TOTAL MAXIMUM DAILY LOAD (TMDL)

For

Fecal Coliform

In

Johns Creek
Cypress Creek South
Lower Nonconnah Creek - RM 0 to 2.1 (Includes Cold Creek)
Nonconnah Creek - RM 2.1 To 11.5
Nonconnah Creek from RM 11.5 to Headwaters

Located In The
Nonconnah Creek Watershed (HUC 08010211)
Shelby County, Tennessee

Prepared by:

U.S. Environmental Protection Agency, Region 4

and

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September 20, 2001

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BMP	Best Management Practices
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	Non-point 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

SUMMARY SHEET
Proposed Total Maximum Daily Load (TMDL)
Lower Nonconnah Creek (includes Segments from RM 0 to RM 2.1 & RM 2.1 to RM 11.5)

1. **303(d) Listed Waterbody Information**
   State: Tennessee
   County: Shelby

   Major River Basin: Memphis Area Basin
   Watershed: Nonconnah Creek (HUC08010211)

   Waterbody Name: Nonconnah Creek
   Waterbody ID: TN08010211NONCON (includes Cold Creek); TN080102110079.1
   Location: Nonconnah Creek from RM 0 to RM 11.5
   Impacted Stream Length: 15.4 mi. Not Supporting; 7.2 mi. Partially Supporting
   Watershed Area: 173 square miles
   Tributary to: Mississippi River

   Constituent(s) of Concern: Fecal Coliform Bacteria

   Designated Uses: Fish and Aquatic Life, Recreation, Livestock Watering & Wildlife, and Irrigation

   Applicable Water Quality Standard for Recreation (most stringent standard):
   The concentration of the fecal coliform group shall not exceed 200 per 100 ml as a geometric mean based on a minimum of 10 samples collected from a given sampling site over a period of not more than 30 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 Non-Point Source Model (NPSM)/Hydrologic Simulation Program Fortran (HSPF) was used to develop this TMDL. A daily time step was used to simulate hydrologic and water quality conditions.

   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 10 years was used to assess the water quality standards for this TMDL. This period includes seasonal variations.

3. **Allocation Watershed/Stream Reach:**
   Wasteload Allocations (WLA): 0 counts/30 days
   Note: All future permitted discharges shall meet the water quality standard for fecal coliform bacteria of 200/100 ml.

   Load Allocation (LA): 3.96 x 10^{13} counts/30 days

   Margin of Safety (MOS): 20 counts/100 ml; conservative modeling assumptions

   Total Maximum Daily Load (TMDL): 3.96 x 10^{13} counts/30 days, 180 counts/100 ml

SUMMARY SHEET
Proposed Total Maximum Daily Load (TMDL)
Nonconnah Creek from RM 11.5 to Headwaters

1. 303(d) Listed Waterbody Information
State: Tennessee
County: Shelby

Major River Basin: Memphis Area Basin
Watershed : Nonconnah Creek (HUC 08010211)

Waterbody Name: Nonconnah Creek
Waterbody ID: TN0801021100718.5
Location: Nonconnah Creek from RM 11.5 to headwaters
Impacted Stream Length: 20.3miles Not Supporting
Watershed Area: 110 square miles
Tributary to: Mississippi River

Constituent(s) of Concern: Fecal Coliform Bacteria

Designated Uses: Fish and Aquatic Life, Recreation, Livestock Watering & Wildlife, and Irrigation

Applicable Water Quality Standard for Recreation (most stringent standard):
The concentration of the fecal coliform group shall not exceed 200 per 100 ml as a geometric mean based on a minimum of 10 samples collected from a given sampling site over a period of not more than 30 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 Non-Point Source Model (NPSM)/Hydrologic Simulation Program Fortran (HSPF) was used to develop this TMDL. A daily time step was used to simulate hydrologic and water quality conditions.

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 10 years was used to assess the water quality standards for this TMDL. This period includes seasonal variations.

3. Allocation Watershed/Stream Reach:
Wasteload Allocations (WLA): 0 counts/30 days
Note: All future permitted discharges shall meet the water quality standard for fecal coliform bacteria of 200/100 ml.

Load Allocation (LA): 1.89 x 10^{13} counts/30 days

Margin of Safety (MOS): 20 counts/100 ml; conservative modeling assumptions

Total Maximum Daily Load (TMDL): 1.89 x 10^{13} counts/30 days; 180 counts/100 ml

SUMMARY SHEET
Proposed Total Maximum Daily Load (TMDL)
Johns Creek

1. **303(d) Listed Waterbody Information**
   State: Tennessee
   County: Shelby

   Major River Basin: Memphis Area Basin
   Watershed: Nonconnah Creek (HUC 08010211)

   Waterbody Name: Johns Creek
   Waterbody ID: TN08010211JOHNSCR
   Location: Johns Creek from confluence with Nonconnah Creek to MS line
   Impacted Stream Length: 8 miles of Not Supporting
   Watershed Area: 22 square miles
   Tributary to: Nonconnah Creek

   Constituent(s) of Concern: Fecal Coliform Bacteria

   Designated Uses: Fish and Aquatic Life, Recreation, Livestock Watering & Wildlife, and Irrigation

   Applicable Water Quality Standard for Recreation (most stringent standard):
   The concentration of the fecal coliform group shall not exceed 200 per 100 ml as a geometric mean based on a minimum of 10 samples collected from a given sampling site over a period of not more than 30 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 Non-Point Source Model (NPSM)/Hydrologic Simulation Program Fortran (HSPF) was used to develop this TMDL. A daily time step was used to simulate hydrologic and water quality conditions.

   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 10 years was used to assess the water quality standards for this TMDL. This period includes seasonal variations.

3. **Allocation Watershed/Stream Reach:**
   Wasteload Allocations (WLA): 0 counts/30 days
   Note: All future permitted discharges shall meet the water quality standard for fecal coliform bacteria of 200/100 ml.

   Load Allocation (LA): 4.12×10^{12} counts/30 days

   Margin of Safety (MOS): 20 counts/100 ml; conservative modeling assumptions

   Total Maximum Daily Load (TMDL): 4.12×10^{12} counts/30 days; 180 counts/100 ml

SUMMARY SHEET
Proposed Total Maximum Daily Load (TMDL)
Cypress Creek South

1. **303(d) Listed Waterbody Information**
   State: Tennessee
   County: Shelby

   Major River Basin: Memphis Area Basin
   Watershed: Nonconnah Creek (HUC 08010211)

   Waterbody Name: Cypress Creek South
   Waterbody ID: TN08010211007
   Location: Cypress Creek South from mouth on Harbor channel to origin
   Impacted Stream Length: 18.1 miles Not Supporting
   Watershed Area: 14 square miles
   Tributary to: McKellar Lake

   Constituent(s) of Concern: Fecal Coliform Bacteria

   Designated Uses: Fish and Aquatic Life, Recreation, Livestock Watering & Wildlife, and Irrigation

   Applicable Water Quality Standard for Recreation (most stringent standard):
   The concentration of the fecal coliform group shall not exceed 200 per 100 ml as a geometric mean based on a minimum of 10 samples collected from a given sampling site over a period of not more than 30 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 Non-Point Source Model (NPSM)/Hydrologic Simulation Program Fortran (HSPF) was used to develop this TMDL. A daily time step was used to simulate hydrologic and water quality conditions.

   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 10 years was used to assess the water quality standards for this TMDL. This period includes seasonal variations.

3. **Allocation Watershed/Stream Reach:**
   Wasteload Allocations (WLA): 0 counts/30 days
   Note: All future permitted discharges shall meet the water quality standard for fecal coliform bacteria of 200/100 ml.

   Load Allocation (LA): 4.26×10^{12} counts/30 days

   Margin of Safety (MOS): 20 counts/100 ml; conservative modeling assumptions

   Total Maximum Daily Load (TMDL): 4.26×10^{12} counts/30 day; 180 counts/100 ml

FECAL COLIFORM TOTAL MAXIMUM DAILY LOAD (TMDL)
NONCONNAH WATERSHED (HUC 08010211)

Nonconnah Creek Including Cold Creek (TN08010211NONCON)
Nonconnah Creek (TN080102110079.1)
Nonconnah Creek (TN0801021100718.5)
Johns Creek (TN08010211JOHNSCR)
Cypress Creek South (TN08010211007)

1.0 INTRODUCTION

1.1 Background

The State of Tennessee assesses its water bodies for compliance with water quality standards criteria established for their designated uses as required by the Federal Clean Water Act (CWA). Assessed water bodies are placed into three categories, supporting, partially supporting, or not supporting their designated uses depending on water quality assessment results. These water bodies are found on Tennessee's 305(b) report as required by that section of the CWA that defines the assessment process, and are published in *The Status of Water Quality in Tennessee* every two years.

Some of the 305(b) partially and not supporting water bodies are also assigned to Tennessee's 303(d) list, also named after that section of the CWA. Water bodies on the 303(d) list are required to have a Total Maximum Daily Load (TMDL) evaluation for water quality constituent(s) that are in violation of applicable water quality standards. The TMDL process establishes the allowable loading of pollutants or other quantifiable parameters for a water body based on the relationship between pollution sources and in-stream water quality conditions. This allows water quality based controls to be developed to reduce pollution and restore and maintain water quality.

Fecal coliform bacteria data were collected from several stations along Nonconnah Creek. For TMDL development, data collected at Perkins Road and at river mile 2.1 were used to evaluate water quality conditions for the upper and lower Nonconnah watersheds, respectively. The upper Nonconnah watershed represents Waterbody ID TN0801021100718.5. The lower Nonconnah watershed represents both Waterbody IDs TN080102110079.1 and TN08010211NONCON (includes Cold Creek). Fecal coliform bacteria data were also collected on Cypress Creek South (Waterbody ID TN08010211007) and Johns Creek (Waterbody ID TN08010211JOHNSCR). The sampling stations on Johns Creek and Cypress Creek South were near the confluence with Nonconnah Creek.

Insufficient data were collected at all sites to calculate 30-day geometric mean values. However, at all sites fecal coliform bacteria exceeded 1000 counts/ 100 ml. As a result, approximately 43 miles of the Nonconnah Creek from McKellar Lake to the headwaters was placed on the 303(d) list and scheduled for a TMDL evaluation. On Cypress Creek South, 18.1 miles from the mouth on Harbor Channel to the origin was placed on the 303(d) list. On Johns Creek, 8 miles from the confluence with Nonconnah Creek to the Mississippi State line was placed on the 303(d) and scheduled for a TMDL evaluation.

It should be noted that fecal coliform TMDLs, based on a mass balance methodology, for some impaired waters in the Nonconnah watershed were originally proposed to EPA Region 4 in October 1999. EPA indicated some reservations with the approach used and the calculated load reductions and suggested that a numerical model be developed. This TMDL document contains the results of the numerical modeling analyses.

1.2 Watershed Description

The Nonconnah Creek watershed is located in the Memphis River basin in western Tennessee, in Shelby County (See Figure 1). Portions of the headwaters of Nonconnah Creek are in Marshall County Mississippi. Headwaters of Cypress Creek South and Johns Creek are located in DeSoto County, Mississippi. Nonconnah Creek flows into McKellar Lake which drains into the Mississippi River. Cypress Creek South flows into McKellar Lake located downstream of Nonconnah Creek. Johns Creek is a tributary of Nonconnah Creek in the eastern portion of the watershed. The lower Nonconnah Creek subwatershed (Nonconnah Creek from RM 0 to RM 11.5 including Cold Creek) has a drainage area of approximately 173 square miles. The upper Nonconnah Creek subwatershed has a drainage area of approximately 110 square miles. The drainage areas of Cypress Creek South and Johns Creek are 14 and 22 square miles, respectively.

The Nonconnah Creek watershed lies in the Level III Mississippi Valley Loess Plains ecoregion. Streams in this region are low-gradient and murky with silt and sand bottoms. Most of Nonconnah Creek and portions of Johns Creek have been channelized. The Tennessee Department of Transportation provided cross-sectional data for the channelized portion of Nonconnah Creek and were used in the model to characterize the reach.

Well fields dominate much of the Nonconnah Creek watershed, as the City of Memphis and other municipalities in the watershed use groundwater for drinking water supplies. Numerous studies have been conducted on the capture zone of the various well fields in the area and the conclusions reached confirm that all aquifers in West Tennessee should be considered leaking (Ground Water Institute, 1994). In developing the hydrology model for the Nonconnah Creek watershed, the parameter used to characterize losses to the deep groundwater system was assumed to be 30 percent.

The land use characteristics of the watershed were determined using data from Tennessee's Multiple Resolution Land Coverage (MRLC). This coverage is based on digital images from the period 1990-1993. Table 1 lists the land use distribution in the watershed. The data show that urban land use throughout the watershed ranges from approximately 43% to 71%. Land use coverage for the watershed is shown in Figure 2.

Figure 1. Location Map

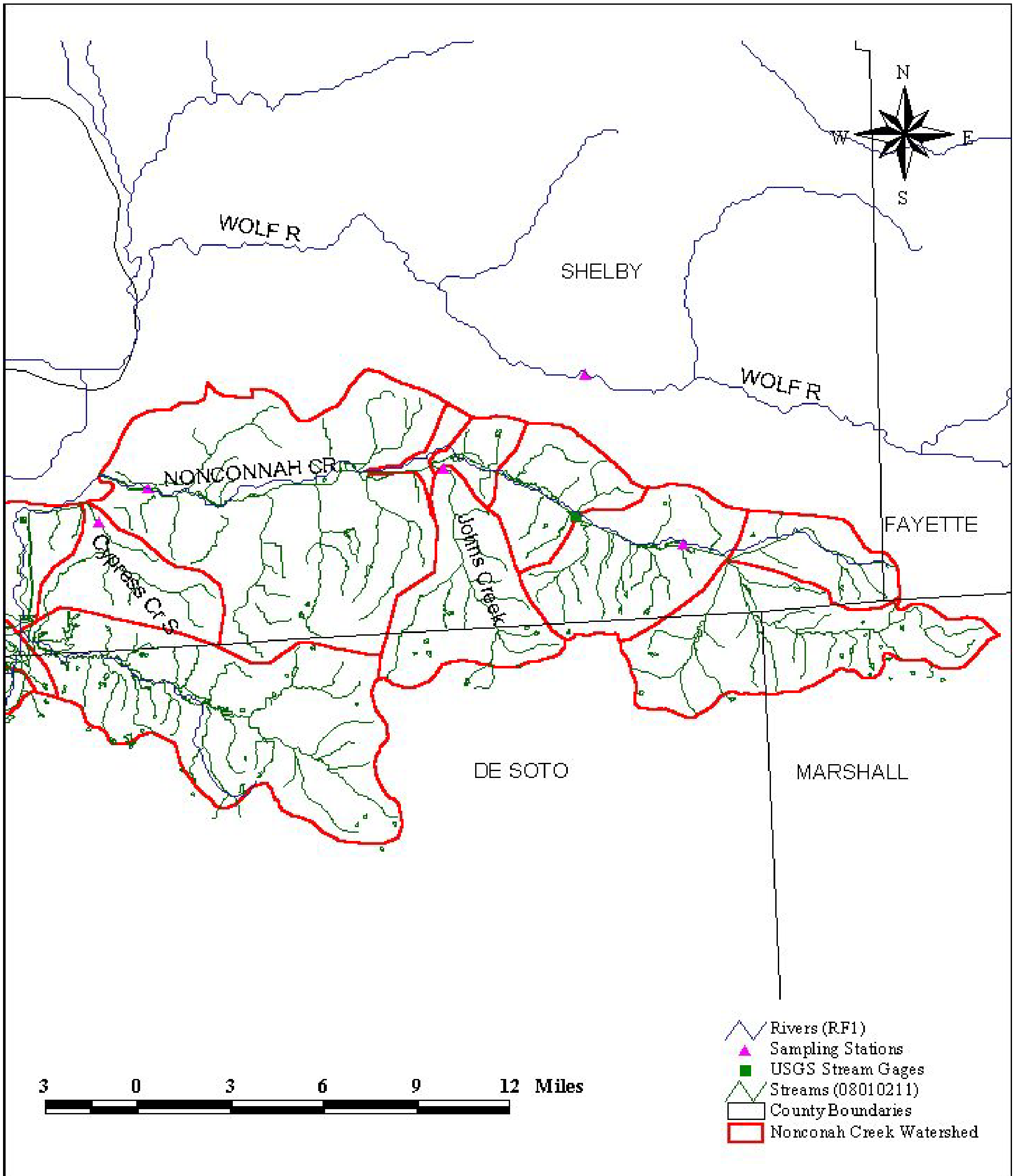

Figure 1. Watershed Map Nonconnah Creek Watershed	Map Projection:	Albers Equal Area Conic Sphere = GRS80 Datum = NAD 83
	Data Sources	USEPA; MRLC, 1994

