TOTAL MAXIMUM DAILY LOAD (TMDL)

For

Fecal Coliform

In

Cane Creek and Swan Creek

Located in the

Upper Elk River Watershed (HUC 06030003)
Lincoln and Marshall Counties, Tennessee

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TABLE OF CONTENTS

APPENDICES

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

BMP	Best Management Practices
CFR	Code of Federal Regulations
DEM	Digital Elevation Model
DMR	Discharge Monitoring Report
EAC	Environmental Assistance Center
EPA	Environmental Protection Agency
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 C++
MEP	Maximum Extent Practicable
MOS	Margin of Safety
MRLC	Multi-Resolution Land Characteristic
MS4	Municipal Separate Storm Sewer System
MSSA	Monteagle Sunday School Assembly
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
Rf3	Reach File 3
STP	Sewage Treatment Plant
TDA	Tennessee Department of Agriculture
TDEC	Tennessee Department of Environment & Conservation
TMDL	Total Maximum Daily Load
TWRA	Tennessee Wildlife Resources Agency
USGS	United States Geological Survey
WCS	Watershed Characterization System
WLA	Waste Load Allocation
WWTF	Waste Water Treatment Facility
WY	Water Year

SUMMARY SHEET
Total Maximum Daily Load (TMDL)

1. 303(d) Listed Waterbody Information

State: Tennessee
Counties: Lincoln and Marshall

Watershed: Upper Elk River (HUC 06030003)

1998 303(d) List :

Waterbody ID	Segment Name	Designated Use	
		Partially Supporting [mi.]	Not Supporting [mi.]
TN06030003063	Swan Creek	82.6	

Proposed Final 2002 303(d) List :

Waterbody ID	Segment Name	Designated Use	
		Partially Supporting [mi.]	Not Supporting [mi.]
TN06030003060-1000	Cane Creek		44.5
TN06030003063-2000	Swan Creek	9.9	

Constituent(s) of Concern: Fecal Coliform Bacteria

Designated Uses: All waterbodies are classified for Fish & Aquatic Life, Recreation, Irrigation, and Livestock Watering & Wildlife.

Applicable Water Quality Standard for Recreation (most stringent standard):

> The concentration of the fecal coliform group shall not exceed 200 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. In addition, the concentration of the fecal coliform group in any individual sample shall not exceed 1,000 per 100 mL.

2. TMDL Development

Analysis/Modeling: The Loading Simulation Program C++ (LSPC) was used to develop the TMDLs. An hourly timestep was used to simulate hydrologic and water quality conditions with results expressed as daily averages.

Critical Conditions: A simulation period of 10 years was used to assess the water quality standards representing a range of hydrologic and meteorological conditions.

Seasonal Variation: A simulation period of 10 years was used to assess the water quality standards. This period includes seasonal variations.

3. TMDLs, WLAs, and LAs:

1998 303(d) List:

Waterbody ID	Waterbody Name	TMDL	WLAs	LAs	In-Stream Fecal Coliform Concentration
		[Counts/30 days]	[Counts/30 days]	[Counts/30 days]	[% Reduction]
TN06030003063	Swan Creek	1.195E+13	1.636E+09	1.195E+13	77.1

Proposed Final 2002 303(d) List:

Waterbody ID	Waterbody Name	TMDL	WLAs	LAs	In-Stream Fecal Coliform Concentration
		[Counts/30 days]	[Counts/30 days]	[Counts/30 days]	[% Reduction]
TN06030003060-1000	Cane Creek	2.589E+13	0	2.589E+13	74.0
TN06030003063-2000	Swan Creek	1.195E+13	1.636E+09	1.195E+13	77.1

TOTAL MAXIMUM DAILY LOAD (TMDL) FOR FECAL COLIFORM UPPER ELK RIVER WATERSHED (HUC 06030003)

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 meeting designated uses. The TMDL process establishes the allowable loadings of pollutants or other quantifiable parameters for a waterbody based on the relationship between pollution sources and in-stream water quality conditions, so that states can establish water quality based controls to reduce pollution from both point and nonpoint sources and restore and maintain the quality of their water resources (USEPA, 1991).

2.0 WATERSHED DESCRIPTION

The Upper Elk River watershed (HUC 06030003) is located in southern middle Tennessee (Figure 1). The watershed falls within the Level III Interior Plateau (71) and Southwestern Appalachians (68) ecoregions. The Cane Creek and Swan Creek subwatersheds lie entirely in the Level IV Outer Nashville Basin (71h) subecoregion. Subecoregion 71h is a heterogeneous region characterized by rolling and hilly topography, having streams of low to moderate gradient, with productive, nutrient-rich waters.

The Cane Creek subwatershed has a drainage area of approximately 105.7 square miles (mi^2) and the Swan Creek subwatershed has a drainage area of approximately 50.2 mi^2 (Figure 3). 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. Land use is summarized in Table 1 and shown in Figure 4. Predominate land use in the Cane Creek and Swan Creek subwatersheds is forest (55.0% and 61.4%, respectively) followed by agriculture (44.4% and 38.5%). Urban areas represent less than 1.0% (0.6% and 0.1%) of the total drainage area of each subwatershed (Figure 5).

3.0 PROBLEM DEFINITION

EPA Region IV approved Tennessee's final 1998 303(d) list (TDEC, 1998) on September 17, 1998. The list identified one segment of the Upper Elk River watershed, Swan Creek, as not fully supporting designated use classifications due, in part, to pathogens (Figure 6). In addition, the Proposed Final 2002 303(d) List (TDEC, 2002), identified an additional segment of Upper Elk River, Cane Creek, as not fully supporting designated use classifications due, in part, to pathogens (Figure 7). The fecal coliform group is an indicator of the presence of pathogens in a stream. Therefore, the objective of this study is to develop fecal coliform TMDLs for listed waterbodies in the Upper Elk River watershed.

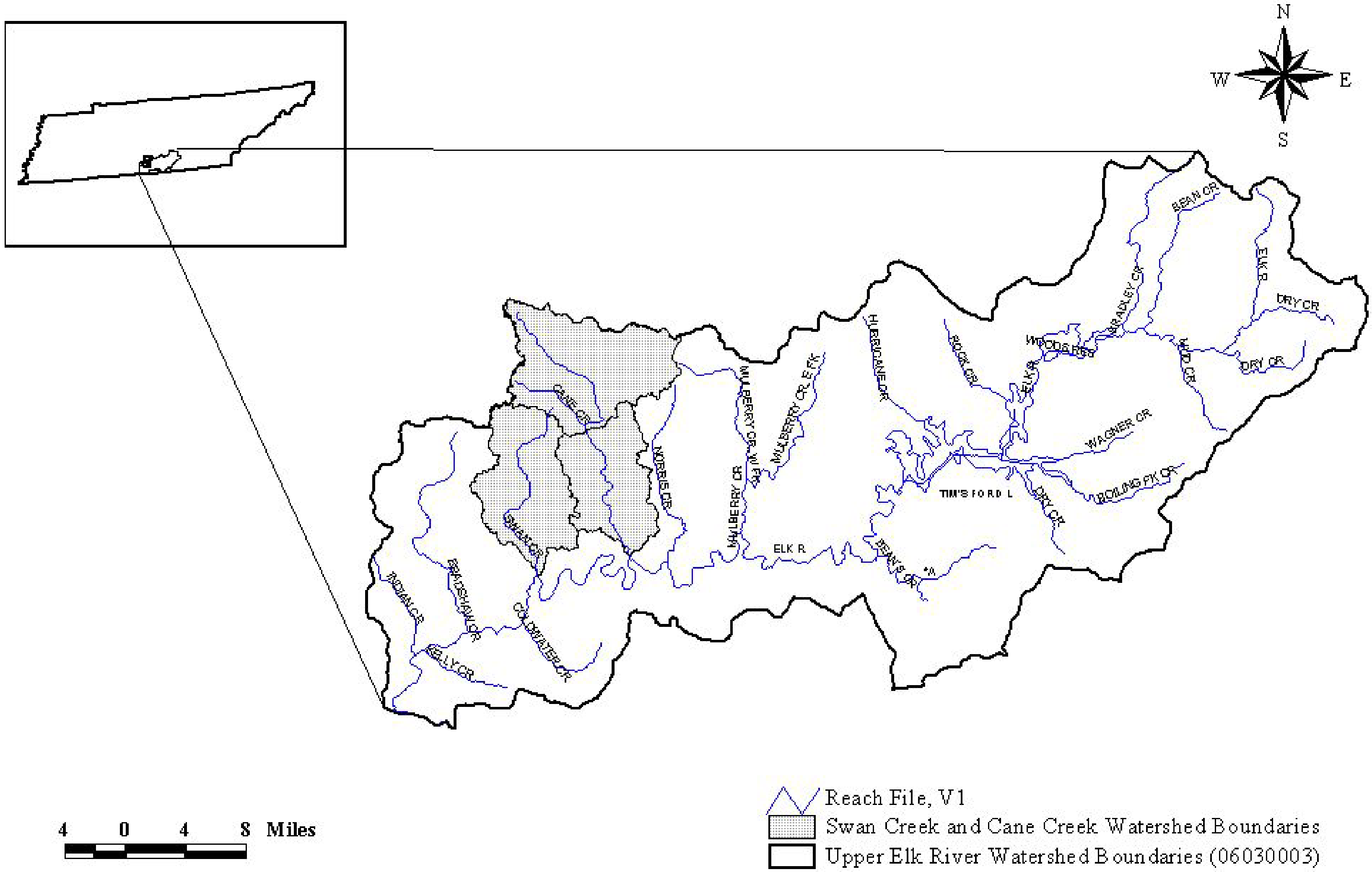

Figure 1. Location of the Upper Elk River Watershed.

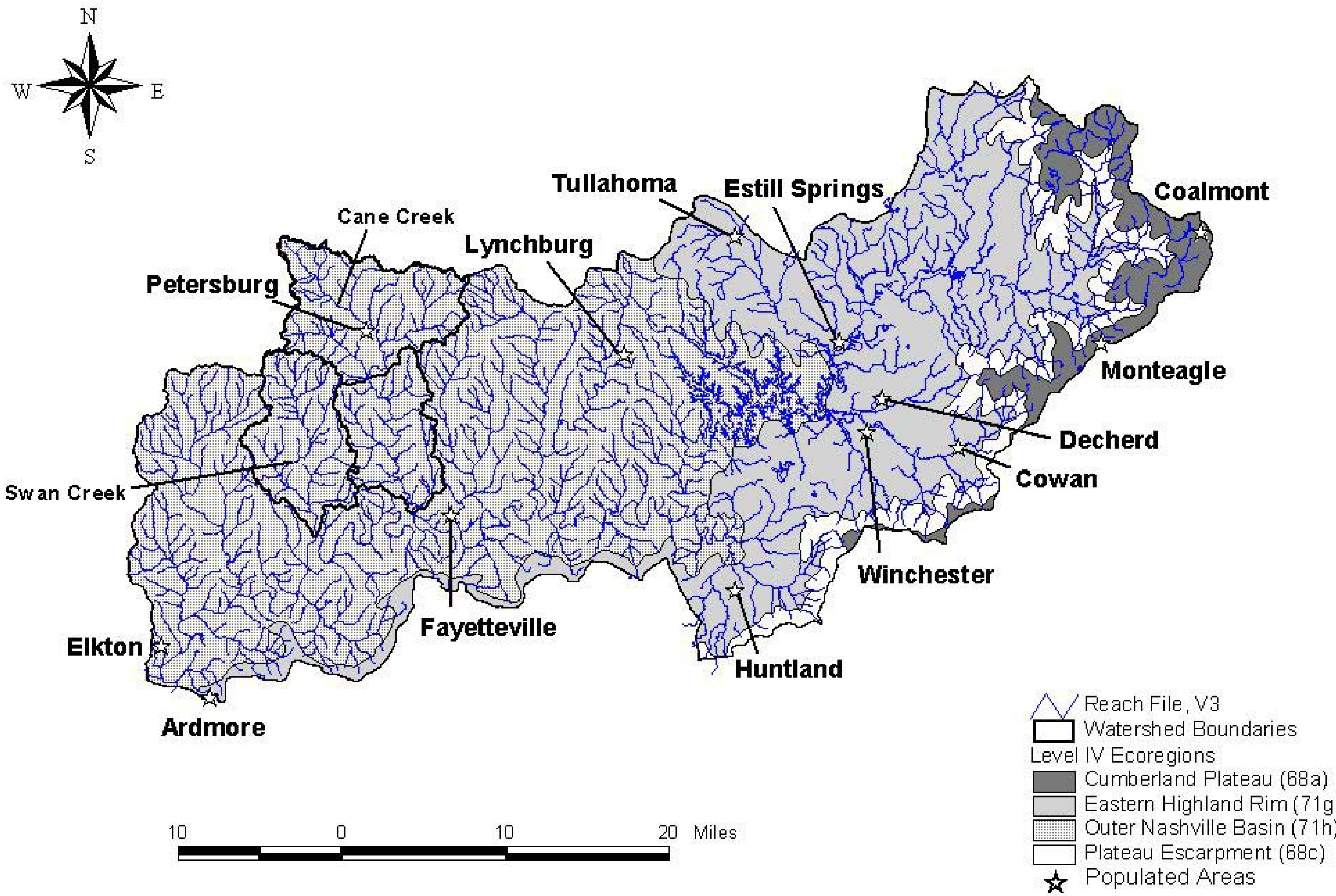

Figure 2. Level IV Ecoregions in the Upper Elk River Watershed.

