TOTAL MAXIMUM DAILY LOAD (TMDL)

For

Fecal Coliform

In

Wolf River
Fletcher Creek, Cypress Creek, and Grissum Creek

Located In The

Wolf River Watershed (HUC 08010210)
Shelby, Fayette, & Hardeman Counties, Tennessee

Prepared by:

Tennessee Department of Environment and Conservation
Division of Water Pollution Control
6th Floor L & C Tower
401 Church Street
Nashville, TN 37243-1534

January 30, 2003

TABLE OF CONTENTS

APPENDICES

LIST OF TABLES

LIST OF FIGURES

LIST OF FIGURES (Continued)

LIST OF ABBREVIATIONS

BMP	Best Management Practices
BPJ	Best Professional Judgment
CFS	Cubic Feet per Second
DEM	Digital Elevation Model
DMR	Discharge Monitoring Report
DWPC	Division of Water Pollution Control
EPA	Environmental Protection Agency
GIS	Geographic Information System
HSPF	Hydrological Simulation Program - FORTRAN
HUC	Hydrologic Unit Code
LA	Load Allocation
MGD	Million Gallons per Day
MOS	Margin of Safety
MRLC	Multi-Resolution Land Characteristic
NPDES	National Pollutant Discharge Elimination System
NPSM	Nonpoint Source Model
NRCS	Natural Resources Conservation Service
Rf3	Reach File 3
RM	River Mile
STORET	STORage RETrieval database
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	Wastewater Treatment Facility

SUMMARY SHEET
Total Maximum Daily Load (TMDL)

1. 303(d) Listed Waterbody Information

State: Tennessee
County: Shelby, Fayette, & Hardeman

Watershed: Wolf River - HUC08010210

Impaired Waterbodies (1998 303(d) List):

Waterbody ID	Segment Name	Designated Use	
		Partial Support [mi.]	Not Support [mi.]
TN08010210001	Wolf River – mouth to Fletcher Cr.	21.1	44.3
TN08010210002	Wolf River – Fletcher Cr. To Hwy 177		34.6
TN08010210005	Grissum Creek	36.6	
TN08010210023	Fletcher Creek		58
TN08010210032	Cypress Creek		14.6

Constituent(s) of Concern: Fecal Coliform Bacteria

Designated Uses: All waterbodies are classified for Fish and Aquatic Life, Recreation, Livestock Watering & Wildlife, Irrigation. The Wolf River, from the mouth to the L&N Railroad Bridge (~RM 6.7) are also classified for Industrial Water Supply and Domestic Water Supply.

Applicable Fecal Coliform Water Quality Standard for Recreation (most stringent):
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 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 Nonpoint Source Model (NPSM) was used to develop this TMDL. An hourly time step 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 for this TMDL representing a range of hydrologic and meteorological conditions.

Seasonal Variation:
A simulation period of 11 years was used to assess the water quality standards for this TMDL. This period includes seasonal variations.

3. TMDLs, WLAs, & LAs:

Subwatershed	TMDL	WLAs		LAs		Instream Fecal Coliform Concentration *
		WWTFs	MS4s	Precipitation Induced Nonpoint Sources	Other Direct Sources	
	[cts/30 day]	[cts/30 day]	[% Reduction]	[% Reduction]	[% Reduction]	[% Reduction]
Wolf River at mouth (includes all areas)	7.99×10^{13}	2.05×10^{12}	63.0	63.0	54.3	56.3
Wolf River (between Hwy 177 and Fletcher Cr)	3.34×10^{13}	2.05×10^{12}	60.9	60.9	51.9	51.4
Cypress Creek	1.53×10^{13}	0	74.8	74.8	60.0	87.6
Fletcher Creek	1.13×10^{13}	0	61.0	61.0	90.0	78.7
Grissum Creek	2.30×10^{11}	0	61.6	61.6	70.0	65.8

* Overall reduction required to achieve an instream water quality criterion (+ explicit MOS) of 180 counts/100ml (expressed as a geometric mean).

.

FECAL COLIFORM TOTAL MAXIMUM DAILY LOAD (TMDL)
WOLF RIVER WATERSHED (HUC 08010210)

Wolf River (TN08010210001 & TN08010210002)
Cypress Creek (TN08010210032)
Fletcher Creek (TN08010210023)
Grissum Creek (TN08010210005)

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 water bodies 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 Wolf River watershed (HUC 08010210) is located in western Tennessee and northern Mississippi (Figure 1). The watershed primarily falls within the Level III Mississippi Valley Loess Plains (74) and Southeastern Plains (65) ecoregions. The eastern portion of the watershed is in the Level IV Southeastern Plains and Hills subecoregion (65e) and is typified by increased gradients, generally sandy substrates, and distinctive faunal characteristics for West Tennessee. The majority of the watershed is located in the Level IV Loess Plains subecoregion (74b). Irregular plains, level to gently rolling, with wide, flat bottomlands and floodplains, characterize the physiography of the region. Streams in this subecoregion are generally low gradient and murky with silt and sand bottoms, and most have been channelized (USEPA, 1997). A very small section of the watershed, near the mouth, is in the Level IV Northern Mississippi Alluvial Plain (73a) subecoregion.

The Wolf River watershed drains an area of approximately 819 square miles and flows into the Mississippi River. Approximately 68.4% of the total drainage area is in Tennessee with the remaining 31.6% in Mississippi. Cypress Creek, Fletcher Creek, and Grissum Creeks are tributaries of the Wolf River. 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 for this time period is summarized in Table 1 and shown in Figure 2. Predominate land uses in the upper portion of the Wolf River watershed is forest (48%) and agriculture (39%). Urban areas dominate the land use in the lower portion of the Wolf River watershed, as well as in the Cypress Creek and Fletcher Creeks subwatersheds.

Figure 1 Location of the Wolf River Watershed

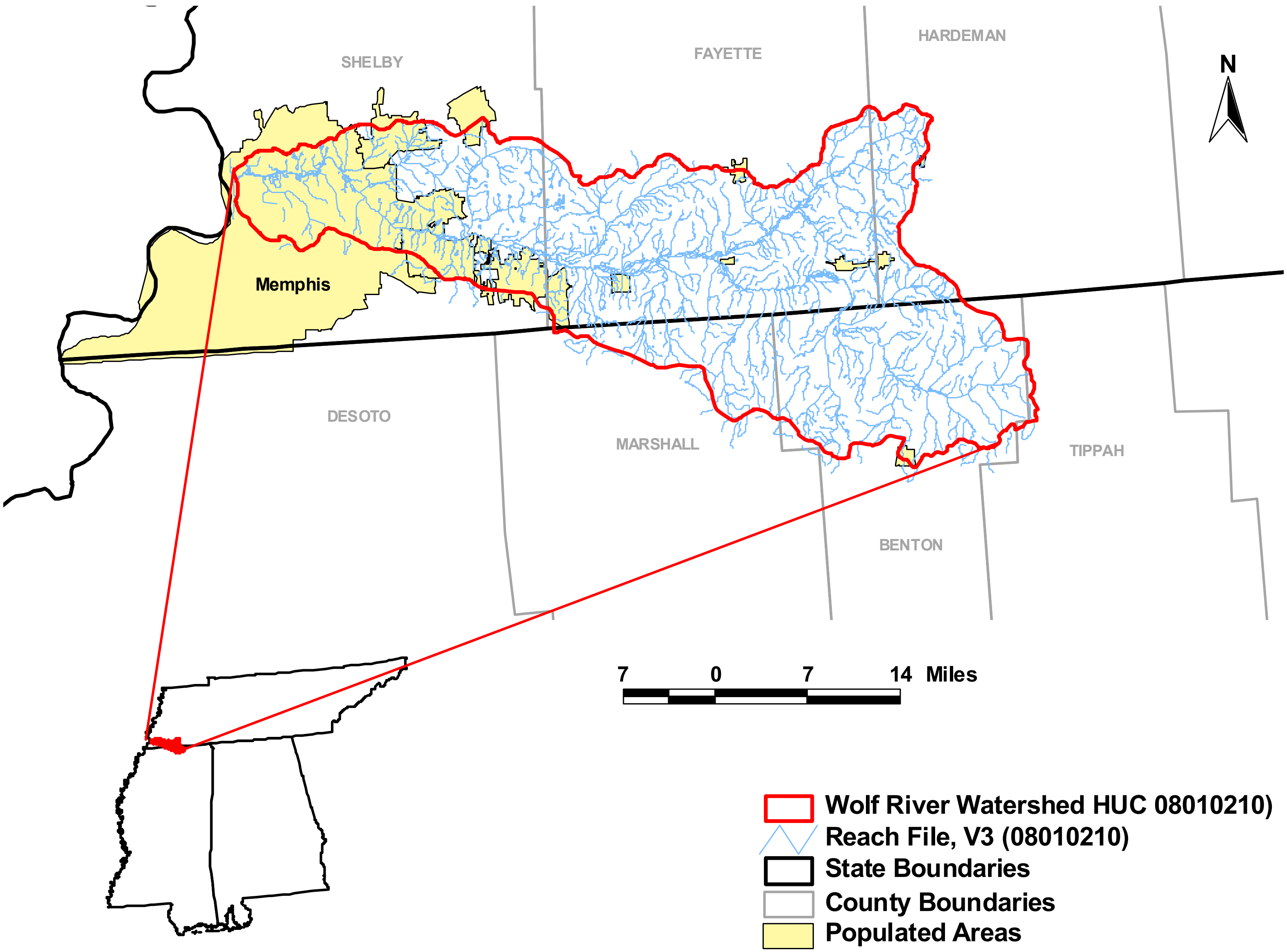
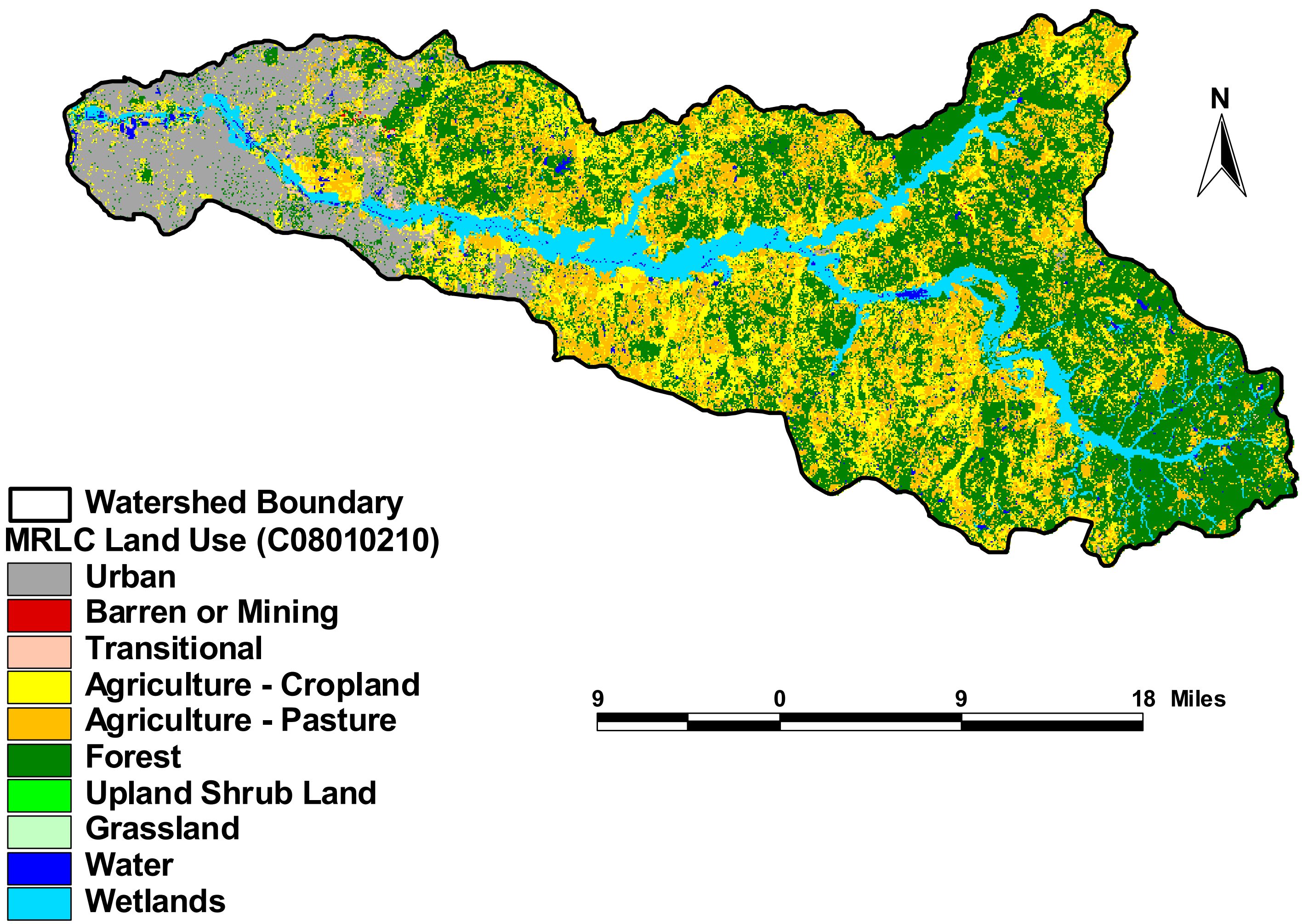


Table 1 Land Use Distribution in the Wolf River Watershed

Land Use	Subwatershed									
	Wolf River Upstream of Mouth		Wolf River Upstream of Hwy 177		Cypress Creek		Fletcher Creek		Grissum Creek	
	[acres]	[%]	[acres]	[%]	[acres]	[%]	[acres]	[%]	[acres]	[%]
Bare Rock/Sand/Clay	137	0	84	0	0	0	84	0	0	0
Quarries/Strip Mines/Gravel Pits	109	0	29	0	0	0	29	0	0	0
High Intensity Commercial/ Industrial/ Transport.	7,701	1	6,948	8	1,275	11	999	5	9	0
High Intensity Residential	18,394	4	17,116	19	3,037	26	3,830	18	1	0
Low Intensity Residential	33,651	6	30,372	34	5,679	49	5,357	25	24	0
Deciduous Forest	145,286	28	5,836	7	303	3	2,543	12	1,676	20
Evergreen Forest	21,953	4	935	1	17	0	477	2	68	1
Mixed Forest	35,588	7	4,361	5	360	3	1,737	8	190	2
Other Grasses (Urban/Recreational)	4,187	1	3,856	4	618	5	1,286	6	0	0
Pasture/Hay	107,890	21	5,352	6	107	1	2,203	10	2,831	34
Row Crops	95,125	18	5,982	7	231	2	2,002	9	3,391	41
Transitional	1,797	0	1,329	1	16	0	446	2	0	0
Emergent Herbaceous Wetlands	245	0	0	0	0	0	0	0	0	0
Woody Wetlands	44,756	9	5,608	6	10	0	64	0	2	0
Open Water	7,182	1	1,801	2	10	0	183	1	118	1
Total	**524,001**	**100**	**89,609**	**100**	**11,663**	**100**	**21,240**	**100**	**8,310**	**100**

Figure 2. MRLC Land Use in the Wolf River Watershed



3.0 PROBLEM DEFINITION

EPA Region IV approved Tennessee's final 1998 303(d) list on September 17, 1998. The list identified two segments of the Wolf River, Cypress Creek, Fletcher Creek and Grissum Creek as impaired due, in part, to pathogens (see Table 2). The designated uses for all waterbodies in the Wolf River watershed include fish & aquatic life, recreation, irrigation, and livestock watering & wildlife. In addition, the Wolf River, from the mouth to the L&N Railroad Bridge (~RM 6.7), is also classified for industrial water supply and domestic water supply. The fecal coliform group is an indicator of the presence of pathogens in a stream.

Table 2 1998 303(d) List – Stream Impairment Due to Pathogens

Waterbody ID	Segment Name	RM Partially Supporting Desig. Uses	RM Not Supporting Desig. Uses
TN08010210001	Wolf River from mouth to Fletcher Creek (Harrington Ck. is partially supporting)	21.1	44.3
TN08010210002	Wolf River from Fletcher Creek to Hwy 177 (Germantown Rd)		34.6
TN08010210005	Grissum Creek	36.6	
TN08010210023	Fletcher Creek		58
TN08010210032	Cypress Creek		14.6

Waterbodies in the Wolf River watershed were reassessed by the State in 2000 & 2002 using more recent data and a revised waterbody identification system. The 2002 assessment information shown in Table 3 is considered to be the most accurate representation of pathogen impairment in the Wolf River watershed to date and is part of the 2002 303(d) list proposed by the Division of Water Pollution Control in July, 2002. The information in Table 3 is referred to as the "2002 assessment" in the remainder of this TMDL document. TMDLs have been developed for all waterbodies identified as impaired due to pathogens in either the 1998 303(d) list or the 2002 assessment.

The portion of the Wolf River watershed located in northern Mississippi has not been identified as impaired due to pathogens on Mississippi's 1998 303(d) list. According to the Mississippi Department of Environmental Quality (MDEQ), there are no known pathogen stream monitoring data available for the Wolf River watershed in Mississippi.

Table 3 Proposed 2002 303(d) List – Stream Impairment Due to Pathogens

Waterbody ID	Segment Name	RM Partially Supporting Desig. Uses	RM Not Supporting Desig. Uses	Reference to 1998 303(d) List Waterbody ID
TN08010210001-0100	Harrington Creek	16.5		TN08010210001
TN08010210001-0300	Workhorse Bayou	3.7		TN08010210001
TN08010210001-1000	Wolf River – Mouth to Fletcher Creek		12.8	TN08010210001
TN08010210005-1000	Grissum Creek	17.9		TN08010210005
TN08010210023-0200	Unnamed Tributary to Fletcher Creek		6.5	TN08010210023
TN08010210023-1000	Fletcher Creek		10.7	TN08010210023
TN08010210032-1000	Cypress Creek		13.6	TN08010210032

4.0 TARGET IDENTIFICATION

As previously stated, the designated use classifications for waterbodies in the Wolf River watershed include: fish and aquatic life, irrigation, livestock watering & wildlife, recreation, industrial water supply, and domestic water supply. 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 for TMDL development. The fecal coliform water quality criteria for protection of the recreation use classification, as 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:

> 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.

The geometric mean standard for fecal coliform of 200 counts/100 ml has been selected as the primary target value for the TMDLs since it is representative of average stream conditions. In the TMDL, simulated concentrations are expressed in terms of a 11-year geometric mean plot. Critical conditions are determined from this 11-year period (see Section 8.1). A 11-year graph with the proposed reductions is used to show compliance with the geometric mean criteria and to illustrate the criteria has been met for all seasons. An explicit margin of safety (MOS) of 20 counts/100 ml has been included to address uncertainties in the analysis, resulting in an effective target geometric mean concentration of 180 counts/100 ml.

The instantaneous criteria are difficult to model and insufficient data are available to calibrate the water quality model for the instantaneous maximum. By meeting the geometric mean criteria, compliance with the instantaneous criteria is expected to be met during most flow regimes.