Table 1. Land Use Distribution

Land Use	Lower Nonconnah Creek (RM 0 to RM 11.5 & Cold Creek)		Nonconnah Creek (RM 11.5 to HW)		Cypress Creek South		Johns Creek	
	Area [acres]	Area [%]	Area [acres]	Area [%]	Area [acres]	Area [%]	Area [acres]	Area [%]
Deciduous Forest	9559	8.6	7147	10.2	886	9.7	1435	10.2
Emergent Herbaceous Wetlands	34	0.03	6	0	48	0.5	0	0
Evergreen Forest	450	0.4	279	0.4	37	0.4	67	0.5
High Intensity Commercial/Industrial/ Transportation	11211	10.1	2675	3.8	242	2.6	1395	9.9
High Intensity Residential	8040	7.3	6997	10.0	1043	11.4	1403	10.0
Low Intensity Residential	27068	24.4	9079	13.0	5243	57.1	2135	15.2
Mixed Forest	5378	4.9	3382	4.8	659	7.2	1081	7.7
Open Water	649	0.6	428	0.6	27	0.3	121	0.9
Other Grasses Urban/Recreational	5624	5.1	2005	2.9	202	2.2	554	3.9
Pasture/Hay	17981	16.3	16821	24.1	180	2.0	2395	17.1
Quarries/Strip Mines/Gravel Pits	375	0.3	34	0.01	35	0.4	0	0
Row Crops	19819	17.9	17619	25.2	189	2.1	2928	20.9
Transitional	1240	1.1	791	1.1	6	0.1	425	3
Woody Wetlands	3335	3.0	2665	3.8	380	4.1	100	0.7
Total	110793	100	69928	100	9178	100	14039	100

Figure 2. Land Use Distribution

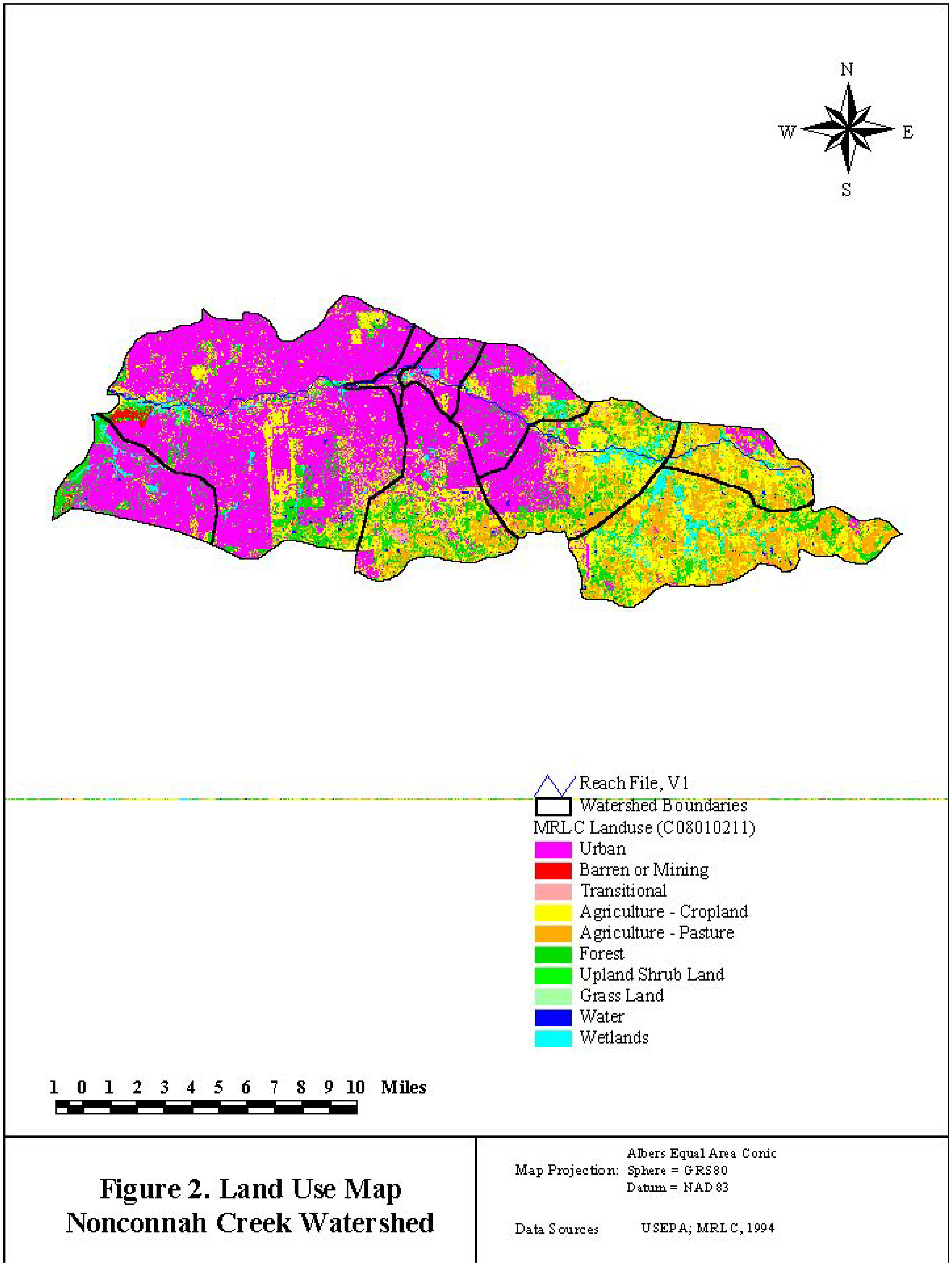

Figure 2. Land Use Map
Nonconnah Creek Watershed

1.3 Water Quality Standard

Surface waters in the Nonconnah Creek watershed have two use classifications with numeric criteria for fecal coliform: 1) Fish & Aquatic Life and 2) Recreation. The Recreation classification is the more stringent of the two and will be used for TMDL development. The water quality standard for fecal coliform bacteria is found in *State of Tennessee Water Quality Standards, Chapter 1200-4-3, General Water Quality Criteria, October,1999* and can be summarized as:

> The concentration of the fecal coliform group shall not exceed 200 per 100 ml as a geometric mean based on a minimum of 10 samples collected from a given sampling site over a period of not more than 30 consecutive days with individual samples being collected at intervals of not less than 12 hours. In addition, the concentration of the fecal coliform group in any individual sample shall not exceed 1,000 per 100 ml.

2.0 WATER QUALITY ASSESSMENT

Table 2 lists the fecal coliform bacteria concentrations for select sampling stations in the Nonconnah Creek watershed that were used to calibrate the water quality model. Due to the limitation of the model to simulate conditions through December 31, 1998, additional water quality data collected since 1999 were used only to evaluate the current water quality of the listed streams. These data, tabulated in Appendix A, indicate continued impairment of these waterbodies. The data collected at RM 2.1 was used to characterize the lower Nonconnah Creek (including Cold Creek) and the reach segment between RM 2.1 and RM 11.5.

Insufficient data were collected to calculate 30-day geometric mean values. However, at all sites, individual samples exceeded 1,000-counts/100 ml. Therefore, three segments of Nonconnah Creek, Johns Creek, and Cypress Creek South were listed as not supporting designated uses and were scheduled for a TMDL evaluation.

3.0 SOURCE ASSESSMENT AND LOAD ALLOCATION

A source assessment is used to characterize the known and suspected sources of fecal coliform bacteria in the watershed for use in the water quality model, and the development of the TMDLs. The general sources of fecal coliform bacteria are point and non-point sources.

A point source can be defined as any discernable, confined, and discrete conveyance from which pollutants are or may be discharged to surface waters. Point source discharges of industrial wastewater, treated sanitary wastewater, storm water associated with industrial activity, or storm water from municipal separate storm sewer systems (MS4) that serve over 100,000 people must be authorized by National Pollutant Discharge Elimination System (NPDES) permits. National Pollutant Discharge Elimination System (NPDES) permitted facilities discharging treated domestic wastewater are considered primary point sources of fecal coliform bacteria.

Table 2. Water Quality Monitoring Data

DATE	Nonconnah Cr. (at RM 2.1)	Nonconnah Cr. (at RM 11.5)	Johns Creek	Cypress Cr. South
	[counts/100 ml]	[counts/100 ml]	[counts/100 ml]	[counts/100 ml]
2/16/93				23000
8/26/93				2700
8/23/94				6100
8/16/95				430
7/23/96	1600	20000	20000	
8/28/96	40000	5000	20000	
9/25/96	150	290	9800	
10/24/96	5100	3600	4300	
11/20/96	1500	740	2100	
12/18/96	5400	1600	580	
1/29/97	2400	1000	600	
3/4/97	3600	1400	940	
3/26/97	29000	15000	5000	
4/23/97	45000	9600	5200	
5/28/97	44000	11000	13000	
6/25/97	2100	3900	10000	
7/30/97	40000	11000	20000	
8/27/97	2600	6000	2000	
9/30/97	1300	4400	21000	
10/23/97	580	980	1000	
11/19/97	600	2000	2200	
12/17/97	430	3900	14000	
6/17/98				203

Non-point sources of fecal coliform bacteria are diffuse sources that cannot be identified as entering the water body at a single location. These sources generally involve land activities that contribute fecal coliform bacteria to streams during rainfall runoff events. Non-point sources of fecal coliform bacteria considered in the analysis include:

- Wildlife
- Land application of agricultural manure
- Grazing animals
- Leaking septic systems
- Urban development (including leaking sewer collection lines & illicit discharges)

For non-point sources involving agricultural activities, the Natural Resources Conservation Service (NRCS) was consulted for information and parameters to characterize agricultural activities in the water quality model. Confined animal feeding operations (CAFOs) are suspected in the watershed, but the exact location could not be verified with the NRCS. CAFOs were assumed to exist in those watersheds have a large percentage of pastureland area based on the MRLC land use. The City of Memphis was consulted for information regarding leaking sewer collection lines. All point and non-point sources of fecal coliform bacteria identified in the watershed are assigned a loading rate based on literature values and population in the watershed. Because of varying decay or die-off rates for fecal coliform bacteria, and varying transport assumptions, the fecal coliform bacteria loading from these sources are computed separately in the model as described in Section 4.

3.1 Point Source Assessment

Within the modeled watershed, there are no permitted discharges of treated sanitary wastewater. Several municipal publicly owned treatment works (POTWs) service urban areas in the Nonconnah Creek watershed, including portions of Memphis, Germantown, and Collierville, TN. These POTWs discharge to waterbodies outside of the Nonconnah Creek watershed and are not included in the TMDL analysis. All future NPDES discharges in the watershed will be required to meet the end-of-pipe water quality standard of 200 counts/100ml.

In addition, a number of industrial NPDES facilities are located in the Nonconnah Creek watershed. None of these facilities is permitted to discharge fecal coliform bacteria, and are not considered in the TMDL analysis.

Point source discharges of urban storm water authorized by the City of Memphis MS4 permit can contain significant levels of fecal coliform bacteria. Due to their number, these discharges are accounted for in the water quality model as part of the non-point source loading from urban land use classifications.

3.2 Non-point Source Assessment

3.2.1 Wildlife

Wildlife deposit fecal coliform bacteria with their feces onto the land where it can be transported during a rainfall runoff event to nearby streams. In the water quality model, the wildlife fecal coliform contribution is accounted for in the deer population. The deer population is estimated to be 30 to 45 animals per square mile in this area (personal comm., NRCS, TDEC, and EPA). The upper limit of 45 deer per square mile has been chosen to account for deer and all other wildlife present in the watershed. It is assumed that the wildlife population remains constant throughout the year, and that wildlife is uniformly distributed on all land classified in the MRLC database as forest, pasture, cropland, and wetlands.

Fecal coliform contributions from wildlife are represented in the model based on deer population. In the model, deer are uniformly distributed to forest, pasture, cropland, and wetland areas at a density of 45 deer per square mile. The loading rate used in the model attributed to wildlife is 5.0×10^8 counts/animal/day. This loading rate is based on best professional judgment based on linear interpolation using the rate and weight of other animals available in Metcalf & Eddy (1991).

3.2.2 Land Application of Agricultural Manure

Processed agricultural manure from confined feeding operations is generally collected in lagoons and applied to land surfaces during the months April through October. In West Tennessee, manure is applied only to pastureland as chemical fertilizer is used on cropland.

Data sources for confined feeding operations include the Census of Agriculture and the NRCS. Livestock data are based on the 1997 Census of Agriculture and are reported by county. In 1997, Shelby County had an estimated cattle population of 9,100, predominately beef cows, and a hog population estimated at 1,300. Horse population in Shelby County was estimated at 2,700 based on data obtained from the US Department of Agriculture, National Agricultural Statistics Service (USDA, NASS, 1999).

In the water quality model, county livestock data are distributed to the subwatersheds based on the percentage of agricultural area in each subwatershed classified as pasture/hay. A spreadsheet analysis was used to calculate fecal coliform loading rates (counts/acre/day) from livestock based on manure application rates and literature values for bacteria concentrations in the livestock manure. Manure application rates from the various animal sources vary monthly according to management practices and are provided in Appendix B. Fecal coliform loading rate for the various animal populations in the watershed are: 1.06×10^{11} counts/day/beef cow, 1.04×10^{11} counts/day/dairy cow, 1.24×10^{10} counts/day/hog, and 4.18×10^8 counts/day/horse (NCSU, 1994).

As manure is not applied to cropland, the only source of fecal coliform bacteria from cropland is from wildlife that deposit feces on the land. In the model, the loading applied to cropland is assumed background and is based on the number of acres of cropland in the watershed and the contribution of fecal coliform from wildlife. In the model, this rate is assumed to be 2.5×10^6 counts/acre-day.

3.2.3 Grazing Animals

Cattle, including beef and dairy, and horses spend time grazing on pastureland and depositing feces onto the land. During a rainfall runoff event, a portion of this material containing fecal coliform bacteria is transported to streams. Beef cattle are assumed to spend all their time in pasture, while dairy cattle are confined periodically. The acres of pastureland in the watershed and the percentage of feces deposited during grazing time are used to estimate the fecal coliform loading rates applied to pastureland. Because there is no assumed monthly variation in animal access to pastures in west Tennessee, the fecal loading rates applied to pastureland does not vary significantly throughout the year to warrant input of this rate as a monthly value. The loading rate to pastureland used in the model is 2.4×10^{10} counts/acre-day. Contributions of fecal coliform from wildlife are also included in this rate.

In addition, cattle, horses, and other unconfined animals often have direct access to streams that pass through pastures. Feces deposited in streams by grazing animals are included in the water quality model as a point source having constant flow and concentration. To calculate the amount of bacteria introduced into streams by animals, it is assumed that only the beef cow and horse populations have access to the streams and of those approximately 12 percent defecate in streams (personal communication, EPA).

In the water quality model, a point source of constant flow and concentration was added in each subwatershed having a significant number of beef cows and horses to represent animal access to streams. This load was added to the urban load from leaking sewer collection lines and is referred in the model as a miscellaneous point source. Depending on the size of the subwatersheds, the resulting fecal coliform bacteria load from miscellaneous sources ranges from 3×10^7 to 2×10^9 counts/hour.

3.2.4 Failing Septic Systems

Table 3 shows estimates from county census data of people in the watershed on septic systems. In west Tennessee, EPA estimates that there are approximately 2.5 people per household on septic systems. For modeling purposes, it is assumed that 20 percent of the septic systems in the watershed leak at a rate of 70 gallons/person-day and a concentration of 10,000-counts/100 ml (Horsley and Witten, 1996; Metcalf & Eddy, 1991). Failing septic systems are included in the water quality model as a point source having constant flow and concentration. The loading rate attributed to failing septic systems ranges from 6.6×10^6 to 1.3×10^9 counts/hr.