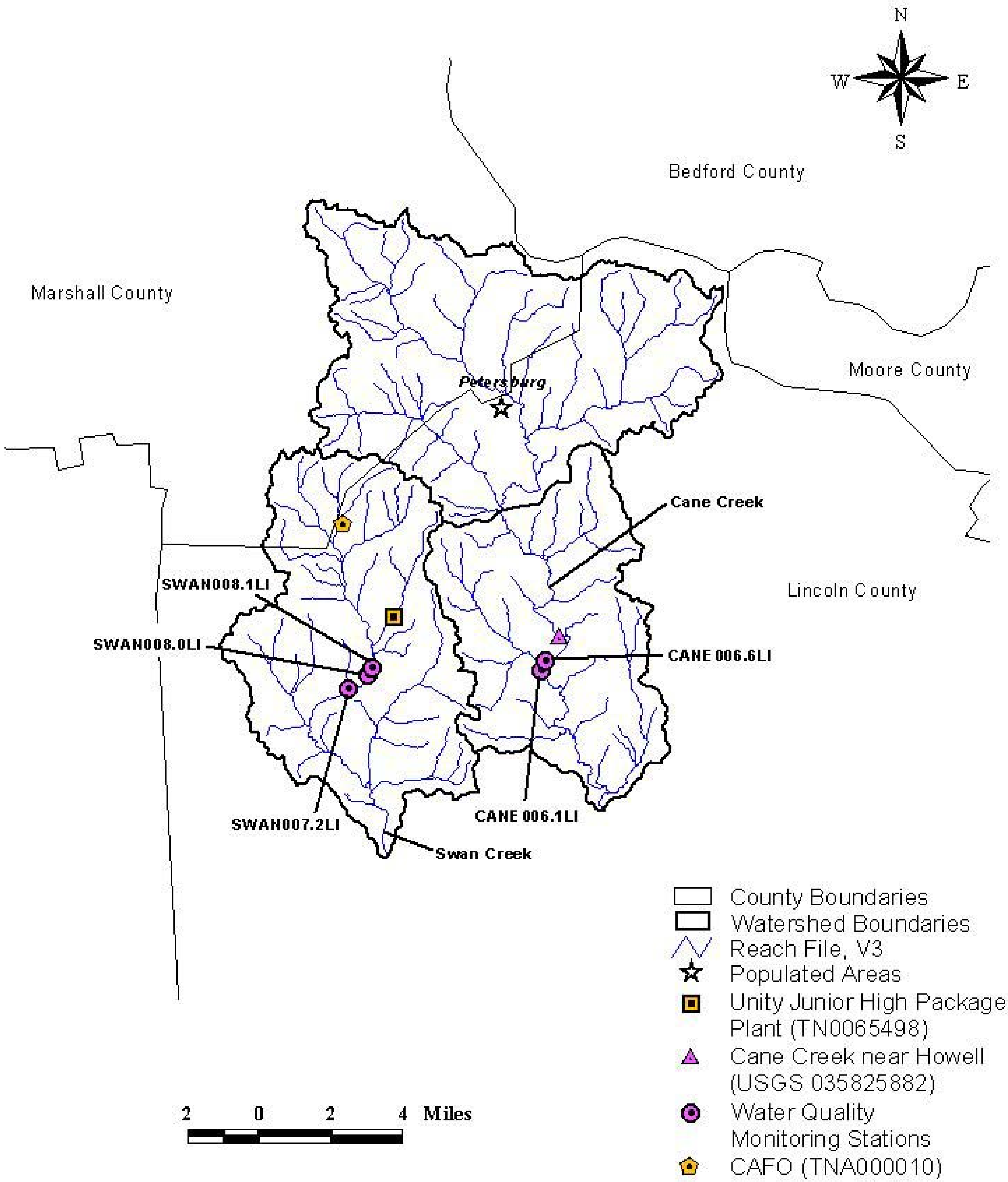

Figure 3. Swan Creek and Cane Creek Watershed Boundaries.

Table 1. MRLC Land Use Distribution by Subwatershed

	Cane Creek		Swan Creek	
Land Use	Area (ac)	%	Area (ac)	%
Deciduous Forest	17,328	25.6	8917	27.7
Emergent Herbaceous Wetlands	2	0.0[1]	0	0
Evergreen Forest	5206	7.7	3118	9.7
High Intensity Comm./Industrial/ Transportation	128	0.2	11	0.0[1]
High Intensity Residential	14	0.0[1]	0	0
Low Intensity Residential	208	0.3	28	0.1
Mixed Forest	14,060	20.8	7685	23.9
Open Water	22	0.0[1]	8	0.0[1]
Other Grasses (Urb./recreation; e.g. parks, lawns)	167	0.2	0	0
Pasture/Hay	24,403	36.1	9991	31.1
Quarries/Strip Mines/Gravel Pits	32	0.0[1]	0	0
Row Crops	5586	8.3	2363	7.4
Transitional	36	0.1	0	0
Woody Wetlands	459	0.7	17	0.1
Total (mi^2)	67,650 (105.7)	100	32,138 (50.2)	100

[1] < 0.05 %.

4.0 TARGET IDENTIFICATION

The designated use classifications for waterbodies in the Upper Elk River watershed include Fish & Aquatic Life, Recreation, Irrigation, and Livestock Watering & Wildlife. Of the use classifications with numeric criteria for fecal coliform bacteria, the recreation use classification is the most stringent and will be used as the target level for TMDL development. The fecal 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, October, 1999*. Section 1200-4-3-.03 (4) (f) states that the concentration of the fecal coliform group shall not exceed 200 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. In addition, the concentration of the fecal coliform group in any individual sample shall not exceed 1,000 per 100 mL. The geometric mean and instantaneous maximum standards are the target values for the TMDLs.

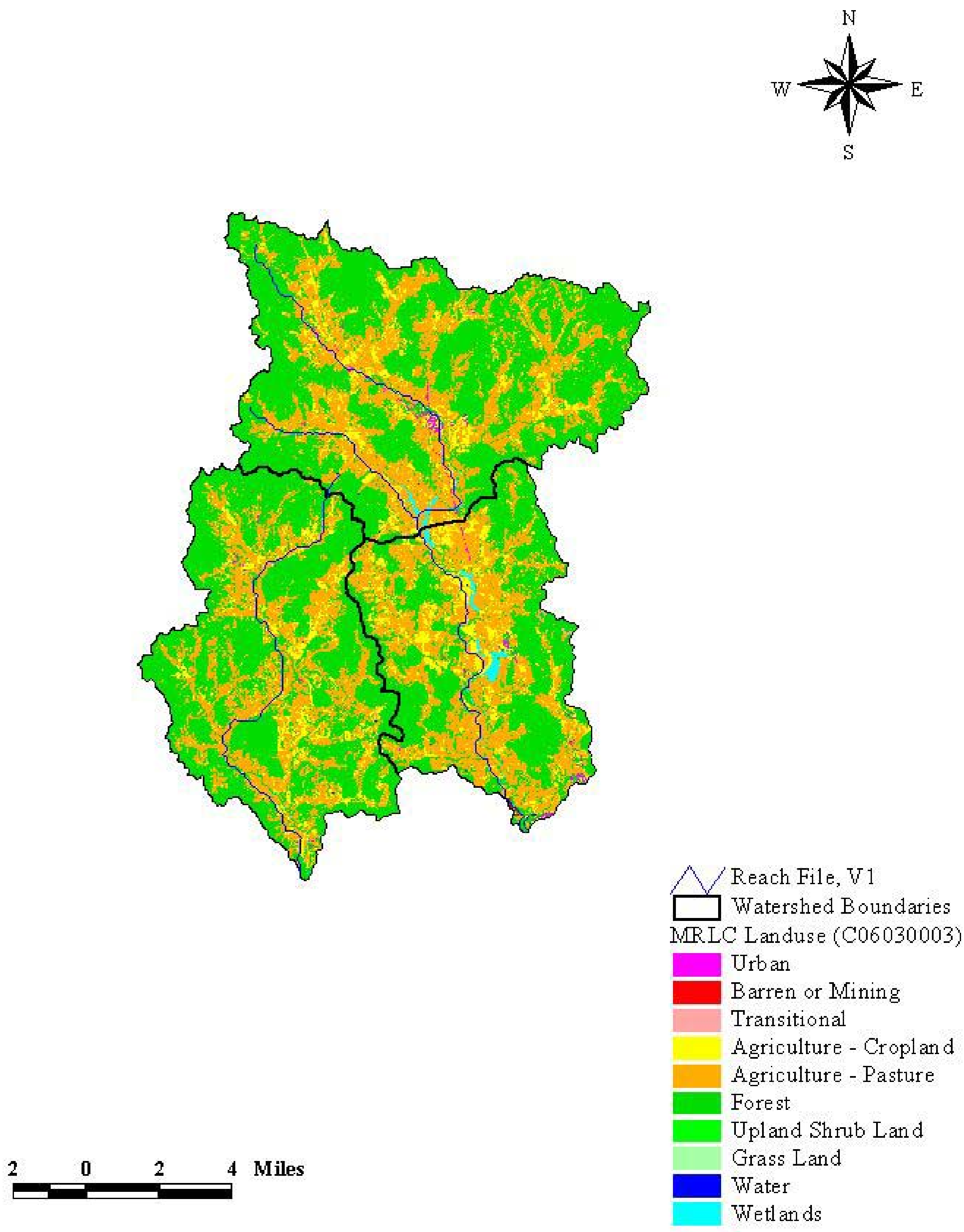

Figure 4. Land Use Distribution.

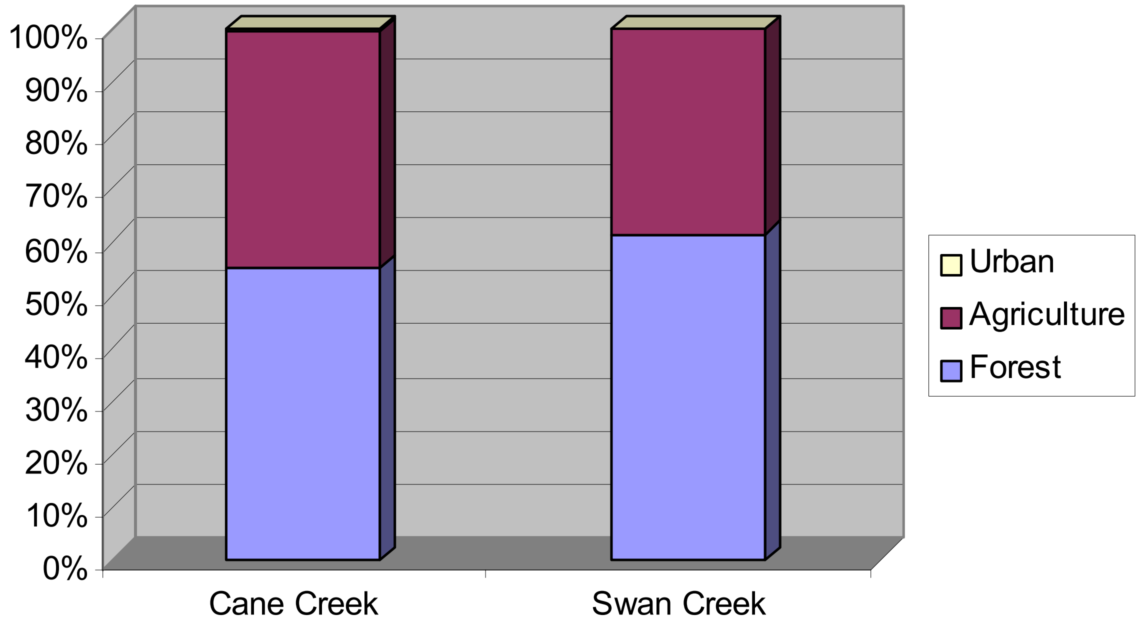

Figure 5. Landuse Distribution in the Cane Creek and Swan Creek Subwatersheds.

5.0 WATER QUALITY ASSESSMENT AND DEVIATION FROM TARGET

Limited fecal coliform water quality data have been collected in the Cane Creek and Swan Creek subwatersheds in recent history (Table 2) (Figure 3). At USGS 035825882, Cane Creek, located at approximately mile 7.9, ten samples were collected from January to September 1999. Five other monitoring locations on Cane Creek (2) and Swan Creek (3) have between 1 and 12 fecal coliform samples, most collected during 2002 and 2003. Individual samples exceeded the 1000 counts/100 mL maximum at Cane Creek mile 7.9 (USGS 035825882) and at two of the Swan Creek water quality sampling locations (Appendix A). Consequently, Cane Creek and Swan Creek were scheduled for TMDL evaluation.

Table 2. Water Quality Monitoring Data.