5.0 WATER QUALITY ASSESSMENT AND DEVIATION FROM TARGET

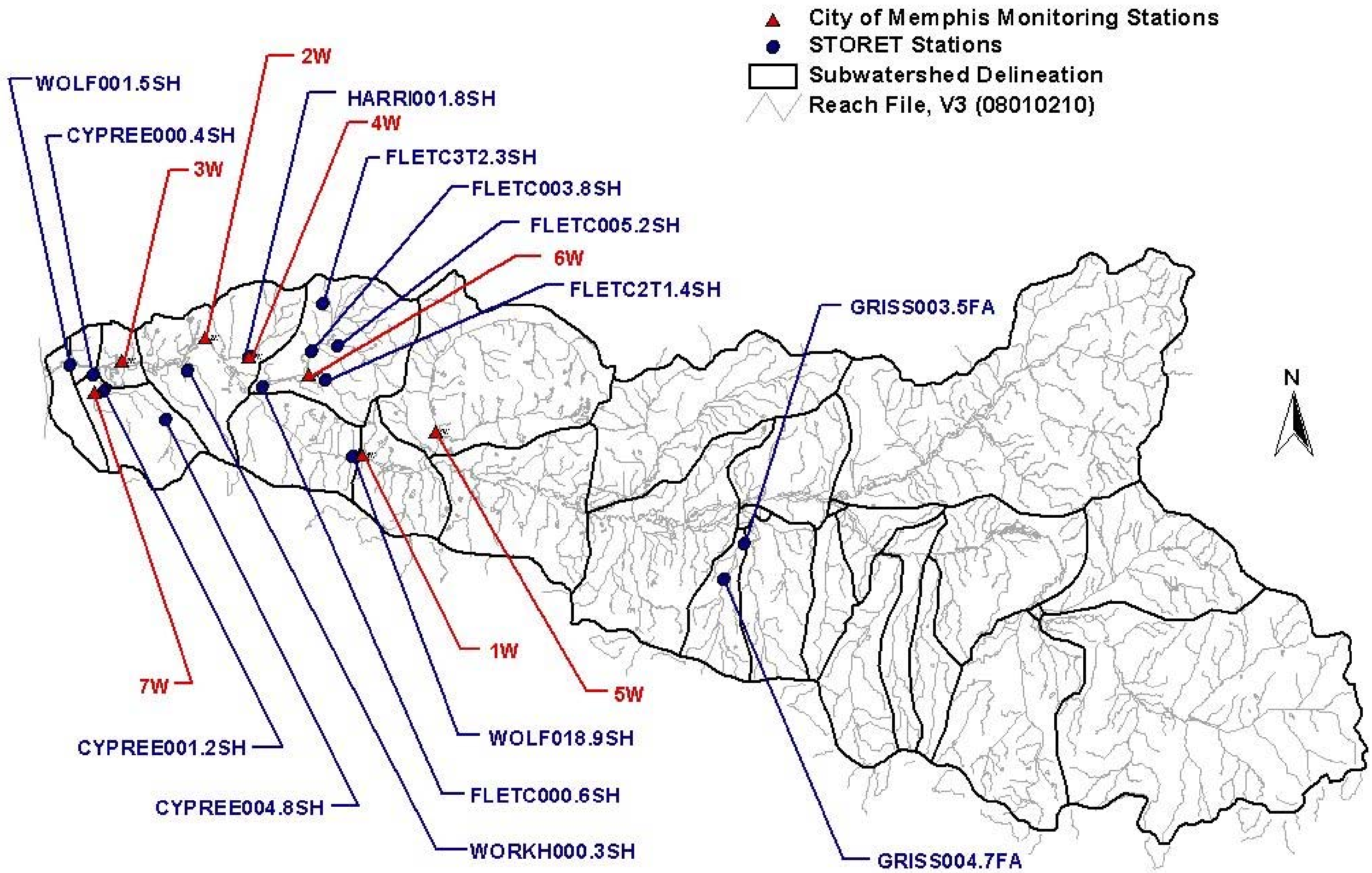
With respect to pathogens, the existing water quality of impaired streams in the Wolf River watershed can be characterized by data collected since 1990 at the following monitoring sites (see Figure 3):

- STORET Station WOLF001.5SH – Wolf River at Hwy. 51 bridge, near mouth
- STORET Station WOLF018.9SH – Wolf River at Germantown Road (Hwy. 177)
- STORET Station CYPRE000.4SH – Cypress Creek at pumping station
- STORET Station CYPRE001.2SH – Cypress Creek at North Watkins Street
- STORET Station CYPRE004.8SH – Cypress Creek at Summer Avenue
- STORET Station WORKH000.3SH – Workhouse Bayou at pumping station
- STORET Station HARRI001.8SH – Harrington Creek at Raleigh-Lagrange Road
- STORET Station FLETC000.6SH – Fletcher Creek at Bartlett Road
- STORET Station FLETC003.8SH – Fletcher Creek at Whitten Road
- STORET Station FLETC005.2SH – Fletcher Creek at Appling Road
- STORET Station FLETC2T1.4SH – Unnamed Tributary to Fletcher Ck. at Dexter Rd.
- STORET Station FLETC3T2.3SH – Unnamed Trib. to Fletcher Ck. at Appling Rd.
- STORET Station GRISS003.5FA – Grissum Cr. at Rt. 57
- STORET Station GRISS004.7FA – Grissum Cr. at Mount Pleasant Road

Fecal coliform and *E. coli* monitoring data are summarized in Tables A-1, A-2, & A-3 of Appendix A. Although insufficient data were collected to calculate 30-day geometric mean values for either fecal coliform or *E. coli*, individual samples exceeded the 1,000-counts/100 ml maximum for fecal coliform at all of the monitoring sites listed.

The City of Memphis also collects water quality data in the Wolf River watershed in accordance with their Storm Water Management Plan (SWMP). Fecal coliform and *E. coli* monitoring data collected by the City of Memphis are summarized in Tables A-4 & A-5 of Appendix A.

Figure 3 Water Quality Monitoring Stations in the Wolf River Watershed



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 nonpoint 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. All discharges authorized by National Pollutant Discharge Elimination System (NPDES) permits are point sources. and include discharges from municipal and industrial wastewater treatment facilities (WWTFs), as well as storm water discharges from municipal separate storm sewer systems (MS4s) in urbanized areas.

Nonpoint 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 nonpoint sources of fecal coliform bacteria include:

- Wildlife
- Land application of agricultural manure
- Livestock grazing
- Leaking septic systems
- Urban development
- Animals having access to streams

6.1 Point Sources

6.1.1 Municipal and Industrial Wastewater Treatment Facilities

There are a number of point sources with NPDES permits for the discharge of treated sanitary wastewater located in the drainage areas of the 303(d) listed stream segments (see Figure 4). The design flow and fecal coliform loading for these facilities are summarized in Table 4. The fecal coliform bacteria load is based on the design flow and concentration of 200 counts per 100 ml. Bacteria loads are expressed as counts per 30-days to reflect the target water quality criterion. This load represents the total load the facility can discharge in a 30-day period for the stream to maintain water quality standards.

Figure 4 Permitted Waste Water Treatment Facilities in the Wolf River Watershed

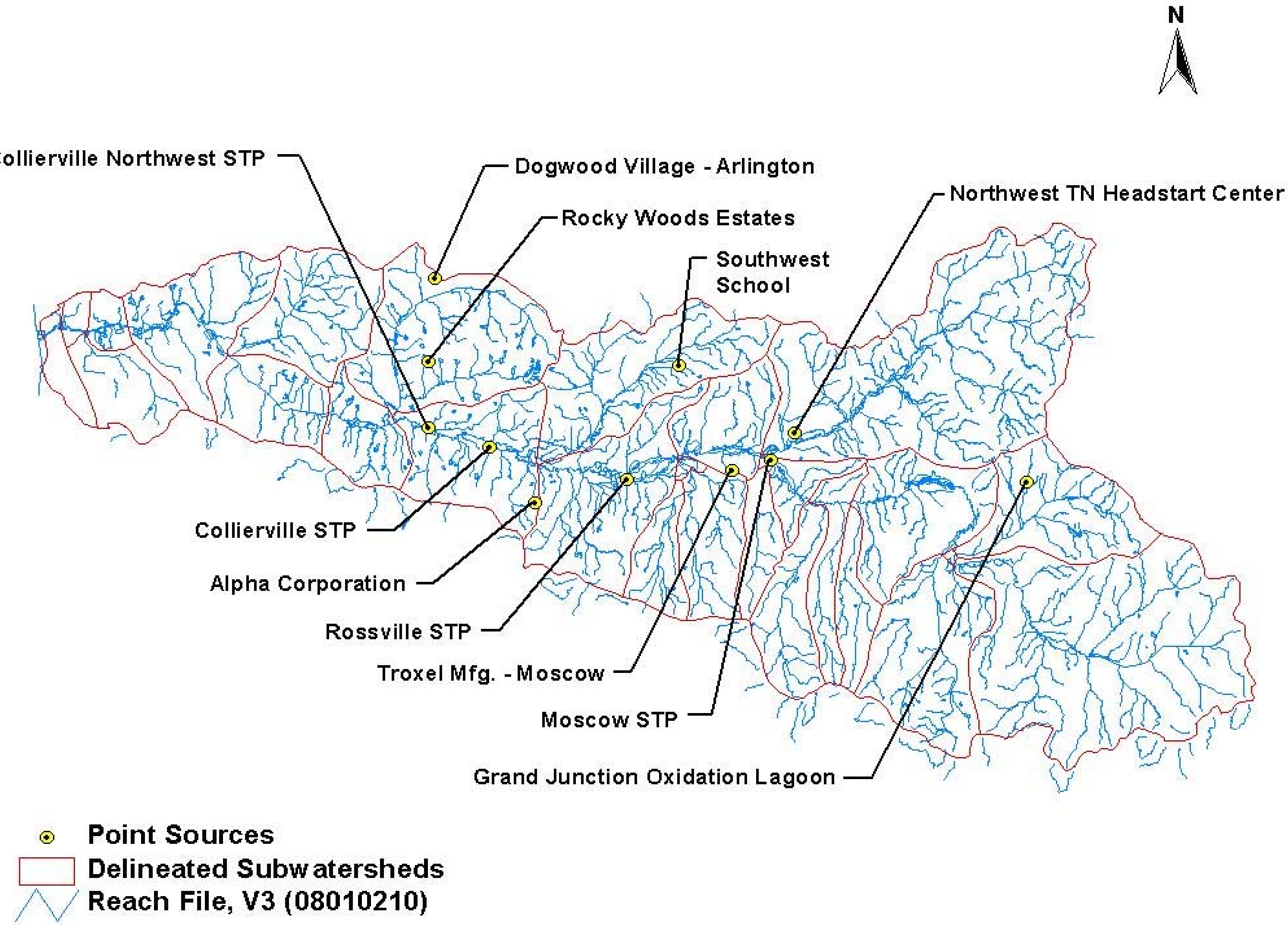


Table 4 NPDES Facilities Discharging Fecal Coliform in Wolf River Watershed

Facility Name	NPDES Permit No.	Sub-Watershed [a]	Design Flow [MGD]	Fecal Coliform Loading [b] [cts/30 days]
Grand Junction Oxidation Pond	TN0022560	012	0.12	2.72×10^{10}
Moscow STP	TN0021164	021	0.06	1.368×10^{10}
Northwest TN Headstart Center	TN0065293	011	0.015	3.41×10^{9}
Rossville STP	TN0064092	009	2.2	5.004×10^{11}
Southwest School	TN0023787	008	0.02	4.55×10^{9}
Collierville Northwest STP	TN0074543	007	3.00	6.81×10^{11}
Collierville STP	TN0057461	007	3.50	7.99×10^{11}
Rocky Woods Estates	TN0056391	006	0.05	1.138×10^{10}
Dogwood Village - Arlington	TN0055069	006	0.014	3.18×10^{9}
Alpha Corporation	TN0000442	007	0.007	1.59×10^{9}
Troxel Mfg Moscow	TN0000451	010	0.029	6.588×10^{9}

a. Number refers to delineated subwatershed as shown in Figure 5.
b. Loading based on Monthly Average permit limit (200 counts/ 100 ml) at design flow.

Discharge monitoring reports (DMRs) submitted by NPDES facilities were reviewed to identify facilities discharging fecal coliform bacteria in excess of permit limits. Most facilities were in compliance with permit limits and, in most cases, discharge fecal coliform bacteria at levels below permit limits. Several facilities, however, had one or more reporting periods where the daily maximum fecal coliform concentration exceeded the daily maximum permit limit. For the period from 1/98 through 5/02, these included:

NPDES Permit No.	Facility	Periods Out of Compliance
TN0000451	Troxel Mfg. - Moscow	9
TN0021164	Moscow Lagoon STP	27
TN0022560	Grand Junction Oxid. Pond	3
TN0057461	Collierville STP	11
TN0074543	Collierville Northwest STP	2 [a]

a. Period 7/01 – 5/02

6.1.2 Urban Areas Covered Under Phase I & II Storm Water Regulations

Municipal Separate Storm Sewer Systems (MS4s) may also discharge pathogens to waterbodies in response to storm events. Large and medium MS4s serving populations greater than 100,000 people are required to obtain a NPDES storm water permit. At present, the City of Memphis is the only MS4 of this size in the Wolf River watershed that is regulated by the NPDES program (TNS068276). In March 2003, small MS4s serving urbanized areas will be required to obtain a permit under the Phase II storm water regulations. An urbanized area is defined as an entity with a residential population of at least 50,000 people and an overall population density of 1,000 people per square mile. The City of Bartlett, City of Collierville, City of Germantown, Southwest Tennessee Community College, Tennessee Technology Center at Memphis, and Shelby County will be covered under Phase II of the NPDES Storm Water Program. The Tennessee Department of Transportation (TDOT) is also being issued MS4 permits for state roads in urban areas.

6.2 Nonpoint Sources

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 densities for several counties in the Wolf River watershed, provided by the Tennessee Wildlife Resources Agency (TWRA), range from 83 to 94 animals per square mile of "suitable habitat". For purposes of the water quality model, suitable habitat is interpreted as lands classified as either forest or wetlands. Fecal coliform loads due to deer are estimated by EPA to be 5.0×10^8 counts/animal/day.

6.2.2 Agricultural Animals

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

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

- Processed agricultural manure from confined feeding operations is generally collected in lagoons and applied to land surfaces during the months April through October. In the Wolf River watershed, manure is applied only to pastureland since chemical fertilizer is used on cropland. 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).

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

Livestock data from the 1997 Census of Agriculture for the major counties in the Wolf River watershed are listed in Table 5. Estimates of county horse population are based on 1999 data provided by the Tennessee Agricultural Statistics Service (USDA, 1999). Cattle and swine are the predominate livestock in these counties.

On the 1998 303(d) list and the 2002 assessment, agriculture/pasture grazing is identified as a possible pollutant source in Grissum Creek. The Shelby County Correctional Center raises cattle at their facility near Germantown, TN. The City of Memphis has identified this facility as a potential source of fecal coliform contamination as cattle are often found grazing near the Wolf River.

In the model, fecal coliform loading rates are expressed in terms of an accumulation rate in units of counts/acre/day. The accumulation rate from each animal is calculated by multiplying the fecal contribution from a particular animal by the ratio of that animal population in the county to the number of acreage of pastureland. In the land use database, agricultural lands are denoted as either pasture, or hay, and crops. Livestock are assumed present on lands classified as pasture, or hay. The fecal coliform contribution from the various animals for which population values are known are estimated to be: 1.06×10^{11} counts/day/beef cow, 1.24×10^{10} counts/day/hog, 1.04×10^{11} counts/day/dairy cow, 1.38×10^{8} counts/day/layer chicken, 1.22×10^{10} counts/day/sheep, and 4.18×10^{8} counts/day/horse (NCSU, 1994). The total accumulation load applied to pastureland, is the sum of the contributions from the individual animals in the county database.

Table 5 Livestock Distribution By County

Livestock	Shelby	Fayette	Hardeman	Benton, MS	Marshall, MS
Cattle	8628	25437	15877	7281	22032
Beef	4980	13,421	295	4586	13,277
Dairy	42	965	62	12	366
Swine	335	25,667	5221	47	66
Poultry (layers)	484	See note a	See Note a	See Note a	245
Sheep	148	124	144	See Note a	48
Horses	2512	1929	519	213	582

a. Data withheld in agricultural census inventory to avoid disclosing data for individual farms

6.2.3 Failing Septic Systems

Some fecal coliform loading in the Wolf River watershed can be attributed to failure of septic systems and illicit discharges of raw sewage. Estimates from 1997 county census data of people in selected subwatersheds utilizing septic systems are shown in Table 6. In western Tennessee, EPA estimates that there are approximately 2.5 people per household on septic systems, some of which can be reasonably assumed to be failing.

Table 6 Estimated Population on Septic Systems by County

County	Population on Septic Systems
Shelby, TN	8,229
Fayette, TN	6,387
Hardeman, TN	5,545
Marshall, MS	7,015
Benton, MS	2,063

6.2.4 Urban Development

Fecal coliform loading from urban areas is 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 considered to be significant contributors to fecal coliform loading to impaired waterbodies in urbanized areas.

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 condition for the TMDL analysis. Several computer-based tools were also utilized to generate input data for the model.

The Nonpoint Source Model (NPSM) is a watershed model capable of simulating nonpoint source runoff and associated pollutant loadings, account for point source discharges, and performing flow and water quality routing through stream reaches. NPSM is based on the Hydrologic Simulation Program - Fortran (HSPF). In these TMDLs, NPSM was used to simulate point source discharges, simulate the deposition and transport of fecal coliform bacteria from land surfaces, and compute the resulting water quality response. Model details are provided in Appendix B.

In addition to NPSM, 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 Wolf River watershed. This information includes land use categories, point source dischargers, soil types and characteristics, population data (human and livestock), and stream characteristics.

Results of the WCS characterization are input to a spreadsheet developed by Tetra Tech, Inc. to estimate NPSM input parameters associated with fecal coliform buildup (loading rates) and wash off from land surfaces. In addition, the spreadsheet can be used to estimate direct sources of fecal coliform loading to water bodies from leaking septic systems and animals having access to streams. Information from the WCS and spreadsheet tools were used as initial input for variables in the NPSM model.

7.2 Model Setup

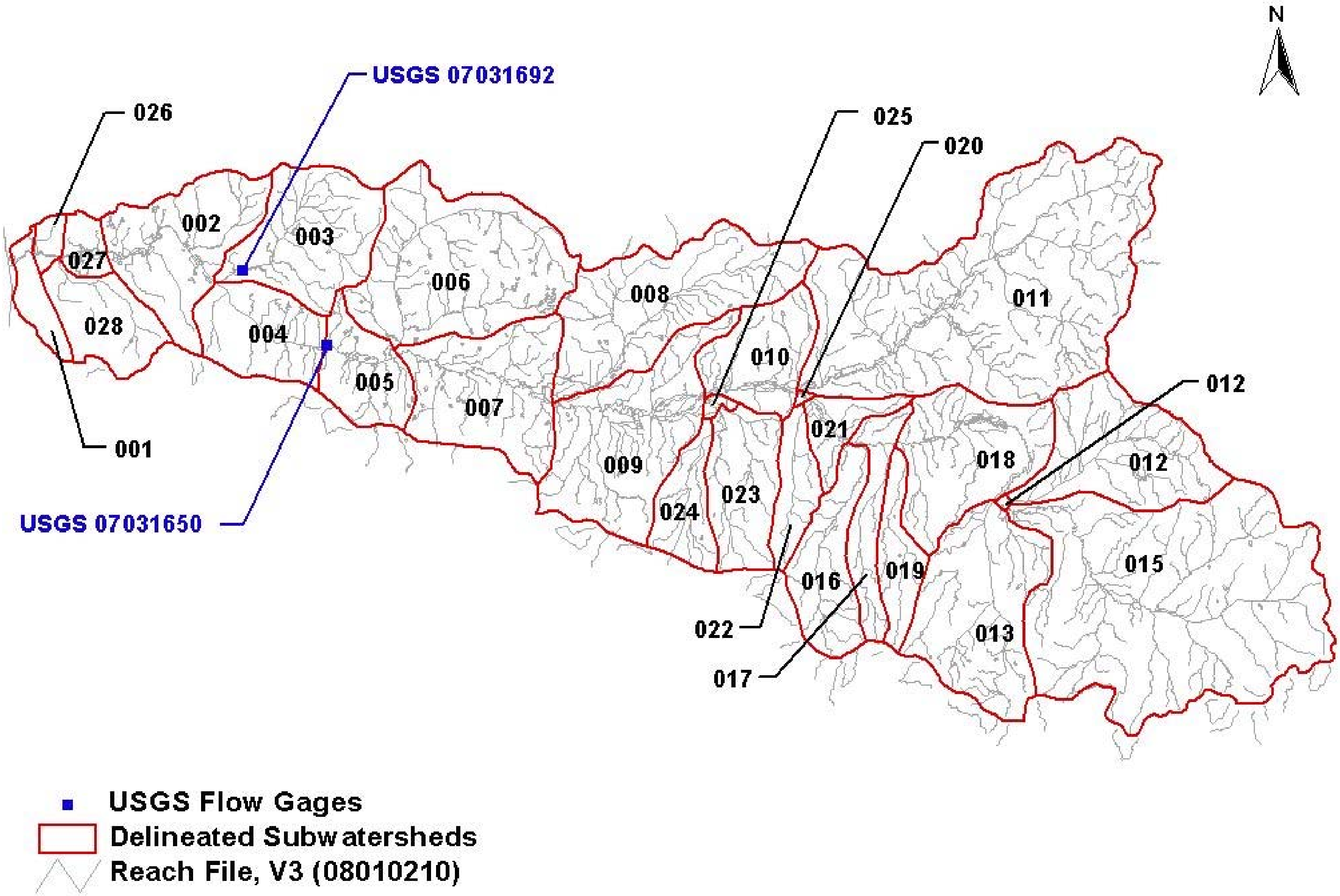
The Wolf River watershed was delineated into 28 subwatersheds in order to characterize relative fecal coliform bacteria contributions from significant contributing drainage areas (see Figure 5). Boundaries were constructed so that subwatershed “pour points” coincided, when possible, with water quality monitoring stations or flow gages. Watershed delineation was based on the Reach File 3 (Rf3) stream coverage and Digital Elevation Model (DEM) data. This discretization allows management to vary load reduction alternatives 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 build-up and wash-off of fecal coliform bacteria from the land into the streams, as well as the dilution potential of the stream. Weather data from the Memphis meteorological station were used for simulations in all subwatersheds.

7.3 Model Calibration

Calibration of the watershed model included both hydrology and water quality components. The hydrology 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 stream flow data in the watershed for the same period of time. The USGS stream gaging station on the Wolf River at Germantown, TN (USGS 07031650) was used in the hydrology calibration (see Figure 5). Model parameters adjusted include: evapotranspiration, infiltration, upper and lower zone storage, groundwater storage, recession, losses to the deep groundwater system, and interflow discharge.

Figure 5 Delineated Subwatersheds



The model was also calibrated for water quality. Appropriate model parameters were adjusted to obtain acceptable agreement between simulated instream fecal coliform concentrations and observed data collected at sampling stations on the impaired reaches as well as at the reference station. Results show that the model adequately simulates peaks in fecal coliform bacteria in response to storm events and base concentrations during low flow events. Results of the hydrologic and water quality calibrations are presented in Appendix B (Figures B-1 t0 B-3 & B-9 to B-16).