Table 3. Estimated Number of Septic Systems in Nonconnah Creek Watershed

Watershed	Septic Systems
Upper Nonconnah Creek (includes headwater reaches)	4564
Lower Nonconnah Creek	558
Johns Creek	1265
Cypress Creek South	40

3.2.5 Urban Development

Fecal coliform bacteria from urban areas may originate from various sources including runoff through storm water sewers (e.g., residential, commercial, industrial, and road transportation), illicit discharges of sanitary waste, and runoff from improper disposal of waste materials. Due to the proximity of the watershed to the various municipal POTW facilities, overflowing sanitary sewers and leaking collection lines may be a source fecal coliform bacteria in the watershed, although based on discussions with the City of Memphis collection system failures are a minor source of contamination (personal communication, EPA, TDEC and City of Memphis, April 17, 2001). In the model, leaking sewer collection lines and illicit discharges of fecal coliform bacteria are included with animal access to streams and referred to as a miscellaneous point source having constant flow and concentration.

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. 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 includes loading from discharges from the City of Memphis municipal separate storm sewer system (MS4). This rate of $2.5\text{x } 10^{8}$ counts/acre-day is assumed constant throughout the year.

4.0 MODELING APPROACH

Establishing the relationship between in-stream water quality and source loading is an important component of TMDL development. It provides for the identification of sources, and their relative contribution, as well as the examination of potential water quality changes resulting from varying management options to meet the water quality standard. This relationship can be developed using a variety of techniques ranging from qualitative assumptions based on scientific principles to numerical computer modeling techniques. In this section, the numerical modeling techniques developed to simulate fecal coliform bacteria fate and transport in the watershed is discussed.

4.1 Model Selection

A dynamic computer model was selected for the fecal coliform bacteria TMDL evaluation in order to satisfy a variety of objectives. The first objective is to simulate the time varying behavior of fecal coliform bacteria deposition on the land surface and transport to receiving water bodies. The second objective was to use a continuous simulation period to identify the critical condition and from which to develop the TMDL. Finally, the continuous simulation model provides the means to incorporate seasonal effects on the production and fate of fecal coliform bacteria. A series of computer-based tools were used to accomplish these objectives.

First, the Watershed Characterization System (WCS), a geographic information system (GIS) tool, was used to display and analyze GIS information including land use, land type, point source discharges, soil types, population, and stream characteristics. The WCS was used to identify and summarize the sources of fecal coliform bacteria in the watershed, as well as the other factors that affect its fate and transport.

Information derived from WCS was used in a series of spreadsheet applications designed to compute fecal coliform bacteria loading rates in the watershed from varying land uses including urban, cropland, pastureland, and forestry as described in Section 3.0. Computed loading rates were used in a hydrologic and water quality model, NPSM (Non-Point Source Model), to simulate the deposition and transport of fecal coliform bacteria, and the resulting water quality response. The NPSM program uses the Hydrologic Simulation Program Fortran (HSPF) to develop the TMDLs. NPSM simulates non-point source runoff as well as the transport and flow of pollutants in stream reaches. A necessary feature of NPSM is its ability to integrate both point and non-point sources of fecal coliform bacteria and determine the in-stream water quality response.

4.2 Model Set Up

The Nonconnah Creek watershed was delineated into nine watersheds in order to characterize the relative fecal coliform bacteria contributions from the significant contributing subwatersheds (see Figure 1). Water quality stations and USGS flow gages marked the pour point of the individual watersheds. Watershed delineation was based on the RF3 stream coverage and elevation data. This discretization allows management and load reduction alternatives to be varied by subwatershed.

A continuous simulation period from January 1, 1984 to December 31, 1998 was used in the analysis. The period from January 1, 1984 to December 31, 1984 was used to allow the model results to stabilize. The period from October 1, 1985 to January 31, 1995 was used to calibrate the hydrology portion of the model. The period from July 23, 1996 to December 17, 1997 was used to calibrate the water quality portion of the model for Nonconnah Creek ,Johns Creek, and Cypress Creek South as this is when monthly sampling was collected in the watershed. Model results from January 1, 1989 to December 31, 1998 were used to identify the critical condition period from which to develop the TMDL (see Figures 3 through 6). The purpose of the 10-year simulation is to show the impact current fecal coliform loading applications have on in-stream water quality under a variety of weather conditions.

An important factor driving 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 in the simulation.

4.3 Model Calibration

The calibration of the watershed model involves both hydrology and water quality components. The hydrology calibration is performed first and involves comparing simulated stream flows to historic stream flow data from a U.S. Geological Survey (USGS) stream gaging station for the same period of time. Calibration of the hydrologic model involves adjusting model parameters used to represent the hydrologic cycle, until an acceptable agreement is achieved between simulated and observed stream flow. Some of the model parameters adjusted include evapotranspiration, infiltration, upper and lower zone storage, groundwater storage and, recession, losses to the deep groundwater system, and interflow discharge. The USGS gage on Nonconnah Creek near Germantown, Tennessee (USGS 07032200) was used to calibrate the flow model. Results of the hydrology calibration are summarized as monthly flows and are included in Appendix C.

Monthly fecal coliform bacteria data available for the Nonconnah Creek were those data collected in 1996 and 1997. Additional samples were collected in from 1993 to 1999, however the data is sparse and it is not possible to identify seasonal trends. Only monthly data collected in 1996 and 1997 were used to calibrate the water quality model.

A comparison of simulated water quality concentrations and observed concentrations for sampling stations in Nonconnah Creek and Johns Creek are shown in Appendix C. Results show that the model adequately 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 an unknown source that is not included in the model.

4.4 Critical Conditions

Critical conditions for non-point fecal coliform sources are an extended dry period followed by a rainfall runoff event. During the dry weather period, fecal coliform bacteria build up on the ground and when it rains, it is washed off the ground by rainfall runoff. Critical conditions for point sources occur during low stream flows and corresponding reduced dilution potential. Both conditions are simulated in the NPSM model.

The ten-year simulation period from January 1, 1989, to December 31, 1998, was used to identify the critical conditions from which to base the fecal coliform bacteria TMDL. This 10-year period contained a range of hydrological conditions including low and high stream flows. The range of hydrological conditions provided an opportunity to identify the fecal coliform bacterial critical conditions period, as well as the amount of in-stream fecal coliform bacteria in the stream that can be used to develop the TMDL.

5.0 MODEL RESULTS

5.1 Existing Conditions

Model results indicate that non-point sources related to urban activities (including Memphis MS4 discharges) have an impact on the fecal coliform bacteria loading in the Nonconnah Creek watershed. Agricultural activities also impact bacteria loading in the watershed. Reductions in these loading rates reduce the in-stream fecal coliform bacteria levels. Non-point source loading rates representing existing model conditions are shown in Table 4. Miscellaneous sources represent animal access to streams, illicit discharges of fecal coliform bacteria, and leaking sewer collection lines. Runoff represents the largest loads as it is associated with wet weather conditions resulting in higher flows and dilution as compared to the loading from leaking septic systems and miscellaneous sources which are an indication of low flow conditions.

Table 4. Non-point Source Loading Rates and Instream Fecal Coliform Bacteria Concentrations for Existing Conditions

Watershed	Runoff from all Lands	Leaking Septic Systems	Miscellaneous Sources	Instream Fecal Coliform Levels[1]
	[Cts / 30 days]	[Cts / 30 days]	[Cts / 30 days]	[Cts / 100 ml]
Upper Nonconnah Creek	8.37×10^{14}	2.31×10^{12}	9.11×10^{11}	2738
Lower Nonconnah Ck. (includes 2 segments of Nonconnah Ck. & Cold Ck.)	1.99×10^{15}	2.52×10^{12}	9.66×10^{11}	3074
Johns Creek	1.89×10^{14}	5.03×10^{11}	2.88×10^{11}	3229
Cypress Creek South	2.26×10^{14}	1.26×10^{10}	1.63×10^{10}	3366

1. Instream concentrations represent the simulated geometric mean concentration during the critical period (see Section 5.2)

5.2 Critical Condition

Results of the ten-year simulation for existing conditions are shown in Figures 3 through 7. 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 standard (EPA, 1991). Achieving water quality standards during this period ensures that water quality standards can be achieved for the entire ten-year period.

Periods of model instability or periods of extreme rainfall were excluded from the TMDL analysis. Model instability occurs when the simulated stream flow approaches zero and the resulting fecal coliform concentrations become a negative value. These conditions occur in 1990, 1991, and 1994. For the listed segments in the Nonconnah Creek watershed, the highest violation of the 30-day geometric mean occurred on August 3, 1998. The critical period is July 5, 1998 through August 3, 1998. To achieve the TMDL, the in-stream loads are reduced until the spikes in the 30-day geometric mean plots fall below the 200 counts/100ml standard line. For the critical period, the simulated geometric mean concentration at all stations was much less than 200 counts/ 100 ml but for the overall 10-year period a target concentration of 180 counts/ 100 ml was assumed protective of water quality standards.

6.0 ALLOCATION

6.1 Total Maximum Daily Load

A TMDL is the sum of the individual waste load allocations (WLAs) for point sources and load allocations (LAs) for non-point sources and natural background (40 CFR 130.2). The sum of these components may not result in an exceedance of water quality standards for that water body. To protect against exceedances, the TMDL must also include a margin of safety (MOS), either implicitly or explicitly, that accounts for the uncertainty in the relationship between pollutant loads and the water quality response of the receiving water body. Conceptually, a TMDL can be expressed as follows:

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

The TMDL is the total amount of pollutant that can be assimilated by the receiving water body while maintaining water quality standards. TMDLs establish allowable pollutant loadings that are less than or equal to the TMDL, and thereby provide the basis to establish water quality based controls. For some pollutants, TMDLs are expressed on a mass loading basis (e.g., pounds per day). For fecal coliform bacteria the TMDL are expressed in terms of counts per 30 day as this is how the water quality standard is expressed and in terms of instream concentration. Therefore, the TMDL represents the maximum fecal coliform bacteria load that can be assimilated by the stream during the critical 30-day period while maintaining the fecal coliform bacteria levels below the water quality standard of 200 counts/100 ml. Regardless of the flow in the stream, if the geometric mean concentration is less than 200 counts/100 ml and 10 percent of the samples do not exceed the instantaneous value of 1000 counts/100 ml, the stream will meet water quality standards.

The total maximum daily load of fecal coliform bacteria was determined by adding the WLA and the LA. The MOS (as described in Section 6.5) was implicitly included in the TMDL analysis and does not factor directly in the TMDL equation as shown above. Table 5 shows the computation of the total maximum daily loads for the listed streams using the WLAs and the LAs for the critical condition.

Table 5. TMDL Components (counts/30 day)

Watershed	WLA	LA	MOS	TMDL
Upper Nonconnah Cr.	0	1.89×10^{13}	Implicit	1.89×10^{13}
Lower Nonconnah Cr. (includes 2 segments of Nonconnah Ck. & Cold Ck.)	0	3.96×10^{13}	Implicit	3.96×10^{13}
Johns Creek	0	4.12×10^{12}	Implicit	4.12×10^{12}
Cypress Creek South	0	4.26×10^{12}	Implicit	4.26×10^{12}

1. Percent reduction is based on existing instream fecal coliform bacteria concentrations for existing conditions (Table 4) and the target concentration of 180 counts/ 100 ml

6.2 Waste Load Allocations

There are no NPDES permitted municipal or industrial discharges of fecal coliform bacteria identified in the modeled portion of the Nonconnah Creek watershed. Future facility permits will require end-of-pipe limits equivalent to the water quality standard of 200-counts/100 ml.

6.3 Load Allocations

There are two modes of transport for non-point source fecal coliform bacteria loading in the model. First, loading from failing septic systems, animals in the stream, and leaking sewer system collection lines are modeled as direct sources to the stream and are independent of precipitation. The second mode involves loading resulting from fecal coliform accumulation on land surfaces and wash-off during storm events. For the purposes of the model, this includes all loading from discharges covered under the Memphis MS4 permit. Fecal coliform applied to land is subject to a die-off rate and an absorption rate before it is transported to the stream. Fecal coliform bacteria can also reproduce both on land and in the receiving water bodies. In the model, reproduction of bacteria on land and in water is accounted by using a conservative die-off value.

Model results indicate that non-point sources related to urban runoff and agricultural activities have an impact on the fecal coliform bacteria loadings in the Nonconnah Creek watershed. Runoff from failing septic systems and other miscellaneous sources also contribute to the fecal coliform bacteria loading to the streams in the Nonconnah Creek watershed. By achieving an instream fecal coliform concentration of 180 counts/100 ml, compliance with the water quality geometric mean and instantaneous standard are obtained.

A possible allocation scenario that would meet in-stream water quality standards in the Nonconnah Creek is a 93 to 96 percent reduction in fecal coliform bacteria loads from non-point sources associated with urban land uses. Best management practices (BMPs) that could be used to implement this TMDL include controlling pollution from urban runoff, identification and elimination of illicit discharges, and repair of failing septic systems. The continual prompt response by the City of Memphis to fix leaking sewer collection lines and overflowing sanitary sewers should minimize the adverse affect of collection line failures. In addition, loading from agricultural sources could be minimized by adoption of NRCS resource management practices. NRCS practices include measures such as covering manure stacks exposed to the environment; reducing animal access to streams; and applying manure to croplands at agronomic rates. Fecal coliform loading rates for this allocation scenario are shown in Table 6. Additional monitoring and characterization of the watershed could be conducted to verify the various miscellaneous sources of fecal coliform bacteria in the watershed.

Table 6. Load Allocations in Nonconnah Creek Watershed

Watershed	Existing Load (Counts / 30 days)	Allocated Load (Counts / 30 days)	Required Reduction
	[Counts / 30 days]	[Counts / 30 days]	[%]
Upper Nonconnah Ck.	8.41×10^{14}	1.89×10^{13}	93.4
Lower Nonconnah Ck. (includes 2 segments)	2.83×10^{15}	3.96×10^{13}	94.1
Johns Creek	1.90×10^{14}	4.12×10^{12}	94.4
Cypress Creek South	2.26×10^{14}	4.26×10^{12}	94.6

6.4 Seasonal Variation

Seasonal variability was incorporated in the continuous simulation water quality model by using varying monthly loading rates and daily meteorological data. The combination of a continuous simulation with varying loading rates and meteorological conditions creates a condition of seasonal variation.

6.5 Margin of Safety

The MOS is a required component of TMDL development. There are two basic methods for incorporating the MOS: 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. For this TMDL the MOS was implicitly incorporated into the modeling process by selecting a critical time period and critical default values for each of the summer and winter seasons based on the results of a 10-year simulation. In the model, leaking septic systems discharge directly into the stream, when in reality they often filter through the ground water system resulting in a greater die-off of fecal coliform bacteria. Also, all land types are directly connected to the stream as the model does not allow for flow over different land types before entering the stream. Manure that is applied to the land is probably subject to a greater die-off than what is assumed in the model. This results in a higher concentration of fecal coliform being applied to the land and subject to runoff. An explicit MOS is incorporated in the model as the peak associated with the critical period used to develop the TMDLs are below the 200-counts/100 ml standard line. An explicit MOS is considered in the TMDLs by requiring an instream geometric mean concentration of 180 counts / 100ml.

7.0 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 the Nonconnah watershed so as to support its Recreation use classification. 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.

7.1 Point Source Facilities

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

7.2 Urban Sources of Fecal Coliform Loading

7.2.1 Municipal Entities Covered Under Phase 1 Storm Water Regulations

The Memphis MS4 permit became effective on June 1, 1996 and 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 MS4 permit requires the development of a Storm Water Management Program (SWMP) to reduce the discharge of pollutants to the maximum extent practicable and not to cause or contribute to violations of State water quality standards in receiving streams. The City is in the fifth year of the existing permit term and is proceeding according to the schedule specified 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:

a) A reduction of fecal coliform loading in point and non-point source storm water runoff discharges to the Nonconnah watershed in accordance with the Load Allocations specified in Table 9. (For the purposes of this TMDL, the Waste Load Allocations for point source discharges covered under the Memphis MS4 permit were calculated as a part of the Load Allocations – see Section 8.4). The objective of these reductions is instream patrhogen concentrations in compliance with water quality standards.

b) Identification of sources and 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.

