrated high correlation between E. coli and fecal coliform in this watershed. In the state of Tennessee, E. coli and fecal coliform are well correlated (R = 0.902) when evaluating all available ecoregion data (623 observations). The concentrations of fecal coliform and E. coli were plotted for the entire watershed and for each subwatershed (see Appendix B). The data plots showed a strong correlation between the concentration of fecal coliform and the concentration of E. coli. The correlation between E. coli and fecal coliform for all monitoring data in the Ft. Loudoun Lake watershed is good (875 observations; R = 0.866), as is the correlation in the Cloyd Creek subwatershed (R=0.867). The correlation in the Floyd Creek subwatershed (R=0.221) is poor due to the high number of E. coli analytical results exceeding the reporting limits of the test (reported as ">2419").

Therefore, this TMDL employs both the E. coli water quality standard and the surrogate fecal coliform by determining the results from four different methodologies: 1) the geometric mean for fecal coliform of 200 counts/100 mL, 2) the fecal coliform sample maximum of 1,000 counts/100 mL, 3) the geometric mean standard for E. coli of 126 counts/100mL, and 4) the E. coli sample maximum of 941 counts/100 mL. The most protective (or highest percent of load reduction) of the four methodologies will determine the percent reduction(s) required for impaired waterbodies. The analysis of fecal coliform data is only part of the methodology and is not included to comply with current water quality standards.

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

Table 2. 2002 303(d) List for Pathogen Impaired Waterbodies – Ft. Loudoun Lake Watershed

Waterbody ID	Impacted Waterbody	RM Partially Supporting	RM Not Supporting	Cause (Pollutant)	Pollutant Source
TN06010201083 – 1000	FLOYD CREEK	7.3		Pathogens Siltation	Pasture Grazing
TN060102011015 – 1000	CLOYD CREEK	11.3		Siltation Other Habitat Alterations Pathogens	Pasture Grazing Livestock in Stream

Table 3. Water Quality Assessment of Waterbodies Impaired Due to Pathogens - Ft. Loudoun Lake Watershed

Waterbody ID	Segment Name	Cause	Sources	Comments
TN06010201083 – 1000	FLOYD CREEK	Pathogens	Grazing in Riparian or Shoreline Zones	2003 TDEC pathogen station at RM0.5; 10 E.coli samples out of 12 was over 1000. E.coli G.M. = 1622. 1999 LAB biological survey at mile 0.5; 7 EPT, 15 total genera. BR score = 7. Habitat score = 120. E.coli elevated (1733). Cows in stream. TVA station at RM1.4. IBI = 28 (poor). 10 EPT families, 18 total families.
TN060102011015 – 1000	CLOYD CREEK	Pathogens	Grazing in Riparian or Shoreline Zones Livestock Grazing or Feeding Operations	2003 TDEC pathogen station at RM1.5; 3 E.coli samples out of 12 was over 1000. E.coli G.M. = 591. 1999 LAB biological survey at mile 1.5; 5 EPT, 21 total families. Habitat score = 90. E.coli elevated (2419). Cows in creek. TVA station at mile 2.6. Fish IBI = 36 (poor).

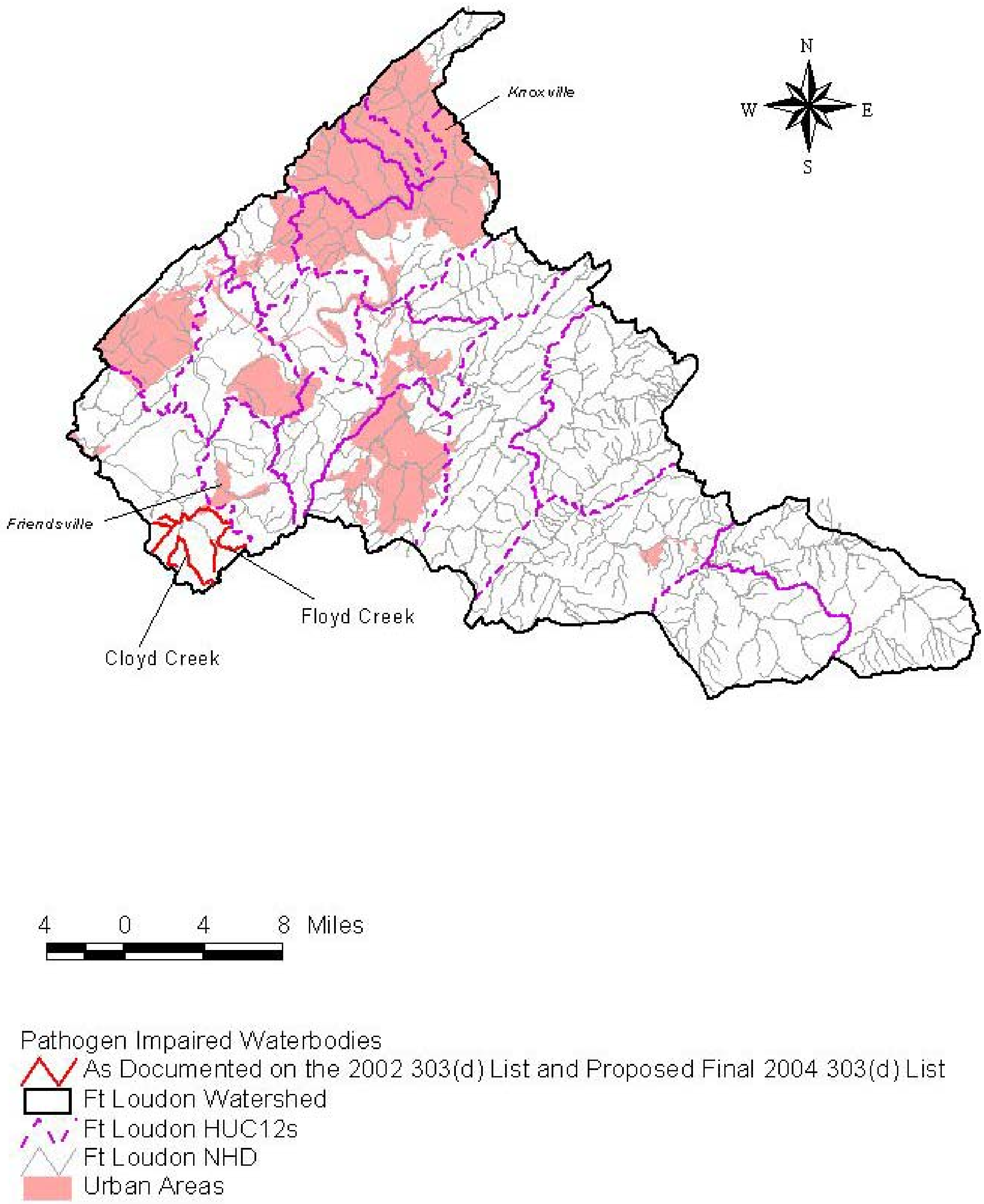

Figure 4. Waterbodies Impaired by Pathogens (as Documented on the 2002 303(d) List and Proposed Final 2004 303(d) List).

6.0 WATER QUALITY ASSESSMENT AND DEVIATION FROM GOAL

There are several water quality monitoring stations that provide data for waterbodies identified as impaired for pathogens in the Ft. Loudoun Lake watershed:

- Cloyd Branch Subwatershed:
  - CLOYD001.5LO – Cloyd Creek, 1.5 mi. upstream of confluence with Ft. Loudoun Reservoir
- Floyd Creek Subwatershed:
  - FLOYD000.5LO – Floyd Creek, 100 yds. downstream of Kiser Station Rd.

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 violations of the 1,000 counts/100 mL maximum fecal coliform concentration and the 941 counts/100 mL maximum E. coli standard at both monitoring stations. Water quality monitoring results for these stations are summarized in Table 4.

Whenever a minimum of 5 samples was collected at a given monitoring station over a period of not more than 30 consecutive days, the geometric mean was calculated. All calculated geometric means were in violation of the 200 counts/100 mL geometric mean standard for fecal coliform.

All waterbodies listed on either the 2002 303(d) list or the Proposed Final 2004 303(d) List are provided a TMDL for pathogen loading.

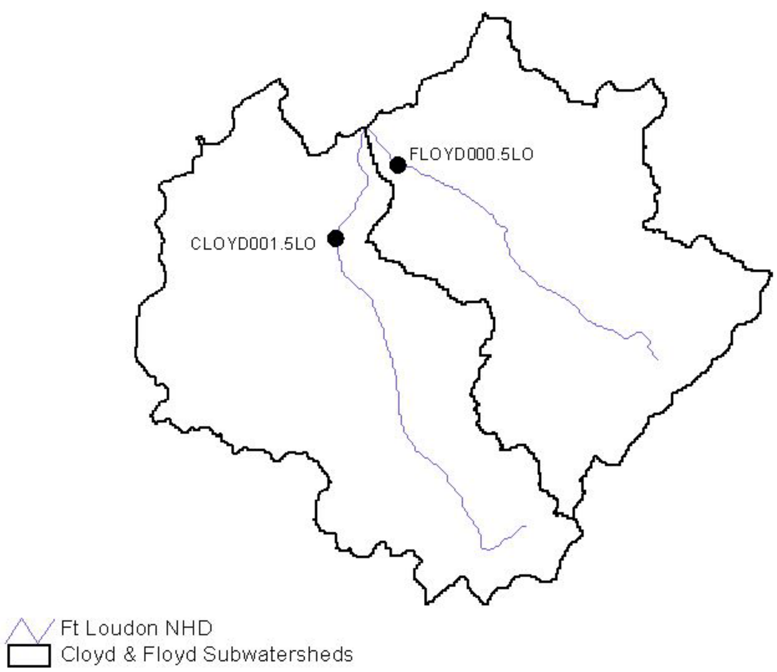

Figure 5. Water Quality Monitoring Stations in Cloyd Creek and Floyd Creek

Table 4. Summary of Water Quality Monitoring Data

Monitoring Station	Monitoring Dates	Fecal Coliform						E. Coli					
		Data Pts.	[Counts/100 mL]			No. Viol. WQ Std.	Percent Viol. WQ Std.	Data Pts.	[Counts/100 mL]			No. Viol. WQ Std.	Percent Viol. WQ Std.
			Min.	Avg.	Max.				Min.	Avg.	Max.		
CLOYD001.5LO	1999 - 2003	13	176	962	3,500	3	23.1%	13	144	>954	>2419	4	30.8%
FLOYD000.5LO	1999 - 2003	13	380	2,384	5,400	11	84.6%	13	236	>1,872	>2419	11	84.6%

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 no NPDES permitted WWTFs discharging to the impaired subwatersheds of the Ft. Loudoun Lake watershed.