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 <u>other appropriate measure</u>. The TMDLs for the listed streams in the Wolf River watershed are expressed as counts/30-days. This load represents the total load the stream can assimilate in a 30-day period and maintain the water quality criterion of 200 counts/100mL (as modified by the explicit Margin of Safety: see Section 8.3).

8.1 Critical Conditions

The critical condition for nonpoint 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 stream flow when dilution is minimized. Both conditions are simulated in the water quality model.

The 11-year period from January 1, 1990, to December 31, 2000 was used to simulate a continuous 30-day geometric mean concentration to compare to the target. This period contained a range of hydrological conditions that included both low and high stream flows from which critical conditions were identified and used to derive the TMDL values.

The simulated geometric mean concentrations for existing conditions are presented in Appendix B (Figures B-17 to B-21). From these figures, critical conditions can be determined. The 30-day critical period in the model is the period preceding the largest simulated violation of the geometric mean criteria. Violations in the geometric mean criterion resulting from extreme meteorological conditions (i.e., floods or severe droughts) are excluded from the critical period analysis. Meeting the water quality criteria during the critical period ensures that water quality criteria can be achieved throughout the 11 year period.

8.2 Existing Conditions

The existing fecal coliform load for each of the 303(d) listed waterbodies in the Wolf River watershed was determined in the following manner:

- The calibrated model, corresponding to the portion of the Wolf River watershed that is upstream of the “pour point” of the listed waterbody segment was run for a time period that included the critical condition for that waterbody (1/1/90 – 12/31/00).

- 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 precipitation induced loading from urban and agricultural land uses (includes discharges from MS4s and nonpoint sources) is the largest source of fecal coliform bacteria loading in the Wolf River watershed. Direct inputs of fecal coliform bacteria from “other sources” (i.e., animal access to streams, illicit discharges of fecal coliform bacteria, and failing septic systems) are also shown to have an impact on bacteria loading in the watershed. Reductions in these loading rates reduce the in-stream fecal coliform bacteria levels. Precipitation induced loading, loading from other direct sources, and the geometric mean in-stream concentration simulated during the critical period, that represent existing conditions in the model are shown in Table 7.

In general, point source loads from NPDES regulated WWTFs do not significantly contribute to the impairment of the listed stream segments since discharges from these facilities are required to be treated to levels corresponding to instream water quality criteria.

Table 7 MS4 & Nonpoint Source Loading - Existing Conditions

Subwatershed	Precipitation Induced Loading (MS4s & Nonpoint Sources)	Other Direct Sources	In-Stream Fecal Coliform Bacteria Concentration [a]
	[counts / 30 days]	[counts / 30 days]	[counts/100 ml]
Wolf River at Mouth (includes all modeled areas)	1.85×10^{14}	2.06×10^{13}	412
Wolf River at Confluence with Fletcher Creek	5.73×10^{13}	1.86×10^{13}	370
Cypress Creek	6.08×10^{13}	2.04×10^{10}	1,452
Fletcher Creek	2.88×10^{13}	1.10×10^{12}	845
Grissum Creek	9.47×10^{10}	6.47×10^{11}	526

a. Fecal coliform bacteria concentrations represent the maximum simulated geometric mean concentration during the critical period (see Section 8.1).

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 and explicit and implicit MOS were used. The explicit MOS is applied to the load allocation portion only and is equivalent to 20 counts/100 ml below the in-stream target concentration. The implicit MOS includes the use of conservative modeling assumptions and a 11-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; all land uses connected directly to streams; fecal coliform applied to land surfaces was not subjected to die-off or absorption rates ;and a conservative value was used to estimate the in-stream decay of fecal coliform in the waterbodies.

8.4 Determination of TMDL, WLAs, & LAs

The TMDL is the total amount of pollutant that can be assimilated by a water body while maintaining water quality standards. Fecal coliform bacteria TMDLs are expressed as counts per 30 day period, as this is how the target water quality criterion 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 criterion (including explicit MOS) of 180 counts/100 ml. The TMDL components were estimated according to the following procedure:

- The calibrated model, corresponding to the portion of the Wolf River watershed that is upstream of the “pour point” of the listed waterbody segments was run for a time period that included the critical period.

- Existing NPDES permitted facilities were assumed to discharge at design flows, and a fecal coliform permit limit of 200 counts/100 ml, where applicable.

- Fecal coliform land loading variables and the magnitude of loading from sources modeled as “other direct sources” were adjusted within reasonable range of literature values until the resulting fecal coliform concentration at the “pour point” of the listed water body segment is less than 180 counts/100ml (includes explicit MOS).

- The $\sum$WLAs was divided into two component parts:

  $$\sum WLAs = [\sum WLAs]_{WWTF} + [\sum WLAs]_{MS4}$$

  $[\sum WLAs]_{WWTF}$ is the load associated with the daily discharge loads of all modeled NPDES permitted facilities summed over the 30-day critical period. The bacteria load for each facility is based on the permitted flow and a fecal coliform concentration of 200 counts/100 ml. $[\sum WLAs]_{MS4}$ represents the daily fecal coliform load discharged from MS4s as a result of buildup/wash off processes and summed over the 30-day critical period. $[\sum WLAs]_{MS4}$ is expressed as a required percent reduction of fecal coliform loading for the 30-day critical period.

- The $\sum$LAs was also divided into two component parts:

$$\sum LAs = [\sum LAs]_{SW} + [\sum LAs]_{DS}$$

$[\sum LAs]_{SW}$ represents the daily fecal coliform load indirectly going to surface waters from all modeled land use areas as a result of buildup/wash off processes. $[\sum LAs]_{SW}$ is expressed as a required percent reduction of fecal coliform loading for the 30-day critical period. $[\sum LAs]_{DS}$ is the daily discharge load from sources modeled as "other direct sources" that has been summed over the 30 day critical period.

- The percent reductions for the $[\sum WLAs]_{MS4}$ and $[\sum LAs]_{SW}$ terms are derived from the existing maximum simulated 30-day geometric mean concentration (instream) at the "pour point" of the listed water body segment and 180 mg/l (target + explicit MOS).

The TMDL and associated loads for the listed water bodies are summarized in Table 8.

Table 8 TMDL Loading Summary

Subwatershed	Loads				MOS *
	WWTFs	Precipitation Induced (MS4 + Nonpoint Sources)	Other Direct Sources	TMDL	
	[cts/30 day]	[cts/30 day]	[cts/30 day]	[cts/30 day]	
Wolf River at mouth (includes all areas)	2.05×10^{12}	6.84×10^{13}	9.43×10^{12}	7.99×10^{13}	Explicit & Implicit
Wolf River (between Hwy 177 and Fletcher Cr)	2.05×10^{12}	2.24×10^{13}	8.93×10^{12}	3.34×10^{13}	Explicit & Implicit
Cypress Creek	0	1.53×10^{13}	8.15×10^{9}	1.53×10^{13}	Explicit & Implicit
Fletcher Creek	0	1.12×10^{13}	1.10×10^{11}	1.13×10^{13}	Explicit & Implicit
Grissum Creek	0	3.63×10^{10}	1.94×10^{11}	2.30×10^{11}	Explicit & Implicit

* Explicit MOS = 20 counts/30 day 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.

8.4.1 Waste Load Allocations

8.4.1.1 Wastewater Treatment Facilities

There are 11 NPDES permitted WWTFs that discharge treated sanitary wastewater in the Wolf River watershed. Existing NPDES facilities have permit limits that meet instream fecal coliform water quality standards and no further reductions are required. Any future facility permitted to discharge fecal coliform bacteria in the watershed will be require to have end-of-pipe limits equivalent to the water quality criterion of 200-counts/100 ml. Future facilities discharging at concentrations less than the water quality standard should not cause or contribute fecal coliform bacteria impairment in the watershed.

8.4.1.2 Municipal Separate Storm Sewer Systems

The percent reduction in precipitation induced fecal coliform loading was calculated by comparing existing loading (ref: Table 7) with the TMDL component loading (ref: Table 8) for the subwatersheds of interest. As a simplifying assumption, the reductions required for MS4 drainage areas and nonpoint source drainage areas were considered to be equivalent. WLAs for MS4s are expressed as a required percent reduction in fecal coliform loading and are applicable to MS4 drainage areas the specified subwatersheds. WLAs for MS4s are summarized in able 9.

Table 9 WLAs & LAs for Precipitation Induced Loading

Subwatershed	Precipitation Induced Loads (MS4 + Nonpoint Sources)		Required Load Reduction	
	Existing Load	TMDL Load Component	WLA (MS4s)	LA (Nonpoint Sources)
	[cts/30 day]	[cts/30 day]	[%]	[%]
Wolf River at mouth (includes all areas)	1.85×10^{14}	6.84×10^{13}	63.0	63.0
Wolf River (between Hwy 177 and Fletcher Cr)	5.73×10^{13}	2.24×10^{13}	60.9	60.9
Cypress Creek	6.08×10^{13}	1.53×10^{13}	74.8	74.8
Fletcher Creek	2.88×10^{13}	1.12×10^{13}	61.0	61.0
Grissum Creek	9.47×10^{10}	3.63×10^{10}	61.6	61.6

8.4.2 Load Allocations

8.4.2.1 Load Allocations for Precipitation Induced Nonpoint Sources Discharges

LAs for precipitation induced pathogen loading from nonpoint sources were calculated as stated in Section 8.4.1.2 and are expressed as a required percent reduction. This loading results from fecal coliform accumulation on land surfaces and wash-off during storm events. LAs for these discharges are summarized in Table 9.

8.4.2.2 Load Allocations from Other Direct Sources

Fecal coliform loading from failing septic systems and animals in the stream are modeled as "other direct sources" and are independent of precipitation. LAs for these sources were calculated by comparing existing loads (ref: Table 7) with TMDL component loads (ref: Table 8) and are expressed as a required percent reduction. LAs for nonpoint sources are summarized in Table 10.

Table 10 Load Allocations for "Other Direct Sources"

Subwatershed	"Other Direct Sources		LA (Required Load Reduction)
	Existing Load	TMDL Load Component	
	[cts/30 day]	[cts/30 day]	[%]
Wolf River at mouth (includes all areas)	2.06×10^{13}	9.43×10^{12}	54.3
Wolf River (between Hwy 177 and Fletcher Cr)	1.86×10^{13}	8.93×10^{12}	51.9
Cypress Creek	2.04×10^{10}	8.15×10^{9}	60.0
Fletcher Creek	1.10×10^{12}	1.10×10^{11}	90.0
Grissum Creek	6.47×10^{11}	1.94×10^{11}	70.0

8.4.3 Seasonal Variation

Seasonal variation was incorporated in the water quality model by simulating an 11-year period that included seasonal fluctuations in meteorological conditions.

8.4.4 TMDL, WLA, & LA Summary

Fecal coliform TMDLs, WLAs, and LAs for the Wolf River watershed are summarized in Table 11.

Table 11 Summary of TMDLs, WLAs, & LAs

Subwatershed	TMDL	WLAs		LAs		Instream Fecal Coliform Concentration *
		WWTFs	MS4s	Precipitation Induced Nonpoint Sources	Other Direct Sources	
	[cts/30 day]	[cts/30 day]	[% Reduction]	[% Reduction]	[% Reduction]	[% Reduction]
Wolf River at mouth (includes all areas)	7.99×10^{13}	2.05×10^{12}	63.0	63.0	54.3	56.3
Wolf River (between Hwy 177 and Fletcher Cr)	3.34×10^{13}	2.05×10^{12}	60.9	60.9	51.9	51.4
Cypress Creek	1.53×10^{13}	0	74.8	74.8	60.0	87.6
Fletcher Creek	1.13×10^{13}	0	61.0	61.0	90.0	78.7
Grissum Creek	2.30×10^{11}	0	61.6	61.6	70.0	65.8

* Overall reduction required to achieve an instream water quality criterion (+ explicit MOS) of 180 counts/100ml (expressed as a geometric mean).

9.0 IMPLEMENTATION PLAN

The TMDL analysis was performed using the best data available to specify WLAs & LAs that will meet the water quality criteria for pathogens (fecal coliform) in Wolf River watershed so as 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 that are causing impairment of water quality.

9.1 Point Sources

9.1.1 Wastewater Treatment Facilities

All discharges from industrial and municipal wastewater treatment facilities are required to be in compliance with the conditions of their NPDES permit at all times.

9.1.2. Urban Areas Covered Under Phase I Storm Water Regulations

The City of Memphis has had a MS4 permit since June 1, 1996. This permit authorizes existing or new storm water induced, point source discharges to surface waters from the municipal separate storm sewer system and covers all areas located within the corporate boundary of the City of Memphis. The City has developed and implemented a Storm Water Management Plan (SWMP) as required by the permit. Annual reports have been submitted detailing implementation of the SWMP and the results of sampling activities.

In accordance with the load allocations developed in this TMDL, the Memphis MS4 permit should be modified to require the review and revision, as necessary, of the Memphis SWMP to accomplish the following:

- Identification of all sources of fecal coliform loading to the Wolf River watershed within the City of Memphis.

- A reduction of fecal coliform loading in point and non-point source storm water runoff discharges to the Wolf River watershed in accordance with the Load Allocations specified in Table 9.

- Reduction of fecal coliform loading, to the maximum extent practicable, due to failing septic systems and miscellaneous sources located within the city limits. Miscellaneous sources include, but are not limited to, leaking collection systems, illicit discharges, and unidentified sources.

- Appropriate discharge and stream monitoring to verify the effectiveness of pollution reduction measures.

9.1.3 Urban Areas Covered Under Phase II Storm Water Regulations

The City of Bartlett, City of Collierville, City of Germantown, Southwest Tennessee Community College, Tennessee Technology Center at Memphis, Shelby County, and TDOT will be issued NPDES Municipal Separate Storm Sewer System (MS4) permits under the Phase II storm water regulations. Applications are due by March 10, 2003. Each permitted entity will be required to develop a Storm Water Management Program (SWMP). The SWMP covers the duration of the permit (5-year renewable) and comprises a comprehensive planning process which involves public participation and intergovernmental coordination to reduce the discharge of pollutants to the maximum extent practicable using management practices, control techniques, public education, and other appropriate methods and provisions. With respect to fecal coliform pollution reduction, additional activities and programs conducted by city, county, and state agencies are recommended to support the SWMP:

- Field screening and monitoring programs to identify the types and extent of fecal coliform water quality problems, relative degradation or improvement over time, areas of concern, and source identification.

- Requirements that all new and replacement sanitary sewage systems are designed to minimize discharges from the system into the storm sewer system.

- Mechanisms for reporting and correcting illicit connections, breaks, surcharges, and general sanitary sewer system problems with potential to release to the municipal separate storm sewer system.

- Require NPDES facilities to comply with permit limits.

9.2 Nonpoint Sources - Agricultural Sources of Fecal Coliform Loading

The Tennessee Department of Environment & Conservation (TDEC) will coordinate with the Tennessee Department of Agriculture (TDA) and the Natural Resources Conservation Service (NRCS) to address issues concerning fecal coliform loading from agricultural land uses in the Wolf River watershed. It is recommended that additional information (such as livestock populations by subwatershed, animal access to streams, manure application practices, etc.) be evaluated to better identify and quantify agricultural sources of fecal coliform loading in order to 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.

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 Wolf River watershed includes monthly grab samples and intensive sampling for one month during both the wet season (January-March) and 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 Wolf River Watershed in Mississippi

The portion of the Wolf River watershed located in northern Mississippi has not been identified as impaired due to pathogens on Mississippi's 1998 303(d) list. TDEC will cooperate with the Mississippi Department of Environmental Quality (MDEQ) regarding water quality issues in the Wolf River watershed. Waterbodies flowing into Tennessee from another state must meet Tennessee water quality criteria for pathogens (ref.: Section 4.0).

9.5 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 Wolf River watershed. TDEC will coordinate with the City of Memphis, MS4 Phase II urban areas, and TDA 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 the City of Memphis and MS4 Phase II urban areas for development of SWMPs, 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 water bodies. 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, the proposed fecal coliform TMDLs for the Wolf River watershed was placed on Public Notice for a 35-day period and comments solicited. Steps taken in this regard include:

1) Notice of the proposed TMDLs was posted on the Tennessee Department of Environment and Conservation website on November 11, 2002. The announcement invited public and stakeholder comment until December 16, 2002. A link was provided to a downloadable version of the TMDL document.

2) Notice of the availability of the proposed TMDLs (similar to the website announcement) was be 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 letter was sent to wastewater treatment facilities in the study area that are permitted to discharge treated sanitary wastewater advising them of the proposed fecal coliform TMDLs and their availability on the TDEC website. The letter also stated that a written copy of the draft TMDL document would be provided on request. Letters will sent to the following facilities:

   Alpha Corporation (TN0000442)
   Troxel Manufacturing Moscow (TN0000451)
   Grand Junction Oxidation Pond (TN0022560)
   Moscow STP (TN0021164)
   Northwest TN Headstart Center (TN0065293)
   Rossville STP (TN0064092)
   Southwest School (TN0023787)
   Collierville Northwest STP (TN0074543)
   Collierville STP (TN0057461)
   Rocky Woods Estates (TN0056391)
   Dogwood Village – Arlington (TN0055069)

4) A draft copy of the proposed pathogen TMDLs was sent to the City of Bartlett, City of Collierville, City of Germantown, Southwest Tennessee Community College, Tennessee Technology Center at Memphis, Shelby County, and Tennessee Department of Transportation (TDOT). The City of Memphis is covered under Municipal Separate Storm Sewer System (MS4) permit TNS068276. The remaining entities will be issued MS4 permits under the Phase II storm water regulations.

Written comments were received from one party during the public comment period. These comments are included in Appendix D and the Division of Water Pollution Control responses are contained in Appendix E. No requests to hold public meetings were received regarding the proposed TMDLs as of close of business on December 16, 2002.

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:

www.state.tn.us/environment/wpc/tmdl.htm

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

Bruce R. Evans, P.E., Watershed Management Section
e-mail: Bruce.Evans@state.tn.us

Sherry H. Wang, Ph.D., Watershed Management Section
e-mail: Sherry.Wang@state.tn.us

REFERENCES

ASAE Standards, 45th Edition, Standards Engineering Practices Data. American Society of Agricultural Engineers (ASAE), 1998.

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.

Metcalf & Eddy, 1991. *Wastewater Engineering: Treatment, disposal, Reuse,* Third Edition, McGraw-Hill, Inc., New York.

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.

TDEC. 2000. *The Status of Water Quality in Tennessee, Year 2000 305(b) Report.* State of Tennessee, Department of Environment and Conservation, Division of Water Pollution Control.

TDEC. 2000a. *Tennessee Ecoregion Project 1994 - 1999.* State of Tennessee, Department of Environment and Conservation, Division of Water Pollution Control, December, 2000

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.

USDA, 1999. *A Tennessee tradition, Equine '99*, U.S. Department of Agriculture, National Agricultural Statistics Service and Tennessee Department of Agriculture.

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.

USEPA, 2001. *Protocols for Pathogen TMDLs,* U.S. Environmental Protection Agency, Office of Water, Washington, D.C.