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

In addition, the City of Memphis should be encouraged to develop and calibrate a dynamic water quality model, such as the Storm Water Management Model (SWMM), to evaluate urban storm water loading/transport processes and facilitate planning and additional pollution control strategies.

7.2.2 Municipal Entities Covered Under Phase 2 Storm Water Regulations

The City of Millington and Shelby County will be issued NPDES Municipal Separate Storm Sewer System (MS4) permits under the Phase 2 storm water regulations. Applications are due by March 10, 2003. Each permitted entity will be required to develop a SWMP to reduce the discharge of pollutants to the maximum extent practicable and not to cause or contribute to violations of State water quality standards in receiving streams. 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.

In accordance with the load allocations developed in this TMDL, the Millington and Shelby County MS4 permits should require the respective SWMPs to accomplish the following:

a) A reduction of fecal coliform loading in point and non-point source storm water runoff discharges to the Nonconnah watershed in accordance with the Load Allocations specified in Table 9. (For the purposes of this TMDL, the Waste Load Allocations for point source discharges to be covered under the MS4 permits were calculated as a part of the Load Allocations – see Section 8.4). The objective of these reductions is instream patrhogen concentrations in compliance with water quality standards.

b) Identification of sources and 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.

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

7.3 Agricultural Sources of Fecal Coliform Loading

The Tennessee Department of Environment & Conservation (TDEC) should coordinate with the Tennessee Department of Agriculture (TDA) and the Natural Resources Conservation Service (NRCS) to address issues concerning fecal coliform loading from agricultural sources in the Nonconnah 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.

7.4 Stream Monitoring

Tennessee's watershed management approach examines each major watershed in the State, corresponding to 8-digit USGS Hydrologic Unit Codes (HUCs), on a rotating, five year cycle. The six key activities that occur within each cycle include: 1) planning and data collection; 2) monitoring; 3) assessment; 4) TMDL/allocation development; 5) permit issuance; and 6) watershed management plan development. This approach establishes water quality monitoring, stream assessment, and TMDL development/revision as regular, recurring events in each watershed.

Continued monitoring of fecal coliform concentration at multiple water quality sampling points in the watershed is critical in characterizing sources of fecal coliform contamination and documenting reductions 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 Nonconah watershed includes monthly grab samples and intensive sampling (at least one month) during the wet season (January-March). In addition, monitoring efforts should be refined and enhanced in order to characterize dry and wet season base flow conditions (concentrations) and promote selective storm response (hydrograph) characterization. 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.

7.5 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 Nonconnah watershed. TDEC, coordinating with the TDA, will evaluate the progress of implementation strategies and refine the TMDL as necessary in the next phase (next five-year cycle). This will include recommendation of specific implementation plans for identified problem areas with as yet undefined sources and causes of pollution. Cooperation will be maintained with TDA (for possible 319 non-point source grants) and NRCS for developing agricultural 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 exceedances of fecal coliform concentrations (loading) in impacted water bodies. The phased approach will assure progress toward the attainment of water quality standards.

8.0 PUBLIC PARTICIPATION

In accordance with 40 CFR §130.7, announcement of the availability of proposed fecal coliform TMDLs for three sections of Nonconnah Creek (mouth to RM 2.1, RM 2.1 to RM 11.5, and RM 11.5 to headwaters), Cypress Creek South, and Johns Creek was made to the public, effected dischargers, and other concerned parties 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 October 23, 2000 (see Appendix D). The announcement invited public comment until November 27, 2000. The Public Notice announcement was downloaded 30 times and the TMDL document 12 times.

2) Notice of the availability of the proposed TMDLs (similar to the website announcement) was included in one of the NPDES permit Public Notice mailings which are sent to approximately 90 interested persons or groups who have requested this information.

3) An e-mail was sent to the City of Memphis announcing the availability of the TMDLs on the TDEC website and that comments would be received through November 27, 2001. The City of Memphis is covered under Municipal Separate Storm Sewer System (MS4) permit TNS068276.

4) A public meeting was held in Memphis on April 18, 2001 to discuss the proposed TMDLs and fecal coliform modeling. Attendees included representatives from USEPA Region 4, Tennessee Division of Water Pollution Control, and a number of regional stakeholders (40 invited).

Written comments were received from two parties during the public comment period. These comments are included in Appendix E and the Division of Water Pollution Control responses are contained in Appendix F.

9.0 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:

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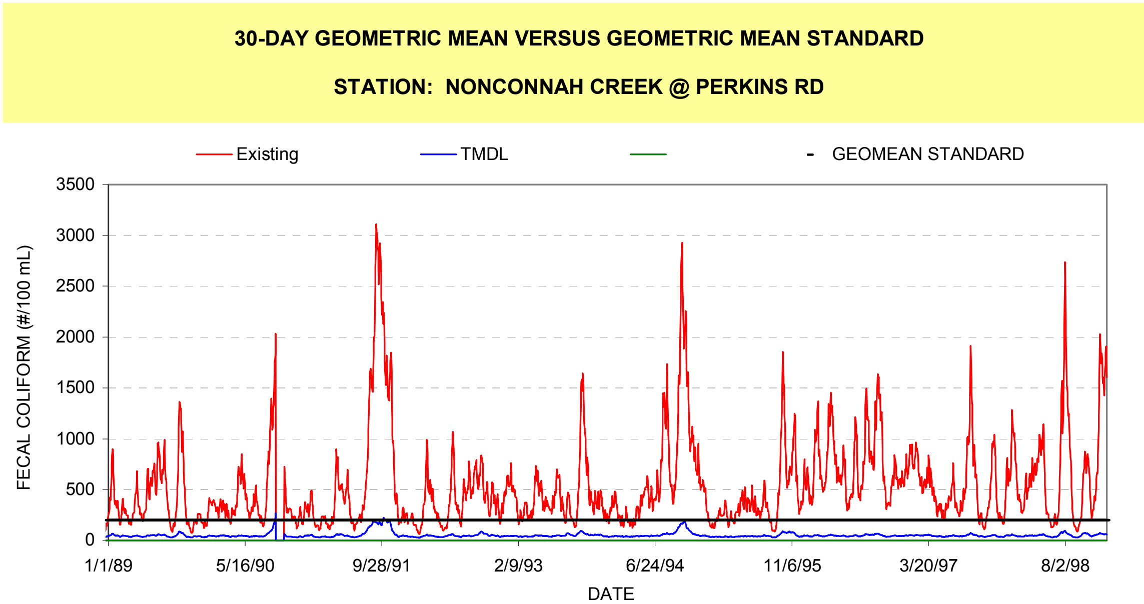

Figure 3. Simulated Geometric Mean for Upper Nonconnah Creek at RM 11.5

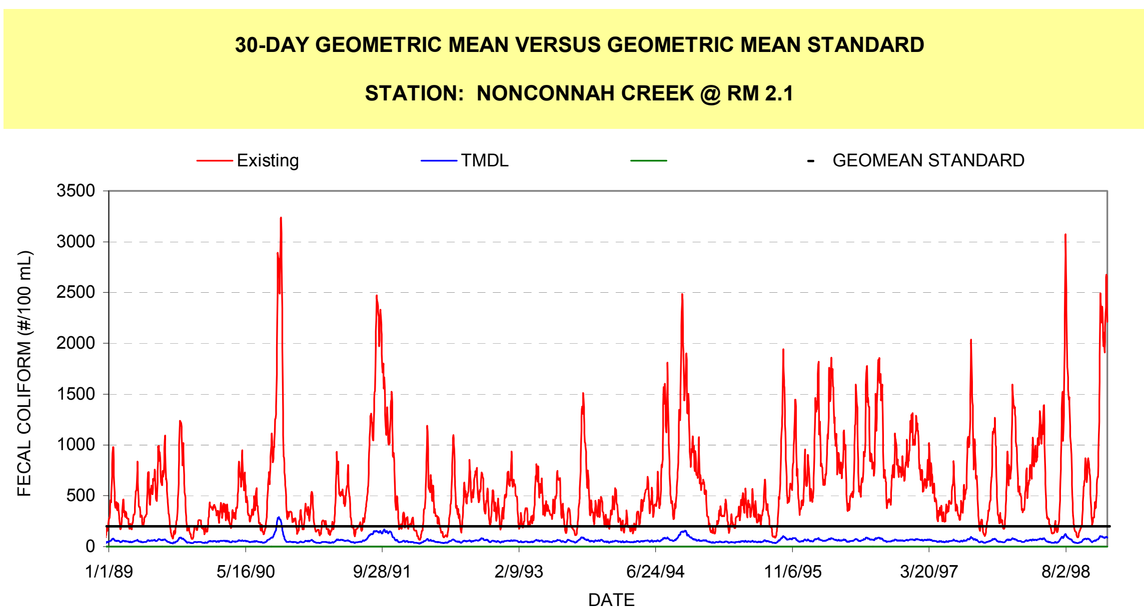

Figure 4. Simulated Geometric Mean for Lower Nonconnah Creek at RM 2.1

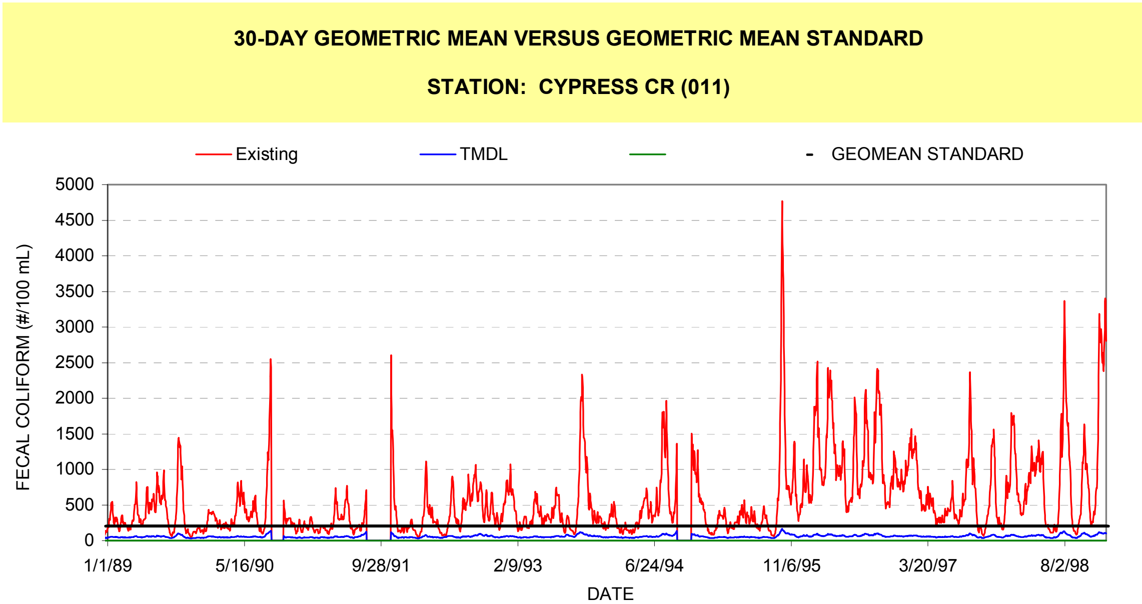

Figure 5. Simulated Geometric Mean for Cypress Creek South

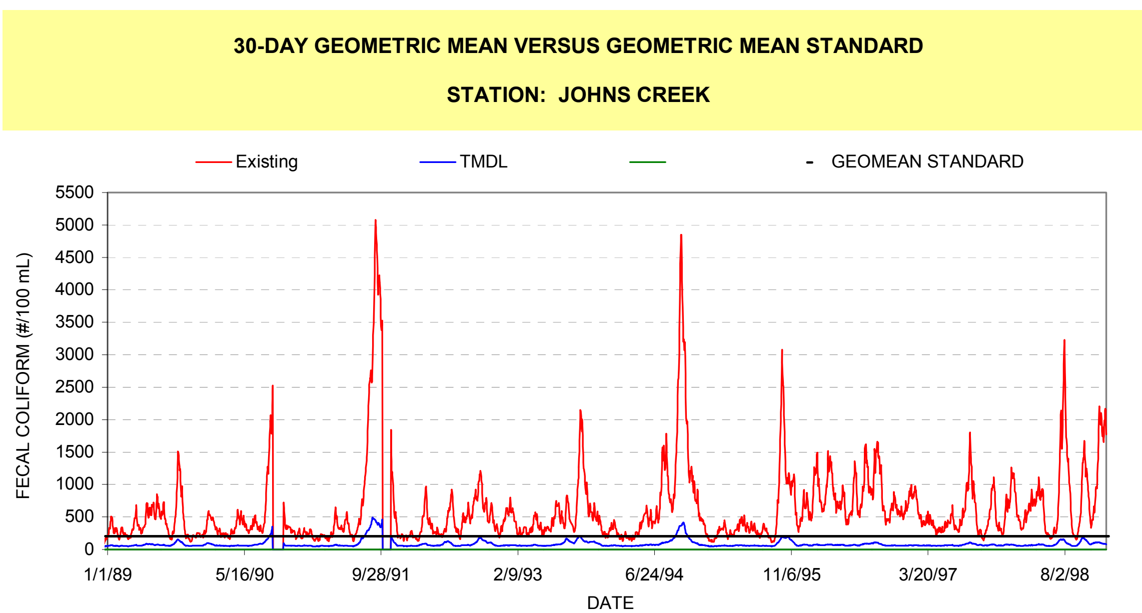

Figure 6. Simulated Geometric Mean for Johns Creek

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APPENDIX A

1999 Water Quality Monitoring Data

Table A-1 1999 Water Quality Monitoring Data

STATION	STATION NAME	HUC CODE:	DATE	TIME	E_COLI
001018	CYPRESS CK	08010211007	990609	0900	85.5
001690	JOHN'S CK	08010211JOHNSCR	990609	1020	2419.2
NONCONNAH014.0	NONCONNNAH CK	0801021100718.5	981209	0850	<2419.2
NONCONNAH014.0	NONCONNNAH CK	0801021100718.5	990225	0825	33.7
NONCONNAH014.0	NONCONNNAH CK	0801021100718.5	990505	0945	R>2419.2
NONCONNAH06.9	NONCONNNAH CK	080102110079.1	981209	0930	<2419.2
NONCONNAH06.9	NONCONNNAH CK	080102110079.1	990225	0905	125.9
NONCONNAH06.9	NONCONNNAH CK	080102110079.1	990505	0900	R>2419.2
NONCONNAH11.85	NONCONNNAH CK	080102110079.1	981209	0910	<2419.2
NONCONNAH11.85	NONCONNNAH CK	080102110079.1	990225	0850	1299.7
NONCONNAH11.85	NONCONNNAH CK	080102110079.1	990505	0930	R>2419.2
SHELBY208015	NONCONNNAH CK RM 2.1	08010211NONCONNAH	981105	0925	Q148.3
SHELBY208015	NONCONNNAH CK	08010211NONCONNAH	990203	0830	1119.9
SHELBY208015	NONCONNNAH CK	08010211NONCONNAH	990505	0840	R>2149.2
SHELBY208015	NONCONNNAH CK	08010211NONCONNAH	990901	0745	95.9
SHELBY208015	NONCONNNAH CK	08010211NONCONNAH	991201	0745	172.5

APPENDIX B

Water Quality Model Assumptions

This sheet contains information relevant to land application of waste produced by agricultural animals in the study area.

Application of hog manure, beef cattle manure, dairy cattle manure, horse manure, poultry litter, and manure from import are considered.
Manure generated by in-county animals is assumed to be applied fresh (thus fecal content from fresh manure is used in calculations).
Manure values can be varied using a multiplication factor, in order to consider die-off due to known treatment/storage methods.
Manure imported into the county is assigned a fecal coliform content based on known storage/treatment methods.
The information is presented based on monthly variability of waste application.
In western TN, manure is not applied to cropland, only pastureland. Manure is not exported or imported.

Hog Manure Available for Wash-off

Storage/treatment of manure prior to application may affect the fecal coliform content in the manure.
The multiplier below can be used to increase or decrease the fecal content in manure that is applied (to consider storage/treatment)
Manure fecal content multiplier 1

This is the fraction of the annual manure application that is applied each month.

