Total Maximum Daily Load
for
Fecal Coliform
in
Sinking Creek

Watauga River Watershed, Tennessee

(HUC 06010103)

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SUMMARY SHEET

Total Maximum Daily Load (TMDL) for Fecal Coliform in Sinking Creek

1. 303(d) Listed Waterbody Information

State: Tennessee
Counties: Washington and Carter

Major River Basin: Holston River Basin
Watershed (Hydrologic Unit Code): Watauga River Watershed (06010103)

Location: Tributary to Watauga River (at river mile 19.9)
Impaired Stream Length: 19.8 miles not supporting
Watershed Area: 13.1 square miles
Waterbody ID: TN06010103SINKINGCR

Constituent of Concern: Fecal Coliform

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

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

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

2. TMDL Development

Analysis/Modeling: The Non-Point Source Model (NPSM)/Hydrologic Simulation Program – Fortran (HSPF) was used to develop this TMDL. Daily timesteps were used to simulate hydrologic and water quality conditions. The model was developed for the entire 303(d)-listed segment.

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

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

3. Watershed/Stream Reach Allocation

Waste Load Allocation: 0.0 counts/30 days

> Note: All future permitted discharges shall meet end-of-pipe limits of 200 counts/100 ml for fecal coliform.

Load Allocation: 1.212×10^{12} counts per 30 days

Margin of Safety: Implicit (conservative modeling assumptions)

Total Maximum Daily Load (TMDL): 1.212×10^{12} counts per 30 days

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EXECUTIVE SUMMARY

Section 303(d) of the Clean Water Act requires each state to list those waters within its boundaries that do not meet minimum water quality standards for designated use classifications. States are required to develop Total Maximum Daily Loads (TMDLs) for these waterbodies. The TMDL process establishes the maximum amount of a pollutant that a waterbody can assimilate without exceeding water quality standards and allocates this load between all contributing pollutant sources. The purpose of the TMDL is to establish water quality objectives required to reduce pollution from both point and nonpoint sources, and to restore and maintain the quality of water resources.

Tennessee's 1998 303(d) list identified Sinking Creek (TN06010103SINKINGCR) as a water quality limited stream impaired by pathogens and not supporting its designated use for Recreation. Waters of this use classification must meet the following quality standards for fecal coliform:

> 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.

For this TMDL evaluation, the water quality standard of the 30-day geometric mean fecal coliform concentration of 200 counts/100 ml defines the target endpoint.

The analysis performed to develop the TMDL for fecal coliforms in Sinking Creek utilized dynamic hydrologic and water quality modeling techniques that incorporated physical characteristics of the watershed, meteorology, hydrologic response parameters, and water quality source loading, transport, and decay parameters. Land use in the watershed was characterized from Landsat Thematic Mapper digital images collected during the period 1990-1993. Fecal coliform contributions represented in model simulations were derived from land use activities and direct in-stream contributions and included septic systems, cattle grazing, manure application, urban development, and wildlife. Initial model parameterization values for urban, agricultural, and forest land uses were provided by EPA. No National Pollutant Discharge Elimination System (NPDES) permitted dischargers were included in the modeling analysis.

A simulation period of ten water years (10/1/88 - 9/30/98) was used to develop the fecal coliform TMDL. This ten-year period included a wide range of hydrologic conditions including low and high streamflows. The range of hydrologic conditions was considered adequate to identify the conditions critical to fecal coliform concentrations in Sinking Creek as well as determining the 30-day geometric mean concentration for TMDL calculation. To achieve the TMDL, load reductions were applied until the simulated 30-day geometric mean of fecal coliform concentrations did not exceed the water quality standard of 200 counts per 100 ml. Modeling assumptions were considered conservative to constitute an implied margin of safety.

Model results indicate that there are two significant categories of sources impacting fecal coliform loading in the Sinking Creek watershed under existing conditions. Urban sources provide the greatest source contribution in the winter wet season when storm runoff events dominate streamflow. Direct in-stream sources (failing septic systems, leaking sewer lines, straight pipes [illicit connections], animals [including cattle], and unknown sources) provide the greatest source contribution during the summer dry season when seasonal low flow dominates and dilution of direct sources is minimized. Direct in-stream sources are the most significant in terms of contribution to exceedances of water quality criteria.