APPENDIX A

Water Quality Data

Table A-1 Wolf River Watershed Fecal Coliform Ambient Monitoring Data

Sample Date	Monitoring Station						
	WOLF001.5SH	WOLF018.9SH	CYPREE000.4SH	CYPREE001.2SH	CYPREE004.8SH	WORKH000.3SH	HARRI001.8SH
	[counts/100 ml]						
5/14/90			5000			5000	
7/25/90			17000				
7/31/90	6000						310
6/12/91	600						
6/20/91						3700	
8/14/91							310
9/12/91	2000						
10/3/91			2100				
2/27/92	3000						
5/27/92		300					
8/18/92	1200						
11/12/92	1200						
2/2/93	50	70					
2/24/93			6400				
4/13/93							200
5/1/93		1200					
5/4/93	880						
8/17/93	210						
9/30/93			5100				
10/19/93							17000
11/9/93	110	88					
11/10/93			12000				
12/1/93						9800	
2/24/94			3500				
3/17/94			240				
4/13/94							600
4/27/94	2200						
8/3/94	1200	1100					
8/17/94			410				
10/12/94							1100
10/26/94	260	455					
2/2/95	110	590					
2/23/95			530				
4/5/95						270	3600
5/2/95	1300	2400					
7/27/95	2900	3000					

Table A-1 Wolf River Watershed Fecal Coliform Ambient Monitoring Data (Continued)

Sample Date	Monitoring Station						
	WOLF001.5SH	WOLF018.9SH	CYPREE000.4SH	CYPREE001.2SH	CYPREE004.8SH	WORKH000.3SH	HARRI001.8SH
	[counts/100 ml]						
8/24/95			540				
9/6/95	600	1600					
10/18/95							460
11/16/95						560	
1/30/96	190	430					
2/20/96			2600				
5/1/96	620	1200					
9/9/98			20				
1/20/99	520	580	740				3300
2/17/99	108	400	136				860
3/3/99						800	
3/17/99	1100	800	2080				1140
4/15/99	600	2500	>600				25000
5/13/99	100	90	780				140000
6/16/99	8300	650	9600				1100
7/21/99	3600	100	7000				360
8/18/99	300	90	2100				320
8/26/99	2800						
9/15/99	1300	88	6400				80
10/5/99				>800			
10/7/99					2600		
10/13/99	960	190	1400				1300
10/21/99						1500	
11/9/99				>6000			
11/17/99	480	44	200				1700
12/15/99	2300	730	400				2700
12/20/99				1700			
1/18/00				3500			
2/16/00				3500			
3/22/00				1300	910		
4/18/00				7200		300	
5/23/00				1300			
3/14/01	330						
6/13/01	210						
8/14/01	3500						
11/20/01	3700						

Table A-2 Fletcher Creek & Grissom Creek Fecal Coliform Ambient Monitoring Data

Sample Date	Monitoring Station						
	FLETC000.6SH	FLETC003.8SH	FLETC005.2SH	FLETC2T1.4SH	FLETC3T2.3SH	GRISS003.5FA	GRISS004.7FA
	[counts/100 ml]						
4/18/90	12000						
7/25/90	1200						
8/27/91						5300	
11/4/91						3100	
3/5/92	130						
10/7/92	230						
4/13/93	740						
9/30/93	30000						
4/12/94	1200						
8/24/94						78	
10/12/94	40000						
4/5/95	80						
7/25/95						2200	
10/15/95	0						
4/24/96	5000						
9/9/98	80						
1/20/99	1900						
2/17/99	2960						
3/17/99	2300						
4/15/99	34000						
5/13/99	400						
6/16/99	680						
7/21/99	1600						
8/18/99	190						
9/15/99	960						
10/5/99		470					
10/7/99			180	5500	58		
10/13/99	480						
11/9/99		64		5600			
11/17/99	160						
12/15/99	1900						
12/20/99		230					
1/5/00							98
1/18/00		140					
2/16/00		1000					
2/23/00		200					
3/22/00		390	250	260			
3/28/00					40		
4/18/00		97					

Table A-3 Wolf River Watershed *E. coli* Ambient Monitoring Data

Sample Date	Monitoring Station [counts/100 ml] WOLF001.5SH	WOLF018.9SH	CYPREEE000.4SH	CYPREEE001.2SH	CYPREEE004.8SH	WORKH000.3SH	HARRI001.8SH
9/9/98			2				
1/20/99	770	192	548				>2419
2/17/99	46	133	107				980
3/3/99						>2419	
3/17/99	373	816	1986				1414
4/15/99	>2419	1986	>2419				>2419
5/13/99	88	104	461				>2419
6/16/99	>2419	410	>2419				214
7/21/99	980	57	>2419				33
8/18/99	257	18	1986				137
8/26/99	436						
9/15/99	579	16	1414				23
10/5/99				>2419			
10/7/99					1414		
10/13/99	308	104	866				345
10/21/99						816	
11/9/99				>2419			
11/17/99	137	31	118				649
12/15/99	>2419	613	308				2149
12/20/99				501			
1/5/00							
1/18/00				1986			
2/16/00				2419			
2/23/00							
3/22/00				>2419	488		
3/28/00							
4/18/00				>2419		548	
5/23/00				1733			
3/14/01	125						
6/13/01	104						
8/14/01	1986						
11/20/01	>2419						

Table A-3 Wolf River Watershed *E. coli* Ambient Monitoring Data (Continued)

Sample Date	Monitoring Station						
	FLETC000.6SH	FLETC003.8SH	FLETC005.2SH	FLETC2T1.4SH	FLETC3T2.3SH	GRISS003.5FA	GRISS004.7FA
	[counts/100 ml]						
9/9/98	4						
1/20/99	>2419						
2/17/99	>2419						
3/3/99							
3/17/99	1733						
4/15/99	>2419						
5/13/99	291						
6/16/99	228						
7/21/99	361						
8/18/99	38						
8/26/99							
9/15/99	121						
10/5/99		291					
10/7/99			41	>2419	44		
10/13/99	387						
10/21/99							
11/9/99		35		10462			
11/17/99	130						
12/15/99	>2419						
12/20/99		199					
1/5/00						78	
1/18/00		88					
2/16/00		>2419					
2/23/00		387					
3/22/00		325	249	517			
3/28/00					19		
4/18/00		104					
5/23/00							
3/14/01							
6/13/01							
8/14/01							
11/20/01							

Table A-4 Wolf River Fecal Coliform Data Collected by the City of Memphis

Sample Date	Monitoring Site[1]						
	1W	2W	3W	4W	5W	6W	7W
	[counts/100 ml]						
1/14/00	100	70	280			80	40000
2/22/00	180	110	130			340	10
3/21/00	360	410	620			1700	140
4/18/00	50	50	60			180	11250
5/24/00	90	30	60			100	1300
6/20/00	120	1160	1700	4300	1700	5300	310
7/19/00	10	26000	39000	42000	30	680	25000
7/27/00		310	340				
8/25/00	220	1800	180	2100	100	283000	1600

Table A-5 Wolf River *E. coli* Data Collected by the City of Memphis

Sample Date	Monitoring Sites						
	1W	2W	3W	4W	5W	6W	7W
	[counts/100 ml]						
6/20/00	50	140	600	1900	1100	2600	60
7/19/00	<10	18000	1700	29000	<10	200	3300
8/25/00	200	100	20	900	100	73000	1100
9/18/00	220	1800	180	2100	100	283000	1600
10/13/00	220	310	1800	8000	1600	250	24000
10/23/00	20	10	60	100	No flow	20	130
11/07/00	5400	3600	3000	4100	5600	41000	8300
11/15/00	50	80	30	<10	210	290	200
12/05/00	40	10	10	50	<10	<10	40
12/19/00	90	110	<10	<10	210	30	<10
01/09/01	<10	30	80	<10	20	1400	20
01/22/01	<10	40	70	20	50	80	<10
02/05/01	10	<10	30	110	310	60	150
02/20/01	40	60	70	80	10	30	2300
03/07/01	20	10	<10	<10	<10	130	5900
03/20/01	40	20	,10	60	50	120	3300
04/02/01	10	80	50	120	40	180	210
04/26/01	350	5000	7000	1100	1000	1400	>80000
05/08/01	130	270	160	190	320	160	410
05/24/01	270	320	260	170	420	290	1700

Note:
1W: Wolf River at Germantown Parkway bridge
2W: Wolf River at Old Austin-Peay bridge
3W: Wolf River at North McLean bridge
4W: Harrington Creek at Raleigh-LaGrange bridge
5W: Gray's Creek at Walnut Grove bridge
6W: Fletcher Creek at North Shelby Oaks Drive bridge
7W: Cypress Creek at pump station

APPENDIX B

Model Development, Calibration, & Determination of Critical Period

B.1 Model Set Up

The Wolf River watershed was delineated into 28 subwatersheds in order to characterize relative fecal coliform bacteria contributions from significant contributing drainage areas (see Figure 5). Boundaries were constructed so that subwatershed "pour points" coincided, when possible, with water quality monitoring stations or continuous flow gages. Watershed delineation was based on the Rf3 stream coverage (1:100,000 scale) 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 file used in the simulation. The pattern and intensity of rainfall affects the build-up and wash-off of fecal coliform bacteria from the land into the streams, as well as the dilution potential of the stream. Weather data from the Memphis meteorological station were available for the time period from January 1970 through December 2000 and were used for all simulations. The model was used to analyze an 11 year time period from 1990 through 2000 to evaluate the impact of a range of rainfall events on current loadings to the watershed. The model was allowed to stabilize for one year (1989) before results from the simulation were analyzed.

B.2 Model Calibration

The calibration of the NPSM watershed model involves both hydrology and water quality components. The model must be calibrated to appropriately represent hydrologic response in the watershed before subsequent calibrations and reasonable water quality simulations can be performed. A sensitivity analysis is part of the calibration process to evaluate the impact model parameters have on the simulated results.

B.2.1 Hydrologic Calibration

The hydrology calibration of the watershed model involves comparing simulated stream flows to historic stream flow data from a continuous stream gaging station for the same period of time. The USGS operate several continuous flow gages in the watershed. The USGS gage at Germantown, TN (USGS 07031650) was the basis of the hydrology calibration as this gage had the longest continuous historical record (1990-current). The calibration involved comparing simulated and observed hydrographs until statistical stream volumes and flows were within acceptable ranges as reported in the literature (Lumb, et.al., 1994). The results of the hydrology calibration and statistical analysis for selected years are shown in figures B-1 through B-3.

An important component to the hydrology calibration is accurate representation of the stream geometry. The default stream geometry is based on the data included in the Rf1 stream coverage (1:250,000 scale). Because many of the streams in western TN have been channelized, the USGS was solicited for information on stream geometry in the Wolf River watershed. The USGS provided cross sectional data for the Wolf River at the following locations: LaGrange, Germantown, Walnut Grove Road, and Hollywood Street. The channel geometry representing the model segments at these locations were adjusted using these data, and is included as Figures B-4 through B-7 (Note: multiple data and cross sections plots at the same location reflect different flow conditions).

Initial values for hydrological 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 stream flow. 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

Wolf River watershed data, generated by WCS, was processed through the spreadsheet applications developed by Tetra Tech, Inc. to generate fecal coliform loading data for use as initial input to the NPSM 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 sensitivity of the model to changes in nonpoint source loading rates is a critical element of the calibration process. The model is very sensitive to loads applied directly into the stream (e.g., leaking septic systems, animal access to streams, etc.) and if the loads are too high, then the model will overpredict concentrations during low flow conditions.

B.2.2.1 Point Sources

For existing conditions, NPDES permitted wastewater treatment plants located in modeled subwatersheds are represented as point sources of constant flow and concentration based on the facility's design flow and permit effluent fecal coliform concentration (see Table 3).

B.2.2.2 Nonpoint Sources

A number of nonpoint source categories are not associated with land loading processes and are represented as direct, instream source contributions in the model. These may include, but are not limited to, failing septic systems, animals in streams, direct discharge of raw sewage, and undefined sources. All other nonpoint sources involve land loading of fecal coliform bacteria and wash off 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 wash off (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. Fecal coliform concentrations from interflow layers were significantly higher in urban areas than other land uses (i.e., forest, cropland, etc.). Interflow is defined as flow discharging from surficial layers of soils. By adjusting the concentration in the interflow component, a better match was obtained between simulated and observed concentrations after storm events.

B.2.2.2.1 Wildlife

Fecal coliform loadings from wildlife are uniformly distributed to forest, pasture, cropland, and wetland areas in the model. A loading rate of 5.0×10^8 counts/animal/day for deer is based on the best professional judgment (BPJ) of EPA. An animal density of 83 to 94 animals/square mile of "suitable habitat" is used to account for deer and all other wildlife. The resulting fecal coliform loading is 2.5×10^6 counts/acre/day and is considered background. This rate is assumed constant throughout the year and is the only load applied to forest, wetlands, and cropland.

B.2.2.2.2 Land Application of Agricultural Manure

In the water quality model, county livestock populations (see Table 4) are distributed to subwatersheds based on the percentage of agricultural area in each subwatershed classified as pasture/hay in the MRLC database. 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 vary monthly according to management practices. Hog manure is applied from March through September; beef cattle manure is applied 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.
- In the Wolf River watershed, manure is not applied to cropland, only pastureland.
- Fecal coliform production rates used in the model for cattle, hogs, poultry, sheep, and horses are: 1.06×10^{11} counts/day/beef cow, 1.24×10^{10} counts/day/hog, 1.04×10^{11} counts/day/dairy cow, 1.38×10^{8} counts/day/layer chicken, 1.22×10^{10} counts/day/sheep, and 4.18×10^{8} counts/day/horse (NCSU, 1994).

An example calculation estimating the load available for runoff from agricultural lands is provided in Figure B-8.

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 western Tennessee, the fecal loading rate does not vary significantly throughout the year. Therefore, the loading rate to pastureland used in the model is assumed to be constant in each county. This rate varies in each county depending on the cattle population. The approximate loads from grazing cattle vary from 1.09×10^{10} to 5.09×10^{10} counts/acre-day. 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 build-up and accumulation rates referenced in Horner (1992). In the water quality model, this rate is assumed constant for all urban areas and varies between 1.16 x 10^8 counts/acre-day in the rural areas of the watershed to 8.16 x 10^{10} counts/acre-day in the urban areas around Memphis.

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, leaking sewer lines, illicit discharges, and other undefined sources. In each subwatershed, all of these miscellaneous sources have been grouped together and modeled as a point source of constant flow and fecal coliform load. The initial 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. It was assumed that 50 % have access to streams and, of those, 25% defecate in or near the stream banks during a portion of the day. The resulting percentage of time fecal coliform bacteria is discharged into the streams from grazing animals is 0.025 percent. Literature values were used to estimate the fecal coliform bacteria concentration in beef cow manure.

- The initial baseline loads attributable to leaking septic systems are based on an assumed failure rate of 20 percent, and literature values for effluent flow and concentration.

These flow and concentration variables were adjusted during water quality calibration to match simulated instream fecal concentrations during dry weather conditions.

B.2.2.3 Water Quality Calibration Results

During water quality calibration, model parameters were adjusted within appropriate limits until acceptable agreement between simulation output and instream 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 “other direct sources” described in B.2.2.2.5

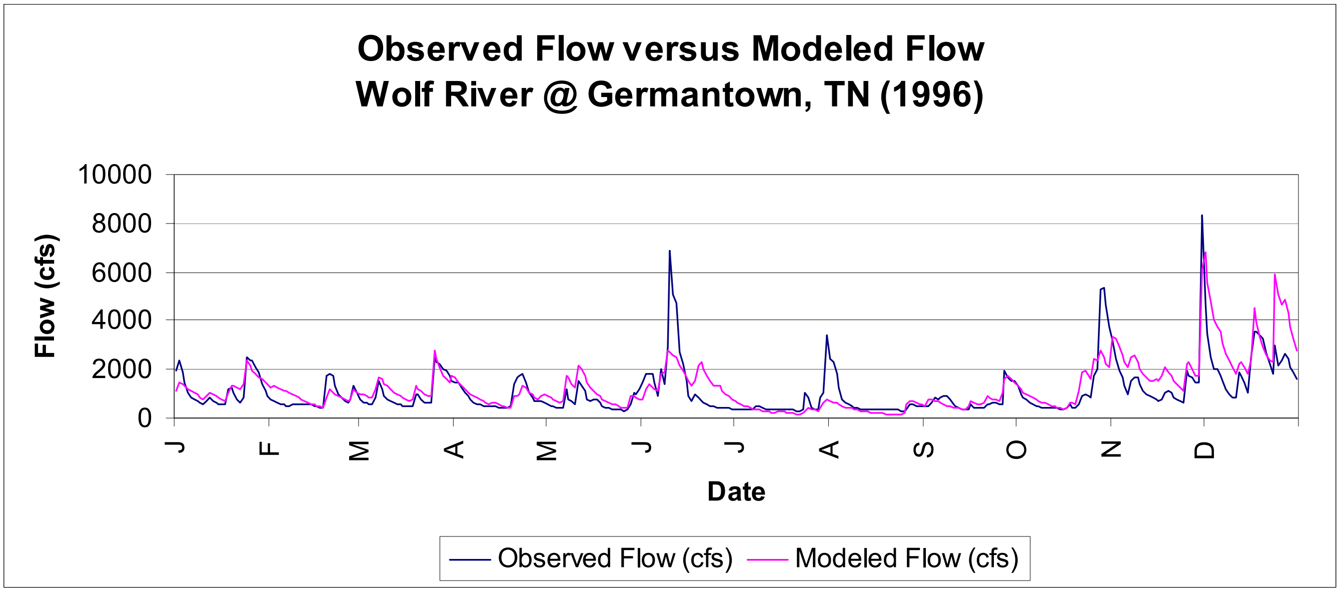
Fecal coliform grab samples, collected quarterly by TDEC at sampling stations in the listed segments of the Wolf River watershed were used for comparison with the simulated daily model results. Fecal coliform data collected by the City of Memphis on the impaired segments within the Memphis MS4 area were also used in the calibration. Only with data collected at ambient stations on the main stem of the Wolf River is it possible to identify seasonal trends.

Comparisons of simulated and observed daily fecal coliform concentrations at sampling stations in the Wolf River watershed are shown in Figures B-9 through B-16. Results show that the model reasonably simulates peaks in fecal coliform bacteria in response to rainfall events. Often a high observed value is not simulated in the model due to lack of rainfall at the meteorological station as compared to the rainfall occurring in the watershed, or is the result of an unknown source that is not included in the model.

B.3 Critical Period

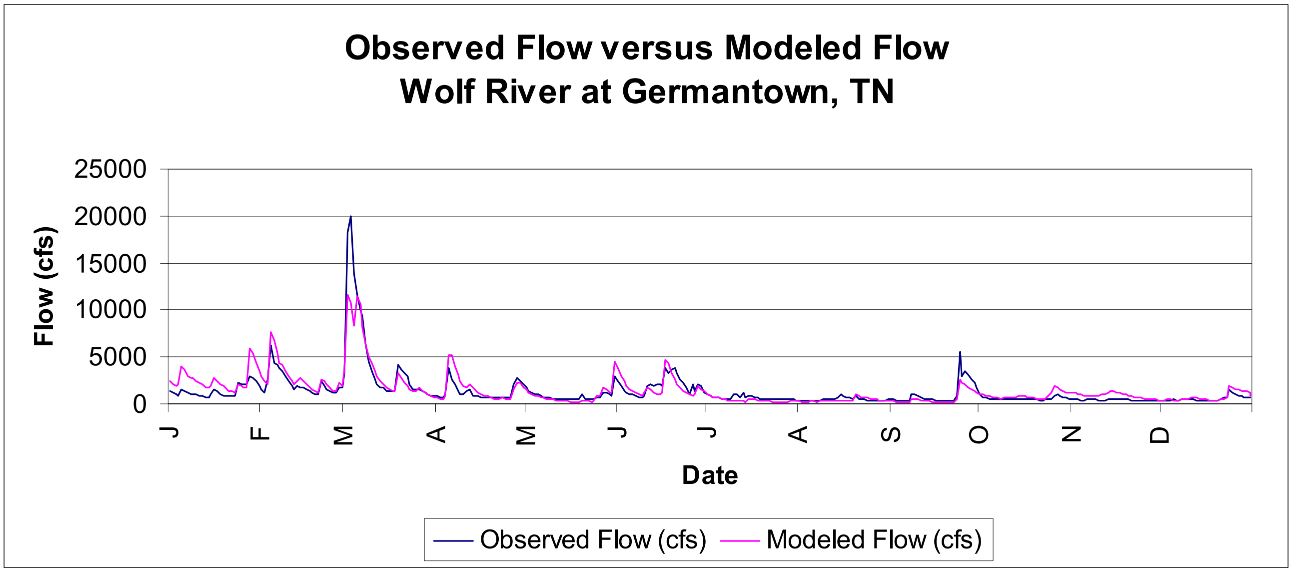
The critical period is defined as the 30-day period preceding a violation of the target concentration. For the TMDLs in the Wolf River, the geometric mean criterion of 200 counts/100mL is the target. An 11 year time period was simulated in the model. Simulated concentrations for both existing and allocation scenarios were converted to running 30-day geometric mean concentrations and the results were compared to the target. The geometric mean plots for the model segments corresponding to the impaired reaches are provided in Figures B-17 though B-21.

Critical period for the impaired streams was evaluated at several time periods and various seasons with the period resulting in the highest percent reduction for each of the impaired waterbodies selected. Although this time period does not always represent the highest violation of the geometric mean criterion, the reduction required to meet the criterion is the largest when compared to other violations. During certain time periods, violations of the geometric mean criterion were excluded from the critical period analysis. Violations of the target at these times are either a result of model instabilities, which occur when streamflow approaches zero and simulated concentrations become negative, or during extreme flood events.