7.1.2 NPDES Regulated Municipal Separate Storm Sewer Systems (MS4s)

Municipal Separate Storm Sewer Systems (MS4s) are considered to be point sources of pathogens. Discharges from MS4s occur in response to storm events through road drainage systems, curb and gutter systems, ditches, and storm drains. Large and medium MS4s serving populations greater than 100,000 people are required to obtain NPDES storm water permits. At present, there are no MS4s of this size in impaired subwatersheds of the Ft. Loudoun Lake watershed. As of March 2003, small MS4s serving urbanized areas, or having the potential to exceed instream water quality standards, are required to obtain a permit under the *NPDES General Permit for Discharges from Small Municipal Separate Storm Sewer Systems* (TDEC, 2002). An urbanized area is defined as an entity with a residential population of at least 50,000 people and an overall population density of at least 1,000 people per square mile. Under the General Permit, an annual report must be submitted to the Director of TDEC Water Pollution Control Division. Monitoring is not currently required.

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

NPDES Permit Number	Phase	Permittee Name	Issuance Date	Effective Date	Expiration Date
TNS075116	II	Blount County	10/17/03	10/20/03	2/26/08
TNS075591	II	Loudon County	3/8/04	10/15/03	2/26/08

The Tennessee Department of Transportation (TDOT) is also being issued MS4 permits for State roads in urban areas. Information regarding storm water permitting in Tennessee may be obtained from the TDEC website at http://www.state.tn.us/environment/wpc/stormh2o/.

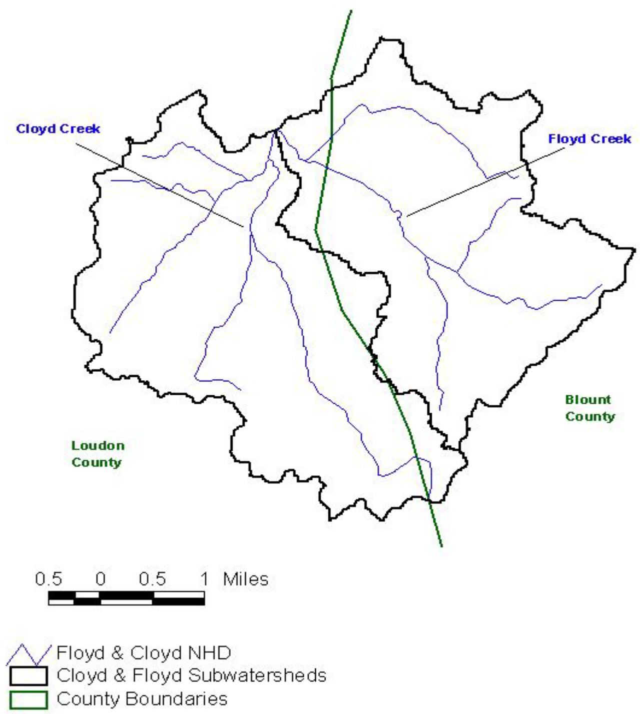

Figure 6. NPDES Regulated MS4s in the Cloyd and Floyd Creek subwatersheds.

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. Among the provisions of the general CAFO permit are:

- Development and implementation of a site-specific Nutrient Management Plan (NMP), and approval of the NMP by the Tennessee Department of Agriculture (TDA).
- Requirements for the design, construction, operation, and maintenance of CAFO liquid waste handling 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.
- Requirements regarding manure, litter, and wastewater land application Best Management Practices (BMPs).

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/.

As of July 2, 2004, there are no Class II CAFOs in the Ft. Loudoun Lake watershed with coverage under the general NPDES permit. 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 pathogen loading are primarily associated with agricultural and urban land uses. The vast majority of waterbodies identified on the approved 2002 303(d) list and on the Proposed Final 2004 303(d) list as impaired due to pathogens are attributed to nonpoint agricultural or urban sources.

7.2.1 Wildlife

Wildlife deposit coliform bacteria, with their feces, onto land surfaces where it can be transported during storm events to nearby streams. The overall deer density for Tennessee was estimated by the Tennessee Wildlife Resources Agency (TWRA) to be 23 animals per square mile. In order to account for higher density areas and loading due to other species, a conservative density of 45 animals per square mile was used for modeling purposes. Fecal coliform loads due to deer are estimated by EPA to be 5.0×10^8 counts/animal/day.

7.2.2 Agricultural Animals

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

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

Livestock data for pathogen-impaired subwatersheds were compiled from the 2002 Census of Agriculture utilizing the Watershed Characterization System (WCS) and summarized in Table 5. 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.

Table 5. Livestock Distribution in the Ft. Loudoun Lake Watershed

Subwatershed	Livestock Population (WCS)			
	Beef Cow	Milk Cow	Sheep	Horse
Cloyd Creek	358	116	10	52
Floyd Creek	204	28	6	47

7.2.3 Failing Septic Systems

Some coliform loading in the Ft. Loudoun Lake 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 Ft. Loudoun Lake watershed utilizing septic systems were compiled using the WCS and are summarized in Table 6. In east 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. Population on Septic Systems in the Ft. Loudoun Lake Watershed

Subwatershed	Population on Septic Systems
Cloyd Creek	624
Floyd Creek	644

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. Cloyd Creek and Floyd Creek each have only 1.0% urban land area. Land use for the Ft. Loudoun Lake impaired drainage areas is summarized in Figures 7 and 8 and tabulated in Appendix A.

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:

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

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.

8.1 Scope of TMDL Development

This document describes pathogen TMDL, Waste Load Allocation (WLA), and Load Allocation (LA) development for waterbodies identified as impaired due to pathogens on the 2002 303(d) list or on the Proposed Final 2004 303(d) list. TMDL analyses are performed primarily on a 12-digit hydrologic unit area (HUC-12) basis for subwatersheds containing waterbodies identified as impaired due to pathogens on the 2002 303(d) list and on the Proposed Final 2004 303(d) list.

8.2 Critical Conditions

The critical condition for non-point source fecal coliform loading is an extended dry period followed by a rainfall runoff event. During the dry weather period, fecal coliform bacteria builds up on the land surface, and is washed off by rainfall. The critical condition for point source loading occurs during periods of low streamflow when dilution is minimized. Both conditions are represented in the TMDL analysis.

The ten-year period from October 1, 1994 to September 30, 2004 was used to simulate flow. This 10-year period contained a range of hydrologic conditions that included both low and high streamflows. Critical conditions are accounted for in the load duration curve analysis by using the entire period of flow and water quality data available for the impaired waterbodies. Water quality data have been collected during all flow ranges. Based on the location of the water quality exceedances on the load duration curves, Cloyd Creek and Floyd Creek will require load reductions in both high and low flow regimes (see Section 9.3 and Table 9).

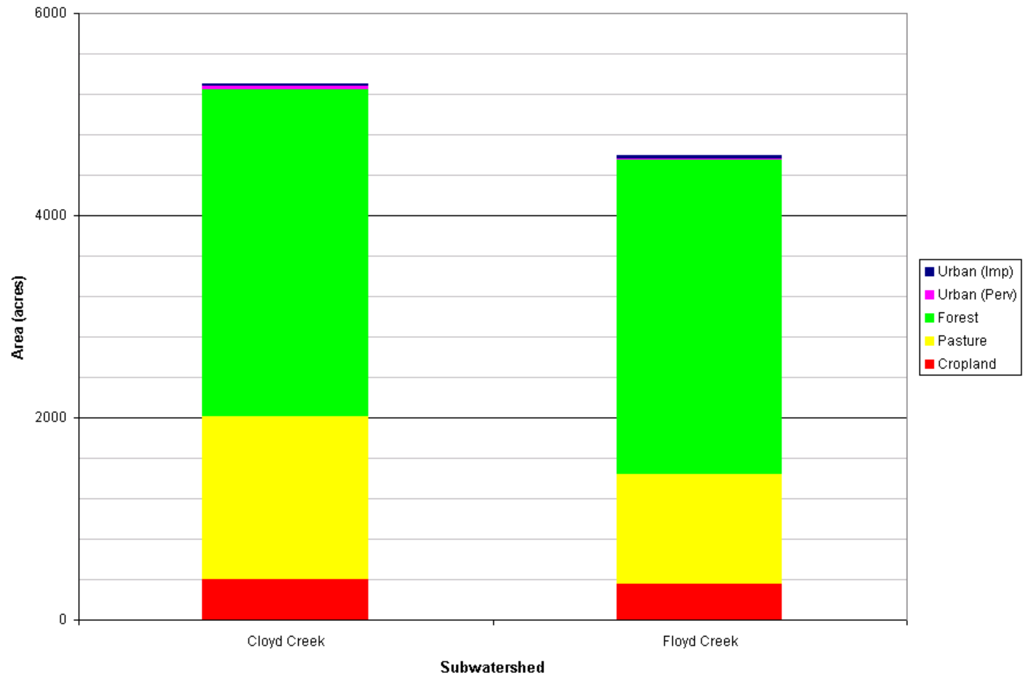

Figure 7. Land Use Area of Ft. Loudoun Lake Pathogen-Impaired Subwatersheds.

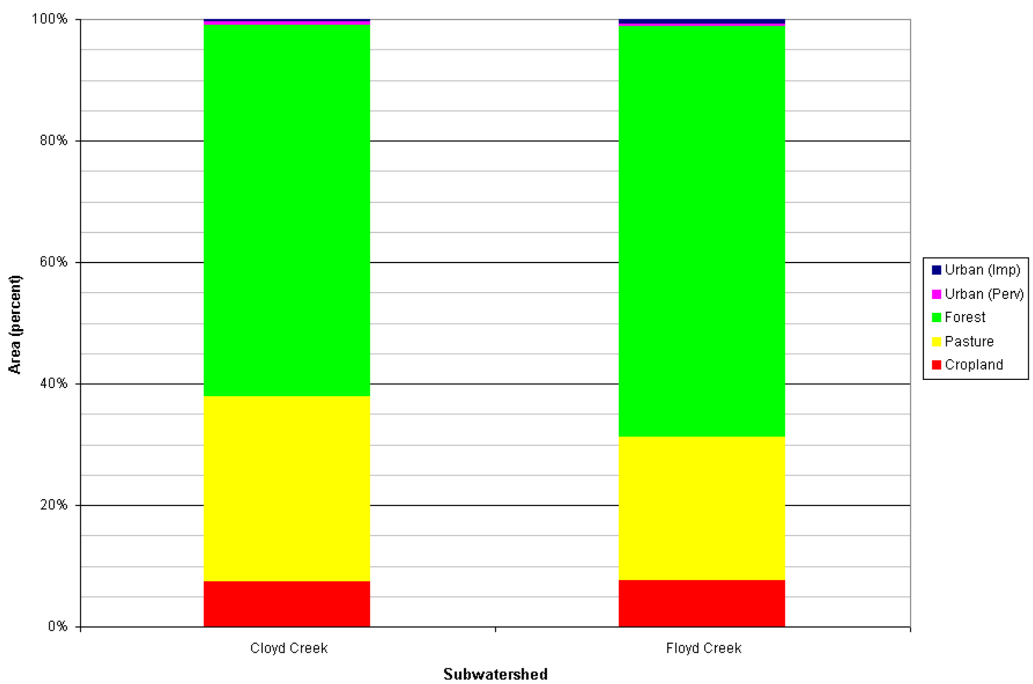

Figure 8. Land Use Percent of the Ft. Loudoun Lake Pathogen-Impaired Subwatersheds.