Watershed/Sampling Location (Mile)	Samples (#)	Samples >200[1] (%)	Samples >1000[1] (%)	Concentration (Counts/100 mL)	
				Minimum	Maximum
Cane Creek (6.1)	1	0	0	150	150
Cane Creek (6.6)	12	33	0	29	760
Cane Creek (7.9)	10	70	50	43	21000
Swan Creek (7.2)	2	0	0	93	110
Swan Creek (8.0)	6	50	33	28	4600
Swan Creek (8.1)	6	50	17	46	15000

[1] Counts/100 mL

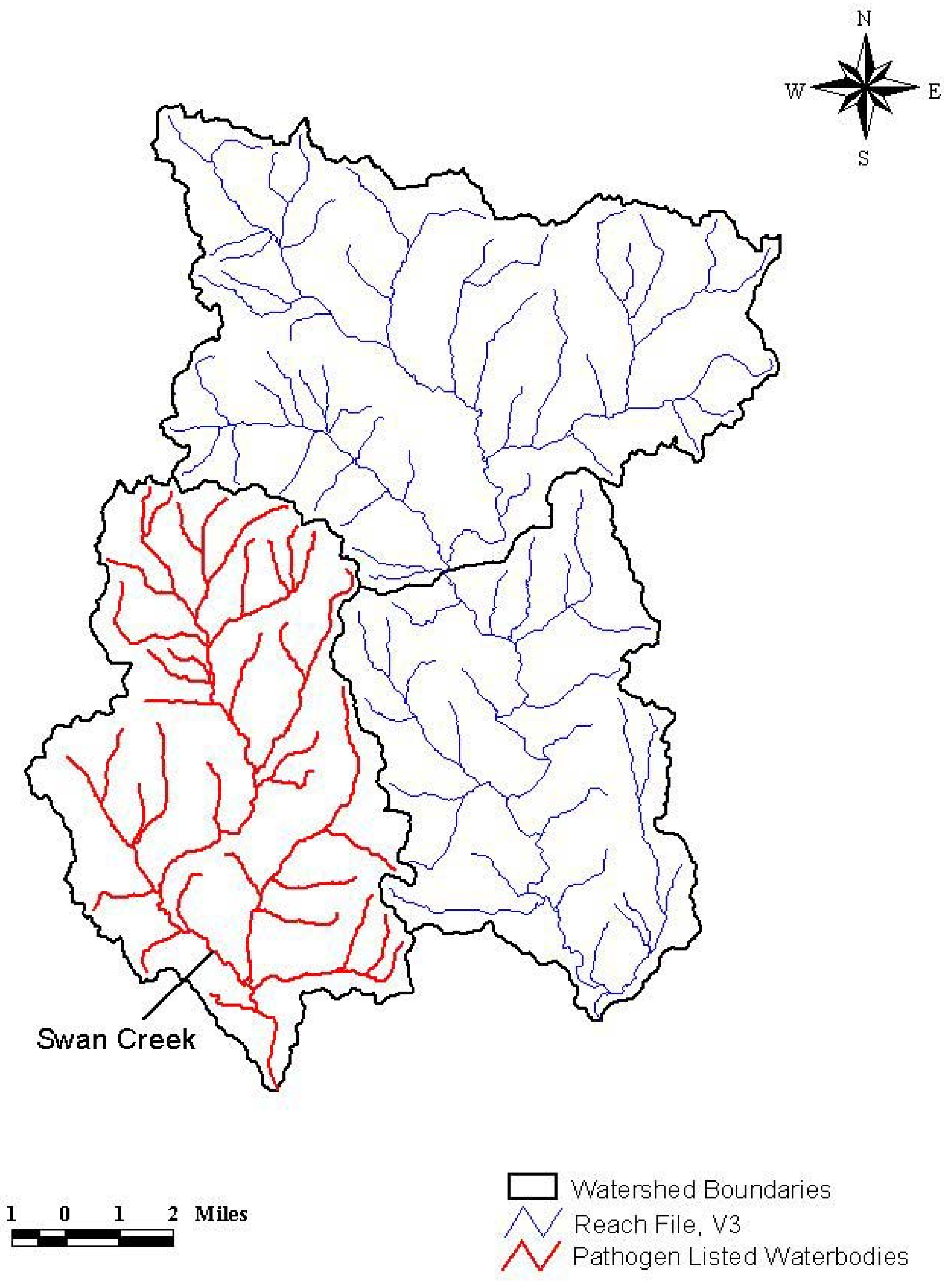

Figure 6. Waterbodies Listed for Pathogens on the 1998 303(d) List.

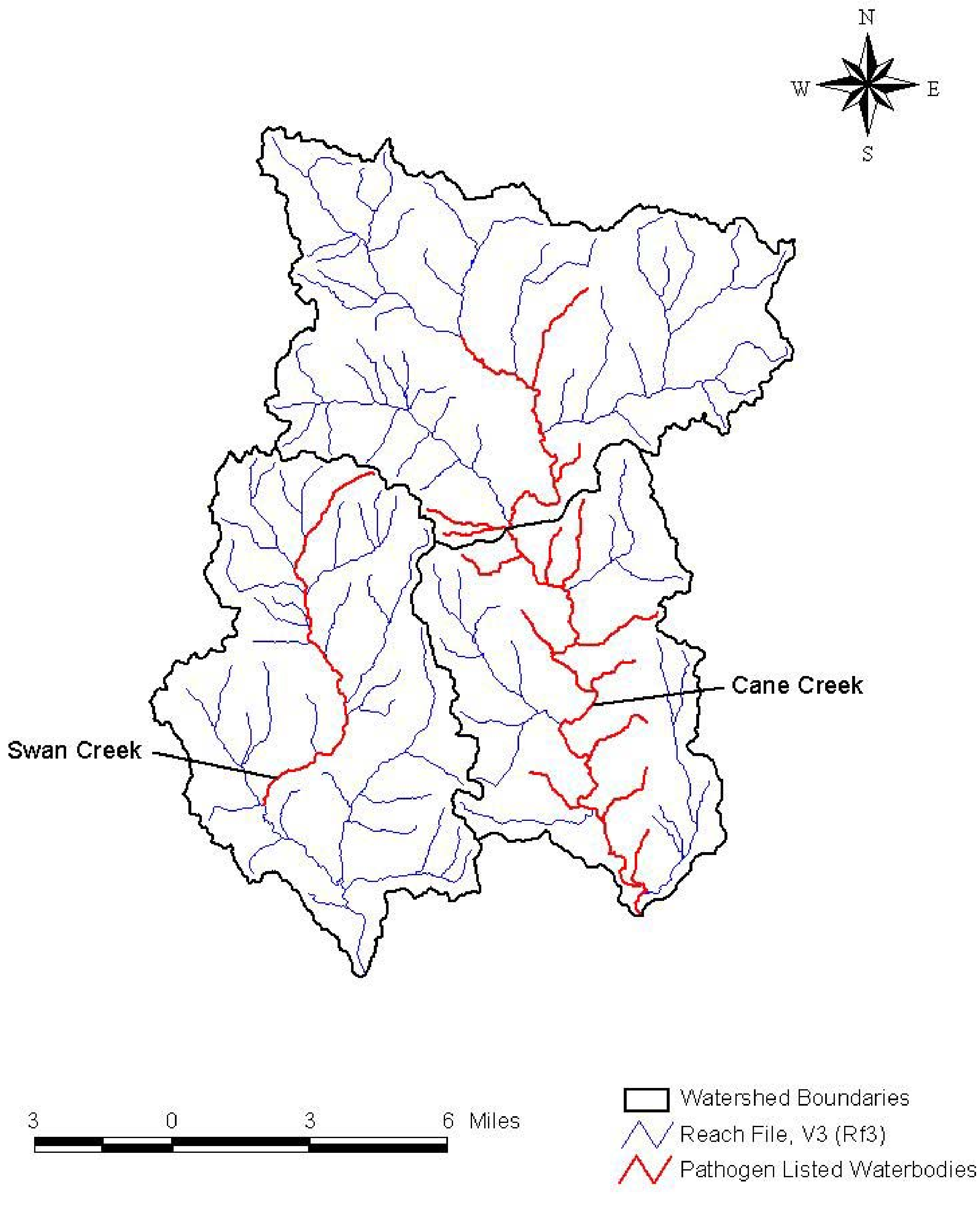

Figure 7. Waterbodies Listed for Pathogens on the 2002 Proposed Final 303(d) List.

6.0 SOURCE ASSESSMENT

An important part of the TMDL analysis is the identification of source categories, source subcategories, or individual sources of fecal coliform bacteria in the watershed and the amount of pollutant loading contributed by each of these sources. Sources are broadly classified as either point or non-point sources.

A point source can be defined as a discernable, confined, and discrete conveyance from which pollutants are or may be discharged to surface waters. Point source discharges of industrial wastewater, treated sanitary wastewater, stormwater associated with industrial activity, and stormwater from municipal separate storm sewer systems (MS4s) that serve urbanized areas of at least 50,000 people and population densities over 1000 per square mile must be authorized by National Pollutant Discharge Elimination System (NPDES) permits. NPDES-permitted facilities discharging treated sanitary wastewater are considered primary point sources of fecal coliform bacteria.

Non-point sources of fecal 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 fecal coliform bacteria on land surfaces and wash off as a result of storm events. Typical non-point sources of fecal coliform bacteria include:

- Urban development (including leaking sewer collection lines)
- Leaking septic systems
- Animals having access to streams
- Land application of agricultural manure
- Livestock grazing
- Wildlife

6.1 Point Sources

6.1.1 Municipal and Industrial Wastewater Treatment Facilities

There is one (1) point source with an NPDES permit for the discharge of treated sanitary wastewater located in the drainage areas of the subject 303(d)-listed stream segments of the Upper Elk River watershed (Figure 3). The Unity Junior High School Package Plant (TN0065498) discharges to Morton Branch (a tributary to Swan Creek) at mile 1.0.

6.1.2 Concentrated Animal Feeding Operation

There is one (1) concentrated animal feeding operation (CAFO) with an NPDES permit located in the drainage areas of the subject 303(d)-listed stream segments of the Upper Elk River watershed (Figure 3). The C & L Dairy (TNA000010) is located on Turney Branch (a tributary to Swan Creek) and is authorized to operate a waste retention structure which shall be designed, constructed and operated to contain all process generated waste waters plus the runoff from a 25-year, 24-hour rainfall event.

6.2 Nonpoint Source Assessment

6.2.1 Wildlife

Wildlife deposit fecal coliform bacteria, with their feces, onto land surfaces where it can be transported during storm events to nearby streams. Deer population data were provided by the Tennessee Wildlife Resources Agency (TWRA) for the state of Tennessee. However, no county-specific data were available for middle Tennessee nor were statistics available for other animals. Therefore, deer were assumed to populate the Upper Elk River watershed according to the upper limit of available population data of 36 per square mile. In addition, in order to account for other forms of wildlife, a deer density of 45 animals/square mile is used. Fecal coliform loading due to deer is estimated by EPA to be 5.0 x 10^8 counts/animal/day.

6.2.2 Agricultural Animals

Agricultural animals are the source of several types of fecal coliform loading to streams in the Upper Elk River watershed:

- As with wildlife, agricultural livestock grazing on pastureland deposit fecal coliform bacteria with their feces onto land surfaces where it can be transported during storm events to nearby streams.

- Agricultural livestock and other unconfined animals (i.e., deer and other wildlife) often have direct access to streams that pass through pastures.

- Processed agricultural manure from confined feeding operations is generally collected in lagoons and applied to land surfaces during the months April through October. There is one (1) CAFO (TNA000010) located in the Swan Creek subwatershed (Figure 3).

Data sources for confined feeding operations are tabulated by county and include the Census of Agriculture (USDA, 1997) and the Natural Resources Conservation Service (NRCS). In addition, the Tennessee Valley Authority (TVA) has conducted an Integrated Pollution Source Identification (IPSI) (TVA, 1997) in the Upper Elk River watershed. The TVA IPSI provides detailed source information on a watershed scale.

Livestock data for the Upper Elk River watershed are listed in Table 3. Cattle are the predominate livestock in the watershed. Fecal coliform loading rates for livestock in the watershed are estimated to be: 1.06 x 10^{11} counts/day/beef cow, 1.04 x 10^{11} counts/day/dairy cow, 1.24 x 10^{10} counts/day/hog, 4.18 x 10^8 counts/day/horse, and 1.38 x 10^8 counts/day/chicken (NCSU, 1994).

6.2.3 Failing Septic Systems

Some fecal coliform loading in the Upper Elk River watershed can be attributed to failure of septic systems and illicit discharges of raw sewage. Estimates from county census data of people in the Cane Creek and Swan Creek subwatersheds utilizing septic systems are shown in Table 4. In middle 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.

Table 3. Livestock Distribution in the Upper Elk River Watershed (IPSI, except Sheep – WCS)

Livestock	Cane Creek	Swan Creek
Beef Cattle	8385	4230
Dairy Cattle	400	600
Swine	60	0
Poultry	160000	0
Sheep	7	40
Horses	45	15

Table 4. Estimated Population on Septic Systems in the Upper Elk River Watershed

Subwatershed	No. of People on Septic Systems
Cane Creek	4521
Swan Creek	1941

6.2.4 Urban Development

Fecal coliform loading from urban areas is potentially attributable to multiple sources including storm water runoff, leaks and overflows from sanitary sewer systems, illicit discharges of sanitary waste, runoff from improper disposal of waste materials, leaking septic systems, and domestic animals. Urban runoff and storm water processes are not considered to be significant contributors to fecal coliform impairment in the Cane Creek and Swan Creek subwatersheds.