Simulation Name:	Wolf River @ Germantown, TN	**1st day of one year simulation:**	January 1, 1996
		Watershed Area (ac):	447,360
Total Simulated In-stream Flow:	**24.49**	Total Observed In-stream Flow:	**21.04**
Total of highest 10% flows:	**6.91**	Total of Observed highest 10% flows:	**6.50**
Total of lowest 50% flows:	**5.67**	Total of Observed Lowest 50% flows:	**4.70**
Simulated Summer Flow Volume (months 7-9):	**2.37**	Observed Summer Flow Volume (7-9):	**2.96**
Simulated Fall Flow Volume (months 10-12):	**11.02**	Observed Fall Flow Volume (10-12):	**8.24**
Simulated Winter Flow Volume (months 1-3):	**5.44**	Observed Winter Flow Volume (1-3):	**4.78**
Simulated Spring Flow Volume (months 4-6):	**5.66**	Observed Spring Flow Volume (4-6):	**5.06**
Total Simulated Storm Volume:	**22.21**	Total Observed Storm Volume:	**15.06**
Simulated Summer Storm Volume (7-9):	**1.79**	Observed Summer Storm Volume (7-9):	**2.37**
Errors (Simulated-Observed)		*Recommended Criteria*	
Error in total volume:	**14.11**	10	
Error in 50% lowest flows:	**17.15**	10	
Error in 10% highest flows:	**6.00**	15	
Seasonal volume error - Summer:	**-24.83**	30	
Seasonal volume error - Fall:	**25.26**	30	
Seasonal volume error - Winter:	**12.10**	30	
Seasonal volume error - Spring:	**10.65**	30	
Error in storm volumes:	**32.19**	20	
Error in summer storm volumes:	**-32.10**	50	

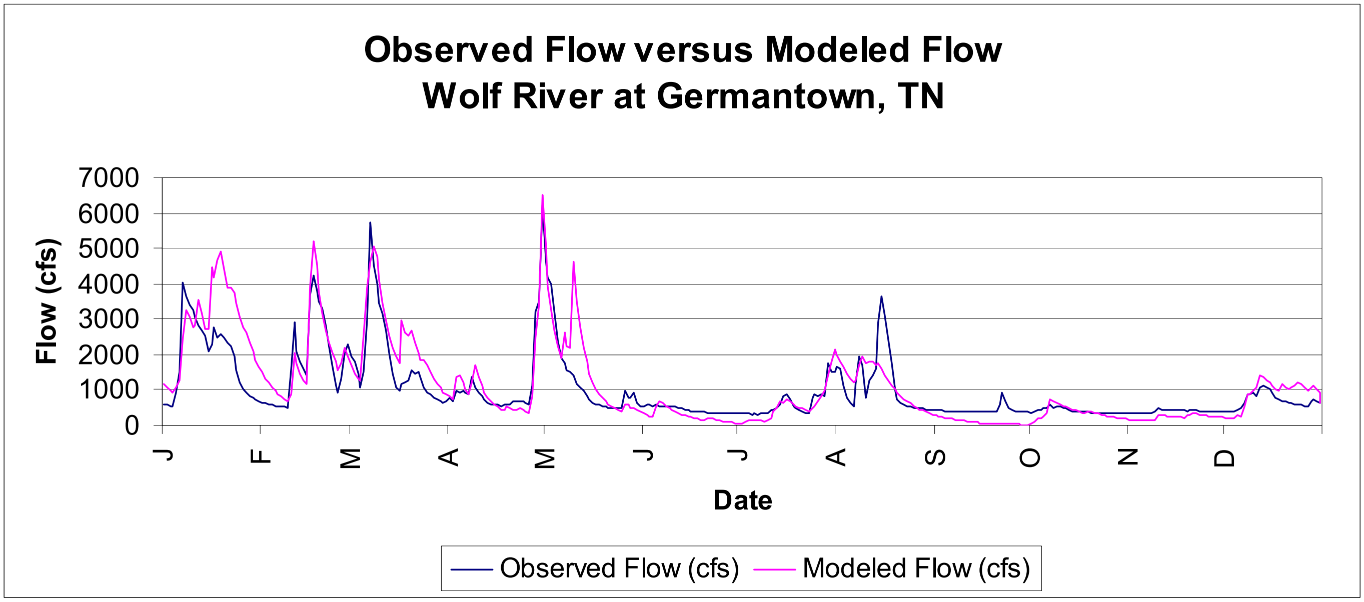
Figure B-1. Comparison of Simulated and Observed Streamflows at USGS Gage 07031650, Wolf River at Germantown, TN for Calendar Year 1996.



Simulation Name:	Wolf River @ Germantown, TN	**1st day of one year simulation:**	January 1, 1997
		Watershed Area (ac):	447,360
Total Simulated In-stream Flow:	**28.07**	Total Observed In-stream Flow:	**25.88**
Total of highest 10% flows:	**10.27**	Total of Observed highest 10% flows:	**10.29**
Total of lowest 50% flows:	**4.77**	Total of Observed Lowest 50% flows:	**4.91**
Simulated Summer Flow Volume (months 7-9):	**2.42**	Observed Summer Flow Volume (7-9):	**3.74**
Simulated Fall Flow Volume (months 10-12):	**4.21**	Observed Fall Flow Volume (10-12):	**2.63**
Simulated Winter Flow Volume (months 1-3):	**14.68**	Observed Winter Flow Volume (1-3):	**12.99**
Simulated Spring Flow Volume (months 4-6):	**6.77**	Observed Spring Flow Volume (4-6):	**6.51**
Total Simulated Storm Volume:	**25.39**	Total Observed Storm Volume:	**18.75**
Simulated Summer Storm Volume (7-9):	**1.74**	Observed Summer Storm Volume (7-9):	**2.42**

Errors (Simulated-Observed)		*Recommended Criteria*
Error in total volume:	**7.82**	10
Error in 50% lowest flows:	**-3.09**	10
Error in 10% highest flows:	**-0.27**	15
Seasonal volume error - Summer:	**-55.04**	30
Seasonal volume error - Fall:	**37.50**	30
Seasonal volume error - Winter:	**11.48**	30
Seasonal volume error - Spring:	**3.84**	30
Error in storm volumes:	**26.15**	20
Error in summer storm volumes:	**-38.83**	50

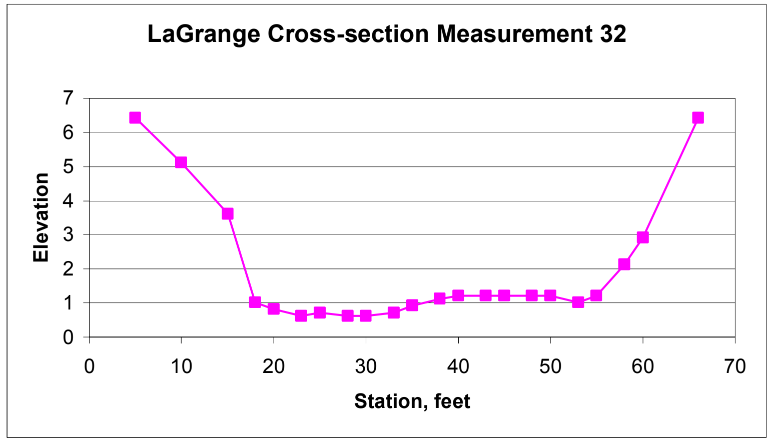
Figure B-2. Comparison of Simulated and Observed Streamflows at USGS Gage 07031650, Wolf River at Germantown, TN for Calendar Year 1997.



Simulation Name:	Wolf River @ Germantown, TN	**1st day of one year simulation:**	January 1, 1998
		Watershed Area (ac):	447,360
Total Simulated In-stream Flow:	**21.86**	Total Observed In-stream Flow:	**19.59**
Total of highest 10% flows:	**7.56**	Total of Observed highest 10% flows:	**6.65**
Total of lowest 50% flows:	**2.83**	Total of Observed Lowest 50% flows:	**4.25**
Simulated Summer Flow Volume (months 7-9):	**2.99**	Observed Summer Flow Volume (7-9):	**3.67**
Simulated Fall Flow Volume (months 10-12):	**2.44**	Observed Fall Flow Volume (10-12):	**2.49**
Simulated Winter Flow Volume (months 1-3):	**11.42**	Observed Winter Flow Volume (1-3):	**8.74**
Simulated Spring Flow Volume (months 4-6):	**5.02**	Observed Spring Flow Volume (4-6):	**4.69**
Total Simulated Storm Volume:	**21.49**	Total Observed Storm Volume:	**13.48**
Simulated Summer Storm Volume (7-9):	**2.89**	Observed Summer Storm Volume (7-9):	**2.99**
Errors (Simulated-Observed)		*Recommended Criteria*	
Error in total volume:	**10.39**	10	
Error in 50% lowest flows:	**-50.06**	10	
Error in 10% highest flows:	**12.05**	15	
Seasonal volume error - Summer:	**-22.98**	30	
Seasonal volume error - Fall:	**-2.10**	30	
Seasonal volume error - Winter:	**23.46**	30	
Seasonal volume error - Spring:	**6.58**	30	
Error in storm volumes:	**37.28**	20	
Error in summer storm volumes:	**-3.26**	50	

Figure B-3. Comparison of Simulated and Observed Streamflows at USGS Gage 07031650, Wolf River at Germantown, TN for Calendar Year 1998.

Measurement 32				
Width	61	Sta	Depth	Elevation
Area	260	5	0	6.42
Vel	0.496	10	1.3	5.12
GH	6.42	15	2.8	3.62
Discharge	129	18	5.4	1.02
		20	5.6	0.82
		23	5.8	0.62
		25	5.7	0.72
		28	5.8	0.62
		30	5.8	0.62
		33	5.7	0.72
		35	5.5	0.92
		38	5.3	1.12
		40	5.2	1.22
		43	5.2	1.22
		45	5.2	1.22
		48	5.2	1.22
		50	5.2	1.22
		53	5.4	1.02
		55	5.2	1.22
		58	4.3	2.12
		60	3.5	2.92
		66	0	6.42



Measurement 25				
Width	116	Sta	Depth	Elevation
Area	499	40	0	9.07
Vel	0.916	61	4.9	4.17
GH	9.07	82	0	9.07
Discharge	457	478	0	9.07
		485	2.5	6.57
		490	4	5.07
		493	4.2	4.87
		496	5.5	3.57
		499	6.1	2.97
		502	6	3.07
		505	6.2	2.87
		508	6.4	2.67
		511	6.4	2.67
		514	6.5	2.57
		517	6.6	2.47
		520	6.8	2.27
		523	6.9	2.17
		526	7.2	1.87
		529	7.9	1.17
		532	8.2	0.87
		535	7.8	1.27
		538	6.8	2.27
		544	5.7	3.37
		548	2.4	6.67
		552	0	9.07

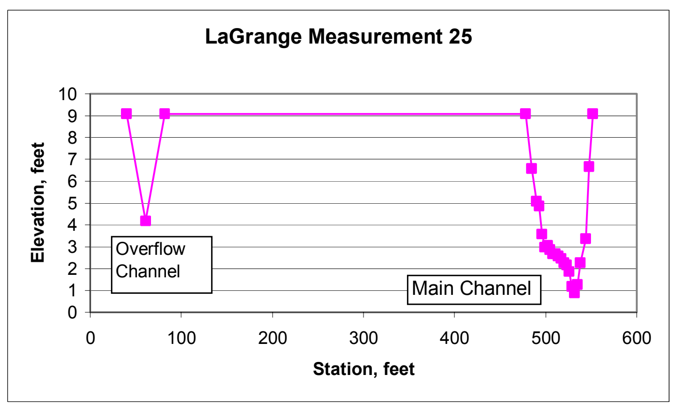
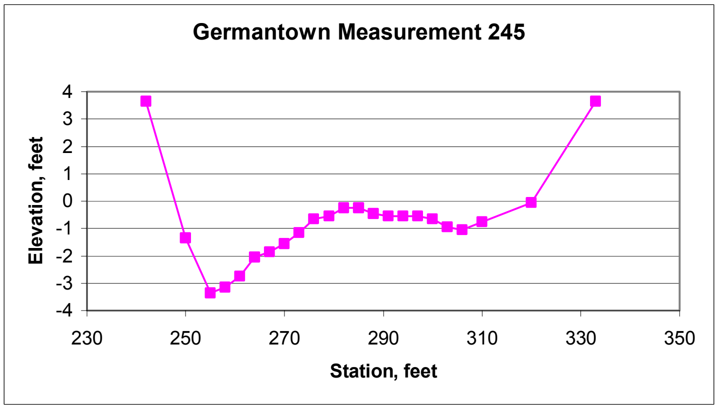


Figure B-4 Channel Geometry of Wolf River at LaGrange, TN (USGS 07030392)

Measurement 245

		Sta	Depth	Elevation
Width	91			
Area	379	242	0	3.65
Vel	0.871	250	5	-1.35
GH	3.65	255	7	-3.35
Discharge	330	258	6.8	-3.15
		261	6.4	-2.75
		264	5.7	-2.05
		267	5.5	-1.85
		270	5.2	-1.55
		273	4.8	-1.15
		276	4.3	-0.65
		279	4.2	-0.55
		282	3.9	-0.25
		285	3.9	-0.25
		288	4.1	-0.45
		291	4.2	-0.55
		294	4.2	-0.55
		297	4.2	-0.55
		300	4.3	-0.65
		303	4.6	-0.95
		306	4.7	-1.05
		310	4.4	-0.75
		320	3.7	-0.05
		333	0	3.65



Measurement 239

		Sta	Depth	Elevation
Width	98			
Area	642	239	0	5.94
Vel	1.76	250	7.3	-1.36
GH	5.94	255	9.4	-3.46
Discharge	1133	260	9.4	-3.46
		263	9.4	-3.46
		266	9.1	-3.16
		269	9.1	-3.16
		272	8.5	-2.56
		275	8.2	-2.26
		278	7.9	-1.96
		281	7.9	-1.96
		284	7.6	-1.66
		287	7.5	-1.56
		290	7.2	-1.26
		293	7.2	-1.26
		296	6.6	-0.66
		299	6.5	-0.56
		302	6.6	-0.66
		305	6.7	-0.76
		308	6.1	-0.16
		311	6.2	-0.26
		315	5.8	0.14
		320	5.7	0.24
		325	6.6	-0.66
		337	0	5.94

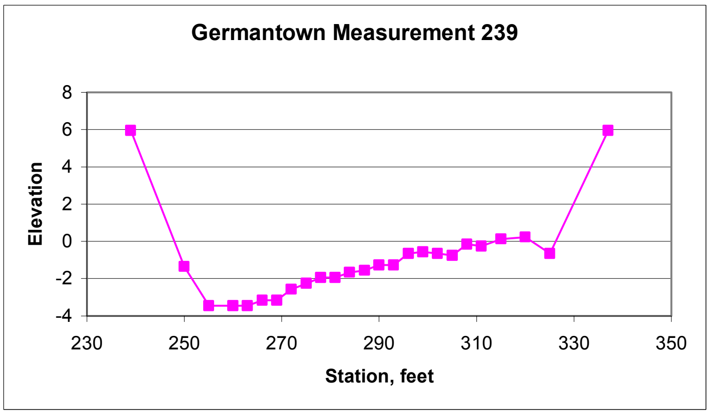


Figure B-5 Channel Geometry of Wolf River at Germantown, TN (USGS 07031650)

Measurement 243

		Sta	Depth	Elevation
Width	130			
Area	1741	220	0	14.34
Vel	4.3	235	6.3	8.04
GH	14.34	240	9.4	4.94
Discharge	7494	245	12	2.34
		250	14.5	-0.16
		255	18.3	-3.96
		258	19	-4.66
		261	19.7	-5.36
		264	20	-5.66
		267	20.4	-6.06
		270	21.7	-7.36
		273	22.6	-8.26
		276	21	-6.66
		279	20.1	-5.76
		282	19	-4.66
		285	18.5	-4.16
		288	18.4	-4.06
		291	19	-4.66
		294	18.6	-4.26
		297	18.3	-3.96
		301	18.4	-4.06
		306	17.3	-2.96
		309	16.4	-2.06
		314	16.5	-2.16
		318	15.4	-1.06
		328	12	2.34
		333	8.8	5.54
		350	0	14.34

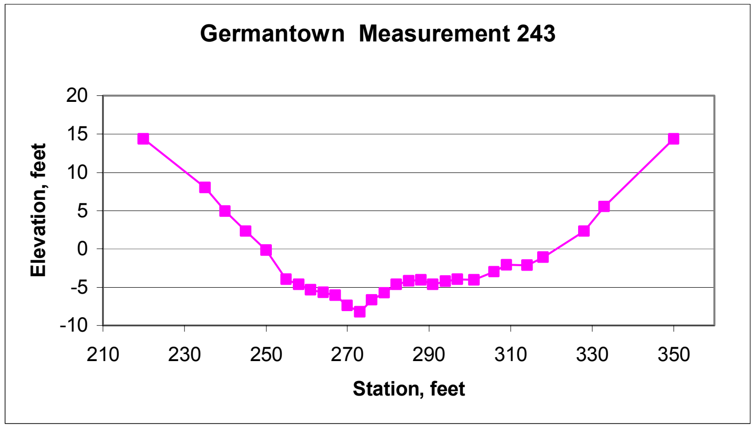


Figure B-5 Channel Geometry in Wolf River at Germantown, TN (USGS 07031650) (Cont.)

Measurement 37

Width	113	Sta	Depth	Elevation
Area	183	113	0	4.28
Vel	1.56	105	1.24	3.04
GH	4.28	95	1.92	2.36
Discharge	286	85	2.28	2
		80	2.1	2.18
		77	1.8	2.48
		74	1.95	2.33
		71	1.45	2.83
		68	1.2	3.08
		65	1.12	3.16
		62	0.96	3.32
		59	0.94	3.34
		56	1.02	3.26
		53	1.17	3.11
		50	1.05	3.23
		47	1.15	3.13
		44	1.52	2.76
		41	1.45	2.83
		38	1.41	2.87
		36	1.41	2.87
		34	1.73	2.55
		30	1.81	2.47
		28	1.75	2.53
		26	1.81	2.47
		24	2	2.28
		22	2.05	2.23
		20	2.14	2.14
		18	2.15	2.13
		16	2.31	1.97
		14	2.2	2.08
		12	2.14	2.14
		10	2.4	1.88
		8	2.65	1.63
		6	2.73	1.55
		3	2.03	2.25
		0	0	4.28

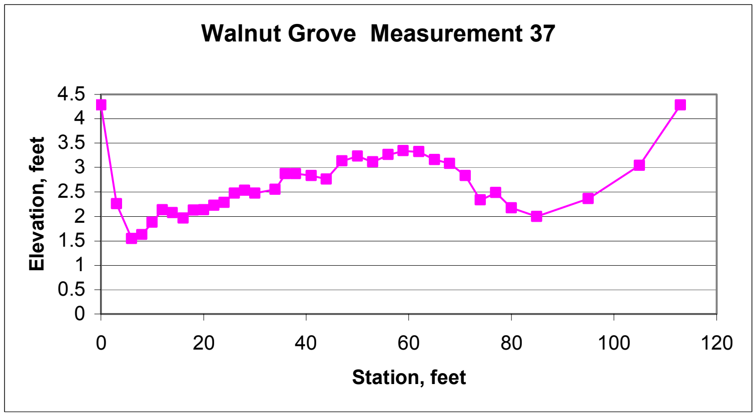


Figure B-6 Channel Geometry of Wolf River at Walnut Grove Road (USGS 07031660)

Measurement 40

		Sta	Depth	Elevation
Width	91			
Area	426	0	0	5.37
Vel	1.52	5	2.9	2.47
GH	5.37	10	4.2	1.17
Discharge	646	14	6	-0.63
		17	6.2	-0.83
		20	6.2	-0.83
		23	6.2	-0.83
		26	6.4	-1.03
		29	6.5	-1.13
		32	6.5	-1.13
		35	6.5	-1.13
		38	6.6	-1.23
		41	6.2	-0.83
		44	6.2	-0.83
		47	6.2	-0.83
		50	5.7	-0.33
		53	5.3	0.07
		56	5	0.37
		60	5	0.37
		64	4.5	0.87
		68	4.1	1.27
		72	3.8	1.57
		77	3.2	2.17
		83	3.2	2.17
		91	0	5.37

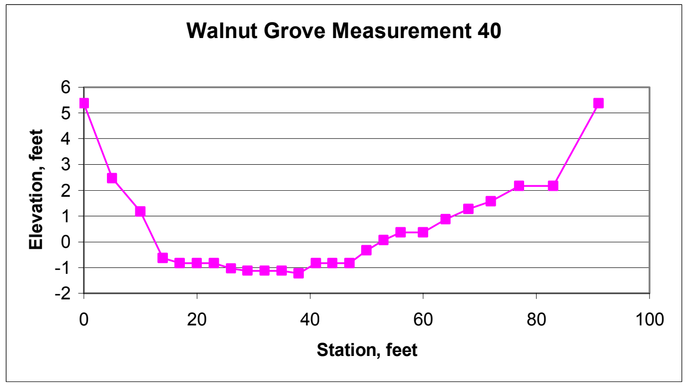
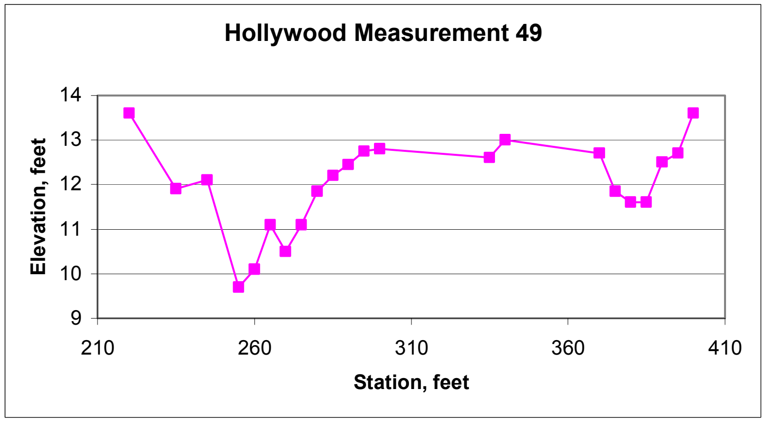


Figure B-6 Channel Geometry of Wolf River at Walnut Grove Road (USGS 07031660) (Cont.)