	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

The fraction of manure available for runoff is dependent on the method of manure application. The fraction available is computed below based on incorporation into soil. These are assumed values.
Fraction incorporated into soil (assumed) 0.80
Fraction available for runoff 0.60 = (1 - [fraction incorporated]) + ([fraction incorporated] * 0.5) NRCS runoff rate: 0.3354

The following is the resulting fraction of annual manure application available for runoff each month based on the monthly fraction applied and incorporation into the soil.

COUNTY ID	January	February	March	April	May	June	July	August	September	October	November	December
Shelby Co	0	0	0.045	0.0945	0.0801	0.0801	0.0801	0.0801	0.0951	0.045	0	0

Beef Cattle Manure Available for Wash-off

Storage/treatment of manure prior to application may affect the fecal coliform content in the manure.
The multiplier below can be used to increase or decrease the fecal content in manure that is applied (to consider storage/treatment)
Manure fecal content multiplier 1 (a value of 1 assumes fresh application)

This is the fraction of the annual manure application that is applied each month.

	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

The fraction of manure available for runoff is dependent on the method of manure application. The fraction available is computed below based on incorporation into soil. These are assumed values.
Fraction incorporated into soil (assumed) 0.75
Fraction available for runoff 0.63 = (1 - [fraction incorporated]) + ([fraction incorporated] * 0.5) NRCS Runoff rate: 0.0098

% Applied to Cropland: 0.00 % Applied to Pastureland: 1.00 **1**

The following is the resulting fraction of annual manure application available for runoff each month based on the monthly fraction applied and incorporation into the soil.

COUNTY ID	January	February	March	April	May	June	July	August	September	October	November	December
Shelby Co	0.052063	0.0520625	0.052063	0.052063	0.052063	0.052125	0.052125	0.052125	0.052125	0.052063	0.052063	0.052063

Horse Manure Available for Wash-off

Storage/treatment of manure prior to application may affect the fecal coliform content in the manure.
The multiplier below can be used to increase or decrease the fecal content in manure that is applied (to consider storage/treatment)
Manure fecal content multiplier 1 (a value of 1 assumes fresh application)

This is the fraction of the annual manure application that is applied each month.

	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

The fraction of manure available for runoff is dependent on the method of manure application. The fraction available is computed below based on incorporation into soil. These are assumed values.
Fraction incorporated into soil (assumed) 0.75
Fraction available for runoff 0.63 = (1 - [fraction incorporated]) + ([fraction incorporated] * 0.5) NRCS Runoff rate: 0.0122

% Applied to Cropland: 0.00 % Applied to Pastureland: 1.00 **1**

The following is the resulting fraction of annual manure application available for runoff each month based on the monthly fraction applied and incorporation into the soil.

COUNTY ID	January	February	March	April	May	June	July	August	September	October	November	December
Shelby Co	0.052063	0.0520625	0.052063	0.052063	0.052063	0.052125	0.052125	0.052125	0.052125	0.052063	0.052063	0.052063

Dairy Cattle Manure Available for Wash-off

Storage/treatment of manure prior to application may affect the fecal coliform content in the manure.
The multiplier below can be used to increase or decrease the fecal content in manure that is applied (to consider storage/treatment)
Manure fecal content multiplier 1 (a value of 1 assumes fresh application)

This is the fraction of the annual manure application that is applied each month.

	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

The fraction of manure available for runoff is dependent on the method of manure application. The fraction available is computed below based on incorporation into soil. These are assumed values.
Fraction incorporated into soil (assumed) 0.75
Fraction available for runoff 0.63 = (1 - [fraction incorporated]) + ([fraction incorporated] * 0.5) NRCS Runoff Rate: 0.2048(confined); 0.0965 (grazing)

% Applied to Cropland: 0.00 % Applied to Pastureland: 1.00 **1**

The following is the resulting fraction of annual manure application available for runoff each month based on the monthly fraction applied and incorporation into the soil.

COUNTY ID	January	February	March	April	May	June	July	August	September	October	November	December
Shelby Co	0	0.0521875	0.046875	0.099063	0.03125	0.083438	0.03125	0.083438	0.046875	0.099063	0	0.051563

APPENDIX C

Hydrologic & Water Quality Calibration

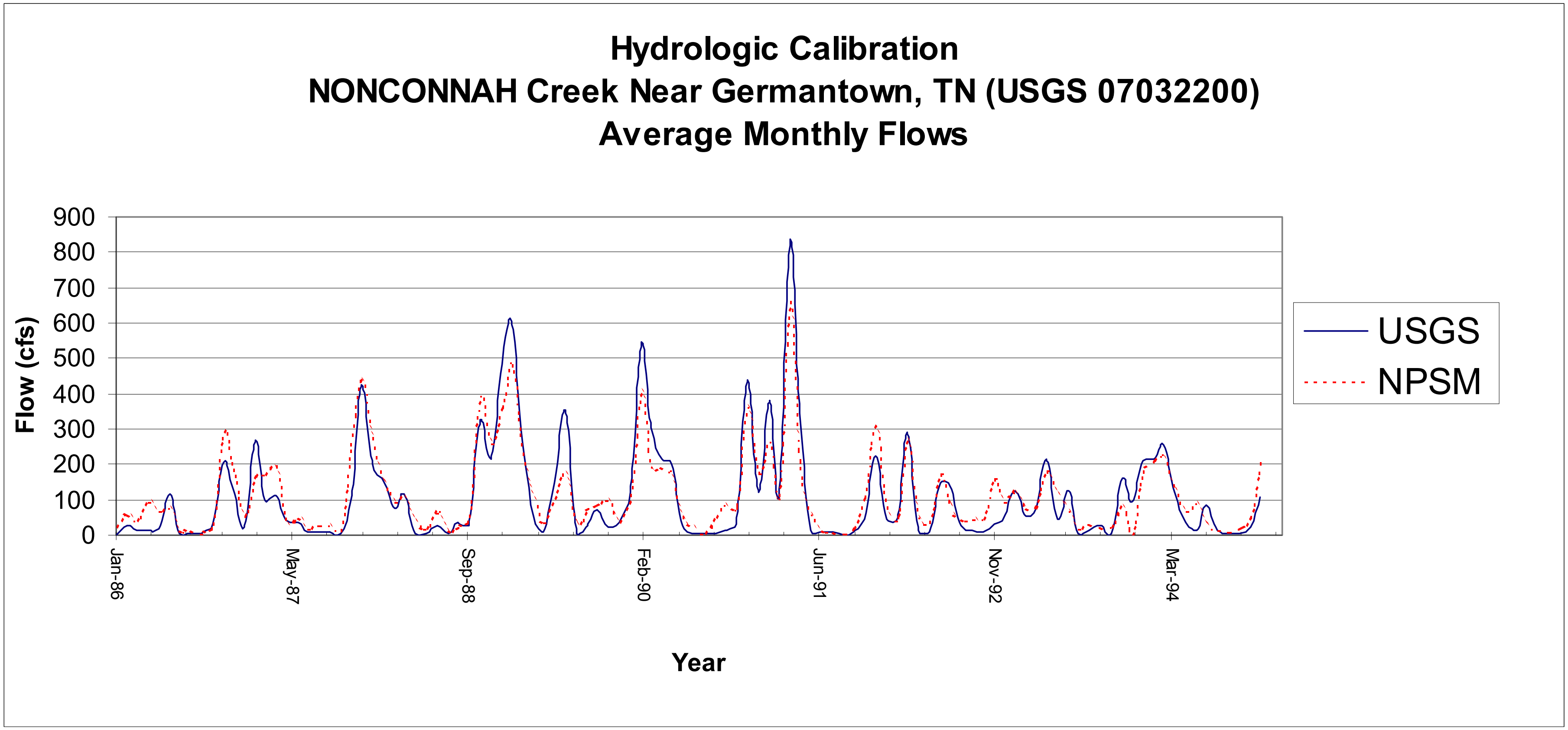


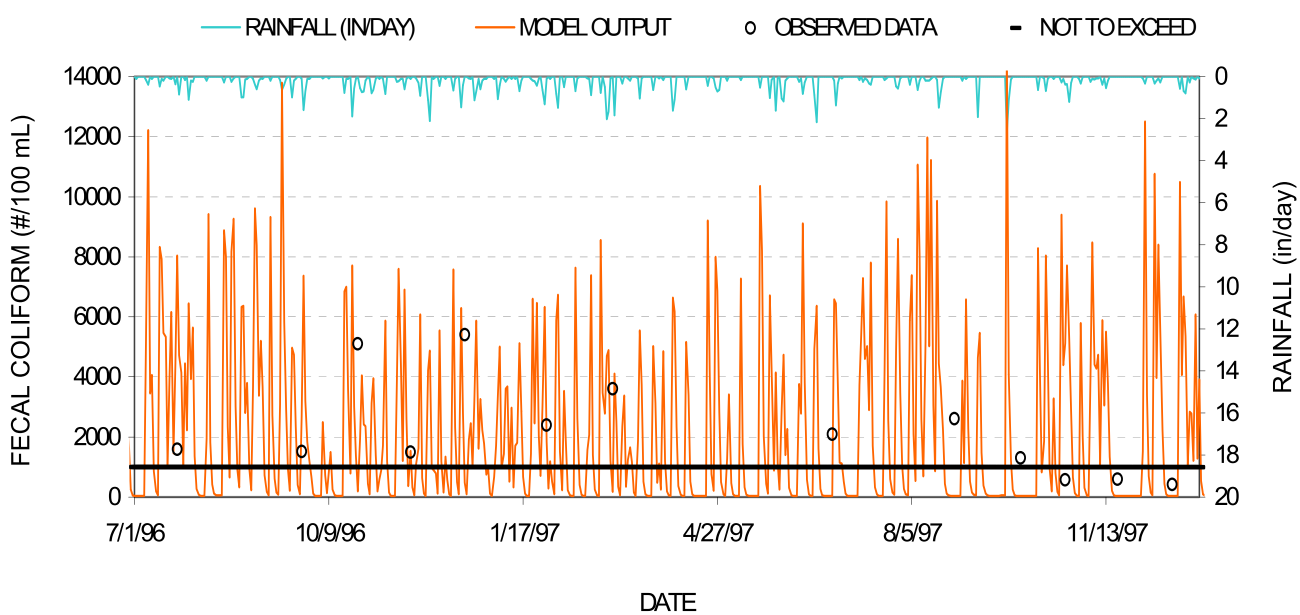
Figure C-1 Hydrologic Calibration at USGS 07032200

MULTI-YEAR TIMESERIES MODEL VS DATA

STATION:
Nonconnah Creek at RM 2.1

MODEL RUN: **1**

1 = EXISTING
2 = ALLOCATION 1
3 = ALLOCATION 2



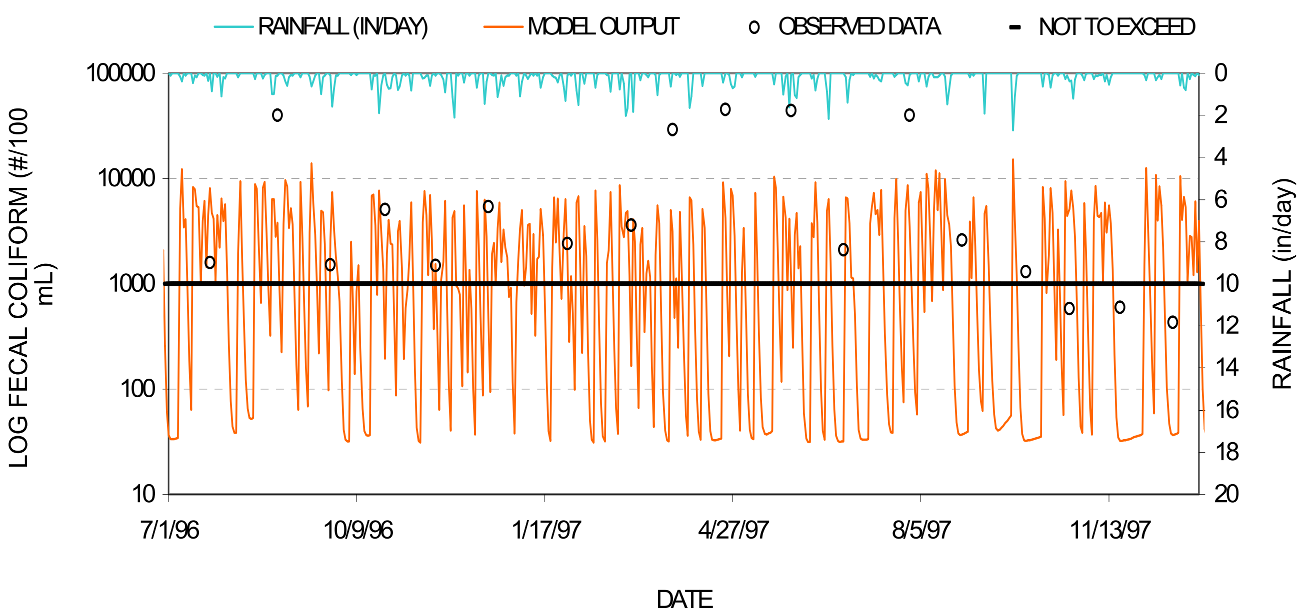


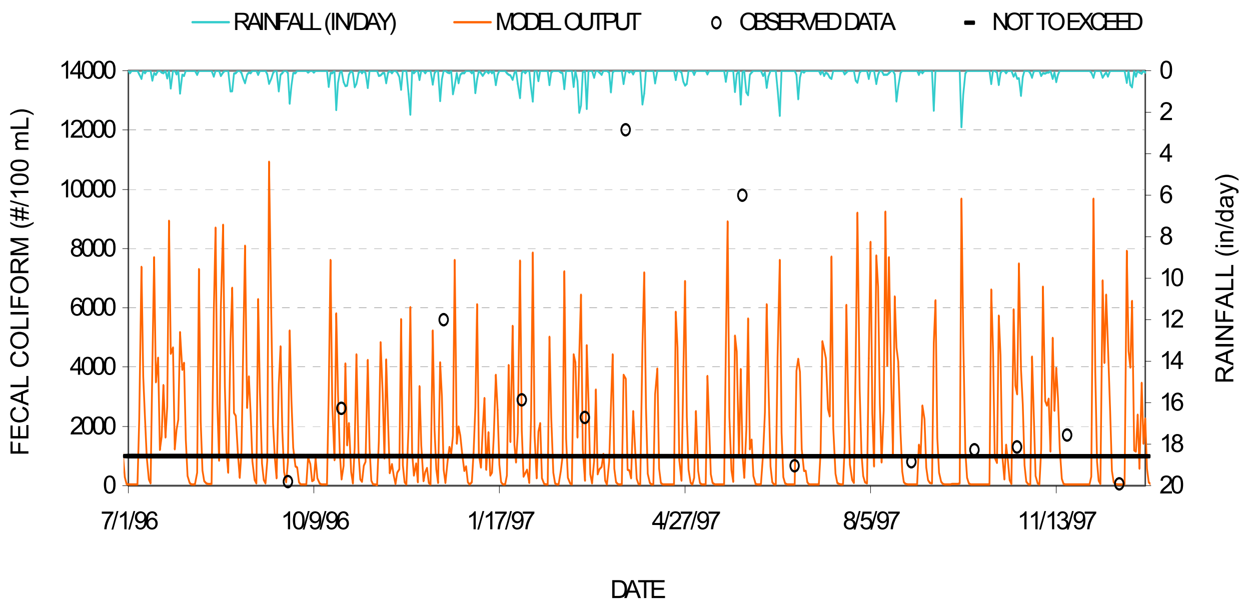
Figure C-2 Water Quality Calibration – Nonconnah Creek RM 2.1