7.0 ANALYTICAL APPROACH

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. In this section, the numerical modeling techniques developed to simulate fecal coliform bacteria fate and transport in the watershed are discussed.

7.1 Model Selection

A dynamic computer model was selected for fecal coliform analysis in order to: a) simulate the time-varying nature of fecal coliform bacteria deposition on land surfaces and transport to receiving waters; b) incorporate seasonal effects on the production and fate of fecal coliform bacteria; and c) identify the critical conditions for the TMDL analysis. Several computer-based tools were also utilized to generate input data for the model.

The Loading Simulation Program C++ (LSPC) is a watershed model capable of simulating nonpoint source runoff and associated pollutant loadings, accounting for point source discharges, and performing flow and water quality routing through stream reaches. LSPC is based on the

Hydrologic Simulation Program - Fortran (HSPF). In these TMDLs, LSPC was used to simulate point source discharges, simulate the deposition and transport of fecal coliform bacteria from land surfaces, and compute resulting water quality response.

The Watershed Characterization System (WCS), a geographic information system (GIS) tool, was used to display, analyze, and compile available information to support water quality model simulations for the Upper Elk River TMDL watersheds. This information includes land use categories, point source dischargers, soil types and characteristics, population data (human and livestock), and stream characteristics. In addition, the TVA IPSI, a GIS-based nonpoint source inventory, provided updated (1994-1997) subwatershed-level livestock data for enhancement of source characterization. Results of the WCS and TVA IPSI characterizations are input to a spreadsheet developed by Tetra Tech, Inc. to estimate LSPC input parameters associated with fecal coliform buildup (loading rates) and subsequent washoff from land surfaces. In addition, the spreadsheet can be used to estimate direct sources of fecal coliform loading to waterbodies from leaking septic systems and animals having access to streams. Information from the WCS, TVA IPSI, and spreadsheet tools were used as initial input for variables in the LSPC model.

7.2 Model Setup

The portion of the Upper Elk River watershed evaluated for these TMDLs was delineated into three (3) subwatersheds in order to characterize relative fecal coliform bacteria contributions from significant contributing drainage areas to the impaired streams (see Figures 2, 3, 6, and 7). Watershed delineations were constructed at HUC-12 boundaries and were based on the Reach File 3 (Rf3) stream coverage and Digital Elevation Model (DEM) data. This discretization allows management and load reduction alternatives to be varied by subwatershed.

An important factor influencing model results is the precipitation data contained in the meteorological data file used in the simulation. The pattern and intensity of rainfall affects the buildup and washoff of fecal coliform bacteria from the land into the streams, as well as the dilution potential of the stream. Weather data from the Lewisburg meteorological station were used for simulations in the Cane Creek and Swan Creek subwatersheds. Due to availability of precipitation data for use in model simulations, data collected through September 2001 were used in the hydrologic and water quality calibrations.

7.3 Model Calibration

Calibration of the watershed models included both hydrology and water quality components. Hydrologic calibration was performed first and involved adjustment of the model parameters used to represent the hydrologic cycle until acceptable agreement was achieved between simulated flows and historic streamflow data from a U.S. Geological Survey (USGS) streamflow gaging station for the same period of time. The USGS streamflow gaging station on Cane Creek near Howell (035825882) was used in the hydrologic calibration. Model parameters adjusted include: evapotranspiration, infiltration, upper and lower zone storage, groundwater storage, recession, losses to the deep groundwater system, and interflow discharge.

The models were also calibrated for water quality. Fecal coliform samples collected on Cane Creek were used for comparison with simulated daily model results. Appropriate model parameters were adjusted to obtain acceptable agreement between simulated in-stream fecal coliform concentrations and observed data. The Cane Creek watershed input parameters were utilized for model simulations of the Cane Creek and Swan Creek subwatersheds. Results show that the model adequately simulates peaks in fecal coliform bacteria in response to storm events and base concentrations during low-flow events.

The details and results of the hydrologic and water quality calibrations are presented in Appendix B.

8.0 DEVELOPMENT OF TOTAL MAXIMUM DAILY LOAD

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), which takes into account any uncertainty concerning the relationship between effluent limitations and water quality:

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

The objective of a TMDL is to allocate loads among all of the known pollutant sources throughout a watershed so that appropriate control measures can be implemented and water quality standards achieved. 40 CFR §130.2 (i) states that TMDLs can be expressed in terms of mass per time (e.g. pounds per day), toxicity, or other appropriate measure. The TMDLs for the listed waterbodies in the Upper Elk River watershed, developed by numerical modeling techniques, are expressed as counts/30 days. This load represents the total load the stream can assimilate during the 30-day critical period and maintain the water quality criterion of 200 counts/100 mL (minus the Margin of Safety).

8.1 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 simulated in the water quality model.

The ten-year period from October 1, 1991 to September 30, 2001 was used to simulate continuous 30-day geometric mean concentrations to compare to the target. This 10-year period contained a range of hydrologic conditions that included both low and high streamflows from which critical conditions were identified and used to derive the TMDL values.

The ten-year simulated geometric mean concentrations for existing conditions are presented in Appendix C. From these figures, critical conditions can be determined. The 30-day critical period for each subwatershed is the period preceding the second highest simulated violation of the geometric mean standard (USEPA, 1991). The highest peaks often result from extreme meteorological conditions (i.e., floods or severe droughts) and warrant exclusion from the critical period analyses. The TMDLs are considered Phase I and may be refined as further data are collected.

Meeting water quality standards during the critical period ensures that water quality standards can be achieved throughout the ten-year period. For the two listed segments evaluated by model simulation in the Upper Elk River watershed, the second highest violations of the 30-day geometric mean occurred on February 16, 1996. Therefore, the critical period is January 18 through February 16, 1996.

8.2 Existing Conditions

The existing fecal coliform loads for the Upper Elk River subwatersheds were determined in the following manner:

- The calibrated models, corresponding to the mouths of the impaired reaches, were run for a time period that included the critical conditions for each.
- The daily fecal coliform load indirectly going to surface waters from all land uses was added to the direct daily discharge load of modeled point sources and the result summed for the 30 day critical period. This value represents the existing load.

Model results indicate that direct inputs of fecal coliform bacteria from “direct sources” (i.e., failing septic systems, illicit discharges of fecal coliform bacteria, leaking sewer collection lines, and animal access to streams) have a minor impact on bacteria loading in non-urban subwatersheds (e.g., Swan Creek and Cane Creek). Non-point sources related to urban land uses have an impact on the fecal coliform bacteria loading in watersheds with populated areas. In non-urban (i.e., agricultural) subwatersheds, loading is shown to be primarily from non-direct (nonpoint) sources. Reductions in these loading rates reduce the in-stream fecal coliform bacteria levels. Non-point source loading rates representing existing conditions in the model are shown in Table 5.

Table 5. Nonpoint Source Loads & In-stream Fecal Coliform Concentrations - Existing Conditions

Subwatershed	Runoff from all Lands	Direct Sources	In-Stream Fecal Coliform Concentration[1]
	[Counts/30 days]	[Counts/30 days]	[Counts/100 mL]
Cane Creek	1.604E+14	0[2]	525
Swan Creek	9.904E+13	0[2]	650

[1] Fecal coliform concentrations represent the simulated 30-day geometric mean concentration during the critical period (see section 8.1).
[2] Direct Sources are minor contributors of fecal coliform in these watersheds.

In general, point source loads from NPDES facilities do not significantly contribute to the impairment of the Cane Creek and Swan Creek subwatersheds since discharges from these facilities are required to be treated to levels corresponding to in-stream water quality criteria.

8.3 Margin of Safety

There are two methods for incorporating an MOS in the analysis: a) implicitly incorporate the MOS using conservative model assumptions to develop allocations; or b) explicitly specify a portion of the TMDL as the MOS and use the remainder for allocations. In these TMDLs, both explicit and implicit MOS were used. The explicit MOS is 20 counts/100 mL below the in-stream target concentration on each watershed. The implicit MOS includes the use of conservative modeling assumptions and a 10-year continuous simulation that incorporates a 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.

An additional MOS is applied to the TMDLs by designating the instantaneous maximum criterion of 1000 Counts/100 mL a secondary target value. Since it is representative of peak storm response conditions with high flows and velocities, times when recreational activities (and therefore, human exposure) are expected to be limited, the instantaneous maximum exceedance will be limited to 10% based on daily mean concentrations. For these TMDLs, this further reduces the critical 30-day geometric mean concentration below 180 counts/100 mL, thereby providing an additional margin of safety relative to the geometric mean standard. The simulated daily mean concentrations for the 30-day critical TMDL allocation periods are presented in Appendix D.

8.4 Determination of TMDLs, WLAs, & LAs

The TMDL is the total amount of pollutant that can be assimilated by a waterbody while maintaining water quality standards. Fecal coliform bacteria TMDLs developed by numerical modeling techniques are expressed as counts per 30-day period since this is how the water quality standard is expressed. The TMDL, therefore, represents the maximum fecal coliform bacteria load that can be assimilated by a stream during the critical 30-day period while maintaining the fecal coliform bacteria water quality standard (including the explicit MOS) of 180 counts/100 mL. As previously stated, the TMDL is calculated using the equation:

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

With MOS = 20 counts/100 mL (explicit MOS), the TMDLs, $\sum$WLAs, & $\sum$LAs were determined according to the following procedure:

- The calibrated models were run for a time period that included the critical conditions for each impaired waterbody.

- Fecal coliform land loading variables and the magnitude of loading from sources modeled as "direct sources" were adjusted within reasonable range of known values until the resulting fecal coliform concentration at the pour point of the subwatershed is less than the water quality standard (minus the explicit MOS) of 180 counts/100mL.

- The $\sum$WLAs is the load associated with the daily discharge loads of all modeled NPDES permitted facilities summed over the 30-day critical period. The existing NPDES-permitted facilities were assumed to discharge at design flow and a fecal coliform permit limit of 200 counts/100 mL.

- The $\sum$LAs is the daily fecal coliform load indirectly going to surface waters from all modeled land use areas as a result of buildup/wash off processes plus the daily discharge load from sources modeled as "other direct sources" and the result summed over the 30-day critical period.

- The percent reduction is based on the maximum simulated geometric mean concentration for the 30-day critical period for existing and TMDL conditions. The maximum simulated concentrations for the TMDL scenario were less than or equal to 180 counts/100 mL for each impaired waterbody.

- Further reductions are based on 10% allowable exceedance of the instantaneous maximum criterion for the 30-day critical period.

The TMDL, WLAs, & LAs for the Upper Elk River watershed are summarized in Table 6.

8.4.1 Waste Load Allocations

There is one (1) NPDES-permitted facility that discharges treated sanitary wastewater into the Swan Creek watershed. Future facility permits will require end-of-pipe limits equivalent to the water quality standard of 200-counts/100 mL. Future facilities discharging at concentrations less than or equal to the water quality standard will not cause or contribute fecal coliform impairment in the watershed.

Table 6. TMDL Components

Watershed	∑WLAs	∑LAs	MOS	TMDL
	[Countts/30 days]	[Countts/30 days]		[Counts/30 days]
Cane Creek	0	2.589E+13	Explicit[1] & Implicit	2.589E+13
Swan Creek	1.636E+09	1.195E+13	Explicit[1] & Implicit	1.195E+13

[1] Explicit MOS = 20 counts/100 mL applied to the LA component only as this represents the largest source contributing to the TMDL. Applying a MOS to the WLA component would have a negligible impact on the overall TMDL value.

8.4.2 Load Allocations

There are two modes of transport for non-point source fecal coliform bacteria loading. First, loading from failing septic systems, illicit connections, leaking sewer system collection lines, and animals in the stream (etc.), are direct sources to the stream and are independent of precipitation. The second mode involves loading resulting from fecal coliform accumulation on land surfaces and wash-off during storm events. Fecal coliform applied to land is subject to a die-off rate and an absorption rate before it is transported to the stream.

Non-point sources related to agricultural runoff have the greatest impact on fecal coliform bacteria loadings in the Cane Creek and Swan Creek subwatersheds. Possible allocation scenarios that would meet in-stream water quality standards include: 84.2-88.2% reduction from runoff and reduction to the maximum extent practicable from “direct sources” of fecal coliform in the stream, resulting in overall reductions of 74.0 – 77.1%.

Best management practices (BMPs) and control measures that could be used to implement these TMDLs include controlling pollution from agricultural runoff, elimination of discharges from other “direct sources” of fecal coliform to the streams, animal exclusion from streams, and riparian buffers. The overall reductions to fecal coliform loading rates for the TMDL allocation scenario are shown in Table 7. Additional monitoring and surveys of the watershed may be conducted to validate and verify the various direct and indirect sources of fecal coliform bacteria.