Measurement 49				
Width	150	Sta	Depth	Elevation
Area	228	220	0	13.6
Vel	1.08	235	1.7	11.9
GH	13.6	245	1.5	12.1
Discharge	246	255	3.9	9.7
		260	3.5	10.1
		265	2.5	11.1
		270	3.1	10.5
		275	2.5	11.1
		280	1.75	11.85
		285	1.4	12.2
		290	1.15	12.45
		295	0.85	12.75
		300	0.8	12.8
		335	1	12.6
		340	0.6	13
		370	0.9	12.7
		375	1.75	11.85
		380	2	11.6
		385	2	11.6
		390	1.1	12.5
		395	0.9	12.7
		400	0	13.6



Measurement 44				
Width	168	Sta	Depth	Elevation
Area	239	217	0	13.73
Vel	1.27	230	3.6	10.13
GH	13.73	255	1	12.73
Discharge	304	260	1.2	12.53
		265	2	11.73
		270	2	11.73
		278	2	11.73
		280	2.2	11.53
		285	2.5	11.23
		290	2.5	11.23
		295	2.3	11.43
		300	1.5	12.23
		305	1.2	12.53
		310	1	12.73
		315	1.1	12.63
		320	1.1	12.63
		325	1.3	12.43
		330	0.8	12.93
		335	0.8	12.93
		360	0	13.73
		370	0.7	13.03
		380	0.9	12.83
		390	1	12.73
		400	0	13.73

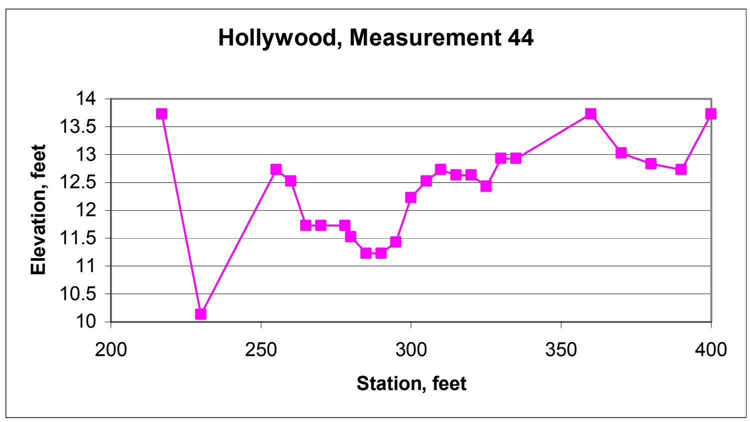


Figure B-7 Channel Geometry of Wolf River at Hollywood Street (USGS 07031740)

EXAMPLE CALCULATION OF RUNOFF LOAD (example shown for runoff from pastureland in Fayette Co)

COUNTY	AGRICULTURAL ANIMALS (NRCS and WWW.NASS.GOV for horses)								
	CATTLE	BEEF	DAIRY	SWINE	SHEEP	BROILERS	LAYERS	HORSES	cattle access to stream
Shelby	8628	4980	42	335	148	0	515	2720	yes
Fayette	25437	13421	965	25667	124	0	15	2195	yes

LOAD ESTIMATES BASED ON ANIMAL POPULATION AND LAND APPLICATION OF MANURE

Runoff from pastureland (COUNTS/DAY) = Number animals * Fecal concentration (counts/animal/day) * Fecal content multiplier * Runoff rate * monthly application rate
Model units are in terms of counts/acre-day and are calculated by dividing the load by the area of pasture land in the county (calculation not shown)

Hog Manure Available for Wash-off

Fecal concentration	1.24E+10	counts/animal/day (NCSU, 1994)
Manure fecal content multiplier	0.75	(assume 25% dies-off in lagoon - EPA conservative assumption)
Fraction available for runoff	0.63	(EPA assumption)

Hog manure application rates (NRCS):

	January	February	March	April	May	June	July	August	September	October	November	December	
Fraction of manure applied each month	0	0	0.075	0.1575	0.1335	0.1335	0.1335	0.1335	0.1585	0.075	0	0	1

Hog manure runoff from pastureland (counts/day):

	January	February	March	April	May	June	July	August	September	October	November	December
Fayette Co	0.00E+00	0.00E+00	1.79E+13	3.76E+13	3.19E+13	3.19E+13	3.19E+13	3.19E+13	3.78E+13	1.79E+13	0.00E+00	0.00E+00

Beef Cattle Manure Available for Wash-off

Fecal concentration	1.06E+11	counts/animal/day (NCSU, 1994)
Manure fecal content multiplier	1	(a value of 1 assumes fresh application - worse case scenario)
Fraction available for runoff	0.6	(EPA assumption)

Beef cattle manure application rates (NRCS):

	January	February	March	April	May	June	July	August	September	October	November	December	
Fraction of manure applied each month	0.0833	0.0833	0.0833	0.0833	0.0833	0.0834	0.0834	0.0834	0.0834	0.0833	0.0833	0.0833	1

Beef manure runoff from pastureland (counts/day):

	January	February	March	April	May	June	July	August	September	October	November	December
Fayette Co	7.11E+13	7.11E+13	7.11E+13	7.11E+13	7.11E+13	7.12E+13	7.12E+13	7.12E+13	7.12E+13	7.11E+13	7.11E+13	7.11E+13

Figure B-8 Example Calculation of Runoff Load from Agricultural Lands Using County Agricultural Data

Dairy Cattle Manure Available for Wash-off

Fecal concentration	1.04E+11	counts/animal/day (NCSU, 1994)											
Manure fecal content multiplier	1	(a value of 1 assumes fresh application - worse case scenario)											
Fraction available for runoff	0.63	(EPA assumption)											
Dairy cattle manure application rates (NRCS):													
	January	February	March	April	May	June	July	August	September	October	November	December	
Fraction of manure applied each month	0	0.0835	0.075	0.1585	0.05	0.1335	0.05	0.1335	0.075	0.1585	0	0.0825	1
Dairy manure runoff from pastureland (counts/day):													
Fayette Co.	0.00E+00	5.28E+12	4.74E+12	1.00E+13	3.16E+12	8.44E+12	3.16E+12	8.44E+12	4.74E+12	1.00E+13	0.00E+00	5.22E+12	

Poultry Litter Available for Wash-off (from layers)

Fecal concentration	1.38E+08	counts/animal/day (NCSU, 1994)											
Manure fecal content multiplier	1	(a value of 1 assumes fresh application - worse case scenario)											
Fraction available for runoff	0.2029	(EPA assumption)											
Poultry litter application rates (NRCS):													
	January	February	March	April	May	June	July	August	September	October	November	December	
Fraction of litter applied each month	0	0	0.075	0.1575	0.1335	0.1335	0.1335	0.1335	0.1585	0.075	0	0	1
Poultry litter runoff from pastureland (counts/day):													
Fayette Co.	0.00E+00	0.00E+00	3.15E+07	6.62E+07	5.61E+07	5.61E+07	5.61E+07	5.61E+07	6.66E+07	3.15E+07	0.00E+00	0.00E+00	

Horse Manure Available for Wash-off

Fecal concentration	4.18E+08	counts/animal/day (NCSU, 1994)											
Manure fecal content multiplier	0.75	(a value of 1 assumes fresh application - worse case scenario)											
Fraction available for runoff	0.63	(EPA assumption)											
Horse manure application rates (NRCS):													
	January	February	March	April	May	June	July	August	September	October	November	December	
Fraction of manure applied each month	0.0833	0.0833	0.0833	0.0833	0.0833	0.0834	0.0834	0.0834	0.0834	0.0833	0.0833	0.0833	1
Horse manure runoff from pastureland (counts/day):													
Fayette Co	3.61E+10	3.61E+10	3.61E+10	3.61E+10	3.61E+10	3.62E+10	3.62E+10	3.62E+10	3.62E+10	3.61E+10	3.61E+10	3.61E+10	

Runoff load from pastureland (counts/day)	January	February	March	April	May	June	July	August	September	October	November	December
from all animals - Fayette Co.	7.11E+13	7.64E+13	9.38E+13	1.19E+14	1.06E+14	1.12E+14	1.06E+14	1.12E+14	1.14E+14	9.91E+13	7.11E+13	7.64E+13

Estimation of load from animal access to streams (for calculation purposes assume only beef cattle have access to streams)
assume 50 % of beef cattle in the watershed have access to streams and of those 25% defecate in or near the stream banks about 3 minutes per day
(resulting stream access is 0.00025 (i.e., 0.5 x 0.25 x 3min/(24*60))

Total load from cattle in stream =number beef cows in watershed * fecal concentration * 0.00025

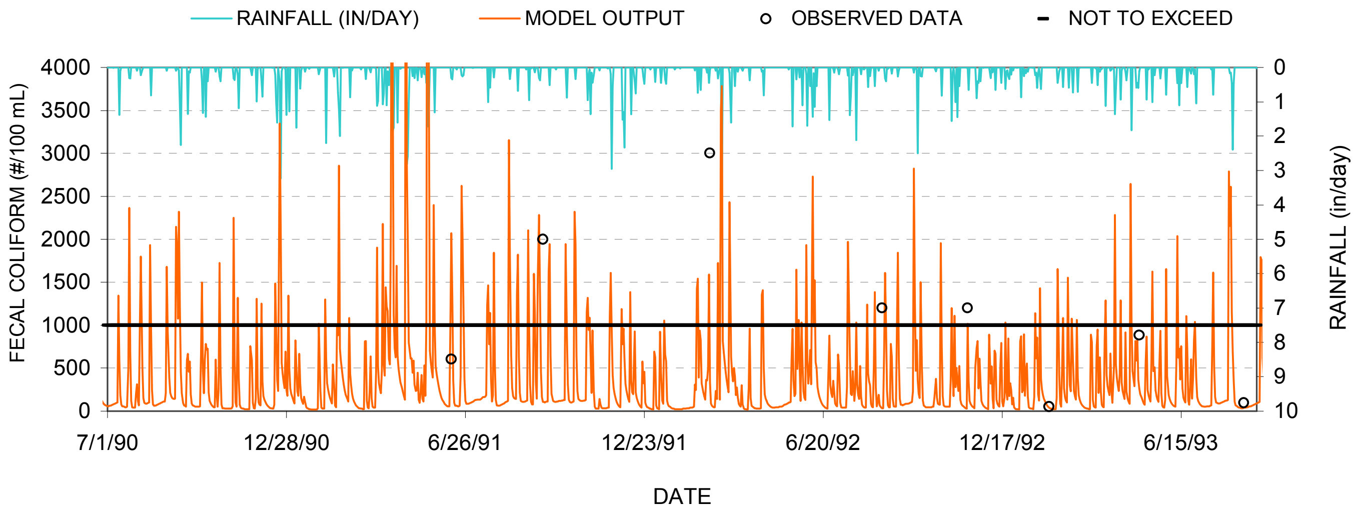
Figure B-8 Example Calculation of Runoff Load from Agricultural Lands Using County Agricultural Data (Cont.)

MULTI-YEAR TIMESERIES MODEL VS DATA

STATION: **Wolf River @ Sta. 05174**

MODEL RUN: **1**

1 = EXISTING
2 = ALLOCATION 1
3 = ALLOCATION 2



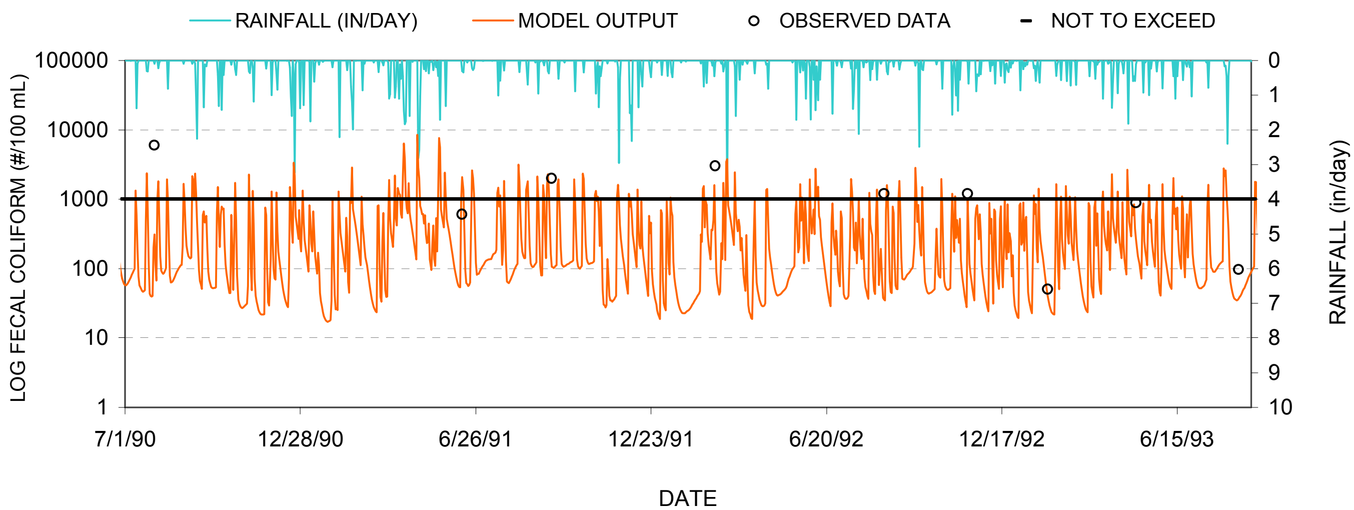


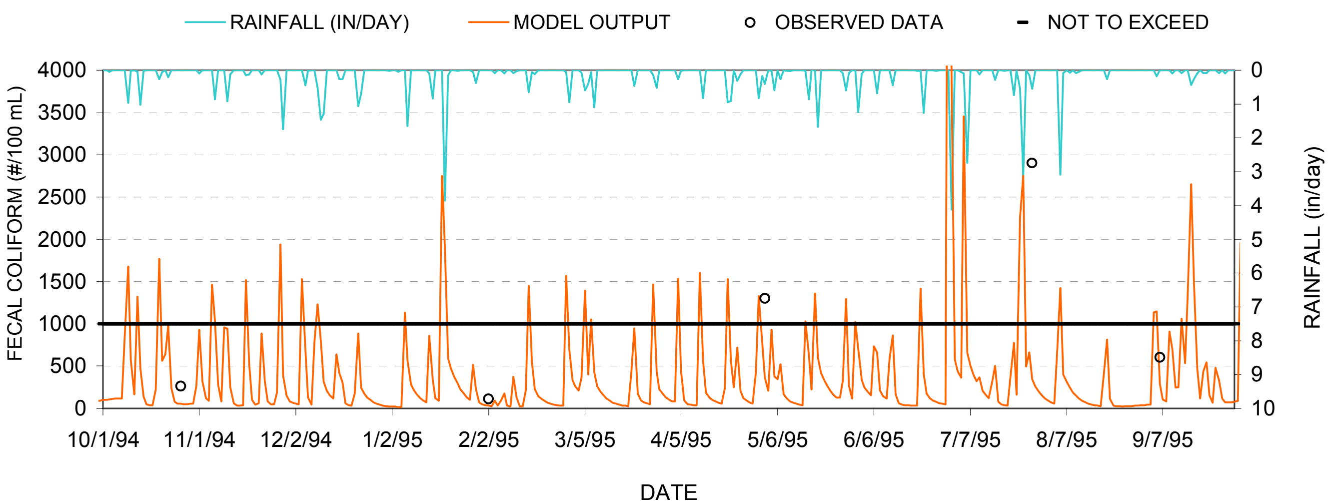
Figure B-9 Water Quality Calibration - Wolf River at STORET Sta. WOLF001.5SH (1990-1993)

MULTI-YEAR TIMESERIES MODEL VS DATA

STATION: **Wolf River @ Sta. 05174**

MODEL RUN: **1**

1 = EXISTING
2 = ALLOCATION 1
3 = ALLOCATION 2



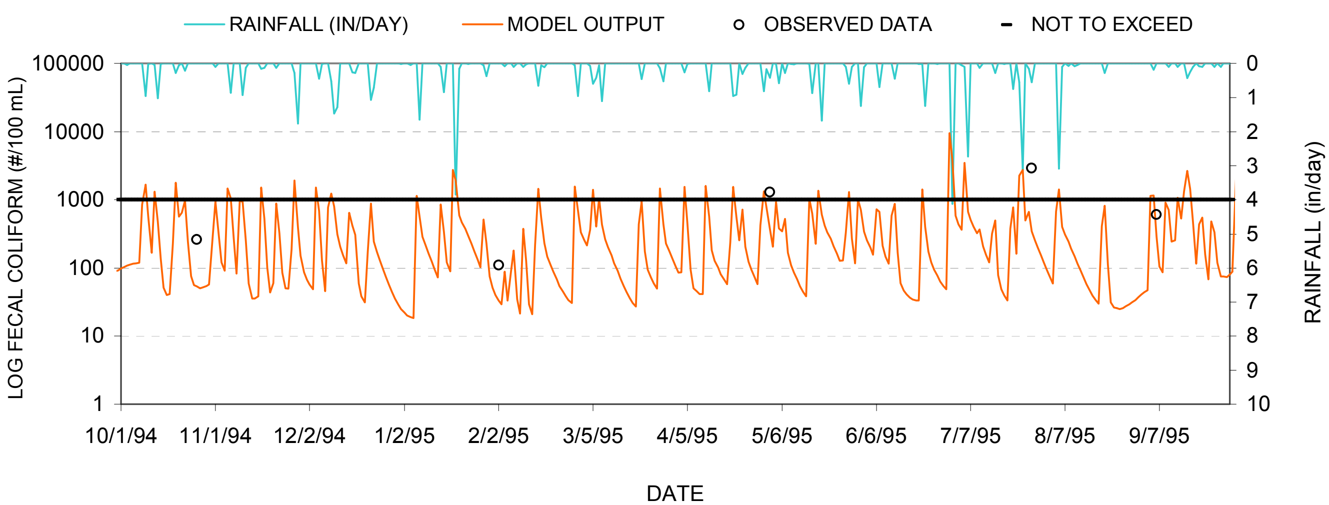
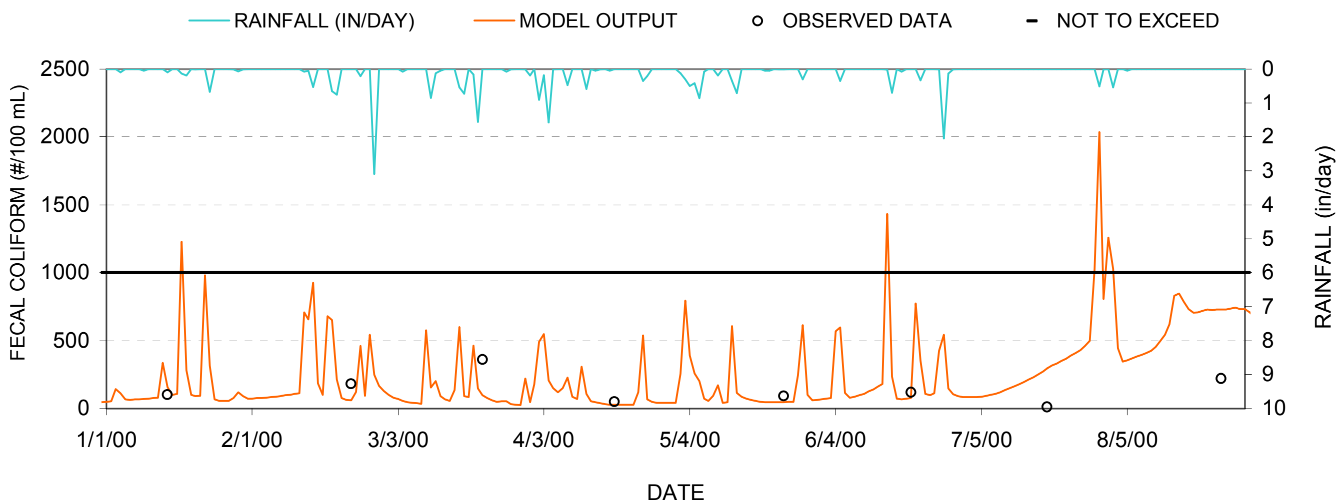


Figure B-10 Water Quality Calibration - Wolf River at STORET Sta. WOLF001.5SH (1994 – 1995)

MULTI-YEAR TIMESERIES MODEL VS DATA

STATION: **Wolf River @ Confluence with Fletcher Cr**

MODEL RUN: **1** *1 = EXISTING* *2 = ALLOCATION 1* *3 = ALLOCATION 2*



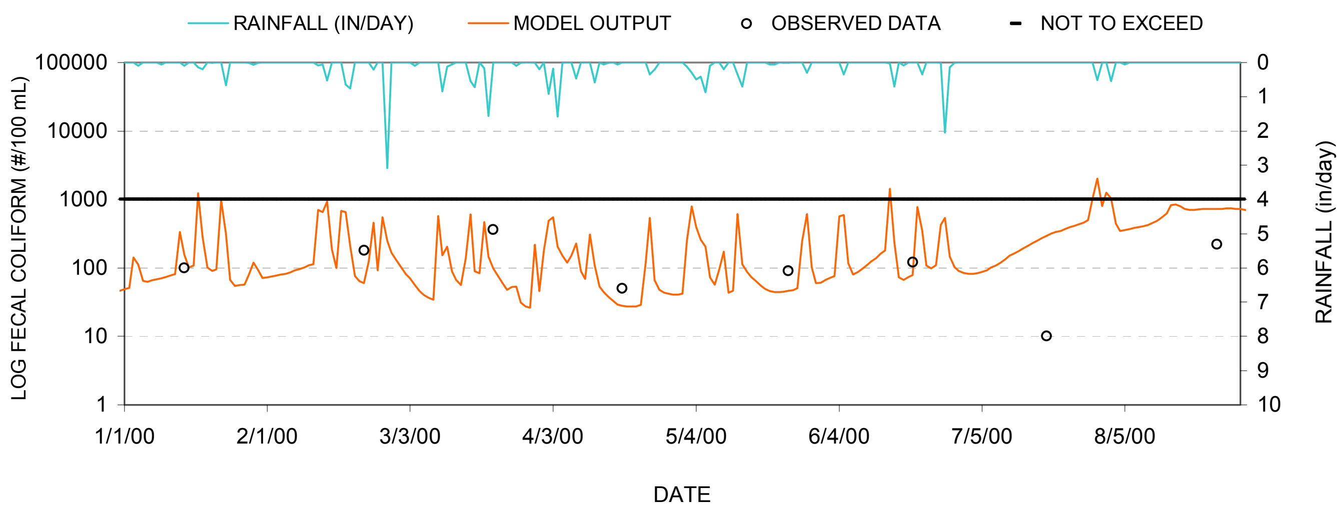


Figure B-11 Water Quality Calibration - Wolf River at City of Memphis Monitoring Sta. 1W