MULTI-YEAR TIMESERIES MODEL VS DATA

STATION: **Nonconnah Creek at RM 11.5**

MODEL RUN: **1**

1 = EXISTING
2 = ALLOCATION 1
3 = ALLOCATION 2



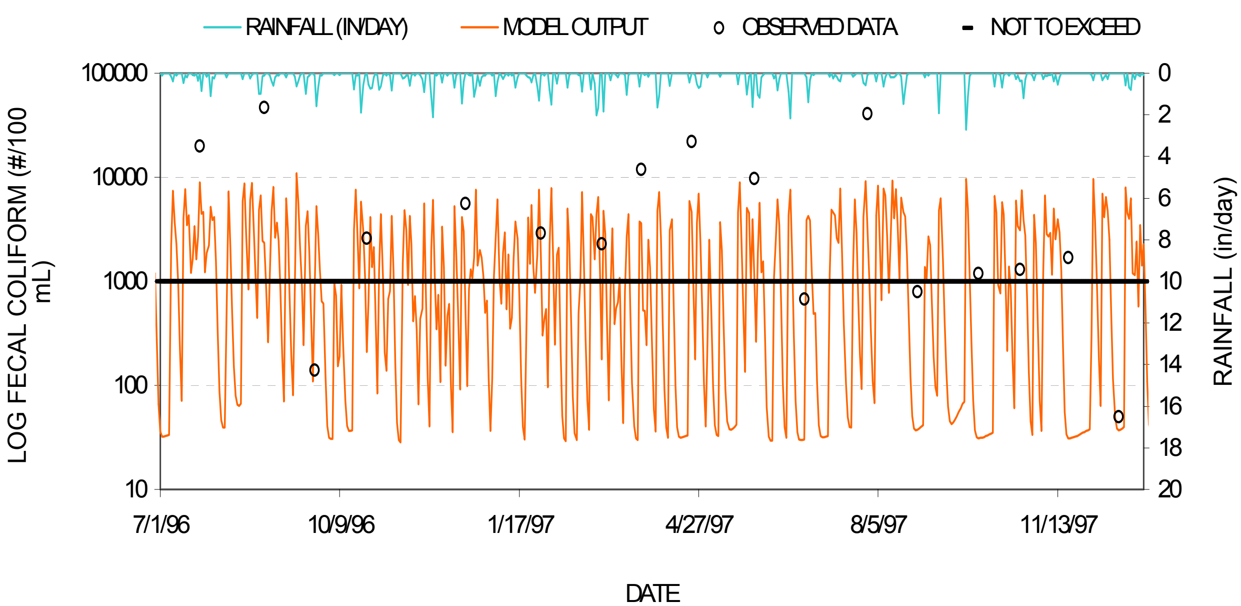


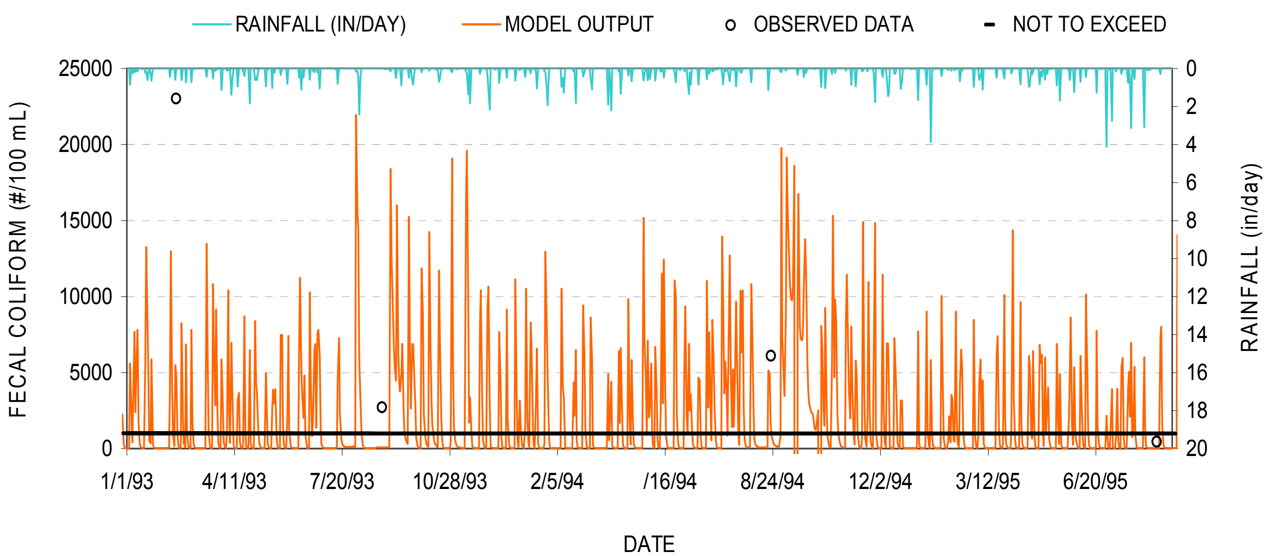
Figure C-3 Water Quality Calibration – Nonconnah Creek RM 11.5

MULTI-YEAR TIMESERIES MODEL VS DATA

STATION: **Cypress Creek South**

MODEL RUN: 1

1 = EXISTING
2 = ALLOCATION 1
3 = ALLOCATION 2



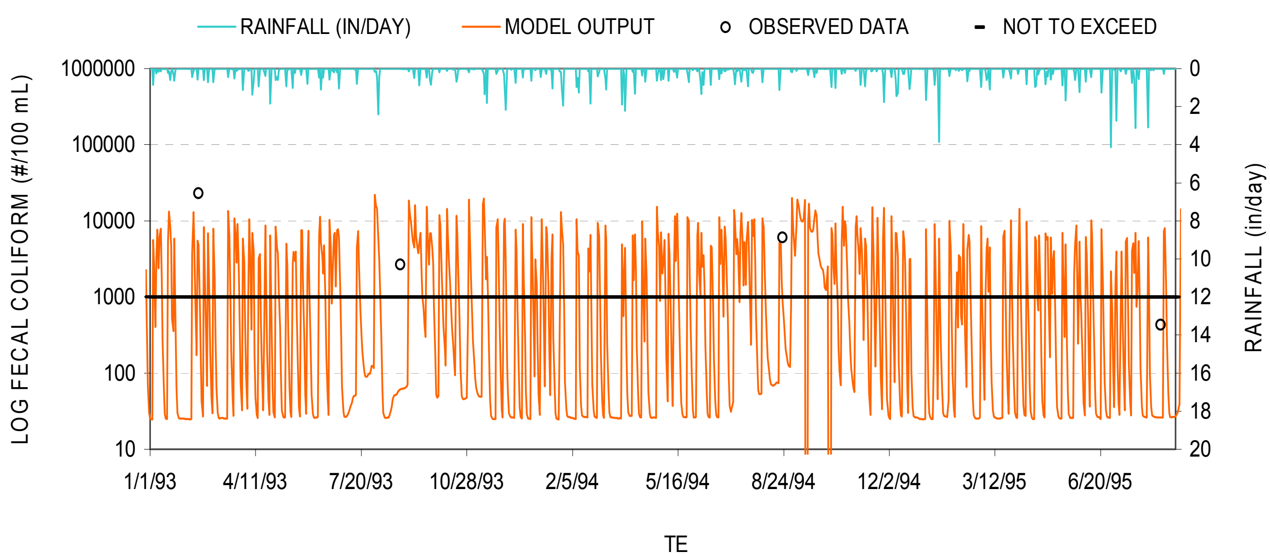


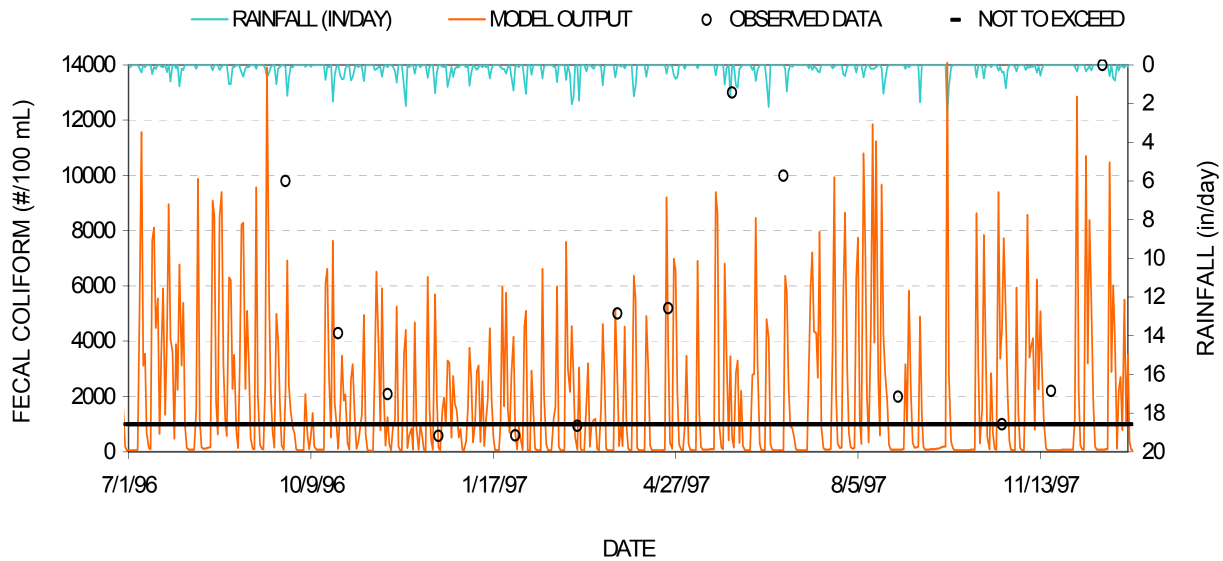
Figure C-4 Water Quality Calibration – Cypress Creek South

MULTI-YEAR TIMESERIES MODEL VS DATA

STATION: **John's Creek**

MODEL RUN: **1**

1 = EXISTING
2 = ALLOCATION 1
3 = ALLOCATION 2



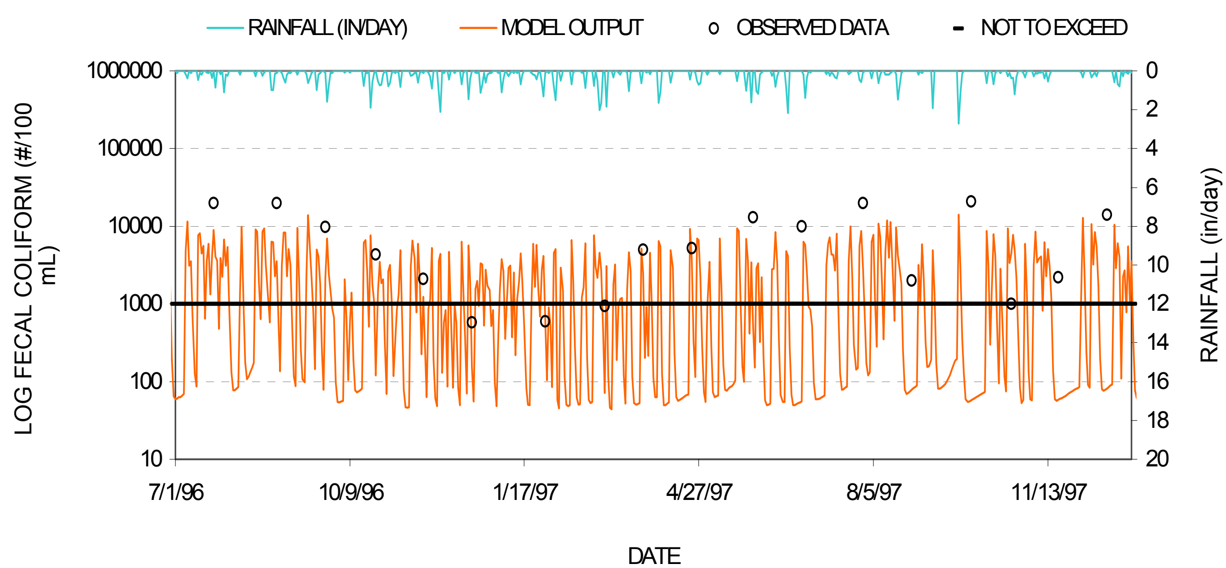


Figure C-5 Water Quality Calibration – Johns Creek

APPENDIX D

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 JOHNS CREEK CYPRESS CREEK SOUTH NONCONNAH CREEK - RM 0 to 2.1 NONCONNAH CREEK - RM 2.1 to 11.5 NONCONNAH CREEK – RM 11.5 to HEADWATERS NONCONNAH CREEK WATERSHED (HUC 08010211), TENNESSEE

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

Johns Creek, Cypress Creek South, Nonconnah Creek from McKellar Lake to RM 2.1, Nonconnah Creek from RM 2.1 to RM 11.5, and Nonconnah Creek from RM 11.5 to the headwaters 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 and collection system failures. 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 fecal coliform loading of approximately 98% in the five 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 November 27, 2000 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 E

Public Comments Received

City Of Memphis Comments

November 22, 2000

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

Dear Ms. Wang:

Thank you for allowing the City of Memphis the opportunity to review and comment on the "Proposed Total Maximum Daily Load (TMDL) for Fecal Coliform in Johns Creek, Cypress Creek South, Lower Nonconnah Creek - RM 0 to 2.1, Nonconnah Creek - RM 2.1 to 11.5, Nonconnah Creek from RM 11.5 to headwaters." We have reviewed the document and offer the following comments:

1) Although a total mass for fecal coliform loading is given, which represents "the maximum fecal coliform bacteria load that can be assimilated by the stream during the critical 30-day period while maintaining the fecal coliform bacteria water quality standard of 200 counts/100 ml," it needs to be explicitly stated in the allocation section that regardless of the flow in the Creek, any fecal coliform count less than or equal to 200 is protective of health and meets the intent of the TMDL document.

2) Section 3.2.1 gives the loading rate attributed to wildlife as 5.0×10^8 counts/animal/day. The reference source for this number needs to be provided.

3) In Section 3.2.1, the upper limit of 45 deer per square mile was chosen to account for deer and other wildlife present in the watershed. While we understand that all of the data necessary to calculate the TMDL using the model may not currently be available, in Section 6.0 ALLOCATION, there should be a listing of the assumptions used in the model along with a statement that the model will be revised once measured or more accurate estimations are available for the assumed numbers. Also, TDEC, EPA or other appropriate agency should be assigned the task of determining the correct numbers for input into the model within two years of issuance of the TMDL, so that the correct numbers can be used to evaluate possible removal of stream segments from the TMDL requirements.

4) Section 3.2.2 gives the loading rate attributed to cropland as 2.5×10^6 counts/acre-day. The reference source for this number needs to be provided.

5) Section 3.2.3 gives the loading rate attributed to pastureland as 2.4×10^{10} counts/acre-day. The reference source for this number needs to be provided.

6) In Section 3.2.3, the statement that "12 percent defecate in streams" needs to be supported by research data. Based upon my own experience with agricultural nonpoint source programs, this issue seems to one of the main issues being addressed. It is believed that defecation in streams is a significant source of contamination. Also, a wet weather water quality sample collected on 6/5/98 by the City and reported to TDEC via the annual Storm Water Report for a field where approximately 20 cattle were grazing and had access to the stream being sampled resulted in a fecal coliform level of 542,000. The sample on 8/7/98 had a level of 87,333. At some point, grazing was discontinued. The sample on 4/14/99 had a fecal result of 7,000, indicating that the levels dropped significantly once the cattle were removed.

7) In section 3.2.3, regarding the statement that the "fecal loading rates to pastureland does not vary significantly throughout the year," the increase in vegetation in the summer should result in significantly less runoff of fecal material than during the winter months. The model should be revised as necessary to reflect the variation in fecal discharge.

8) In section 3.2.4, the reference given is for a study relating to bacterial loading in Brunswick and Maine, which is not representative of the conditions in West Tennessee. An appropriate reference should be found and used.

9) In section 3.2.5, the rate of 2.5×10^8 counts/acre-day is given for discharge from urban land. Provide the reference source for this number. The model assumptions assume that leaking sanitary sewer systems are a major source of fecal coliform contamination. The model, however, does not take into account that Memphis, unlike most other cities, has no Combined Sewers Overflows (CSOs), very few wet weather Sanitary Sewer Overflows (SSOs), and a very small quantity of waste water escaping the system as a result of dry weather stoppages.

10) Section 6.3 states that "fecal coliform applied to land is subject to a die-off rate and an absorption rate before it is transported to a stream." This statement and the model should also include reproduction of the bacteria both on land and in the waterbodies that receive fecal loadings from the various sources as shown by current research.