Table 7. TMDL Reductions for the Upper Elk River Watershed

Subwatershed	Overall Reduction (Existing to Allocated Conditions)
	(% Reduction)
Cane Creek	74.0
Swan Creek	77.1

8.4.3 Seasonal Variation

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

9.0 IMPLEMENTATION PLAN

The TMDL analysis was performed using the best, readily available data to specify WLAs and LAs that will meet the water quality criteria for pathogens (fecal coliform) in the Upper Elk River watershed in order to support its designated use classifications. The following recommendations and strategies are targeted toward source identification, collection of data to support additional modeling and evaluation, and subsequent reduction in sources causing impairment of water quality.

9.1 Point Sources

All 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 addition, all future NPDES facilities will be required to meet end-of-pipe criteria for fecal coliform discharge.

9.2 Nonpoint Sources - Agricultural Sources of Fecal Coliform Loading

Agricultural sources contributing to fecal coliform loading in the Upper Elk River watershed are believed to be numerous, widespread, and variable in character and magnitude. The current TMDL analysis represents a gross allotment of agricultural source terms with a high degree of uncertainty. The Tennessee Department of Environment & Conservation (TDEC) will coordinate with the Tennessee Department of Agriculture (TDA) and the NRCS to address issues concerning fecal coliform loading from agricultural land uses in the Upper Elk River watershed. Potential action items may include, but are not limited to, development of appropriate Best Management Practices (BMPs), encouraging good housekeeping measures through education, and conducting sampling and monitoring to evaluate effectiveness of avoidance, minimization, and mitigation measures.

BMPs have been utilized in the Upper Elk River watershed to reduce the amount of fecal coliform transported to surface waters from agricultural sources. These BMPs (e.g., riparian buffers, fencing, field borders, livestock exclusion, etc.) may have contributed to reductions in in-stream concentrations of fecal coliform in one or more of the subject watersheds during the TMDL evaluation period. The TDA keeps a database of BMPs implemented in Tennessee. Those listed in Swan Creek and Cane Creek are shown in Figure 8. It is recommended that additional information (such as livestock access to streams, manure application practices, etc.) be provided and evaluated to better identify and quantify agricultural sources of fecal coliform loading in order to

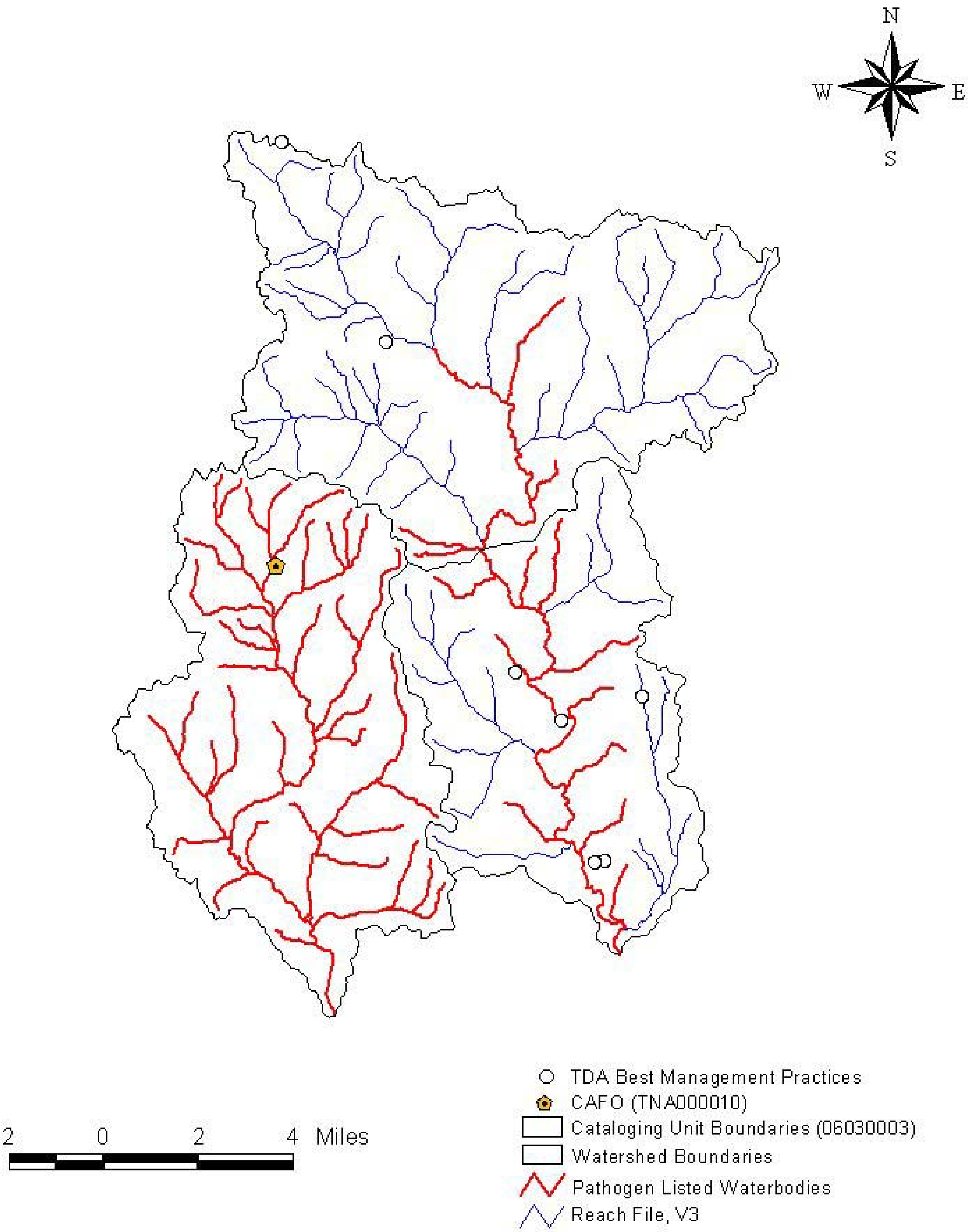

Figure 8. Tennessee Department of Agriculture Best Management Practices located in the Upper Elk River Watershed.

minimize uncertainty in future modeling efforts.

It is further recommended that BMPs be utilized to reduce the amount of fecal coliform bacteria transported to surface waters from agricultural sources to the maximum extent practicable.

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 Stage 2 implementation. Fecal coliform sampling and monitoring should be conducted during low-flow (baseflow) and storm periods at sites with and without BMPs and/or before and after implementation of BMPs.

9.3 Stream Monitoring

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.

Continued monitoring of the fecal coliform concentration at multiple water quality sampling points in the watershed is critical in characterizing sources of fecal coliform contamination and documenting future reduction of loading. In the next watershed cycle, monitoring should be expanded to provide water quality information to characterize seasonal trends and refined source identification and delineation. Recommended monitoring for the Upper Elk River watershed includes monthly grab samples and intensive sampling for one month during both the wet season (January-March) and the dry season (July-September). In addition, monitoring efforts should be refined and enhanced in order to characterize dry and wet season base flow conditions (concentrations). Lastly, stream flow should be measured or estimated with the collection of each fecal coliform sample to characterize the dynamics of fecal coliform transport within the surface-water system.

9.4 Future Efforts

This TMDL represents the first phase of a long-term restoration project to reduce fecal coliform loading to acceptable levels (meeting water quality standards) in the Upper Elk River watershed. TDEC will coordinate with TDA and other stakeholders to evaluate the progress of implementation strategies and refine the TMDL as necessary in the next phase (next five-year cycle). This will include recommending specific implementation plans for identified problem areas with as yet undefined sources and causes of pollution. Cooperation will be maintained with TDA for possible 319 nonpoint source grants and NRCS for developing BMPs. The dynamic loading model may be upgraded and refined in the next phase to more effectively link sources (including background and agricultural) to impacts and characterize the processes (loading, transport, decay, etc.) contributing to violations of fecal coliform concentrations (loading) in impacted waterbodies. The phased approach will assure progress toward water quality standards attainment in the future.

10. 0 PUBLIC PARTICIPATION

In accordance with 40 CFR § 130.7, announcement of the availability of the proposed fecal coliform TMDLS for the Upper Elk River watershed was made to the public, affected dischargers, and other concerned parties and comments solicited. Steps taken in this regard include:

1) Notice of the proposed TMDLs was posted on the TDEC website on September 22, 2003 (see Appendix D). The announcement invited public comment until October 27, 2003.

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

No written comments were received during the proposed TMDLs public comment period. No requests to hold public meetings were received regarding the proposed TMDL as of close of business on October 27, 2003.

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/index.php

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

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REFERENCES

Horner. 1992. *Water Quality Criteria/Pollutant Loading Estimation/Treatment Effectiveness Estimation*. In R.W. Beck and Associates. Covington Master Drainage Plan, King County Surface Water Management Division. Seattle, Washington.

Lombardo, P.S., 1972. *Mathematical Model of Water Quality in Rivers and Impoundments,* Technical Report, Hydrocomp, Inc. Cited in *Rates, Constants, and Kinetics Formulations in Surface Water Quality Modeling (Second Edition)*, EPA/600/3-85/040, June 1985.

Lumb, A.M., McCammon, R.B., and Kittle, J.L., Jr., 1994, Users Manual for an expert system, (HSPFEXP) for calibration of the Hydrologic Simulation Program – Fortran: U.S. Geological Survey Water-Resources Investigation Report 94-4168,102 p.

NCSU. 1994. *Livestock Manure Production and Characterization in North Carolina*, North Carolina Cooperative Extension Service, North Carolina State University (NCSU) College of Agriculture and Life Sciences, Raleigh, January 1994.

TDEC. 1998. *Final 1998 303(d) List, June 1998 (Revised July and September 1998).* State of Tennessee, Department of Environment and Conservation, Division of Water Pollution Control.

TDEC. 1999. *State of Tennessee Water Quality Standards, Chapter 1200-4-3 General Water Quality Criteria, October 1999.* State of Tennessee, Department of Environment and Conservation, Division of Water Pollution Control.

TVA. 1997. Elk River NPS Inventory, 1997. Tennessee Valley Authority, Geographic Information and Engineering. Chattanooga, Tennessee. August 1, 1997.

USDA. 1997. *1997 Census of Agriculture, Volume 1, Geographic Area Series, Part 42*, U.S. Department of Agriculture, National Agricultural Statistics Service. AC97-A-42, March 1999.

USEPA. 1991. *Guidance for Water Quality–based Decisions: The TMDL Process.* U.S. Environmental Protection Agency, Office of Water, Washington, DC. EPA-440/4-91-001, April 1991.

USEPA. 1997. *Ecoregions of Tennessee*. U.S. Environmental Protection Agency, National Health and Environmental Effects Research Laboratory, Corvallis, Oregon. EPA/600/R-97/022.

APPENDIX A

Monitoring Data for the Upper Elk River Watershed

Table A-1. Fecal Coliform (Counts/100 mL) Monitoring Data for the Upper Elk River watershed.

Date	Cane Creek (6.1)	Cane Creek (6.6)	Cane Creek USGS 035825882 (7.9)	Swan Creek (7.2)	Swan Creek (8.0)	Swan Creek (8.1)
1/14/99			8000 E[1]			
2/17/99			2300			
3/9/99			4300			
4/5/99			59 E			
4/29/99			21000			
5/11/99			660			
6/7/99			260			
7/12/99			>20000			
8/11/99			43 E			
9/9/99			67 E			
10/20/99				110		
10/20/99[3]				93		
11/16/99						290
12/27/99						87
3/28/00						540
5/16/00						150
6/20/00						J15000
6/20/00[2]						46
8/7/02	150	J220[3]			4600	
9/10/02		52				
9/10/02[2]		66				
10/7/02		J760			1500	
11/7/02		260			570	
11/7/02[2]		J650				
12/3/02		110			80	
12/3/02[2]		110				
1/6/03		130			110	
1/6/03[2]		90				
2/12/03		36			28	
2/12/03[2]		28				

[1] E = estimated (USGS).
[2] Second sample on same date (duplicate) collected within 15 minutes of first sample.
[3] J = estimated (TDEC).

APPENDIX B

Model Development and Calibration

B.1 Model Set Up

The portion of the Upper Elk River watershed evaluated for TMDLs was delineated into three (3) subwatersheds in order to characterize relative fecal coliform contributions from significant contributing drainage areas (see Figure 3). Boundaries were constructed so that watershed "pour points" coincided, when possible, with water quality monitoring stations. Watershed delineation was based on the Rf3 stream coverage and Digital Elevation Model (DEM) data. This discretization allows management and load reduction alternatives to be varied by subwatershed. Initial input for model variables was developed using WCS and the associated spreadsheet tools.

An important factor influencing model results is the precipitation data contained in the meteorological data files used in these simulations. The pattern and intensity of rainfall affects the buildup and washoff of fecal coliform bacteria from the land into the streams, as well as the dilution potential of the stream. Weather data from the multiple meteorological stations were available for the time period from January 1970 through December 2001. Meteorological data for the period 10/1/90-9/30/01 were used for all simulations. The model was allowed to stabilize for one year (10/1/90-9/30/91) before results from the subsequent 10-year simulation were analyzed.

B.2 Model Calibration

The calibration of the LSPC watershed model involves both hydrology and water quality components. The model must be calibrated to appropriately represent hydrologic response in the watershed before subsequent calibration and reasonable water quality simulations can be performed.