8.3 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 Ft. Loudoun Lake watershed were developed to assure compliance with the E. Coli 126 counts/100 mL geometric mean and 941 counts/100 mL maximum standards while also incorporating the fecal coliform 200 counts/100 mL geometric mean and 1,000 counts/100 mL maximum concentration as surrogates (ref.: Section 5.0).

The Loading Simulation Program C++ (LSPC) is a dynamic watershed model based on the Hydrologic Simulation Program - Fortran (HSPF) and was selected for generation of continuous flow values in the Ft. Loudoun Lake watershed. Details of model development and calibration are presented in Appendix D.

A load duration curve is a cumulative frequency graph that illustrates existing water quality conditions (as represented by loads calculated from monitoring data), how these conditions compare to desired targets, and the portion of the waterbody flow regime represented by these existing loads. Load duration curves were considered to be well suited for analysis of periodic monitoring data collected by grab sample and determination of the load reductions required to meet the target maximum concentration (standard - MOS). Details of load duration curve development for the Ft. Loudoun Lake Watershed are presented in Appendix E.

8.4 Margin of Safety

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

Implicit MOS includes the use of conservative modeling assumptions and a 10-year continuous simulation that incorporates a range of meteorological events.

An explicit MOS, equal to 10% of the geometric mean and maximum coliform concentrations, was utilized for TMDL analysis. Application of the explicit MOS of 20 counts/100 mL to the fecal coliform geometric mean results in an effective geometric mean target concentration of 180 counts/100 mL. Application of the explicit MOS of 100 counts/100 mL to the fecal coliform maximum concentration of 1000 counts/100 mL results in an effective maximum target concentration of 900 counts/100 mL. Application of the explicit MOS of 13 counts/100 mL to the E. coli geometric mean standard of 126 counts/100 mL results in an effective geometric mean target concentration of 113 counts/100 mL. 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.

8.5 Expression of TMDLs, WLAs, & LAs

In this document, the pathogen TMDL is expressed as the percent reduction in instream loading required to decrease: a) the existing 30-day geometric mean concentration of fecal coliform to the target of 180 counts/100 mL, b) the existing 30-day geometric mean concentration of E. coli to the target of 113 counts/100 mL, c) the existing maximum concentration of fecal coliform to the target of 900 counts/100 mL, and d) the existing maximum concentration of E. coli to the target of 847 counts/100 mL. WLAs & LAs for precipitation-induced loading sources are also expressed as required percent reductions in pathogen loading. Allocations for loading that is independent of precipitation (WLAs for WWTFs and LAs for “other direct sources”) are expressed as counts/day.

8.5.1 Determination of TMDLs

Load reductions were developed for impaired segments in the Ft. Loudoun Lake Watershed using Load Duration Curves to achieve compliance with the maximum target concentrations (Appendix E), both fecal coliform and E coli. When sufficient data were available, load reductions were also developed to achieve compliance with the 30-day geometric mean target concentrations (Appendix E). The instream load reductions determined by these two methodologies were compared and the largest required load reduction was selected as the TMDL. TMDL load reductions for the impaired segments are shown in Table 7. In cases where the geometric mean could not be developed, it is assumed that achieving the load reduction based on the maximum target concentrations should result in attainment of the geometric mean criteria.

8.5.2 Determination of WLAs & LAs

WLAs & LAs are developed in Appendix F for point sources and nonpoint sources respectively. TMDLs, WLAs, & LAs for Ft. Loudoun Lake watershed impaired waterbodies are summarized in Table 8.

8.6 Seasonal Variation

Seasonal variation was incorporated in the continuous simulation water quality model by using varying monthly loading rates and daily meteorological data over a ten-year period. 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.

Table 7. Determination of TMDLs for Impaired Waterbodies, Ft. Loudoun Lake Watershed

HUC-12 Subwatershed (06010201__) or Drainage Area	Impaired Waterbody	Impaired Waterbody ID[a]	Required Load Reduction				
			Based on 90th Percentile		Based on 30-day Geometric Mean		TMDL [%]
			Fecal Coliform	E. Coli	Fecal Coliform	E. Coli	
0301	FLOYD CREEK	TN06010201083 – 1000	**79.2**	**>65.0**	**91.7**	**93.9**	**93.9**
	CLOYD CREEK	TN060102011015 – 1000	**52.9**	**63.7**	**79.8**	**86.3**	

[a] Waterbody ID based on Final 2002 303(d) List

Table 8. WLAs & LAs for Ft. Loudoun Lake Watershed, Tennessee

HUC-12 Subwatershed (06010201__) or Drainage Area	Impaired Waterbody	Impaired Waterbody ID	TMDL	WLAs		LAs	
				Leaking Collection Systems[a]	MS4s[b]	Precipitation Induced Nonpoint Sources	Other Direct Sources[c]
			[% Red.]	[cts./day]	[% Red.]	[% Red.]	[cts./day]
0301	FLOYD CREEK	TN06010201083 – 1000	***93.9***	**NA**	***93.9***	***93.9***	**0**
	CLOYD CREEK	TN060102011015 – 1000					

a. The objective for leaking collection systems is a waste load allocation of zero. It is recognized, however, that a WLA of 0 counts/day may not be practical. For these sources, the WLA is interpreted to mean a reduction in coliform loading to the maximum extent practicable, consistent with the requirement that these sources not contribute to a violation of the water quality standard for fecal coliform and/or E. coli.
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 fecal coliform and/or 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 Ft. Loudoun Lake Watershed through reduction of excessive pathogen loading. Adaptive management methods, within the context of the State's rotating watershed management approach, will be used to modify TMDLs, WLAs, and LAs as required to meet water quality goals.

9.1 Point Sources

9.1.1 NPDES Regulated Municipal and Industrial Wastewater Treatment Facilities

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

9.1.2 NPDES Regulated Municipal Separate Storm Sewer Systems (MS4s)

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

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

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

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

9.1.3 NPDES Regulated Concentrated Animal Feeding Operations (CAFOs)

Existing or future CAFOs that are located in impaired subwatersheds will be required to comply with WLAs consistent with their permits. These WLAs will be implemented through the Nutrient Management Plan (NMP), liquid wast handling system, and Best Management Practice (BMP) provisions of NPDES Permit No. TNA000000, *Class II Concentrated Animal Feeding Operation General Permit* or the individual NPDES permit for Class I CAFOs. All wastewater discharges from CAFOs 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, operated to contain:

- All process wastewater resulting from the operation of the CAFO (such as waste 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.

9.2 Nonpoint Sources

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

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

BMPs have been utilized in the Ft. Loudoun Lake 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 Ft. Loudoun Lake watershed during the TMDL evaluation period. The TDA keeps a database of BMPs implemented in Tennessee. Those listed in the Ft. Loudoun Lake 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.

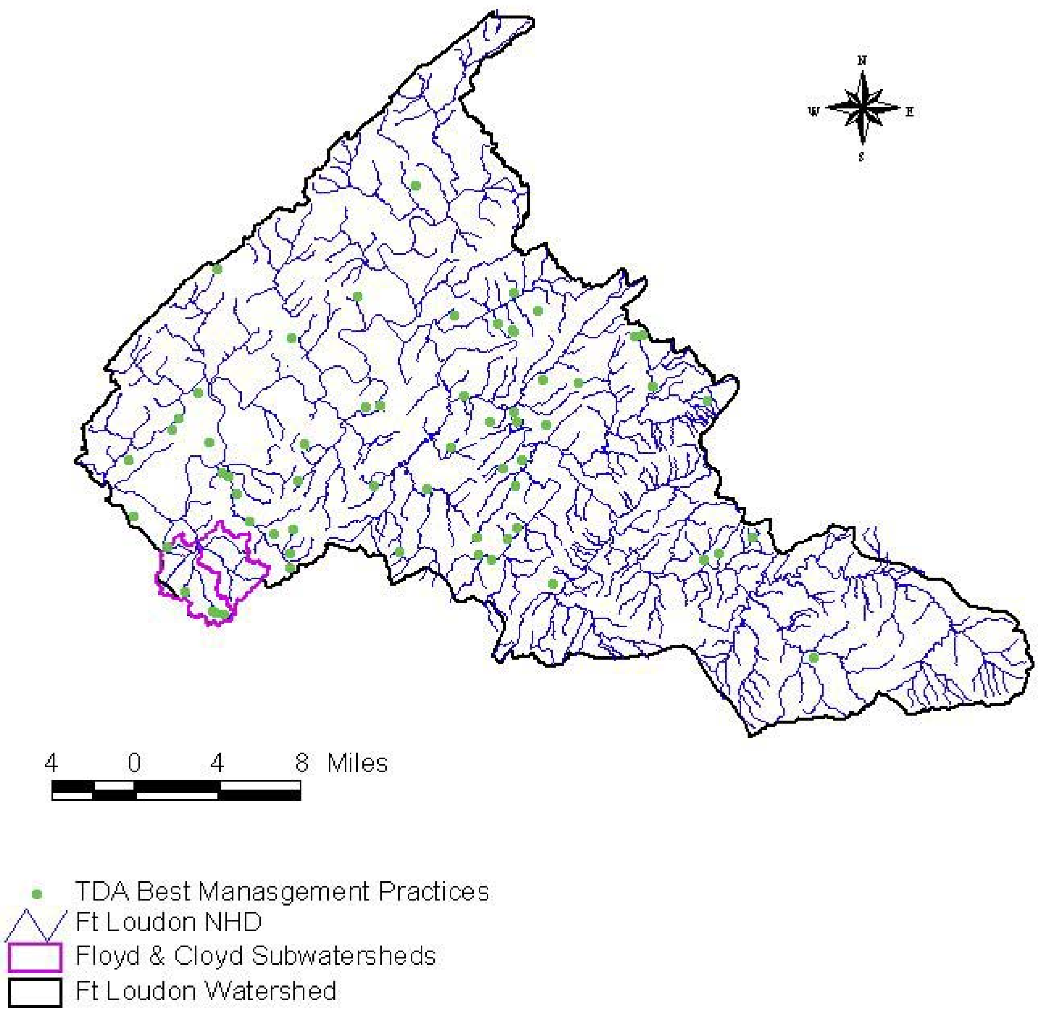

Figure 9. Tennessee Department of Agriculture Best Management Practices located in the Ft. Loudoun Lake Watershed.