11) Section 7.2 addresses Agricultural Sources and Section 7.4 addresses the Watershed Area in Mississippi, yet a percent reduction of these sources is not given as is given for municipal entities in sections 7.1.1 and 7.1.2. All sources contributing to the pollutant loading to the stream should be required to equally eliminate their contribution to the impairment of the water, otherwise the goal of cleaning up the nation's waterways will not be achieved. Of even more importance in achieving pollutant reduction in Nonconnah Creek is the appropriate identification of the sources contributing to the load in the stream. The attempted reduction of discharges for a named source will be ineffective if it is not a source, although it was assumed to be a source in the model calculation. Although the model was used to simulate fecal loading in the Creek, the assumptions made indicate that the modeler

did not have sufficient watershed specific information to determine the appropriate sources. The TMDL should be revised to remove any specific assignments of pollutants to sources and should have, as the goal of the TMDL, the collection of adequate information by EPA and TDEC to adequately assign sources to the fecal levels found in the Creek. Once adequate information is known, the model should be recalculated to determine if a problem exists and, if so, to assign reductions to the known sources.

12) The model is based on fecal coliform sample results. Per EPA guidance, e. Coli levels are better indicators of bacteriological contamination of waterways, thus, it is recommended that the issuance of a TMDL for bacteriological contamination of these waterbodies be postponed until appropriate data can be collected using the e. Coli test to determine if the waterbodies are impacted by urban runoff. The City has e. Coli data for Nonconnah Creek dating back to July, 1999.

13) The TMDL document needs to describe the process that will be used to identify when the Creek has met water quality objectives. I suggest that two years of data showing the geometric mean of fecal coliform levels (or e. Coli levels - see Comment 12) of less than the standard of 200 counts/100 ml should be adequate for considering that the water quality objectives have been met. When implementing the EPA's requirement that the State consider "all existing and readily available" information when determining the list of polluted waters, the data used should accurately represent the conditions in the creek. Data used for the determination of water quality in streams that are being actively tested for the parameter, should be no older than the listing cycle for submission of the impaired waters to the EPA, thus, a reasonable time frame is two years. My understanding of the current TMDL rule is that the listing cycle will be extended to 4 years, beginning April 1, 2002, at which time you may want to consider a longer time frame. Note that for fecal coliform in creeks that tend to be basically dry for part of the year, data over one year old may not be representative of the condition of the water in the stream.

14) Based on the information presented in the TMDL, it has not proven that Nonconnah Creek does not meet the minimum water quality standards for fecal coliform due to urban storm water runoff, although in section 6.3, the assumption is stated that "non-point sources related to urban runoff and leaking sewer collection lines have the most significant impact on the fecal coliform bacteria loadings. For the dates of sampling provided, the samples were not collected during or immediately after storm events (sampled within in the first 30 minutes of initiation of flow during a storm event that is greater than 0.1 inches and that occurs at least 72 hours after any previous storm event of 0.1 inch or greater), thus, they do not represent pollution related to storm water runoff. Therefore, the sample results are not necessarily representative of urban storm water runoff conditions. TDEC needs to conduct sampling during storm conditions in order to accurately gage the contribution of storm water runoff to the fecal coliform loading in the Nonconnah Creek watershed.

15) The TMDL was very confusing regarding the terminology and logic used, particularly in sections 5 and 6 regarding existing conditions and load allocations. It was also unclear

how the “98% reduction” was determined and how it was used to arrive at the numbers given. Due to the large number of people and agencies involved and the importance of all parties involved thoroughly understanding the document to be issued, a public participation/involvement stakeholder meeting should be held in or near the Nonconnah Creek watershed prior to issuance of the TMDL for the Creek. The meeting will provide a forum for TDEC to explain the issues and specifics of the TMDL and for the stakeholders to have input into the process.

16) In our comments to the August 1999 TMDL for Fecal Coliform in Nonconnah Creek that were transmitted in September 1999 and in our meeting with TDEC in July 1999, the City mentioned data collected from Nonconnah Creek. Some of this data was collected at part of the City’s requirements for its storm water NPDES permit. This data has been submitted to TDEC along with our Annual Reports, yet the data is not used in the TMDL analysis. Why is this data not being used? We recommend that when the TMDL is redone, in order to address the comments received, all available appropriate data is used to arrive at the most accurate possible conclusion.

If you have any questions or wish to further discuss this issue, please feel free to contact me at (901) 576-7122.

Sincerely,

Thomas B. Lawrence, P. E.
City of Memphis Storm Water Program

l2sw4nfc.wpd

Southern Environmental Law Center Comments

Southern Environmental Law Center

November 27, 2000

Sherry H. Wang, Ph.D.
Tennessee Department of Environment and Conservation
Division of Water Pollution Control
6'h Floor, L & C Annex
401 Church Street
Nashville, TN 37243-1534

BY FACSIMILE
AND U. S. MAIL

Re: Comments on Revised & Additional Nonconnah Fecal Coliform TMDLs

Dear Sherry:

On behalf of the Tennessee Clean Water Network and the Tennessee Environmental Council, the following comments are submitted regarding the latest TMDLs for the Nonconnah watershed dated October 11, 2000.

1 . Revisions -- This TMDL document appears to be a revision of proposed fecal coliform TMDLs for the same stream segments addressed by a previous version, dated August 2, 1999, with some additional stream segments. It would be helpftil if that were stated up front, with an explanation of any changes, yet it does not appear to be recognized anywhere in this document. In addition, although several sets of written comments were submitted on the previous version, no response to those comments has been received or is included in this effort. We are also unaware of any effort to bring the interested and commenting public stakeholders into the process prior to revising the TMDLs so as to help build support and confidence in the outcome. EPA, TDEC and others contend that public participation is one key to a successful TMDL program. We agree and encourage TDEC to include the public, especially those who have demonstrated a significant interest, in a meaningful way. We suggest that a 30 or 45-day period in which to review and comment upon a completed TMDL does not provide a meaningful opportunity to participate in the process.

2. Segments -- As noted, this latest version contains additional impaired segments, and there are also differences that need to be explained regarding the length or location of some segments. The 303(d) list contains a segment of Nonconnah Creek identified as "LOWER INCL COLD CR" with no stream miles given, along with two more segments - for mile 2. 1 to I *1.* 5 and for mile 1 *1.* 5 to headwaters. This would suggest that the lower segment is for mile 0 to 2.1 and includes Cold Creek, as the list shows it to cover 6 miles of waters. The latest TMDL document lists 5 segments on the cover page, with the lower segment given as mile 0 to 2.1 with no mention of Cold Creek. The summary sheets show Nonconnah to be combined into one lower and one upper segment, with 2 additional segments - one each for Johns Creek and Cypress Creek South.

In addition, some of the segment lengths and watershed areas do not match the values from the previous version. The summary sheet for the new lower Nonconnah segment for mile 0 to 11.5 shows 173 sq. miles, while the previous version shows 175 sq. miles for Nonconnah at mile 2. 1, which should be a smaller value than from mile 0. The summary sheet for mile 1 *1.* 5 to headwaters of Nonconnah shows 20.3 miles and I IO sq. miles, while the previous version gave 18.3 miles and 109 sq. miles. The summary sheet for Johns Creek gives a length of "8 miles of **Supporting".** instead of the **8** miles of not supporting on the 303(d) list, and a watershed area of 22 sq. miles, while the previous version has the area as 23.5 sq. miles. The Gazetteer topo map shows two streams in Memphis named Cypress Creek, but none named Cypress Creek South as used on the 303(d) list and in the TMDL.

The 303(d) list should identify Water Quality Limited Segments (WQLSS) for TMDL development with clearly stated river miles of reasonable length and no overlaps, and then be consistent in the subsequent TMDLs to avoid confusion. Any unavoidable differences or corrections from the list or previous version of these TMDLs should be clearly explained.

3. Margin of Safety (MOS) -- While the last version of these TMDLs incorporated an explicit MOS by using a target of 175/100ml, this revision has no explicit MOS or any explanation as to why it has been dropped. Due to the preliminary nature of this phase of the TMDLS, the lack of sufficient data for calculating mean values and other uncertainties, the apparently extreme overload of the waters requiring an estimated 98% reduction, and the lack of specifics that support an implicit MOS, we do not believe that the required MOS component of the TMDL is adequately addressed. We encourage TDEC to return to the use of an explicit MOS in these TMDLS. And in general we urge the use of an explicit MOS in all TMDLS. When claiming an implicit margin of safety because of conservative modeling assumptions, TDEC should, at least, identify exactly which assumptions are considered conservative and explain how they provide a margin of safety.

4. Units of measure -- There are inconsistencies in the use of units of measure that need to be addressed. The previous version proposed TMDLs in units of colonies/day, while the revised TMDLs are in counts/30 days, with some sources given in counts/hr or counts/acre-day. This makes comparisons difficult or impossible, especially without explanation. As stated in the TMDL, there are insufficient data for determining geometric means, making the single sample or

maximum standard of I 000/1 00ml the logical way for direct comparison and model calibration. However, geometric means are used through the TMDL with no indication of whether or how the maximum standard is addressed or will also be met. It is stated in Section 6.0 that the TMDLs are expressed as means since that is how the standard is given, but this ignores the component of the standard for single samples, especially where data are insufficient to calculate means as in this situation. As stated in our previous comment, meeting the mean standard does not mathematically assure meeting the maximum. In the case of parameters with multiple standards such as the mean and maximum for fecal coliform, a TMDL should be developed to meet both, and whenever a unit other than daily maximum is used for a TMDL, it needs to be clearly explained why a different measure of unit is being used.

In trying to understand changes from the previous version of the TMDL, other unit problems were encountered. The first version gave land use values in sq. miles while the revised TMDL used acres and a different breakdown of land use types. Even though they both gave land use types in %, for those uses which appear to be the same, the % values do not match.

5. Wasteload Allocations (WLAs) -- TMDLs for all the segments establish WLAs of zero. While it might be that for modeling purposes some point sources such as storm water outfalls are treatedasnon ointinputs,theyareinfactpointsources someofwhicharecoveredbyNPDES -P point source pen-nits, and a WLA component is required. Therefore a portion of the Load Allocation (LA) and thus the TMDL should be identified as the WLA and assigned to point sources. This will allow better coordination with monitoring and permit limits.

6. Future Permits -- Since these TMDLs address sources such as municipal storm water covered by MS4 permits, the WLA portion of the TMDLs cannot be zero if such flows are to be permitted with fecal loads. It is stated that all future permitted discharges will have a WLA set at 200/100 ml, and this would presumably include new storm water outfalls covered by MS4 permits, as well as any new STPs or other so ' urces. Since numerous MS4 outfalls already exist that would have fecal loads, WLAs are needed for existing flows, and to be consistent with future ones that are proposed at 200/1 00ml, unless it is really intended that existing outfalls meet a zero load bacteria limit. Additionally, it should be noted that to meet standards in stream or at the end of pipes, both the 200 mean and the 1000 max standards, and thus associated loads, must be considered.

In terms of future permits, it is generally our position that additional loads cannot be allowed into WQLSs that are already exceeding their carrying capacity. We acknowledge the position that meeting standards at end of pipe in effect gets around the permit limitation in federal regulations, 40 CFR 122.4, but in at least some cases this may not be valid. Allowing additional flows containing bacteria adds to the total population or load of pathogens in the public water ways, contributing to the pollution problem and further endangering the public and the environment, despite the dilution argument. In the case of additional loads of bacteria from STPS, sewer leaks, and other human sources, it should be remembered that fecal coliform is just an indicator for other pathogens which can be more dangerous, and that a fecal count from wildlife and other non-human sources is not necessarily the same as from human sources such as household sewage and hospital waste.

7. Maps -- The maps used in this TMDL document, such as in Figure 1, are much improved and make it easier for readers to identify stream locations. It would be useful if additional landmarks such as stream miles and significant roads could also be included. It might be necessary to provide additional maps for each segment so as to not overly clutter one map.

8. Coordination with Mississippi -- As noted in the TMDL and in previous comments, some of the segments are impacted by portions of the watershed in the state of Mississippi. The TMDLs should mention whether or how the two states are cooperating to assure consistency with allocations, TMDLS, monitoring and improvements.

9. Terminology -- Some terms are used that may not be understood by the interested public, such as the "...modified Anderson level one and two system" mentioned in Section 1.2 on page 3.

10. Data -- Some of the data from the previous version are not included with the data shown in Table 2 for the same streams. It should be explained why data have been deleted and why no new data since 1998 have been added. In the section on Model Calibration, it is stated that additional data were collected up to 1999, but it does not appear that such data are reported. -Prior comments also pointed out potential problems with excess sample holding times as indicated by laboratory reports. This issue has not been explained, and it is unclear if any such samples are included in the revised TMDLS. Different sample station indicators are used in the two versions, making comparisons difficult.

In addition, the Memphis MS4 permit, now in its fourth year, requires monitoring and annual reporting of stormwater discharges. These data should also be sumarized and included in these TMDLS, especially as they relate to ambient water quality sampling.

11. Sources -- There are no data reported from monitoring above and below sewer line stream crossings or other possible sources of fecal coliform. Such monitoring that brackets potential sources should be included or added in future efforts to help identify and eliminate problems. CAFOs are'also mentioned as possible sources, but it is unclear as to locations, permits, or if they even actually are at issue here. It is suggested that there be more specific identification of known or suspected sources for each WQLS in a way that differentiates from broad general topics.

12. Model -- The discussion of the model mentions simulations of peaks in fecal levels, but presents other data and TMDL values as monthly. Therefore it is unclear if the model is more accurately a simulation of the **mean or** maximum **fecal levels..** The **peaks** would **seem** to be more appropriately considered with the maximum standard, but there is no explanation of the relationship between the mean and maximums for the data, model, or standards. It is also not clear if or how the fecal die-off rate is considered in the model, if the model outputs shown in Appendix B are simulating means or maximums, or why outputs for Cypress Creek and Cold Creek are not included.

13. Implementation Plan and Reasonable Assurance -- We are concerned that the implementation plan does not provide reasonable assurance that all relevant standards will be achieved in a reasonable time. There are no specific improvements or sources to be reduced or eliminated, and as stated previously, there are no allocations to, or enforceable limits for, existing permitted sources. There is no description of the necessary (forthcoming?) permit modifications for the Memphis MS4 stonnwater permit that might achieve a 98% reduction of fecal coliform loading in the Nonconnah Creek watershed. With a stated need for a 98% reduction and no discussion of detailed steps necessary to achieve this reduction, we believe these problems will not likely be corrected based on these TMDLS. While it is understood that the MS4 permit is hoped to result in improvements, it has already been in effect for a number of years, and there is no documentation here to indicate that fecal coliform levels have been improved. Graphs presented in the Appendix for model outputs, continues to show excursions for some locations, presumably under conditions and loads set by the TMDLS.

In order to provide reasonable assurance that the fecal colifonn standards are achieved in a reasonable period, additional steps need to be taken and changes made in these TMDLs and in relevant permits. These changes could include adding fecal limits to all municipal stonn water permits, issuing the next phase of MS4 permits with limits and sooner than 2003, targetted monitoring for suspected sources and to show the results of corrective actions taken, allowing no new sources until capacity exists, and establishing protected buffers along streams.

We appreciate your consideration of these comments and your continued efforts to improve Tennessee's TMDL program. We are always willing to work with your staff to assist in further improvements, and suggest that it is best if such efforts take place early in the process, before draft TMDLs are released for public comment.

Sincerely,

Richard A. Parrish
Senior Attorney

cc: Tony Able, EPA
Danielle Droitsch, TCWN
Gwen Griffith, TEC
Barry Sulkin

APPENDIX F

Response to Public Comments

Responses to City of Memphis Comments

Note: responses correspond to numbered comments (see Appendix E)

1) The water quality standard is expressed in terms of the 30-day geometric mean or 10 percent of the samples exceeding the instantaneous value of 1000 counts/100 ml. The TMDL document will be revised to state that regardless of the flow, if the geometric mean concentration is less than 200 counts/100 ml and 10 percent of the samples do not exceed the instantaneous value of 1000 counts/100 ml, the stream will meet water quality standards.

2) The loading rate attributed to wildlife is based on the number of deer in the watershed (assumed to be 45 deer per square mile) and the fecal content associated with deer feces estimated to be 5×10^8 counts/animal/day. The fecal coliform production rate for deer was based on best professional judgment based on linear interpolation using the rate for other animals, such as turkey and cattle, which are available in the Metcalf & Eddy (1991). The interpolation was conducted based on each animal weight.