B.2.1 Hydrologic Calibration

Hydrologic calibration of the watershed model involves comparing simulated streamflows to historic streamflow data from USGS stream gaging stations for the same period of time. The USGS gage located on Cane Creek near Howell (035825882) was used in the hydrologic calibration. The calibration involved comparing simulated and observed hydrographs until stream volumes and flows were within acceptable ranges as reported in the literature (Lumb, et.al., 1994). The results of the hydrologic calibration and statistical analyses for selected years are shown in Figure B-1.

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.

B.2.2 Water Quality Calibration

Upper Elk River watershed data, generated by WCS, were processed through the spreadsheet applications developed by Tetra Tech, Inc. to generate fecal coliform loading data for use as <u>initial</u> input to the LSPC model. In the model, in-stream decay of fecal coliform bacteria was conservatively estimated using the values reported in Lombardo (1972). For freshwater streams, decay ranges from 0.008 hr^{-1} to 0.13 hr^{-1}, with a median value of 0.048 hr^{-1}. The median value was used as initial input to model simulations. A final value of 0.083 hr^{-1} was used for the Cane Creek and Swan Creek subwatersheds because it more closely represents site-specific in-stream conditions.

Model sensitivity analyses show that adjustments in nonpoint source loading rates are essential elements of the calibration process. The model is very responsive to loads applied directly into the stream (e.g., leaking septic systems, animal access to streams, etc.) and if the loads are high, then the model can over-predict concentrations during low-flow conditions. In the Upper Elk River watershed, where urban sources (landuse areas) were not significant, it was determined that direct sources were negligible and loading was primarily represented as a buildup-washoff process.

B.2.2.1 Point Sources

For existing conditions, NPDES facilities located in modeled watersheds are represented as point sources of average (constant) flow and concentration based on the facility's flow and effluent fecal coliform concentration as reported on Discharge Monitoring Reports (DMRs).

B.2.2.2 Nonpoint Sources

A number of nonpoint source categories are not associated with land loading processes and are represented as direct, in-stream source contributions in the model. These may include, but are not limited to, failing septic systems, leaking sewer lines, animals in streams, illicit connections, direct discharge of raw sewage, and undefined sources. All other nonpoint sources involve land loading of fecal coliform bacteria and washoff as a result of storm events. Only a portion of the load from these sources is actually delivered to streams due to the mechanisms of washoff (efficiency), decay, and incorporation into soil (adsorption, absorption, filtering) before being transported to the stream. Therefore, land loading nonpoint sources are represented as indirect contributions to the stream. Buildup, washoff, and die-off rates are dependent on seasonal and hydrologic processes.

Initial input for nonpoint sources of fecal coliform loading in the water quality model was developed using watershed information generated with WCS and the Tetra Tech loading calculation spreadsheets.

B.2.2.2.1 Wildlife

Fecal coliform loading from wildlife is considered to be uniformly distributed to forest, pasture, and cropland areas in the Upper Elk River watershed. A loading rate of 5.0×10^8 counts/animal/day for deer is based on best professional judgment. An animal density of 45 animals/square mile is used to account for deer and all other wildlife. The resulting fecal coliform loading is 3.52×10^7 counts/acre/day and is considered background.

B.2.2.2.2 Land Application of Agricultural Manure

In the water quality model, livestock populations (see Table 2) are distributed to subwatersheds based on information derived from WCS. Fecal coliform loading rates were calculated from livestock populations based on manure application rates, literature values for bacteria concentrations in livestock manure, and the following assumptions:

- Fecal content in manure was adjusted to account for die-off due to known treatment/storage methods.
- Manure application rates from the various animal sources are applied according to application practices throughout the year.

- The fraction of manure available for runoff is dependent on the method of manure application. In the water quality model, the fraction available is estimated based on incorporation into the soil.

- Fecal coliform production rates used in the model for beef cattle, dairy cattle, hogs, horses, and chicken are 1.06×10^{11} counts/day/beef cow, 1.04×10^{11} counts/day/dairy cow, 1.24×10^{10} counts/day/hog, 4.18×10^{8} counts/day/horse, and 1.38×10^{8} counts/day/chicken (NCSU, 1994).

B.2.2.2.3 Grazing Animals

Cattle spend time grazing on pastureland and deposit feces onto the land. During storm events, a portion of this material containing fecal coliform bacteria is transported to streams. Beef cattle are assumed to spend all their time in pasture. The percentage of feces deposited during grazing time is used to estimate fecal coliform loading rates from pastureland. Because there is no assumed monthly variation in animal access to pastures in middle Tennessee, the fecal loading rate does not vary significantly throughout the year. Therefore, the loading rate to pastureland used in each subwatershed is assumed to be relatively constant. However, this rate varies across subwatersheds due to the variable beef cattle populations in each subwatershed. Contributions of fecal coliform from wildlife (as noted in Section B.2.2.2.1) are also included in these rates.

B.2.2.2.4 Urban Development

Urban land use represented in the MRLC database includes areas classified as: high intensity commercial, industrial, transportation, low intensity residential, high intensity residential, and transitional. Associated with each of these classifications is a percent of the land area that is impervious. A single, area-weighted loading rate from urban areas is used in the model and is based on the percentage of each urban land use type in the watershed and buildup and accumulation rates referenced in Horner (1992). In the water quality calibrated model, this rate is 1.0×10^{9} counts/acre-day and is assumed constant throughout the year.

B.2.2.2.5 Other Sources

As previously stated, there are a number of nonpoint sources of fecal coliform bacteria that are not associated with land loading and washoff processes. These include animal access to streams, failing septic systems, illicit discharges, and other undefined sources. In each watershed, these miscellaneous sources have been modeled as point sources of constant flow and fecal coliform concentration. The <u>initial</u> baseline values of flow and concentration were estimated using the Tetra Tech, Inc. developed spreadsheets and the following assumptions:

- The load attributed to animals having access to streams is initially based on the beef cow population in the watershed. The percentage of animals having access to streams is derived from assumptions on animals in operations that are adjacent to streams and seasonal and behavioral assumptions. Literature values were used to estimate the fecal coliform bacteria concentration in beef cow manure.

- The initial baseline loads attributable to leaking septic systems is based on an assumed failure rate of 20 percent.

These flow and concentration variables were adjusted during water quality calibration to alter simulated in-stream fecal coliform concentrations during dry weather conditions.

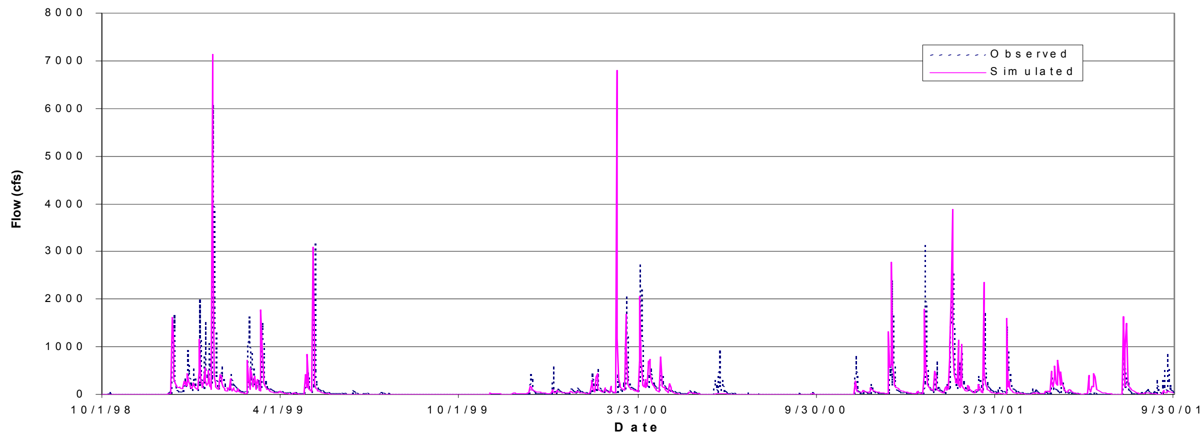
B.2.2.3 Water Quality Calibration Results

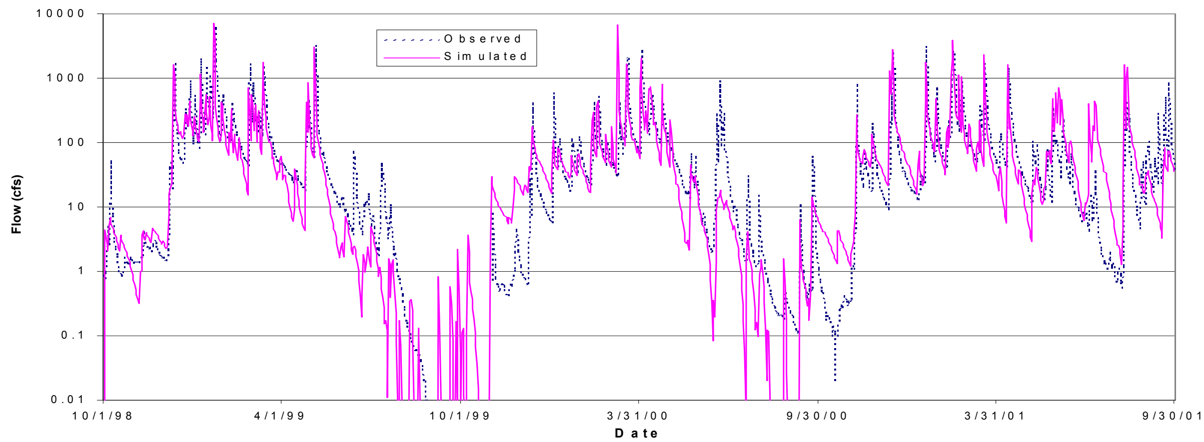
During water quality calibration, model parameters were adjusted within reasonable limits until acceptable agreement between simulation output and in-stream observed data was achieved. Model variables adjusted include:

- Rate of fecal coliform bacteria accumulation
- Maximum storage of fecal coliform bacteria
- Rate of surface runoff that will remove 90% of stored fecal coliform bacteria
- Concentration of fecal coliform bacteria in interflow
- Concentration of fecal coliform bacteria in groundwater
- Concentration of fecal coliform bacteria and rate of flow of direct sources described in B.2.2.2.5
- In-stream fecal coliform decay (die-off) rate

Because fecal coliform samples were not available in adequate numbers for water quality calibration at sampling stations in the Swan Creek subwatershed, Cane Creek was used for the Upper Elk River water quality calibration. Fecal coliform samples collected at USGS 035825882 on Cane Creek were used for comparison with the simulated daily model results. The Cane Creek water quality calibration parameters were utilized for model simulations of the Cane Creek and Swan Creek subwatersheds.

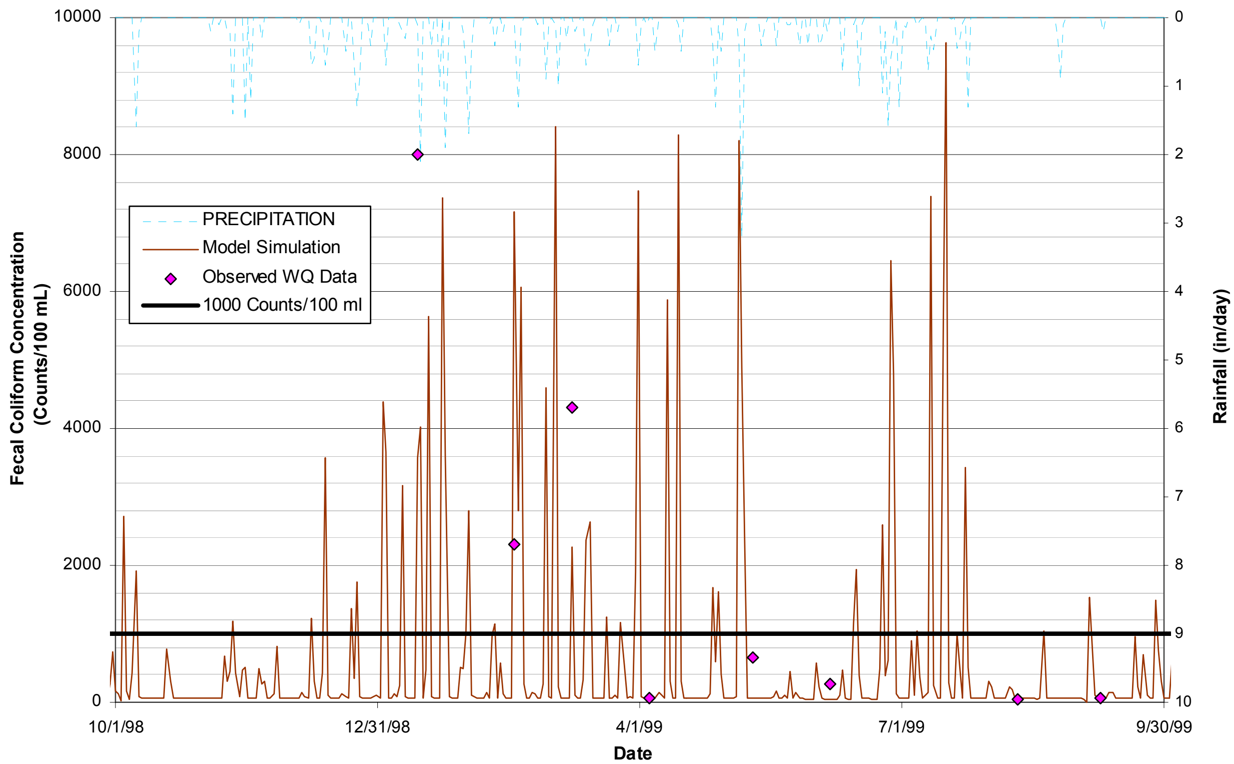
Comparison of simulated and observed daily fecal coliform concentrations at the Cane Creek sampling station (USGS 035825882) in the Upper Elk River watershed is shown in Figure B-2. Simulated daily fecal coliform concentrations at the mouth of Swan Creek are shown in Figure B-3. Figure B-3 presents the water year (October-September) including the 30-day critical period for the Swan Creek. Results show that the model adequately simulates peaks in fecal coliform bacteria in response to rainfall events and pollutant loading dynamics. Often a high observed value is not simulated in the model due to the absence of rainfall at the meteorological station as compared to localized rainfall occurring in the watershed, or is the result of an unknown source that is not included in the model.