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.

9.3 Application of Load Duration Curves for Implementation Planning

The Load Duration Curve methodology (Appendix E) is a form of water quality analysis and presentation of data that aids in guiding implementation by targeting strategies to appropriate flow conditions. One of the strengths of this method is that it can be used to interpret possible delivery mechanisms of pathogens by differentiating between point and non-point problems. The E. coli load duration analysis was utilized for implementation planning. The E. coli load duration curve for each pathogen-impaired subwatershed (Figures 10 and 11) was analyzed to determine the frequency with which water quality monitoring data exceed the E. coli target maximum concentration of 847 counts/100 mL (standard – MOS) under five flow conditions (low, dry, mid-range, moist, and high).

Table 9 presents Load Duration analysis statistics for E. coli in the Ft. Loudoun Lake Watershed and targeted implementation strategies for each source category covering the entire range of flow (Stiles, 2003). Each implementation strategy addresses a range of flow conditions and targets point sources, non-point sources, or a combination of each. Results indicate that the implementation strategies for Cloyd Creek and Floyd Creek will require BMPs targeting both non-point sources (dominant under high flow/runoff conditions) and sources dominant under low flow/dry conditions. The implementation strategies listed in Table 9 are a subset of the categories of BMPs and implementation strategies available for application to the pathogen-impaired Ft. Loudoun Lake Watersheds for reduction of pathogen loading and mitigation of water quality impairment.

See Appendix E for a detailed discussion of the Load Duration Curve Methodology applied to the Ft. Loudoun Watershed.

9.4 Additional Monitoring

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

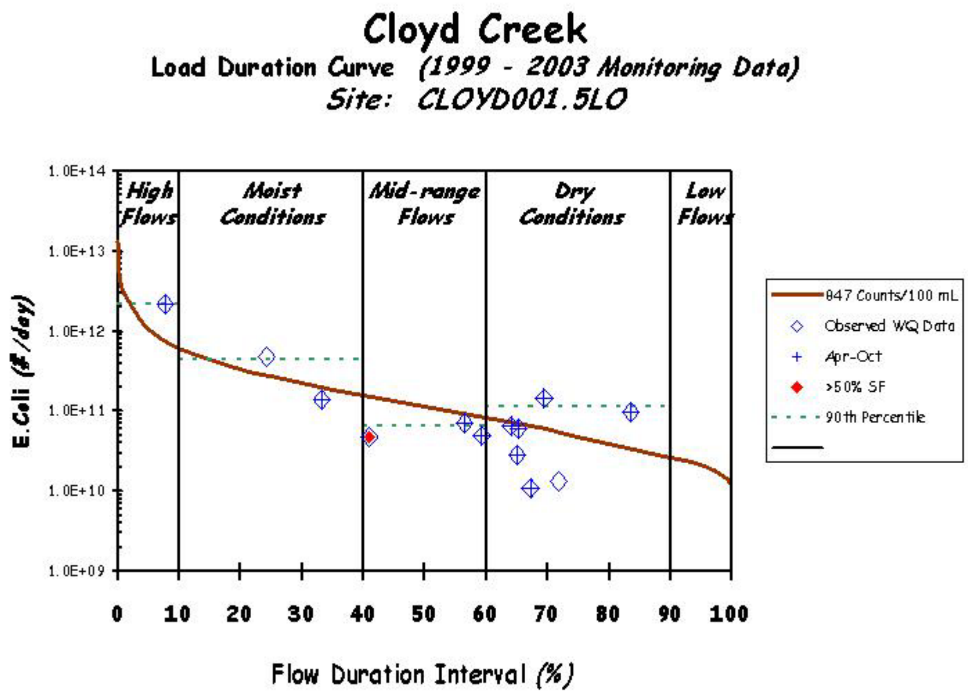

Figure 10. Load Duration Curve for Cloyd Creek Implementation.

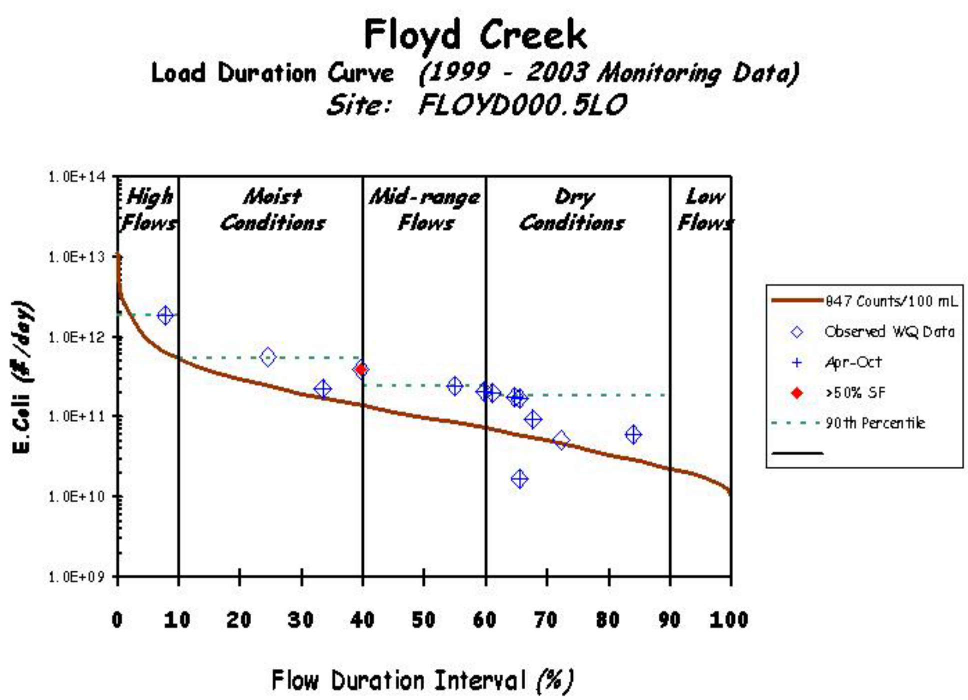

Figure 11. Load Duration Curve for Floyd Creek Implementation.

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

Additional sampling for both fecal coliform and E. coli is recommended to aid in a better understanding of the relationship between fecal coliform concentration and E. coli concentration. Once a better understanding has been achieved, a statewide or regional standard, similar to the translator function developed by the Virginia Department of Environmental Quality, may be developed for Tennessee (VDEQ, 2003).

Additional monitoring and assessment activities are recommended for the Cloyd Creek and Floyd Creek subwatersheds. Examination of monitoring data indicates that few sampling events have occurred during moist conditions or 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 E. coli impaired waterbodies.

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

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

A multi-disciplinary group of researchers is developing and testing a series of different microbial assay methods based on real-time PCR to detect fecal bacterial concentrations and host sources in water samples (McKay, 2005). The assays have been used in a study of fecal contamination and have proven useful in identification of areas where cattle represent a significant fecal input and in development of BMPs. It is expected that these types of assays could have broad applications in monitoring fecal impacts from Animal Feeding Operations, as well as from wildlife and human sources. Other BST projects have been conducted or are currently in progress throughout the state of Tennessee, as presented in sessions of the Thirteenth Tennessee Water Resources Symposium (Lawrence, 2003) and the Fifteenth Tennessee Water Resources Symposium (Bailey, 2005; Farmer, 2005; McKay, 2005).

9.6 Evaluation of TMDL Effectiveness

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

Table 9. Load Duration Curve Summary for E.Coli and/or Fecal Coliform Impaired Segments

Flow Condition		High	Moist	Mid-range	Dry	Low
% Time Flow Exceeded		0-10	10-40	40-60	60-90	90-100
Floyd Creek	% Samples > 941 Counts/100 mL[1]	100.0	100.0	100.0	71.4	0.0
	Reduction[2]	>65.0%	55.4%	>65.0%	>65.0%	0.0%
Cloyd Creek	% Samples > 941 Counts/100 mL[1]	100.0	50.0	0.0	28.6	0.0
	Reduction[2]	>65.0%	36.4%	0.0%	60.8%	0.0%
Example Implementation Strategies						
Municipal NPDES			L	M	H	H
Stormwater Management			H	H	H	
SSO Mitigation		H	H	M	L	
Collection System Repair			L	M	H	H
Septic System Repair			L	M	H	M
Livestock Exclusion[3]				M	H	H
Pasture Management/Land Application of Manure[3]		H	H	M	L	
Riparian Buffers[3]			H	H	H	
		Potential for source area contribution under given hydrologic condition (H: High; M: Medium; L: Low)				

[1] Tennessee maximum daily water quality standard for E.coli (941 Counts/100 mL).
[2] Reductions based on analyses of observed values in each range (see Appendix E).
[3] Example Best Management Practices (BMPs) for Agricultural Source reduction. Actual BMPs applied may vary.

10.0 PUBLIC PARTICIPATION

In accordance with 40 CFR §130.7, the proposed pathogen TMDLs for the Ft. Loudoun Lake 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 were 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) 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:

   Blount County, Tennessee (TNS075116)
   Loudon County, Tennessee (TNS075591)
   Tennessee Dept. of Transportation (TNS077585)

4) Notice of the availability of the proposed TMDL was sent to the Little River Watershed Association in Maryville, Tennessee. The Little River Watershed Association (LRWA) is a community organization that works to protect, preserve, and enhance resources located within and near the Little River watershed.