3) Critical assumptions used to generate the TMDL model are included in the report and it seems redundant to repeat them in section 6. The model may be revised in the next basin cycle (5 years) based on additional monitoring data. TDEC does not have the resources to evaluate all TMDLs within two years of issuance especially since additional data (both stream and water quality) will not be available at this time.

4) The cropland loading rates are based on the number of acres of cropland in the watershed multiplied by the contribution of fecal coliform from wildlife. The acres of cropland are based on the MRLC land use coverage. Only wildlife is assumed to contribute fecal coliform to cropland areas. The TMDL document will be revised to clarify this.

5) The pastureland loading rates are based on the number of acres of pastureland in the watershed multiplied by the contribution of fecal coliform from wildlife, grazing animals, and application of manure from farm animals. The acres of pastureland are based on the MRLC land use coverage. The TMDL document will be revised to clarify this.

6) The percent of grazing animals that defecate in the stream was based on information received from NRCS and their local field offices. Their judgment on cattle in streams was considered the best available source as their local field offices have the best knowledge of agricultural activities in the watershed. Although the City of Memphis data collected during wet weather events showed that fecal coliform levels dropped after cattle access were removed from the stream, the levels were still in violation of the instantaneous value of 1000 counts/100 ml. This indicates a source of contamination beyond animals in streams. The TMDL document states that to achieve stream quality cattle need to be removed from the stream.

7) The fecal loading rates on pastureland do vary monthly, however, in terms of the model sensitivity they are not different enough to warrant input on a monthly basis. Grazing animals are assumed to have access to pastureland year round, and this is the source of the largest load to pastureland. The amount of fecal coliform that is washed off the land is controlled by a model parameter called WSQOP, which is defined as the rate of surface

runoff, which will remove 90 percent of the constituent per hour. In the HSPF model, this parameter does not vary monthly.

8) The reference from Horsley and Witten is sited as this is one of many references we could have used to quantify the average daily loading of fecal coliform from human sources. Metcalf and Eddy also support this value. The TMDL document will be changed to reference Metcalf and Eddy.

9) Even though Memphis has no CSOs, fecal coliform can discharge from sewers via leaks caused by cracks and other sources. It seems unlikely that sewers in the watershed do not leak. In the model the discharge from urban areas is two orders of magnitude less than the load applied to pastureland. The loading rate of 2.5 x 10^8 counts/acre-day is based on literature values in Horsley and Witten, Metcalf and Eddy, and others.

10) The TMDL document will be revised to include the above statement. Reproduction of bacteria both on land and in the water bodies is implicitly included in the model as the die-off rates are much less than what probably occurs in nature. Sunlight and temperature will decay the bacteria faster than what is included in the die-off rates. Comments received from the NRCS on the modeling assumptions related to agriculture, indicated that most of the fecal coliform has probably decayed before application of the manure to the land. In developing the model we chose to reduce the die-off to include other factors such as reproduction of bacteria on the land.

11) TDEC does not have regulatory authority in Mississippi; however, the TMDL document will be revised to state that the water quality standard of 200-counts/100 ml must be met at the state line. The TMDL is preliminary, and it may be revised in the future as additional data become available. The known sources of fecal coliform in the watershed that can be targeted for reductions have been accounted in the model as they are either from urban areas or agriculture. Data collected by the City of Memphis indicates a problem even when cattle are removed from the stream. Sufficient water quality data exists in the watershed to suggest that there is a problem in the stream. A watershed approach will be used to implement the TMDL.

12) Fecal coliform data represent the largest number of samples for bacteria collected in the watershed. The approach used in developing the model was to simulate the parameter representing the largest group of data as to achieve the best calibration over a range of hydrologic events. The rapid pace of TMDL development is being dictated by the time frame set in the lawsuit filed by environmental groups. The HSPF model is limited by the availability of meteorological data, which at the time of model development stopped on December 31, 1998. Therefore, it was not possible to compare simulated and observed e. Coli in the model.

13) TMDL activities will take place within the context of Tennessee's watershed management approach. In each five year cycle, surface waters within the Nonconnah watershed will be reassessed. Water quality goals will be met when, as a result of reassessment, the Division of Water Pollution Control determines that streams in the Nonconnah watershed meet applicable water quality criteria and use classifications are fully supported.

14) The data collected by TDEC indicates violates of the water quality standard and the sources of the contamination is either from urban or agricultural activities. It does not need to rain for sewers to leak especially if they have cracks caused by age, tree roots, or other means. Due to the number of impaired streams in west Tennessee and the inherent scheduling difficulties for the TDEC field offices, it is not always possible to collect data during storm events. The City of Memphis could share data they collect in the watershed with TDEC, which would assist in the development of the TMDL. The TMDL document will be revised to remove reference to leaking sewer collection lines as having the most significant impact on the fecal coliform loadings.

15) Technical reports are often very difficult to write in a manner that explain complex tools, such as numerical modeling, in a tone for the average citizen to understand. It was the intention of the report why certain terminology and logic were explained as they exist in the document. Simulating loadings as they exist currently in the watershed using meteorological events over the past 10-years arrived at existing conditions. The intent was to show the impact of these loads to a variety of seasonal conditions that occurred in the watershed over the past 10 years. Based on the geometric mean plot of the existing conditions for the 10-year period, reductions were applied to the loads in the watershed until all peaks (except those resulting from model instabilities) were below the geometric mean standard of 200-counts/100 ml. To achieve this, a 98% reduction in non-point sources was required. A public meeting, sponsored by the City of Memphis, was held in Memphis on April 18, 2001 to discuss fecal coliform modeling and the the NonconnahTMDLs.

16) The August 1999 TMDL report was redone using numerical modeling techniques. The model is a rainfall driven model and is limited by the availability of continuous weather data. At the time the TMDL model was developed, weather data were available only through December 31, 1998. Data collected by the City was in 1999 and it was not possible to simulate water quality in the stream through 1999. To calibrate the model, simulated water quality results were compared to observed values. If the model is revisited in the future after data are collected in the next basin rotation cycle, then the data the City collected since 1999 will be used.

Responses to Southern Environmental Law Center Comments

1) The TMDL document has been revised to include a statement that fecal coliform TMDLs, based on a mass balance methodology, for some impaired waters in the Nonconnah watershed were originally proposed to EPA Region 4 in October 1999. EPA indicated some reservations with the approach used and the calculated load reductions and suggested that a numerical model be developed. This TMDL document contains the results of the numerical modeling analyses.

2) The first Nonconnah fecal coliform TMDL was developed using a mass balance methodology for for Nonconnah Creek (RM 11.5 to headwaters) and Johns Creek. In response to comments received, a new fecal coliform analysis was performed using the GIS based Watershed Characterization System (WCS) and the HSPF model. The new analysis considered the entire Nonconnah Creek watershed and included several stream segments that were not part of the original effort (Nonconnah Creek – RM 0 to headwaters, Johns Creek, and Cypress Creek South). Since WCS was not available for development of the original TMDL, there are small differences in parameters such as drainage area.

In the new TMDL, the Nonconnah Creek segments from RM 0 to RM 2.1 (includes Cold Creek) and from RM 2.1 to RM 11.5 were combined for analysis purposes. Several typographical errors, present in the new TMDL version placed on "Public Notice" have been corrected in the final submittal document. The stream identification used in the new TMDL correspond to those in the 1998 303(d) list.

3) In modeling the watershed, the following assumptions are considered conservative and warrant no additional reduction of the target level: in the model, leaking septic systems discharge directly to the stream when in reality they will travel through the ground water system and discharge to the stream at a later time. In addition, all lands are connected to the stream when in reality pastureland may be adjacent to cropland and the pollutant would be subject to decay as it travels overland before reaching the stream. Also, manure that is applied to pastureland is subject to a greater die-off than what is accounted for in the model. By assuming manure with a high fecal coliform concentration than what is typically applied to the land, the in-stream concentration from this source is most likely greater than what occurs in the field. In addition to these assumptions an explicit MOS is included in the analysis as the reduction of the peak concentration is below the line representing the water quality geometric mean standard of 200 counts/100ml. The area between the peak and the 200 line is additional capacity available in the stream. The TMDL document will be revised to clearly identify the conservative modeling assumptions. An additional explicit MOS of 20 counts/100 ml was also included.

4) The TMDL is expressed in terms of the geometric mean standard as this is the guidance TDEC received from EPA. The numerical model was calibrated with the instantaneous data and the geometric mean was used to evaluate the TMDL. The instantaneous data were not used to develop the TMDL value as there is insufficient data available and this is why the simulated dataset was used to develop the TMDL. The model uses hourly data and this is the reason point sources (i.e., animals in streams, leaking septic systems, etc) are included in the report as counts/hr. Model units for land application of manure are in counts/acre-day. Model results indicate that by meeting the geometric mean standard the instantaneous standard is also met. The TMDL document will be revised to state this. In the new TMDL, land use areas are given in square miles on the summary sheets and in acres in the body of the report. Reporting acres provided the user and easy way to calculate loads if they are interested in doing this. The difference in the percentage of various land uses between the two TMDL reports is a matter of watershed delineation. The TMDL model uses areas based on the MRLC database.

5) In developing the numerical model, TDEC did not identify any NPDES permits within the modeled watershed. A statement is included in the text that all future NPDES permits will be required to meet end-of-pipe criteria of 200 counts/100 ml.

6) As stated in Section 6.3, storm water induced point source loads and nonpoint source loads within the City of Memphis were both considered as part of the Load Allocation. This approach was selected because of the difficulty in determining what portion of the total fecal coliform load is discharged through discrete conveyances during any given storm event. Also, the methods of controlling fecal coliform loading due to storm water runoff for both point and nonpoint source loads are similar.

   The requirement for future permits, is that they are required to meet the water quality standard of 200-counts/100 ml. This is not expressed as a geometric mean and 200-counts/100 ml is more stringent than 1000 counts/100ml.

7) At the time the maps were developed, a road coverage in the coordinates used in the WCS was not available. Also a coverage of landmarks does not exist.

8) The TMDL document will be revised to state that water quality standards are to be met at the state line. TDEC does not have any regulatory authority in Mississippi. EPA is currently mapping 303(d) listed waters in adjoining states and will be taking the lead on this issue.

9) The TMDL document will be revised to remove this term and will reference the land use coverage to the MRLC database.

10) The numerical model could only simulate water quality up to December 31,1998 as this was the extent of meteorological data available to the public. The TMDL document will be modified to explain this. STORET data collected since this date appears in Appendix A. Data submitted by the City of Memphis as part of the annual report required by their MS4 permit is included in Appendix G.

11) Data used in the model represent data used to list the various stream segments. The NRCS was contacted regarding agricultural activities, but they did not provide locations of CAFO operations. Additional data at sewer line crossings and at other sources would be helpful but it’s not always possible given TDEC’s limited budget and staff for monitoring.

12) The model results are represented as both the 30-day geometric mean and the maximum concentrations. The simulated average in stream concentration is compared to the observed values measured in the field. These plots are included in Appendix B and are used to calibrate the TMDL model. The geometric mean plots are used to develop the TMDL value. In developing the TMDL, the die-off rates for the various manures applied to the land are considered. Output for Cypress Creek was not included in Appendix B as insufficient data were collected in the stream to provide a meaningful calibration.

13) The TMDL analysis was performed using the best data available to specify Load Allocations that will meet the water quality criteria for pathogens (fecal coliform) in Nonconnah Creek so as to support its Recreation use classification. As stated in Section 7.5:

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 Nonconnah Creek watershed. TDEC will evaluate the progress of implementation strategies and modify the TMDL as necessary in the next phase (next five-year cycle). This will include recommending specific implementation plans for delineated and as yet undefined sources and causes of pollution. Cooperation will be maintained with TDA (for possible 319 non-point source grants) and NRCS for developing BMPs. The dynamic loading model will 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 exceedances of fecal coliform concentrations (loading) in impacted water bodies. The phased approach will assure progress toward water quality standards attainment in the future. In accordance with TMDL guidance (EPA, 1991a), the TMDLs may be revised after addition monitoring and source characterization data are collected.

The Division of Water Pollution Control considers the implementation plan outlined in Section 7.0 to be a reasonable approach to reach water quality goals within the context of Tennessee's Watershed Management Program.

APPENDIX G

Fecal Coliform Monitoring Data Submitted by the City of Memphis

Table G-1 Fecal Coliform Monitoring Data Submitted by the City of Memphis in Annual Reports

Date	Ambient Monitoring Site								
	1N	2N	3N	4N	5N	6N	7N	8N	9N
	[cfu/100 ml]								
10/17/96	<10	5600	20000	1000		400	100	<10	
11/20/96	180	450	1080	360		7000	170	600	840
12/10/96	86	104	1200	180		6000	160	600	480
01/21/97	290	360	450	480		3900	>20000	670	2500
20/18/97	20	40	50	110		>20000	40	2000	400
03/20/97	3700	4700	2000	4700		4500	700	5300	5200
04/16/97	60	920	520	850		3600	2300	490	450
05/21/97	2500	9200	2700	5000		1500	3200	2800	4800
06/25/97	700	2600	5600	5300		24000	2300	1200	290
07/30/97	1810	4500	2200	3000		875	2400	380	680
08/27/97	290	610	2900	5400		4000	1500	700	800
09/30/97	500	1430	11500	1650		14100	28000	1700	5300
10/23/97	90	130	1020	270		750	1040	70	170
11/19/97	170	380	880	1000		840	850	1500	30
12/17/97	80	190	3400	6100		1000	140000	180	470
01/21/98	420	210	1400	330	1360	1250	270	570	5000
02/24/98	60	40	620	310	50	630	410	610	180
03/19/98	80	110	220	190	270	1040	170	260	570
04/21/98	16000	6500	38000	12000	6500	3800	20000	6700	890
05/28/98	1300	2800	16000	13000	>80000	4700	600	14000	3700
06/23/98	1000	10	8000	100	1060	100	5600	20	90
07/22/98	150	320	6200	1400	2000	4500	270	280	28
08/24/98	70	90	1900	300	30	1050	230	20	60
09/24/98	20	2400	3600	3800	22000	<2	905	52000	9800
10/15/98	680	900	3400	1100	7200	410	1800	420	1500
11/17/98	80	680	1900	1100	430	50	900	780	290
12/17/98	170	1300	955	590	800	1700	2200	2200	400

Table G-1 Fecal Coliform Monitoring Data Submitted by the City of Memphis in Annual Reports (Continued)

Date	Ambient Monitoring Site								
	1N	2N	3N	4N	5N	6N	7N	8N	9N
	[cfu/100 ml]								
01/25/99	19100	1805	116000	4900	23000	1095	56000	4600	6300
02/23/99	70	170	97000	8500	1090	100	200	210	170
03/23/99	200	350	490	330	5200	3300	18000	870	1800
04/22/99	90	220	4500	1000	6600	110	23900	180	170
05/20/99	600	3100	3300	1320	128000	1600	3600	440	400
06/22/98	720	150	1900	410	90	52000	2600	240	260
07/21/99	40	3500	3100	2900	10	740	110	2500	75000
08/23/99	<10	70	2000	250	3600	30000	110	50	150
09/22/99	70	91000	1900	2500	4800	310	750	80	110
10/20/99	2000	108000	58000	14000	46000	8950	340000	109000	320000
11/16/99	10	50	370	130	150	340	3900	80	31000
12/15/99	2300	3400	44000	7900	113000	660	8800	5500	4700
01/19/00	7400	450	200	370	4400	1400	280	900	4800
02/25/00	4600	300	3000	1100	200	100	80	1300	3100
03/23/00	30	170	1400	300	20	10	60	370	440
04/19/00	40	140	2600	530	60	70	580	400	3400
05/30/00	40	130	300	380	<10	40000	480	150	250

Ambient Monitoring Sites:
1N Nonconnah Creek at Forest Hill – Irene Road
2N Nonconnah Creek at Ridgeway Road
3N Johns Creek at American Way
4N Nonconnah Creek at Perkins Road
5N Ten Mile Creek at American Way
6N Hurricane Creek at Democrat Road
7N Day's Creek at Directors Row
8N Nonconnah Creek at Nonconnah Blvd.
9N Nonconnah Creek at Rivergate Bridge