Simulation Name:	Cane Creek (USGS 035825882)	**Watershed Area (ac):**	67650
Period for Flow Analysis			
Begin Date:	**10/01/98**		
End Date:	**09/30/01**		
Total Simulated In-stream Flow:	**44.94**	Total Observed In-stream Flow:	**45.47**
Total of highest 10% flows:	**32.07**	Total of Observed highest 10% flows:	**31.94**
Total of lowest 50% flows:	**0.95**	Total of Observed Lowest 50% flows:	**0.92**
Simulated Summer Flow Volume (months 7-9):	**3.31**	Observed Summer Flow Volume (7-9):	**2.30**
Simulated Fall Flow Volume (months 10-12):	**6.38**	Observed Fall Flow Volume (10-12):	**5.33**
Simulated Winter Flow Volume (months 1-3):	**25.33**	Observed Winter Flow Volume (1-3):	**27.35**
Simulated Spring Flow Volume (months 4-6):	**9.92**	Observed Spring Flow Volume (4-6):	**10.49**
Total Simulated Storm Volume:	**44.94**	Total Observed Storm Volume:	**45.47**
Simulated Summer Storm Volume (7-9):	**3.31**	Observed Summer Storm Volume (7-9):	**2.30**
Errors (Simulated-Observed)		*Recommended Criteria*	Last run
Error in total volume:	**-1.17**	10	
Error in 50% lowest flows:	**3.11**	10	
Error in 10% highest flows:	**0.41**	15	
*** Seasonal volume error - Summer:	**44.21**	30	
Seasonal volume error - Fall:	**19.72**	30	
Seasonal volume error - Winter:	**-7.40**	30	
Seasonal volume error - Spring:	**-5.48**	30	
Error in storm volumes:	**-1.17**	20	
Error in summer storm volumes:	**44.21**	50	

Figure B-1. Hydrologic Calibration at USGS 035825882, Cane Creek near Howell (WYs 1998-2001).



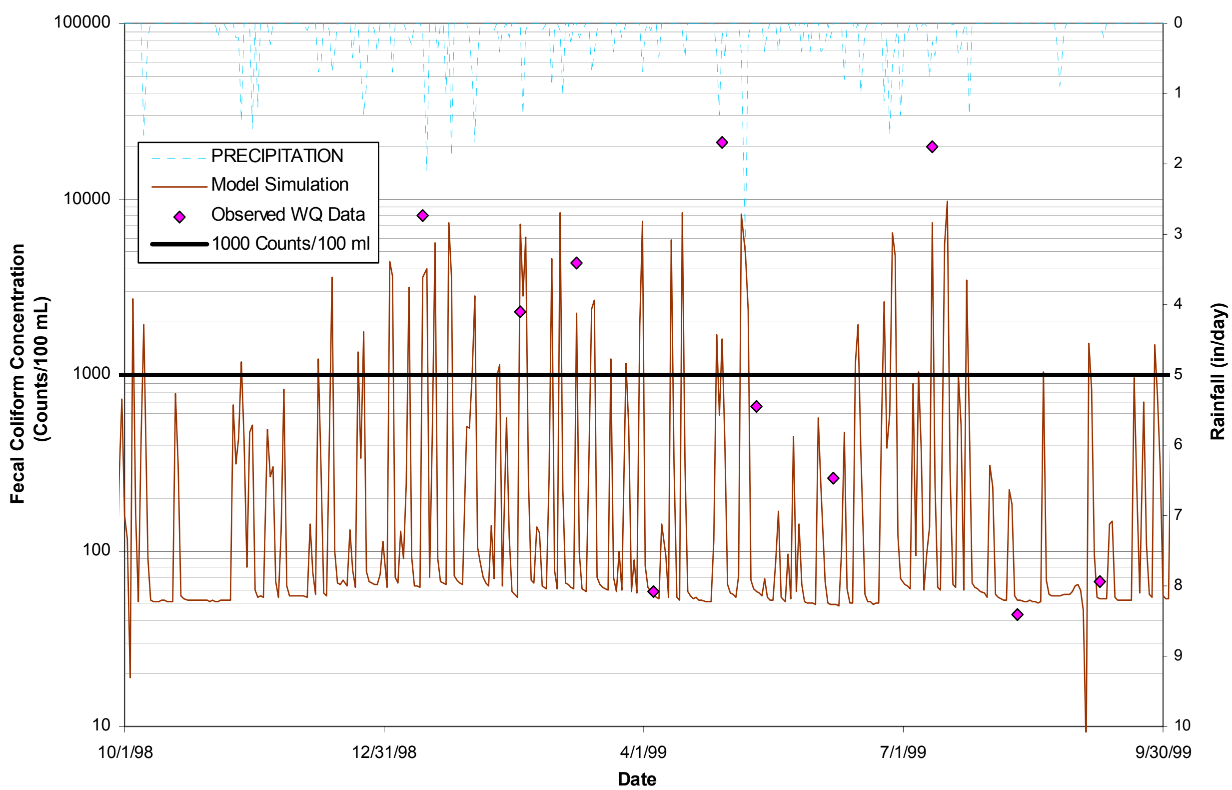
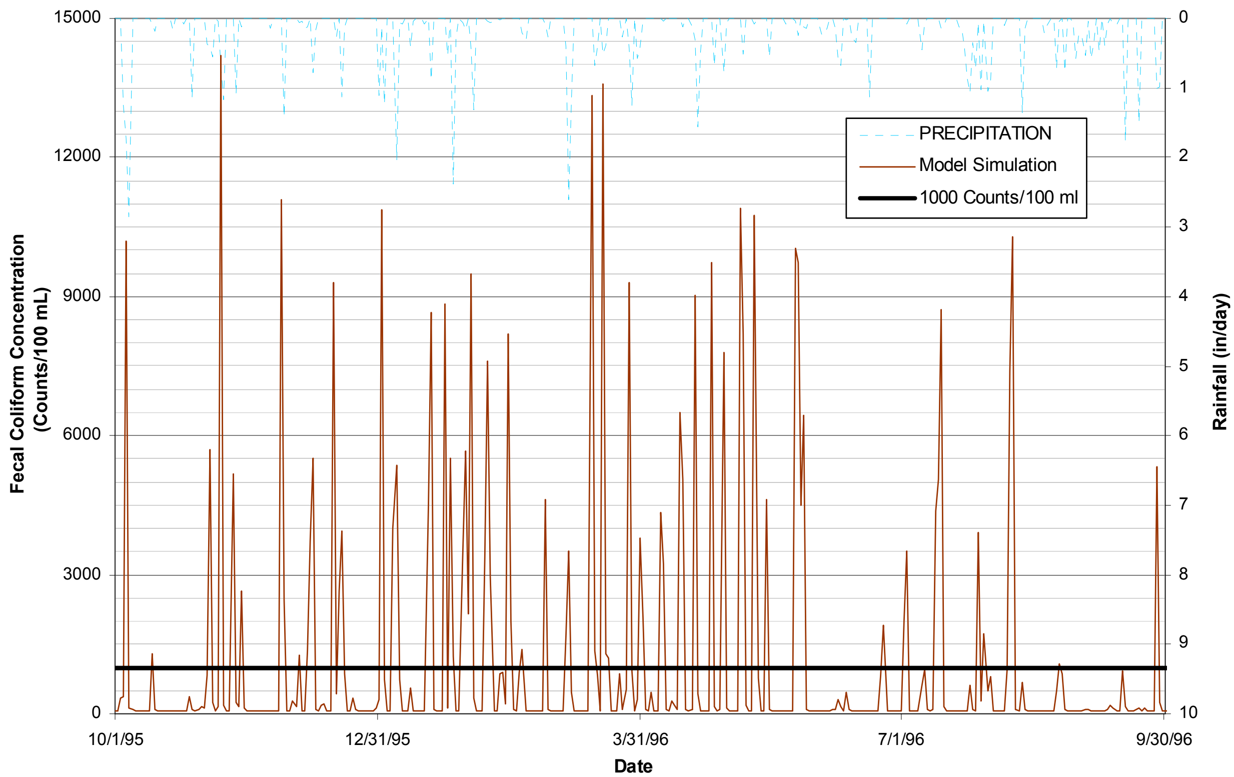


Figure B-2. Water Quality Calibration – Cane Creek at USGS 035825882 (10/1/98 - 9/30/99).



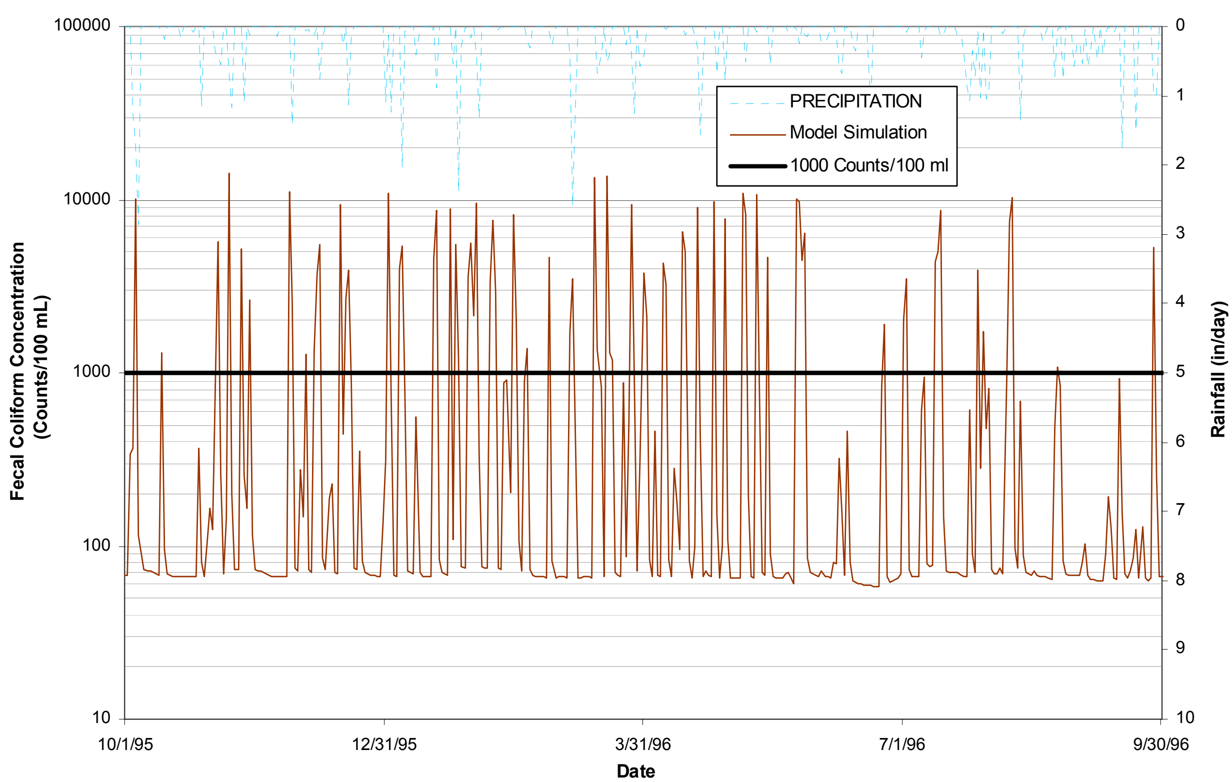


Figure B-3. Water Quality Simulation – Swan Creek at mouth (10/1/95 - 9/30/96).