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 Ft. Loudoun Lake Watershed

Table A-1. MRLC Land Use Distribution of Ft. Loudoun Lake Subwatersheds

Land Use	Ft. Loudoun Lake Subwatersheds			
	Cloyd Creek		Floyd Creek	
	[acres]	[%]	[acres]	[%]
Bare Rock/Sand/Clay	0	0.0	0	0.0
Deciduous Forest	1,171	22.1	1,233	26.8
Emergent Herbaceous Wetlands	0	0.0	0	0.0
Evergreen Forest	886	16.7	760	16.5
High Intensity Commercial/Industrial/Transp.	25	0.5	40	0.9
High Intensity Residential	0	0.0	0	0.0
Low Intensity Residential	29	0.5	6	0.1
Mixed Forest	1,142	21.5	1,121	24.4
Open Water	2	0.0	1	0.0
Other Grasses (Urban/recreation; e.g. parks)	40	0.8	0	0.0
Pasture/Hay	1,614	30.4	1,086	23.6
Quarries/Strip Mines/Gravel Pits	0	0.0	0	0.0
Row Crops	396	7.5	349	7.6
Transitional	0	0.0	0	0.0
Woody Wetlands	0	0.0	0	0.0
Total	5,306	100.0	4,597	100.0

APPENDIX B

Relationship between Concentrations of Fecal Coliform & E. Coli

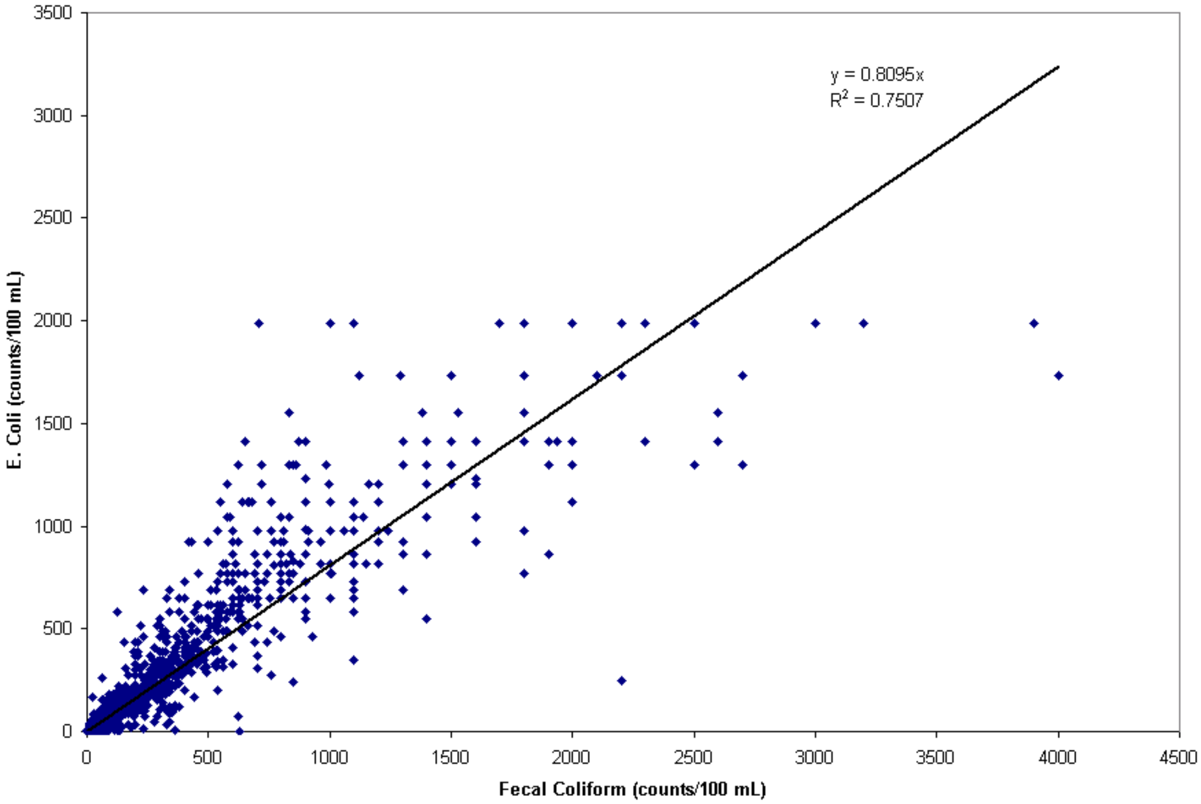

Figure B-1. Comparison of Fecal Coliform and E. Coli Concentrations for the entire Ft. Loudoun Lake Watershed

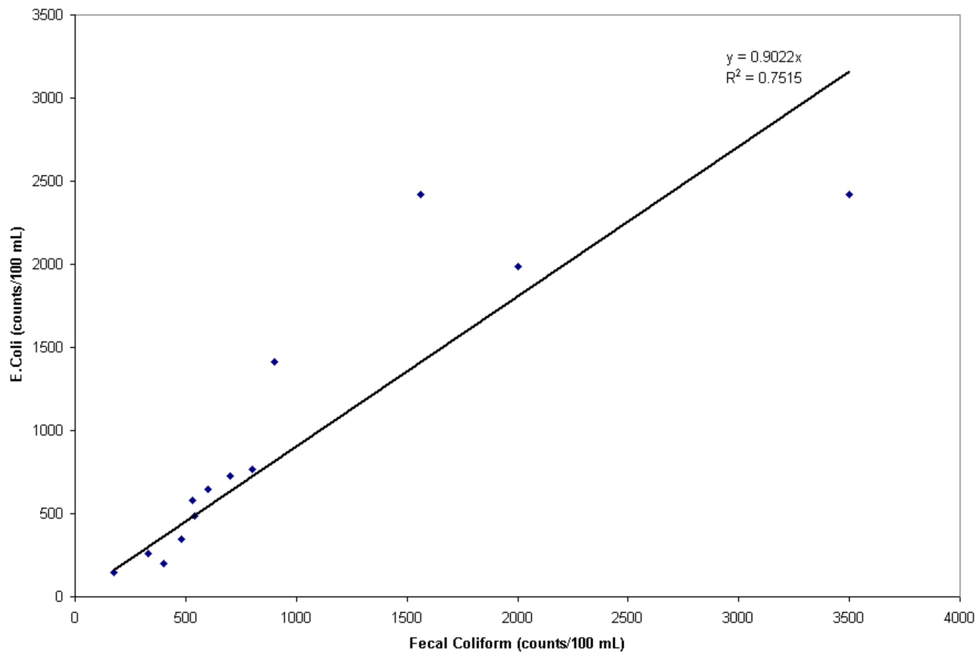

Figure B-2. Comparison of Fecal Coliform and E. Coli Concentrations for Cloyd Creek

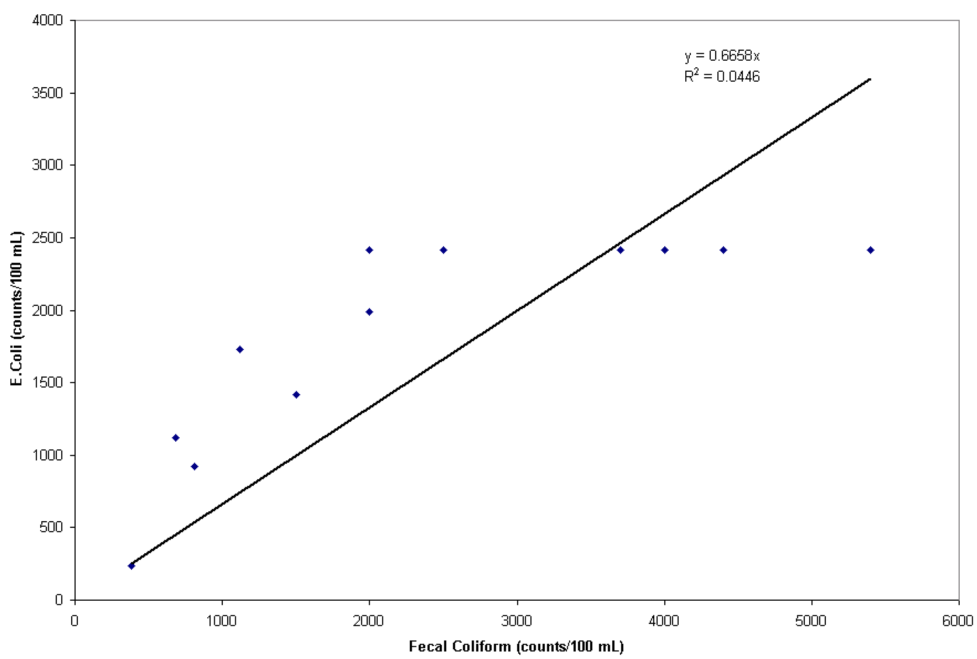

Figure B-3. Comparison of Fecal Coliform and E. Coli Concentrations for Floyd Creek

APPENDIX C

Water Quality Monitoring Data

There are a number of water quality monitoring stations that provide data for waterbodies identified as impaired for pathogens in the Ft. Loudoun Lake watershed. The location of these monitoring stations is shown in Figure 5. Monitoring data recorded at these stations for Fecal Coliform and Escherichia Coli (E. Coli) are tabulated in Table C-1.

Table C-1. Water Quality Monitoring Data – Ft. Loudoun Lake Subwatersheds

Monitoring Station	Date	Fecal Coliform [cts./100 mL]	E. Coli [cts./100 mL]
CLOYD001.5LO	9/8/99	1560	2419
	8/27/03	480	345
	9/3/03	600	649
	9/18/03	700	727
	9/23/03	3500	>2419
	9/30/03	530	579
	10/7/03	540	488
	10/13/03	800	770
	10/20/03	176	144
	10/22/03	2000	1986
	11/4/03	400	201
	11/18/03	330	261
	11/25/03	900	1414
FLOYD000.5LO	9/8/99	1120	1733
	8/27/03	4000	>2419
	9/3/03	3700	>2419
	9/18/03	380	236
	9/23/03	5400	>2419
	9/30/03	680	1120
	10/7/03	2000	>2419
	10/13/03	4400	>2419
	10/20/03	1500	1414
	10/28/03	2500	>2419
	11/4/03	810	921
	11/18/03	2500	>2419
	11/25/03	2000	1986

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 Ft. Loudoun Lake 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 Ft. Loudoun Lake 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 Ft. Loudoun Lake watershed with a sufficiently long and recent historical record was selected as the basis of the hydrology calibration. The USGS station was selected based on similarity of drainage area, Level IV ecoregion, land use, and topography. The calibration involved comparison of simulated and observed hydrographs until statistical stream volumes and flows were within acceptable ranges as reported in the literature (Lumb, et al., 1994).