MULTI-YEAR TIMESERIES MODEL VS DATA

STATION: **Cypress Creek**

MODEL RUN: **1**

1 = EXISTING
2 = ALLOCATION 1
3 = ALLOCATION 2

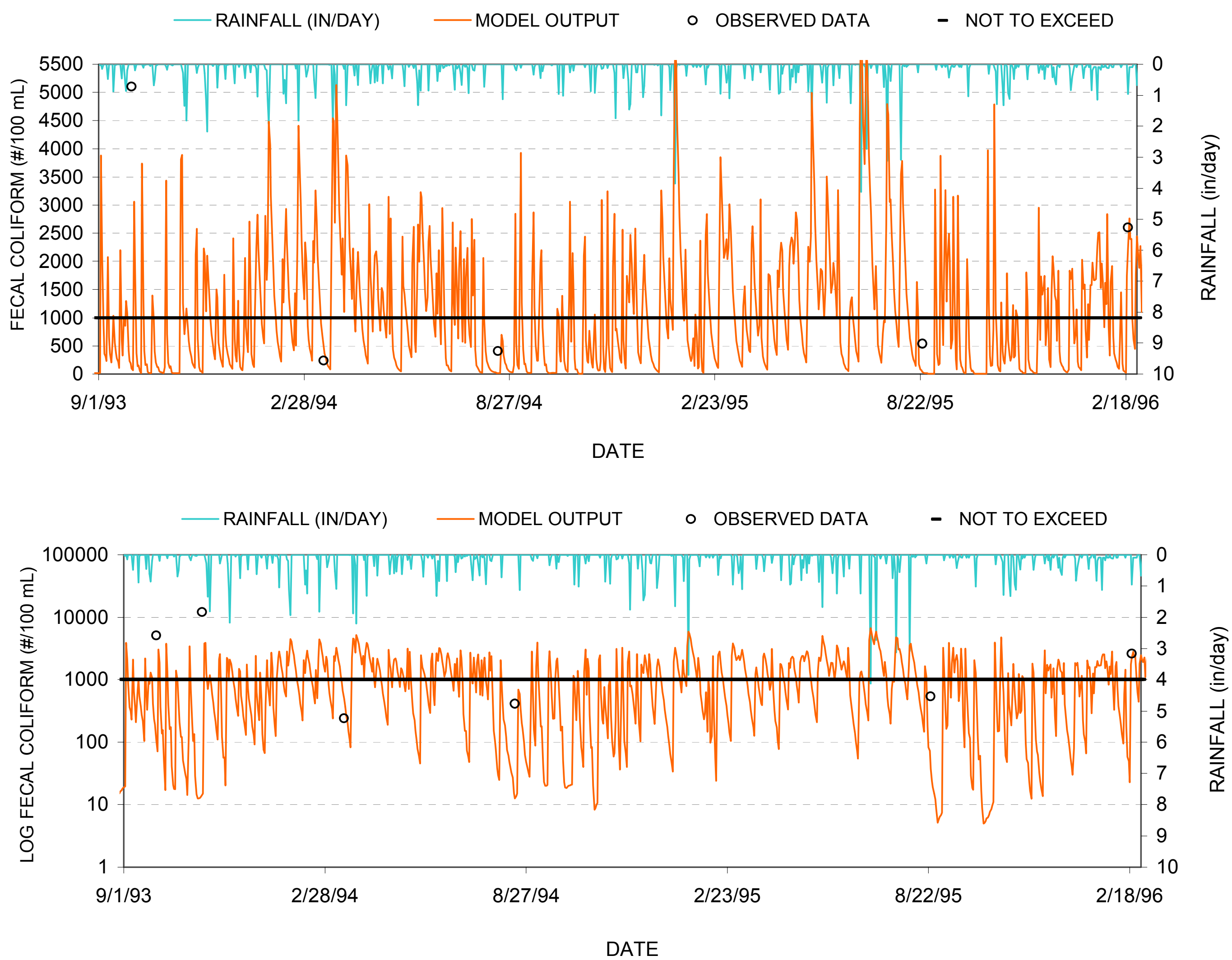


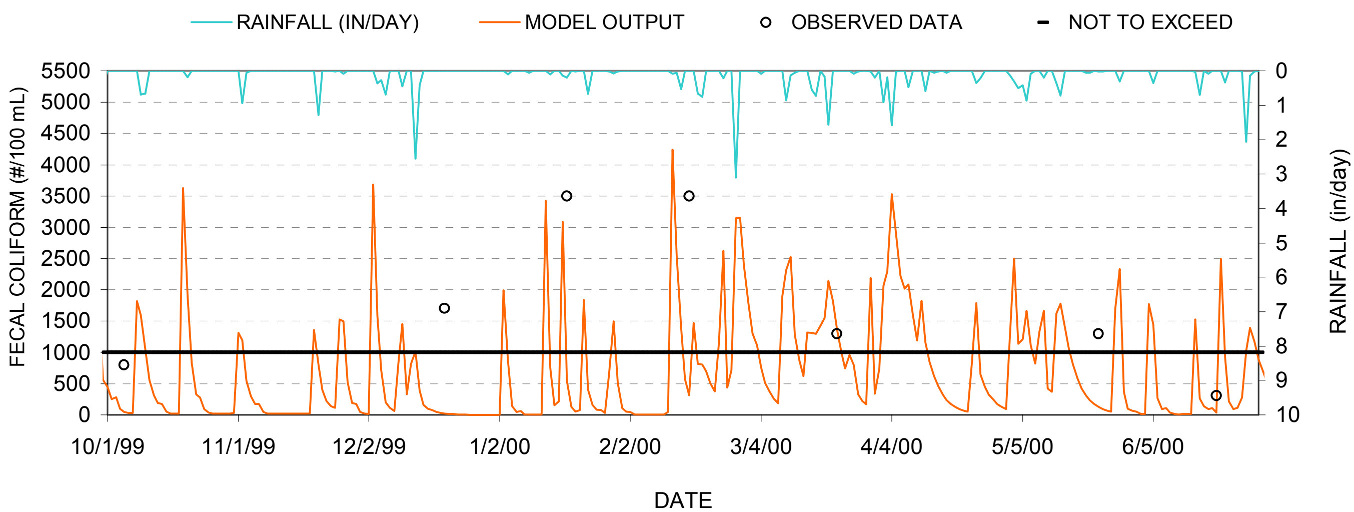
Figure B-12 Water Quality Calibration - Cypress Creek at STORET Sta. CYPRE000.4SH

MULTI-YEAR TIMESERIES MODEL VS DATA

STATION: **Cypress Creek**

MODEL RUN: **1**

1 = EXISTING
2 = ALLOCATION 1
3 = ALLOCATION 2



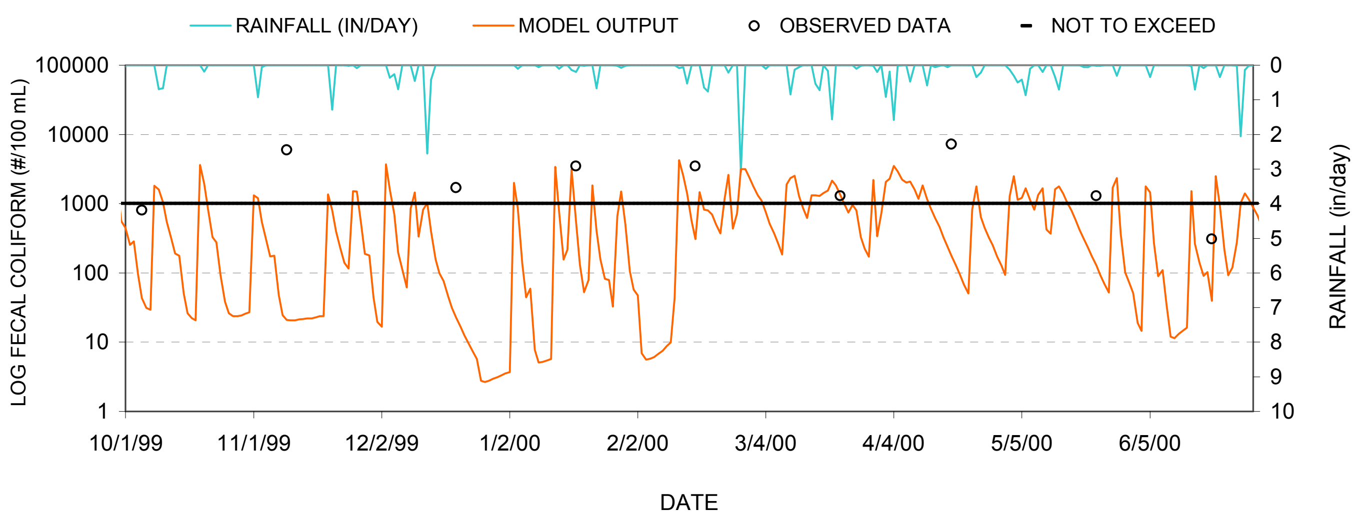


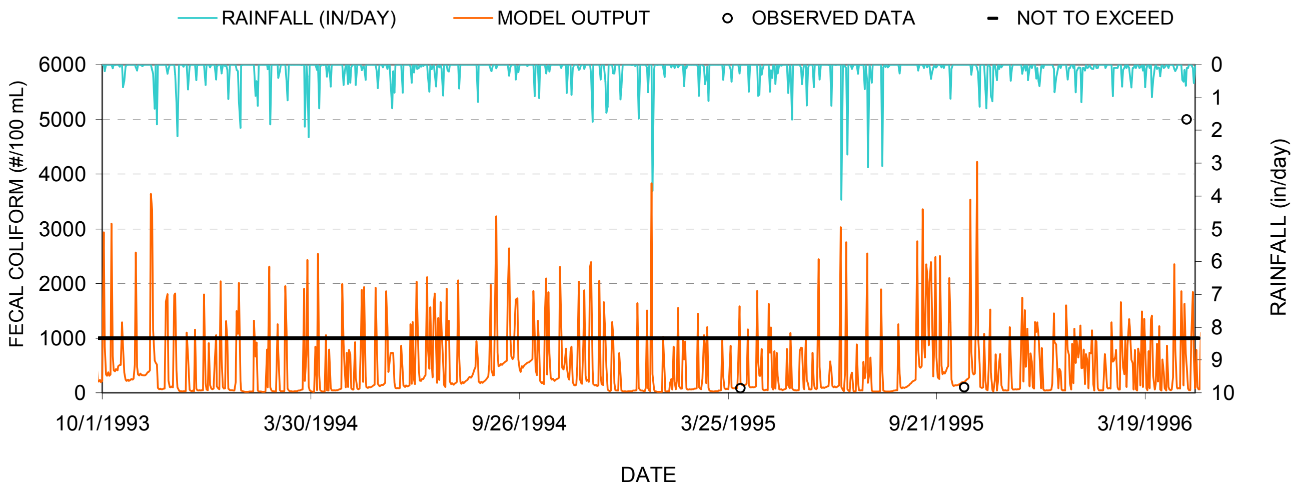
Figure B-13 Water Quality Calibration - Cypress Creek at STORET Sta. CYPRE001.2SH.

MULTI-YEAR TIMESERIES MODEL VS DATA

STATION: **Fletcher Creek**

MODEL RUN: 1

1 = EXISTING
2 = ALLOCATION 1
3 = ALLOCATION 2



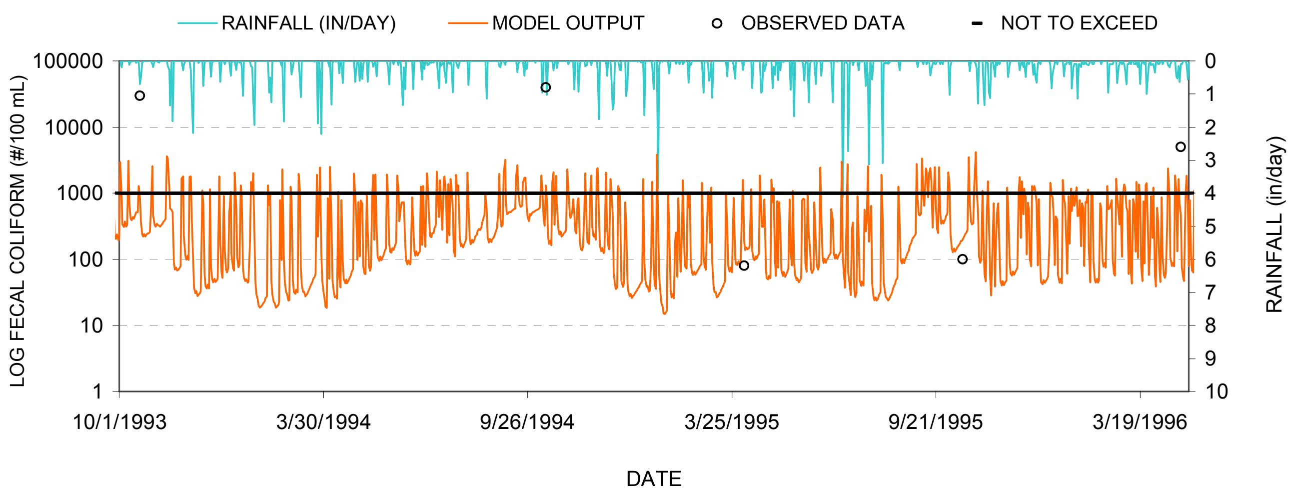


Figure B-14 Water Quality Calibration - Fletcher Creek at STORET Sta. FLETC000.6SH

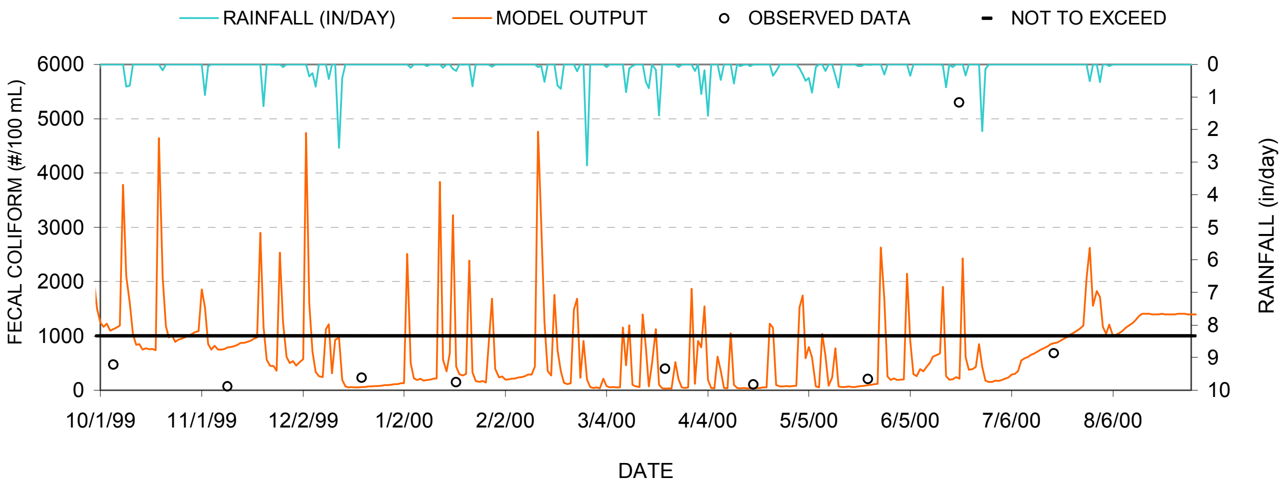
MULTI-YEAR TIMESERIES MODEL VS DATA

Fletcher Creek

STATION:

MODEL RUN: **1**

1 = EXISTING
2 = ALLOCATION 1
3 = ALLOCATION 2



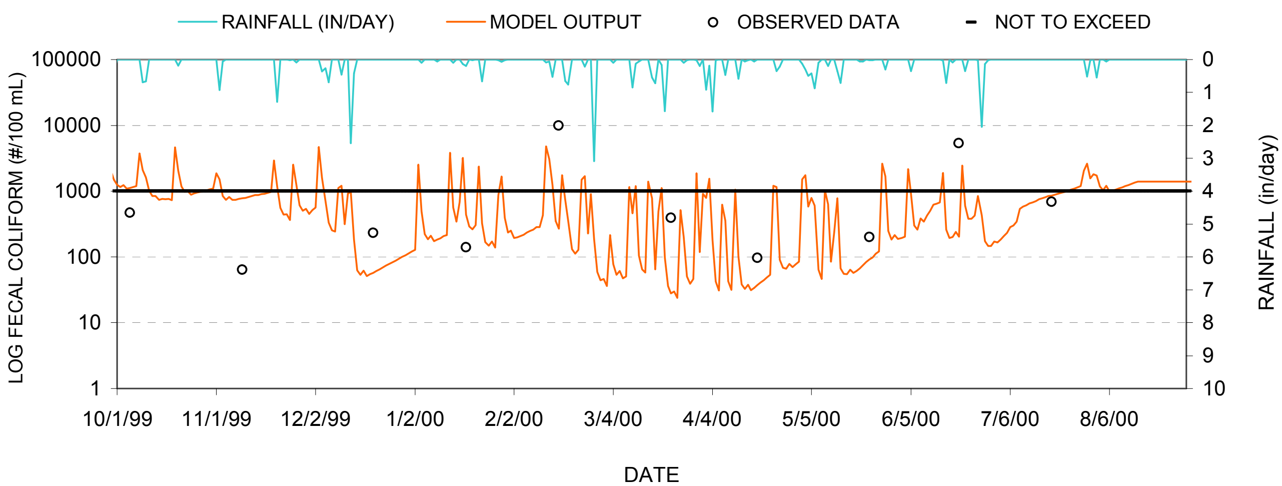


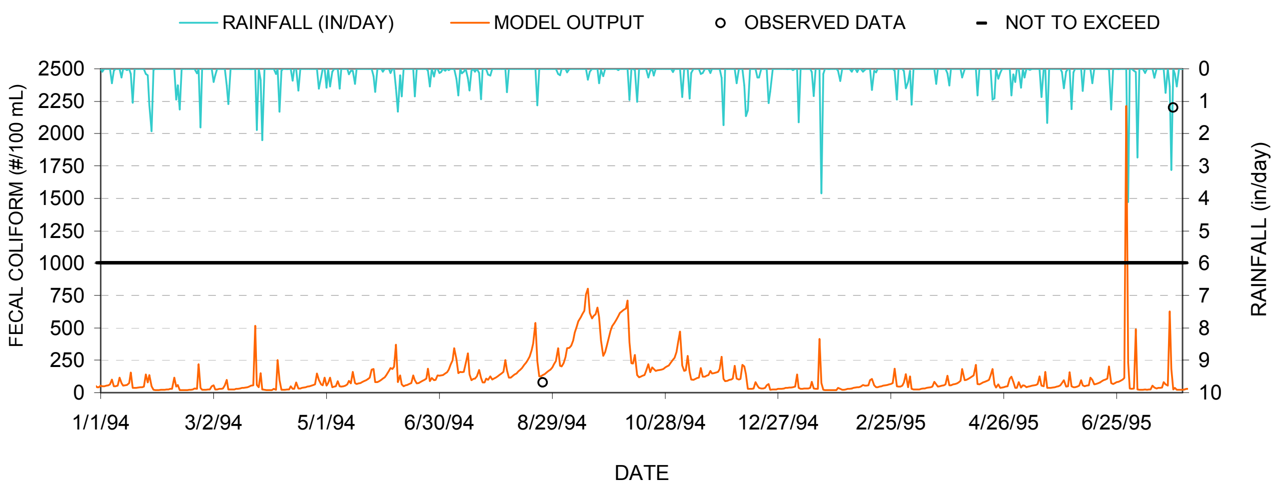
Figure B-15 Water Quality Calibration - Fletcher Creek at STORET Sta. FLETC003.8SH.