APPENDIX C

Determination of Critical Conditions

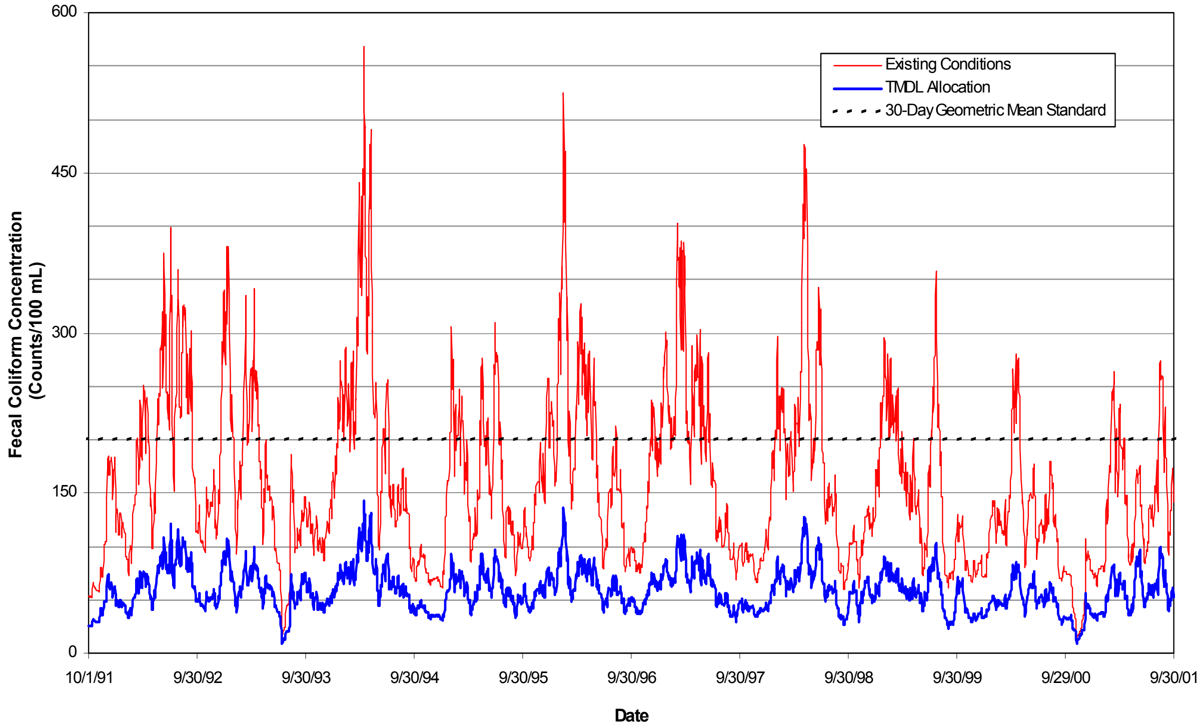


Figure C-1. Simulated 30-Day Geometric Mean Fecal Coliform Concentrations for Cane Creek (USGS 035825882).

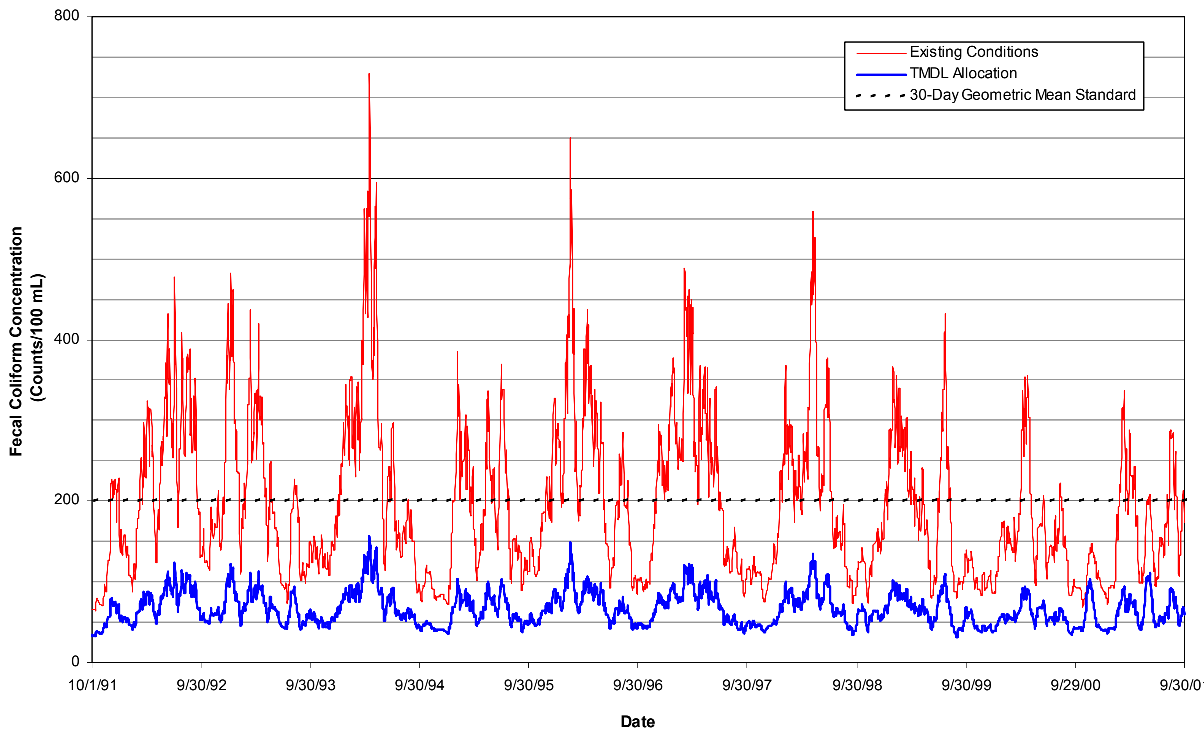


Figure C-2. Simulated 30-Day Geometric Mean Fecal Coliform Concentrations for Swan Creek at the mouth.

APPENDIX D

Instantaneous Maximum Criterion Compliance

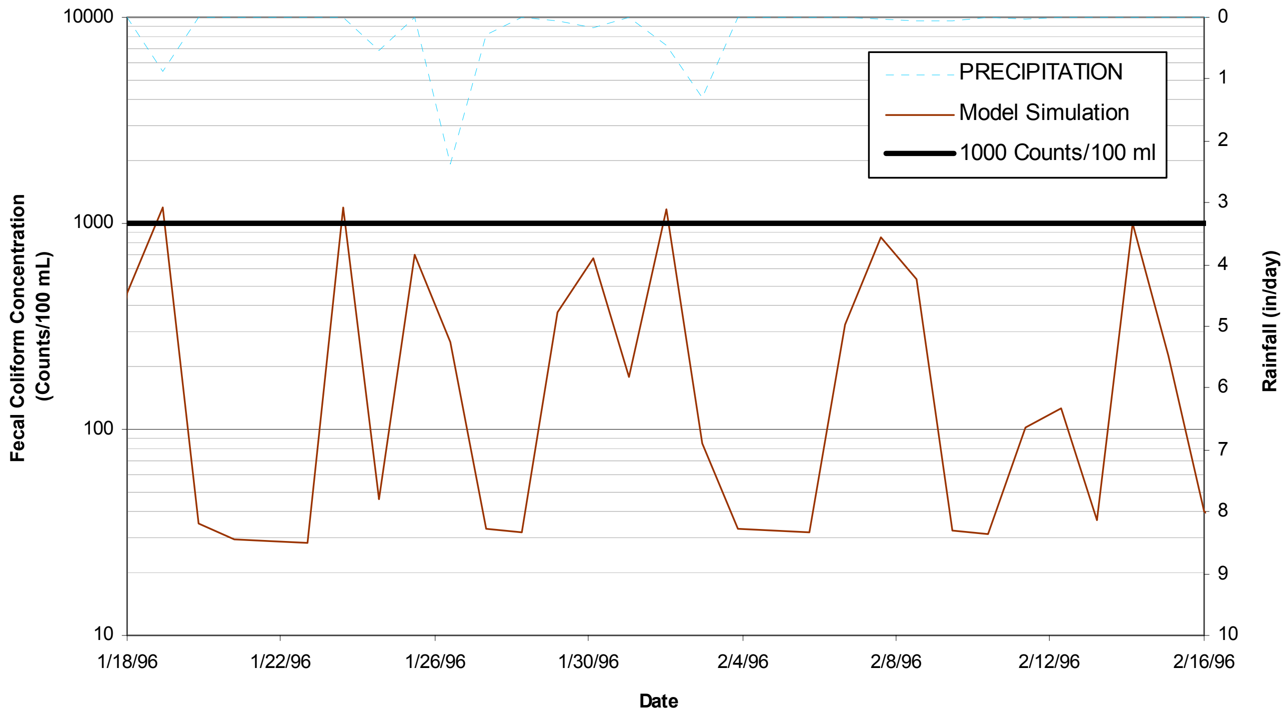


Figure D-1. Simulated Daily Mean Fecal Coliform Concentrations for Cane Creek (USGS 035825882).

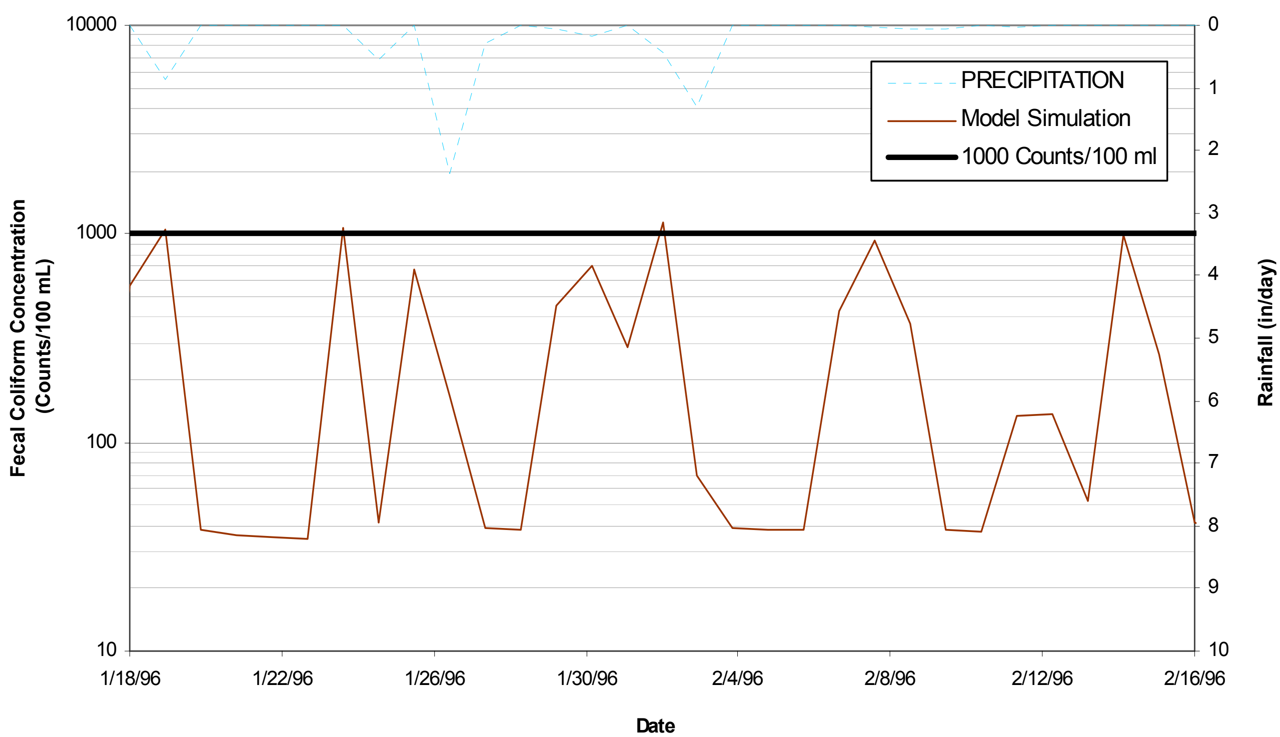


Figure D-2. Simulated Daily Mean Fecal Coliform Concentrations for Swan Creek at the mouth.

APPENDIX E

Public Notice of Proposed Total Maximum Daily Loads (TMDLs) for Fecal Coliform in the Upper Elk River Watershed (HUC 06030003)

DIVISION OF WATER POLLUTION CONTROL

PUBLIC NOTICE OF AVAILABILITY OF PROPOSED TOTAL MAXIMUM DAILY LOADS (TMDLS) FOR FECAL COLIFORM IN THE UPPER ELK RIVER WATERSHED (HUC 06030003), TENNESSEE

Announcement is hereby given of the availability of Tennessee's proposed total maximum daily loads (TMDLs) for fecal coliform in the Upper Elk River watershed, located in middle Tennessee. Section 303(d) of the Clean Water Act requires states to develop TMDLs for waters on their impaired waters list. TMDLs must determine the allowable pollutant load that the water can assimilate, allocate that load among the various point and nonpoint sources, include a margin of safety, and address seasonality.

Cane Creek and Swan Creek are listed on Tennessee's final 1998 303(d) list and/or Proposed Final 2002 303(d) list as not supporting designated use classifications due, in part, to discharge of fecal coliforms from confined animal feeding operations (CAFOs) and undetermined sources. The TMDLs utilize Tennessee's general water quality criteria, recently collected site specific water quality data, continuous flow data from a USGS discharge monitoring station located in the Cane Creek watershed, and a calibrated dynamic water quality model to establish allowable loadings of fecal coliform which will result in reduced in-stream concentrations and attainment of water quality standards. The TMDLs require reductions on the order of 74% for the Cane Creek watershed and 77% for the Swan Creek watershed.

The proposed Upper Elk River fecal coliform TMDLs can be downloaded from the following website:

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

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

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

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

Persons wishing to comment on the proposed TMDL are invited to submit their comments in writing no later than October 27, 2003 to:

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

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

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