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

The results of the hydrologic calibration for Bullrun Creek near Halls Crossroads, USGS Station 03535000, are shown in Table D-1 and Figures D-1 and D-2.

D.4 Margin of Safety

There are two methods for incorporating an MOS in the analysis: a) implicitly incorporate the MOS using conservative model assumptions; or b) explicitly specify a portion of the TMDL as the MOS and use the remainder for allocations. For TMDL analyses, both an explicit and implicit MOS were used. The explicit MOS is equal to 10% of the 1000 counts/100 mL fecal coliform standard and 10% of the 941 counts/100 mL E.coli standard. This results in a target fecal coliform concentration of 900 counts/100 mL and a target e.coli concentration of 847 counts/100 mL. The implicit MOS includes the use of conservative modeling assumptions and a 10-year continuous simulation that incorporates a wide range of meteorological events. Conservative modeling assumptions used include: septic systems discharging directly into the streams; development of the TMDL using loads based on the design flow and fecal coliform permit limits of NPDES facilities; and all land uses connected directly to streams.

Note: In this document, the water quality standard is the instream goal. The term "target concentration" reflects the application of an explicit Margin of Safety (MOS) to the water quality standard. See Section 5.0.

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

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

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

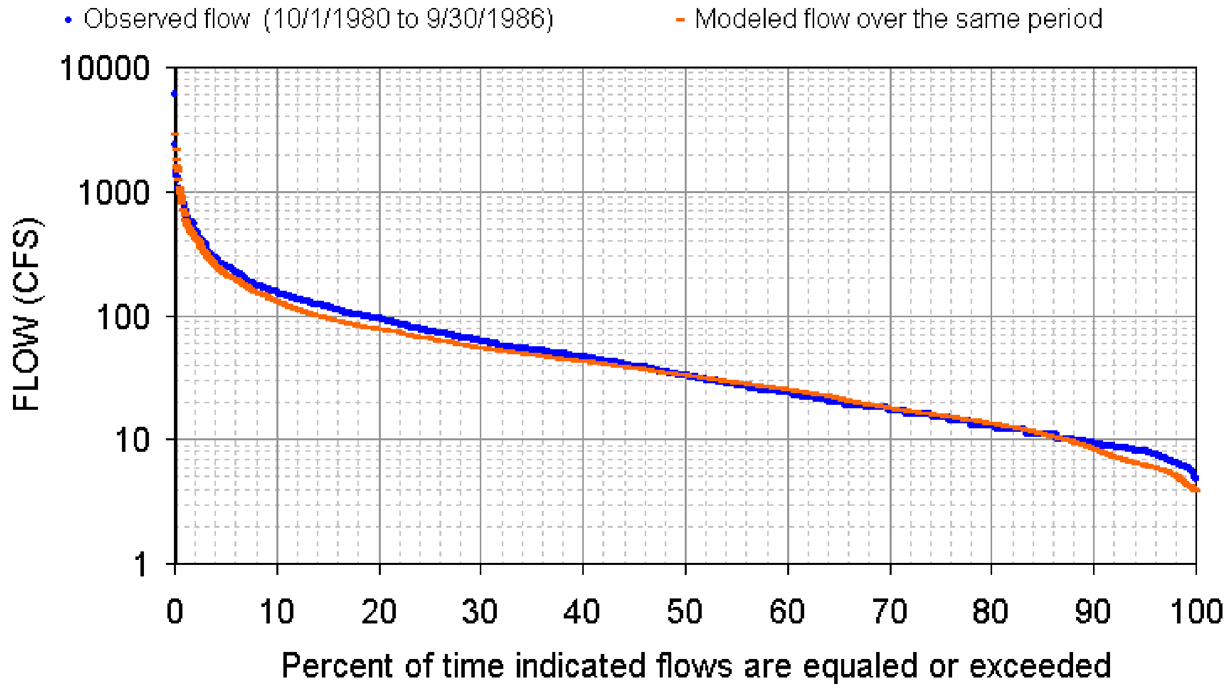

Figure D-1. Hydrologic Calibration: Bullrun Creek, USGS 03535000 (WYs1981-86)

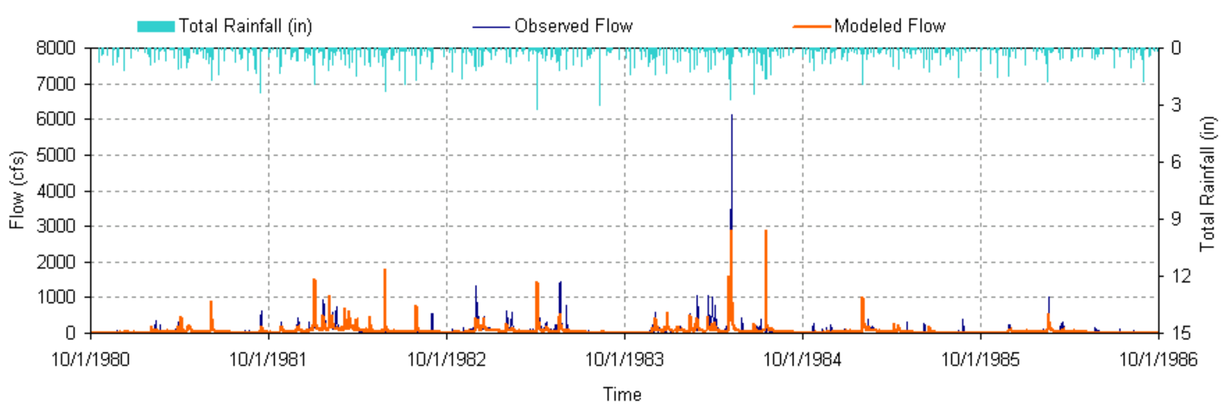

Figure D-2. 6-Year Hydrologic Comparison: Bullrun Creek, USGS 03535000

APPENDIX E

Load Duration Curve Methodology

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 are useful for TMDL analysis:

- Load duration curves can serve as TMDL targets, thereby establishing allowable loading to waterbodies over the entire range of flow.

- Pollutant monitoring data, plotted on a load duration curve, provide a visual depiction of stream water quality with respect to allowable loads. The frequency and magnitude of exceedances are also illustrated.

- Load duration curves can be used to characterize the flow conditions under which exceedances occur. For example, exceedances that occur in the 0% to 10% area of the curve may be considered to represent extreme high flow problems that may be beyond feasible management solutions. Exceedances in the 99% to 100% area reflect extreme drought conditions.

- Different loading mechanisms can dominate at different flow regimes. Exceedances of the load duration curve during high flow conditions may indicate excessive nonpoint source loading associated with rain events, while exceedances at the lower flows can indicate point source problems.

E.1 Development of Flow Duration Curves

Flow duration curves are developed for a waterbody from daily discharges of flow over a period of record. In general, there is a higher level of confidence that curves derived from data over a long period of record correctly represent the entire range of flow. The preferred method of flow duration curve computation uses daily mean data from USGS continuous-record stations located on the waterbody of interest. For ungaged streams, alternative methods must be used to estimate daily mean flow. These include: 1) drainage area extrapolation of data from a nearby continuous-record station of similar size and topography; and 2) calculation of daily mean flow using a dynamic computer model, such as LSPC.

Flow duration curves for impaired waterbodies in the Ft. Loudoun Lake watershed were derived from hydrologic simulations based on parameters derived from calibration at USGS Station No. 03535000, located on Bullrun Creek near Halls Crossroads, in the Lower Clinch watershed. The data used, in each case, included the period of record from 10/1/94 – 9/31/04. The flow duration curves are shown in Figures E-1 and E-2.

E.2 Development of Load Duration Curves

Fecal coliform and E. coli load duration curves for impaired waterbodies in the Ft. Loudoun Lake Watershed were developed from the flow duration curves developed in Section E.1 and available water quality monitoring data. Load duration curves were developed using the following procedure:

1. A load-duration curve was generated for Cloyd Creek by applying the fecal coliform target concentration of 900 cts./100 mL (1,000 cts./100mL - MOS) to each of the ranked flows used to generate the flow duration curve (ref.: Section D.1) and plotting the results. The fecal coliform target load corresponding to each ranked daily mean flow is:

   $(\text{Target Load})_{\text{Cloyd Creek}}$ = (900 cts./100 mL) x (Q) x (UCF)

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

   For E. coli, the target concentration of 847 cts./100 mL was applied to generate load duration curves corresponding to the E. coli water quality standard (see Section 5.0).

2. Daily loads were calculated for each of the water quality samples collected at the monitoring station (ref.: Table C-1) by multiplying the sample concentration by the derived daily mean flow for the sampling date and the required unit conversion factor. Only the most impaired monitoring station in each subwatershed was selected for analysis.

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

3. Using the flow duration curves developed in 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 load duration curves developed in Step 2 according to the PDFE. The resulting fecal coliform and E. coli load duration curves for are shown in Figures E-4 through E-9.

4. For cases where the existing load exceeded the water quality standard, the reduction corresponding to each sample load was determined through comparison with the target load corresponding to the PDFE.

5. The 90th percentile value for the fecal coliform concentration and the E. coli concentration was determined for each impaired subwatershed at the most impaired monitoring station.

6. For cases where the 90th percentile concentration exceeded the water quality standard, the reduction corresponding to the 90th percentile was determined through comparison with the target concentration.

7. The higher of the calculated reductions of existing fecal coliform load and E. coli load, respectively, required to meet the TMDL target for the 90th percentile concentration was considered to be the required load reduction (see Tables E-1 through E-6) in the absence of a higher geometric mean reduction.