MULTI-YEAR TIMESERIES MODEL VS DATA

STATION: **Grissum Creek**

MODEL RUN: **1**

1 = EXISTING
2 = ALLOCATION 1
3 = ALLOCATION 2



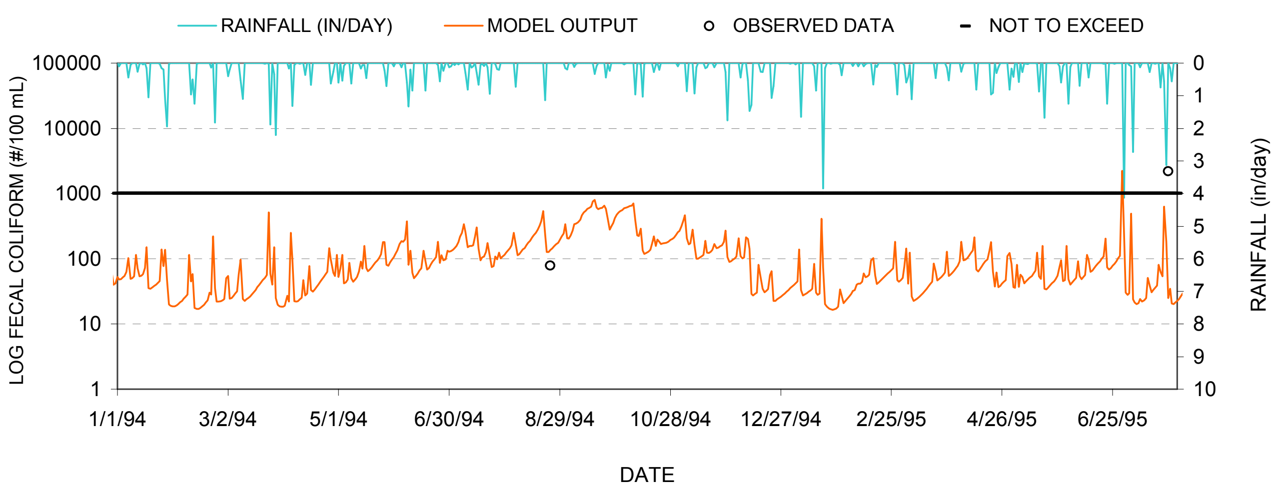


Figure B-16 Water Quality Calibration - Grissum Creek at STORET Sta. GRISS004.7FA.

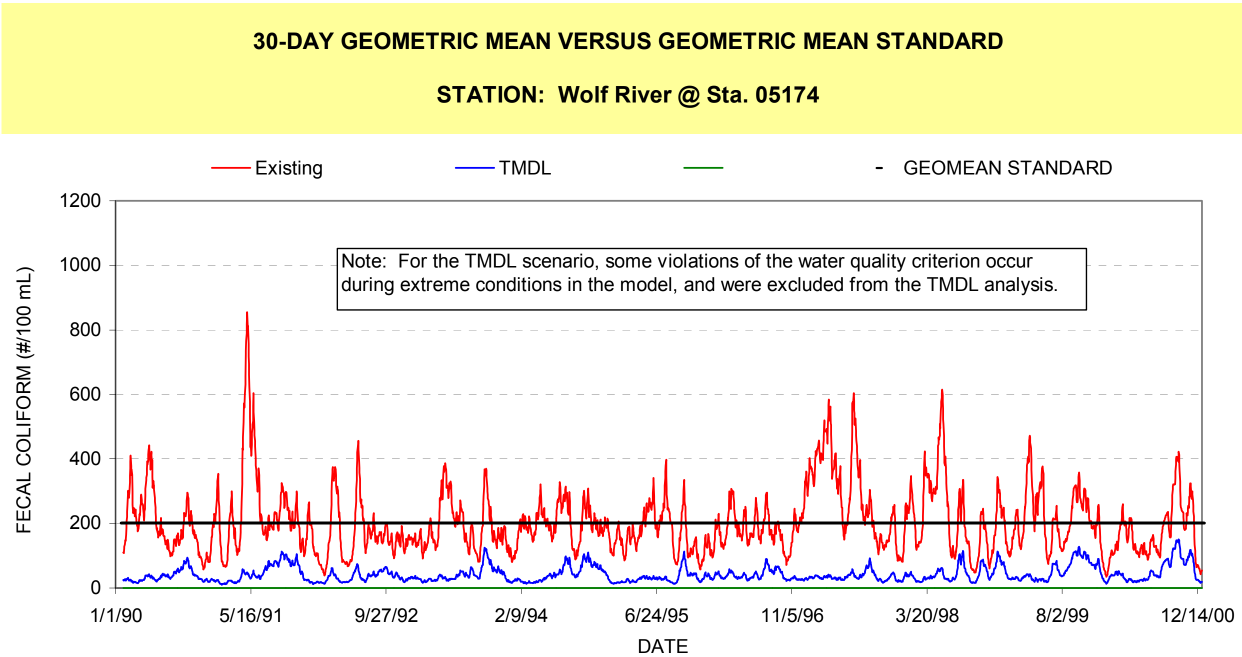


Figure B-17 30-day Geometric Mean Concentration - Wolf River at STORET Sta. WOLF001.5SH

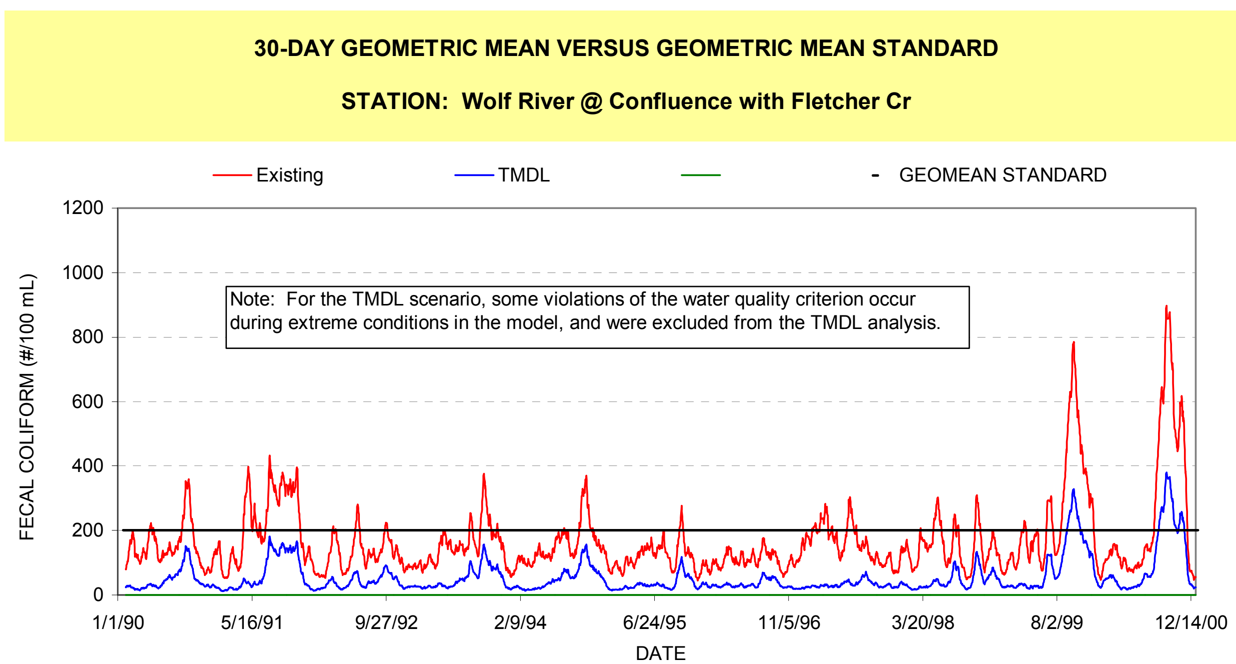


Figure B-18 30-day Geometric Mean Concentration - Wolf River at Confluence with Fletcher Creek

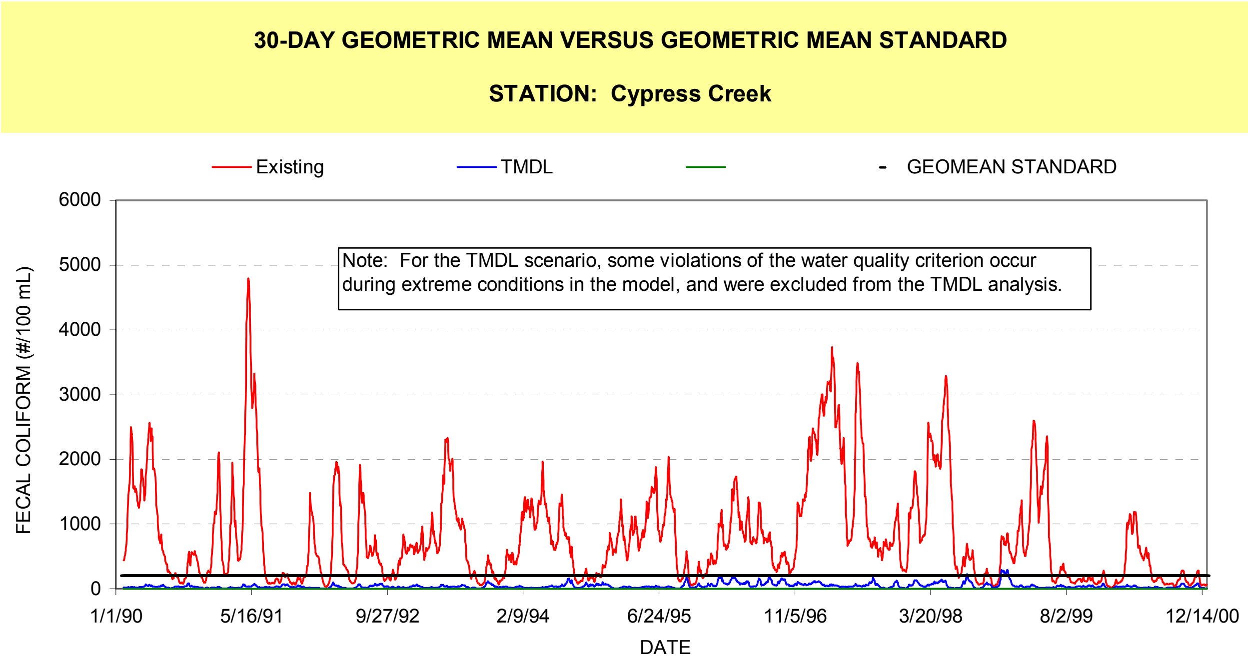


Figure B-19 30-day Geometric Mean Concentration - Cypress Creek

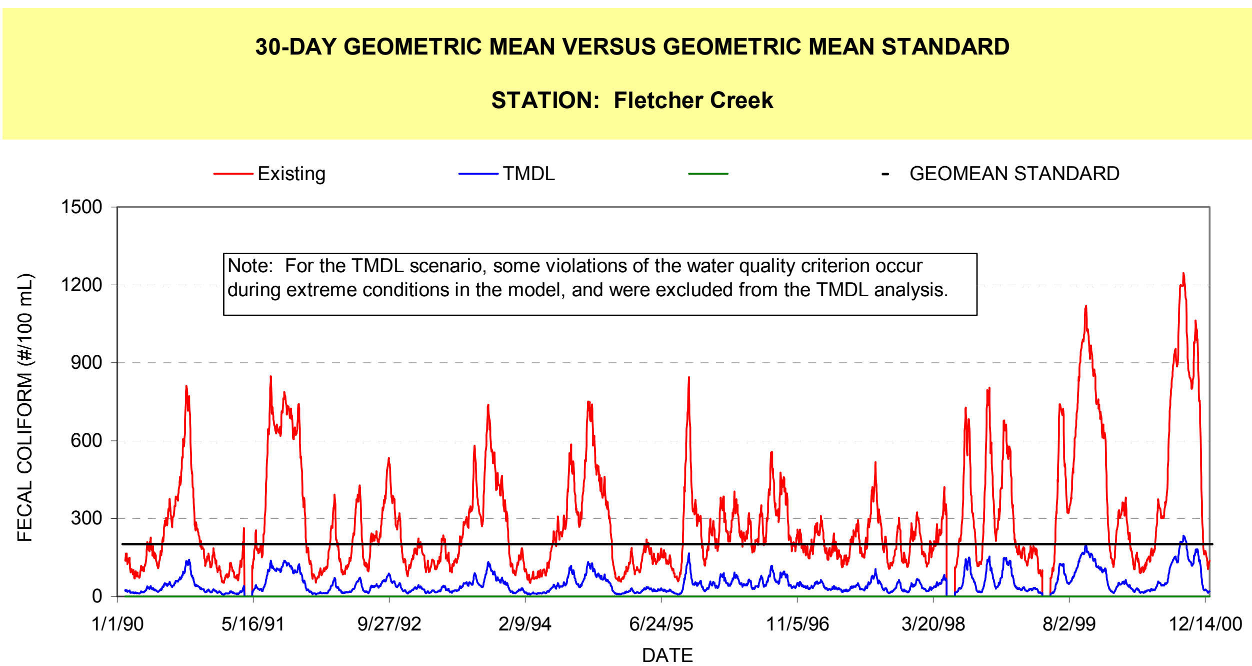


Figure B-20 30-day Geometric Mean Concentration - Fletcher Creek

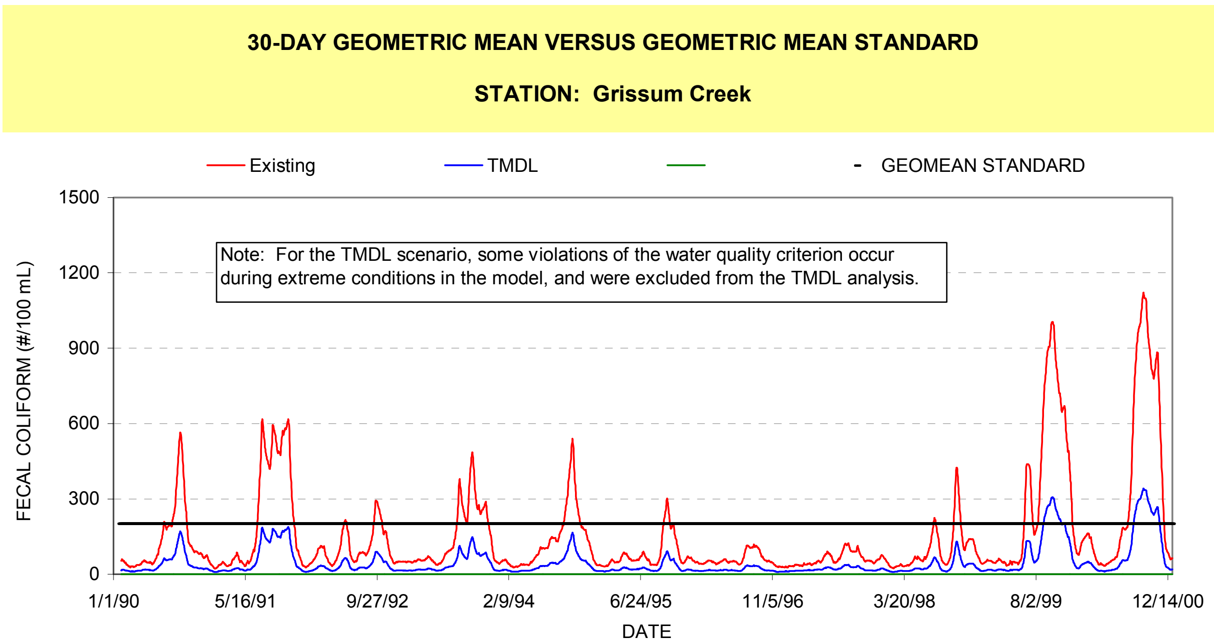


Figure B-21 30-day geometric mean concentration in Grissum Creek

Appendix C

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 FECAL COLIFORM IN WOLF RIVER (Mouth to Fletcher Cr.) WOLF RIVER (Fletcher Cr. To Germantown Rd.) FLETCHER CREEK CYPRESS CREEK GRISSUM CREEK WOLF RIVER WATERSHED (HUC 08010210), TENNESSEE

Announcement is hereby given of the availability of Tennessee's proposed Total Maximum Daily Loads (TMDLs) for fecal coliform in the Wolf River watershed located in western 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.

Fletcher Creek, Cypress Creek, Grissum Creek, and two segments of the Wolf River (mouth to Fletcher Cr. and Fletcher Cr. to Germantown Road) are listed on Tennessee's final 1998 303(d) list as not supporting designated use classifications due, in part, to pathogens associated with urban storm water runoff, storm sewer systems, and agriculture. The TMDLs utilize Tennessee's general water quality criteria, USGS continuous record station flow data, in-stream water quality monitoring data, a calibrated dynamic water quality model, and an appropriate Margin of Safety (MOS) to establish allowable loadings of fecal coliform which will result in reduced in-stream concentrations and the attainment of water quality standards. The TMDLs require reductions in in-stream fecal coliform loading of approximately 51% to 88% in the four listed waterbodies.

The proposed fecal coliform TMDLs may be downloaded from the Department of Environment and Conservation website:

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

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

Bruce R. Evans, P.E., Watershed Management Section
Telephone: 615-532-0668

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

Persons wishing to comment on the TMDLs are invited to submit their comments in writing no later than December 16, 2002 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.

Appendix D

Public Comments Received

Comments from the City of Memphis

From: "Thomas Lawrence" <Thomas.Lawrence@cityofmemphis.org>
To: <swang@mx.state.tn.us>
Date: 12/17/02 1:38PM
Subject: Memphis Comments on Wolf River TMDL

I did not receive a copy of the November 8, 2002 version of the Wolf River Fecal TMDL from TDEC. I received a copy that was sent to Jerry Collins of the City of Memphis and circulated internally. Can you add me onto your TMDL list, so that I also get a copy of the TMDLs that include the City of Memphis in the future? I have asked this in the past and thought that I was on the list, as I have gotten notification of various Watershed meetings. If you did send it to me, please let me know and I'll see if I can find out where it went. It would help if you could fax or send me a copy of the cover letter (Jerry's is dated 11/11/02). My fax number is 901-576-7119.

I looked over the version that was sent to Jerry and it appeared that the comments that I submitted to you on 9/11/02 (regarding the Preliminary draft that you gave me) had not been addressed. I will restate them below, so that you can include them in the public's comments if you have not already included them:

- What is the fecal coliform at the ecoregion stream? If that is higher than the State standard of 200 cfu/100 ml, should the higher number be the target rather than 200?

- There are many conclusions that are stated that don't seem to have data to support them, such as in section 8.2 where it says "Model results indicate that....."

- Similar comments that I have submitted to previous TMDLs, such as how existing loads were figured, die off rates, and the addition of additional Factors of Safety.

- The units are not clear in section B.2.2.

Tom

CC: "Ron KIRBY" <Ron.KIRBY@cityofmemphis.org>,
<Bruce.Evans@state.tn.us>

Appendix E

Response to Public Comments

Responses to City of Memphis Comments

1. **Comment:**
What is the fecal coliform at the ecoregion stream? If that is higher than the State standard of 200 cfu/100 ml, should the higher number be the target rather than 200?

Response:
Ecoregion reference sites are located on streams that are considered “least impacted” waterbodies within an ecoregion that can be monitored to establish a baseline to which other waters can be compared. These reference streams are not necessarily pristine or undisturbed by humans. Although chemical sampling was conducted at candidate sites, ecoregion reference sites were selected primarily based on biological factors relating to fish & aquatic life. With respect to pathogens, *Tennessee Ecoregion Project 1994 – 1999* (TDEC 2000a) states

> Almost all reference sites indicated spikes in bacterial concentrations, especially during high flows. Some of these spikes exceeded water quality standards for pathogen levels in an instantaneous sample. However, no station had geometric mean levels that exceeded water quality standards.

A statistical summary of bacteriological data collected from ecoregion 74 reference sites (1996 – 1999) was reported in this document and is reproduced below for fecal coliform (values in CFU/100 ml):

Mean:	358.5
Std. Dev.:	982.5
Std. Error:	103.0
Count:	91
Minimum:	1.0
Maximum:	8100.0
Geom. Mean:	125.3
Median:	120.0

As stated in Section 4.0, the appropriate target was considered to be the fecal coliform water quality criteria for protection of the recreation use classification, as established by *State of Tennessee Water Quality Standards, Chapter 1200-4-3 General Water Quality Criteria, October 1999* (TDEC 1999).

2. **Comment:**
There are many conclusions that are stated that don't seem to have data to support them, such as in section 8.2 where it says "Model results indicate that....."

Response:
Section 8.2 makes observations regarding existing fecal coliform loading sources in the Wolf River watershed. These observations were based on the results of an HSPF watershed loading model that had been calibrated to field data for both hydrology and water quality over an 11-year period (1/1/90 – 12/31/00). Urban and agricultural runoff are widely recognized in literature as major sources of potential fecal coliform loading. Model construction, calibration, and calibration results are extensively discussed in Appendix B.

3. **Comment:**
   Similar comments that I have submitted to previous TMDLs, such as how existing loads were figured, die off rates, and the addition of additional Factors of Safety.

   Response:
   Comments submitted on the Nonconnah and Loosahatchie fecal coliform TMDLs were addressed in the "Response to Comments" appendices of those TMDL documents. The EPA-approved versions of these documents can be downloaded from the TDEC website (http://www.state.tn.us/environment/wpc/aptmdl.htm). In addition, a stakeholder meeting, hosted by the City of Memphis, was held on April 18, 2001 to discuss issues related to the Nonconnah fecal coliform TMDL. Many of these comments were also addressed at this meeting.

4. **Comment:**
   The units are not clear in section B.2.2.

   Response:
   The unit in Section B.2.2.2 (hr^{-1}) is that specified in the cited reference as the rate constant for first order decay of fecal coliform bacteria.