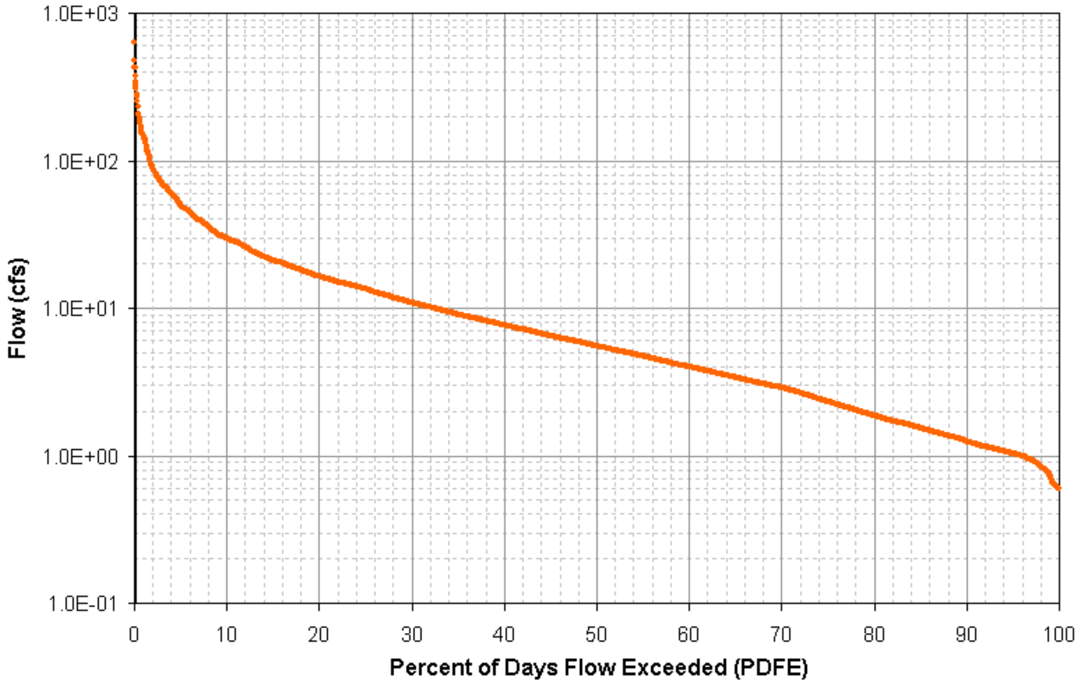

Figure E-1. Flow Duration Curve for Cloyd Creek

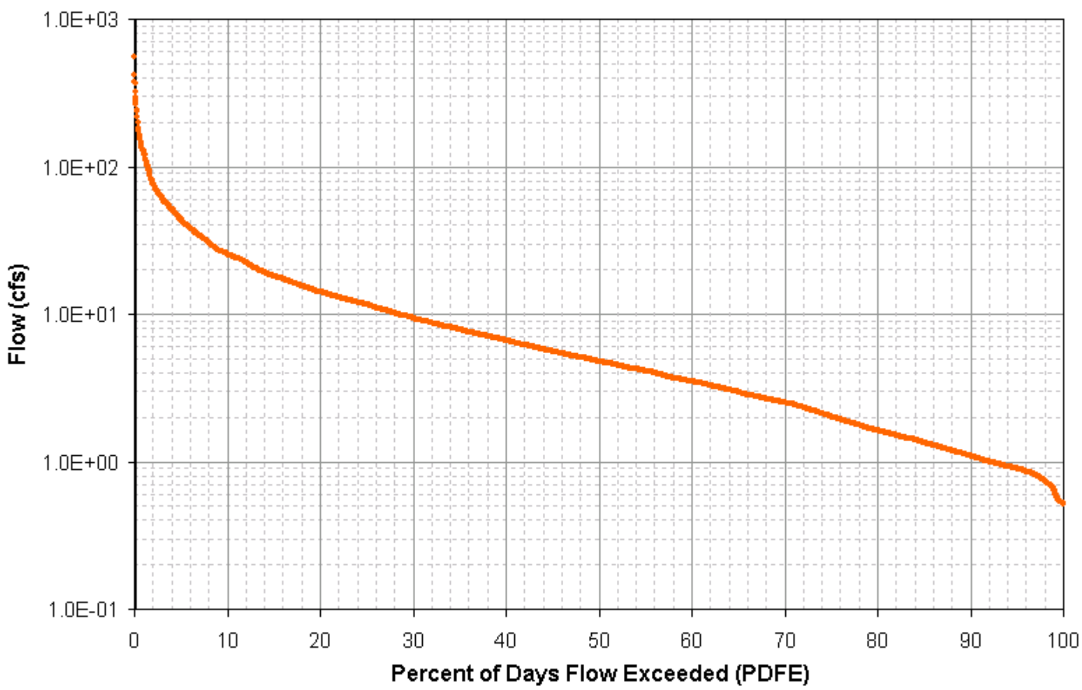

Figure E-2. Flow Duration Curve for Floyd Creek

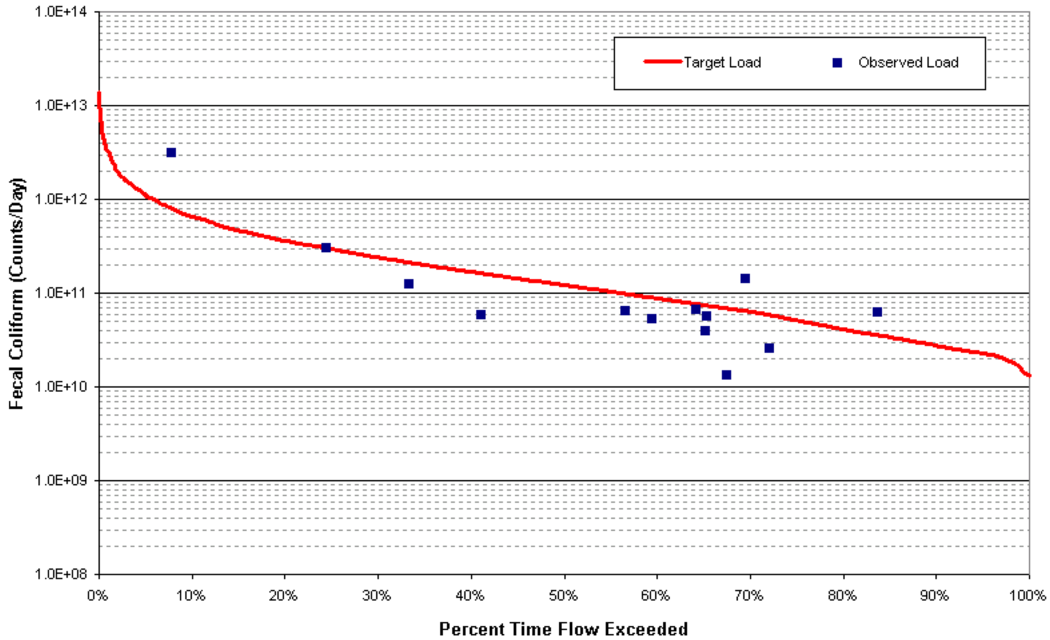

Figure E-3. Fecal Coliform Load Duration Curve for Cloyd Creek

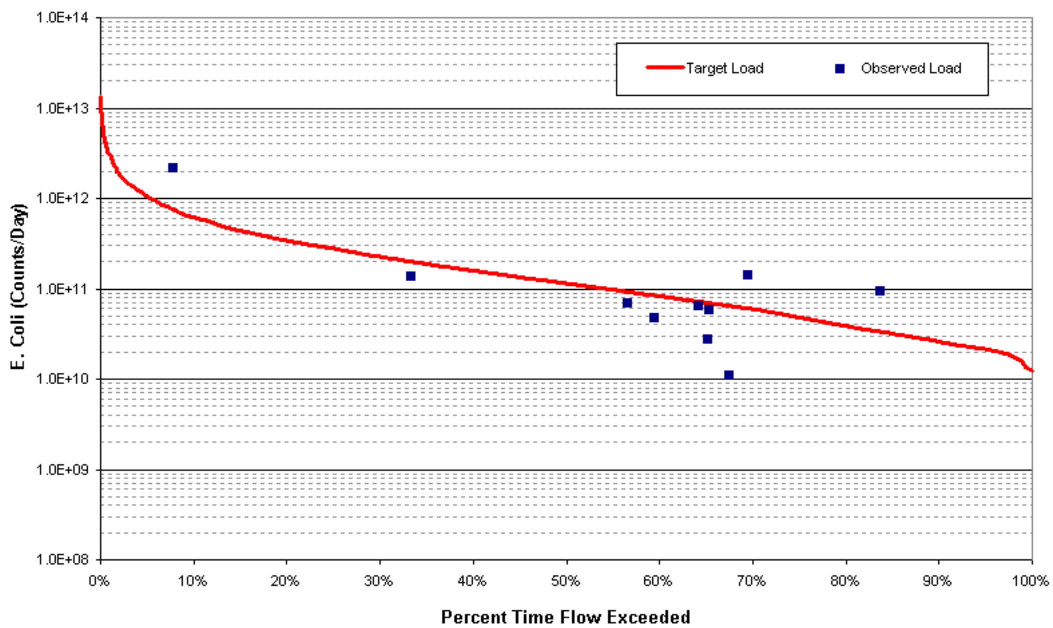

Figure E-4. E. Coli Load Duration Curve for Cloyd Creek

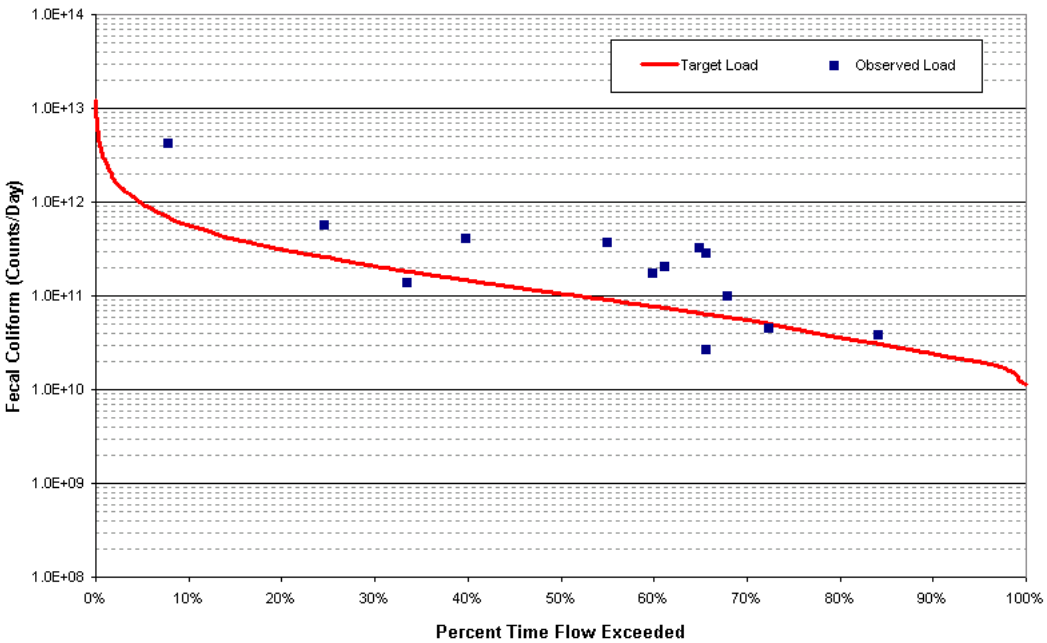

Figure E-5. Fecal Coliform Load Duration Curve for Floyd Creek

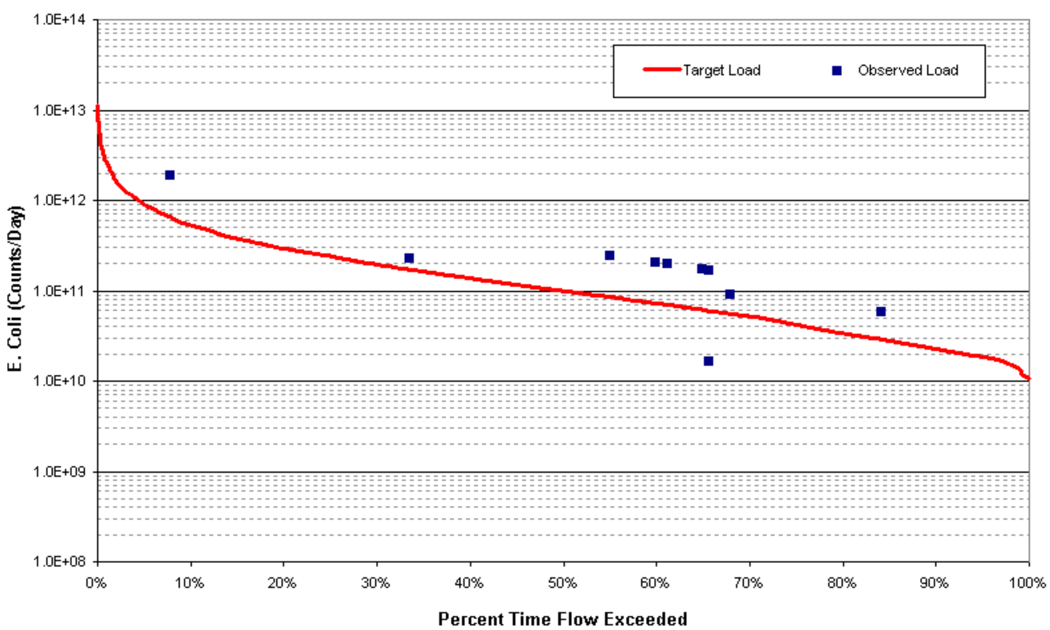

Figure E-6. E. Coli Load Duration Curve for Floyd Creek

Table E-1. Required Reduction for Cloyd creek – Fecal Coliform Analysis

Sample Date	Flow	PDFE	Fecal Coliform			
			Sample Concentration	Required Reduction	Geometric Mean[a]	Required Reduction
	[cfs]	[%]	[cts/100 ml]	[%]	[cts/100 ml]	[%]
9/8/99	1.63	83.6%	**1560**	42.3		
8/27/03	3.35	65.2%	480	**NR**		
9/3/03	4.47	56.5%	600	**NR**		
9/18/03	3.35	65.3%	700	**NR**		
9/23/03	37.05	7.8%	**3500**	74.3		
9/30/03	9.66	33.3%	530	**NR**		
10/7/03	4.09	59.4%	540	**NR**		
10/13/03	3.48	64.2%	800	**NR**	890.81	**79.8**
10/20/03	3.12	67.4%	176	**NR**	675.88	73.4
10/22/03	2.94	69.5%	**2000**	55.0	604.31	70.2
11/4/03	2.67	72.0%	400	**NR**	571.24	68.5
11/18/03	7.38	41.1%	330	**NR**		
11/25/03	13.82	24.4%	900	**NR**		
		90th Percentile	**1912**	**52.9**		

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

Table E-2. Required Reduction for Cloyd Creek – E. Coli Analysis

Sample Date	Flow	PDFE	E. Coli			
			Sample Concentration	Required Reduction	Geometric Mean[a]	Required Reduction
	[cfs]	[%]	[cts/100 ml]	[%]	[cts/100 ml]	[%]
9/8/99	1.63	83.6%	**2419**	65.0		
8/27/03	3.35	65.2%	345	**NR**		
9/3/03	4.47	56.5%	649	**NR**		
9/18/03	3.35	65.3%	727	**NR**		
9/23/03	37.05	7.8%	**>2419**	>65.0		
9/30/03	9.66	33.3%	579	**NR**		
10/7/03	4.09	59.4%	488	**NR**		
10/13/03	3.48	64.2%	770	**NR**	825.19	**86.3**
10/20/03	3.12	67.4%	144	**NR**	596.92	81.1
10/22/03	2.94	69.5%	**1986**	57.4	573.83	80.3
11/4/03	2.67	72.0%	201	**NR**	464.40	75.7
11/18/03	7.38	41.1%	261	**NR**		
11/25/03	13.82	24.4%	**1414**	40.1		
		90th Percentile	**>2332**	**>63.7**		

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

Table E-3. Required Load Reduction for Floyd Creek – Fecal Coliform Analysis

Sample Date	Flow	PDFE	Fecal Coliform			
			Sample Concentration	Required Reduction	Geometric Mean[a]	Required Reduction
	[cfs]	[%]	[cts/100 ml]	[%]	[cts/100 ml]	[%]
9/8/99	1.40	84.1%	**1120**	19.6		
8/27/03	2.88	65.6%	**4000**	77.5		
9/3/03	4.13	54.9%	**3700**	75.7		
9/18/03	2.89	65.6%	380	**NR**		
9/23/03	31.92	7.7%	**5400**	83.3		
9/30/03	8.28	33.5%	680	**NR**		
10/7/03	3.52	59.8%	**2000**	55.0		
10/13/03	3.00	64.8%	**4400**	79.6	1651.33	89.1
10/20/03	2.69	67.8%	**1500**	40.0	2173.18	**91.7**
10/28/03	3.40	61.1%	**2500**	64.0	1862.96	90.3
11/4/03	2.30	72.3%	810	**NR**	1929.30	90.7
11/18/03	6.73	39.7%	**2500**	64.0		
11/25/03	11.81	24.6%	**2000**	55.0		
		90th Percentile	**4320**	**79.2**		

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

Table E-4. Required Load Reduction for Floyd Creek – E. Coli Analysis

Sample Date	Flow	PDFE	E. Coli			
			Sample Concentration	Required Reduction	Geometric Mean[a]	Required Reduction
	[cfs]	[%]	[cts/100 ml]	[%]	[cts/100 ml]	[%]
9/8/99	1.40	84.1%	**1733**	51.1		
8/27/03	2.88	65.6%	**>2419**	>65.0		
9/3/03	4.13	54.9%	**>2419**	>65.0		
9/18/03	2.89	65.6%	236	**NR**		
9/23/03	31.92	7.7%	**>2419**	>65.0		
9/30/03	8.28	33.5%	**1120**	24.4		
10/7/03	3.52	59.8%	**>2419**	>65.0		
10/13/03	3.00	64.8%	**>2419**	>65.0	1301.99	91.3
10/20/03	2.69	67.8%	**1414**	40.1	1862.58	**93.9**
10/28/03	3.40	61.1%	**>2419**	>65.0	1862.58	**93.9**
11/4/03	2.30	72.3%	921	**NR**	1791.11	93.7
11/18/03	6.73	39.7%	**>2419**	>65.0		
11/25/03	11.81	24.6%	**1986**	57.4		
		90th Percentile	**>2419**	**>65.0**		

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

APPENDIX F

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 other appropriate measure.

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

- $[\sum WLAs]_{WWTF}$ 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.

- $[\sum WLAs]_{CAFO}$ is the allowable load for all CAFOs in an impaired subwatershed. Since discharges from a CAFO liquid waste handling facility to waters of the state during a chronic or catastrophic rainfall event (in excess of a 25-year, 24-hour rainfall event), or as a result of an unpermitted discharge, upset, or bypass of the system, are not to cause or contribute to an exceedance of Tennessee water quality standards, the WLA = 0.

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

LA terms include:

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

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

Explicit MOS has already been incorporated into TMDL development as stated in Appendix E and Appendix F. TMDLs, WLAs, & LAs are applied to the entire subwatershed. WLAs & LAs for Ft. Loudoun Lake waterbodies are summarized in Table F-1.

Table F-1. WLAs & LAs for Ft. Loudoun Lake, Tennessee

HUC-12 Subwatershed (06010201__) or Drainage Area	Impaired Waterbody	Impaired Waterbody ID	TMDL	WLAs		LAs	
				Leaking Collection Systems[a]	MS4s[b]	Precipitation Induced Nonpoint Sources	Other Direct Sources[c]
			[% Red.]	[cts./day]	[% Red.]	[% Red.]	[cts./day]
0301	FLOYD CREEK	TN06010201083 – 1000	***93.9***	**NA**	***93.9***	***93.9***	**0**
	CLOYD CREEK	TN060102011015 – 1000					

a. *The objective for leaking collection systems is a waste load allocation of zero. It is recognized, however, that a WLA of 0 counts/day may not be practical. For these sources, the WLA is interpreted to mean a reduction in coliform loading to the maximum extent practicable, consistent with the requirement that these sources not contribute to a violation of the water quality standard for fecal coliform and/or E. coli.*
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 fecal coliform and/or E. coli.*
d. *Load reductions were determined based on comparison of the geometric mean of all monitoring data (excluding highest and lowest values)to the 30-day geometric mean target concentrations. Additional monitoring is recommended.*

APPENDIX G

Public Notice Announcement

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

PUBLIC NOTICE OF AVAILABILITY OF PROPOSED TOTAL MAXIMUM DAILY LOAD (TMDL) FOR PATHOGENS IN FLOYD CREEK AND CLOYD CREEK FORT LOUDOUN LAKE WATERSHED (HUC 06010201), TENNESSEE

Announcement is hereby given of the availability of Tennessee's proposed Total Maximum Daily Load (TMDL) for pathogens in the Fort Loudoun 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.

Floyd Creek and Cloyd Creek are listed on Tennessee's Proposed Final 2004 303(d) list as not supporting designated use classifications due, in part, to discharge of pathogens from pasture land and livestock in stream. 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 85-95% in the listed waterbodies.

The proposed Fort Loudoun Lake pathogen TMDL may be downloaded from the Department of Environment and Conservation website:

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

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

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

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

Persons wishing to comment on the proposed TMDLs are invited to submit their comments in writing no later than June 13, 2005 to:

Division of Water Pollution Control
Watershed Management Section
6th Floor, L & C Annex
401 Church Street
Nashville, TN 37243-1534

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

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