A possible allocation scenario that would meet in-stream water quality standards on all segments of Sinking Creek includes nonpoint source loading reductions of 90-97.5% (varied by subwatershed) to urban land use loading and 75-99.25% to direct in-stream sources. Reductions to direct in-stream sources consist of 75-90% reduction in failing septic systems and 86.9-99.25% reduction to combined loading from cattle in streams and other/unknown direct in-stream sources. Recommended strategies for subsequent reduction of sources causing impairment of water quality are targeted toward field surveys for improved source delineation and identification, reduction of septic system failure rates, establishment of an urban stormwater management program to identify and eliminate sources related to urban stormwater runoff, and additional monitoring to support modeling and evaluation of load reductions.

The Total Maximum Daily Load for fecal coliform in Sinking Creek, at the New Sinking Creek Pump Station (most downstream monitored location in the watershed), is 1.212×10^{12} counts per 30 days. This is consistent with the fecal coliform water quality standard of 200 counts/100 ml as a 30-day geometric mean.

1.0 INTRODUCTION

1.1 Background

Section 303(d) of the Clean Water Act requires each state to list those waters within its boundaries for which technology-based effluent limitations are not stringent enough to protect any water quality standard applicable to such waters. Listed waters are prioritized with respect to designated use classifications and the severity of pollution. In accordance with this prioritization, states are required to develop Total Maximum Daily Loads (TMDLs) for those water bodies that are not meeting designated uses. The TMDL process establishes the allowable loadings of pollutants or other quantifiable parameters for a water body based on the relationship between pollution sources and in-stream water quality conditions so that states can establish water quality based controls to reduce pollution from both point and nonpoint sources and restore and maintain the quality of their water resources (USEPA, 1991).

Tennessee's 303(d) list was approved by EPA Region IV on September 17, 1998. The list identified Sinking Creek (TN06010103SINKINGCR) as a water body that does not meet the minimum water quality standard for fecal coliform, due to urban runoff/stormwater and Pastureland. The objective of this study is to develop a fecal coliform TMDL for Sinking Creek.

1.2 Watershed Description

The Watauga River watershed (HUC 06010103) is in the northeast region of Tennessee and northwest North Carolina (Figure 1). Sinking Creek is a tributary to the Watauga River and lies in the Level III Blue Ridge Mountains (66) and Ridge and Valley (67) ecoregions. Sinking Creek enters the Watauga River at approximately river mile 19.9. According to the 303(d) list, there are 19.8 impaired stream miles in the Sinking Creek watershed, including tributaries. Sinking Creek (Figure 2) is approximately 9.8 miles long and drains an area of 13.1 square miles, partially located within the Johnson City, Tennessee city limits. Catbird Creek is a major tributary to Sinking Creek that drains an area to the southeast and partially outside the Johnson City city limits.

The Sinking Creek watershed was originally divided into 5 subwatersheds for this TMDL study:

Subwatershed	Reach Number or ID
001	06010103 46 0.00
*002**	*06010103 623 0.00*
003	06010103 46 1.21
004	06010103 46 2.52
005	06010103 46 4.78

* Subwatershed 002 was combined with and summed at the outlet to subwatershed 001 for TMDL water quality modeling purposes. See Table 1, below.

The land use characteristics of the Sinking Creek watershed were determined using data from Tennessee's Multiple Resolution Land Coverage (MRLC). This coverage is based on Digital Landsat Thematic Mapper imagery for 1990-1993. The classification is based on a modified Anderson level one and two system. Table 1 presents land use distribution in the watershed. The dominant land use in the watershed is forest (65.5%), followed by urban (25.3%), with approximately 9.0% agricultural (primarily pasture).

Designated beneficial uses and water quality standards are established by the State of Tennessee in the *State of Tennessee Water Quality Standards, Chapters 1200-4-3, General Water Quality Criteria,* and *1200-4-4, Use Classifications for Surface Waters*, *October 1999.* The impaired water body has two designated use classifications that comprise fecal coliform criteria: 1) Fish and Aquatic Life and 2) Recreation.

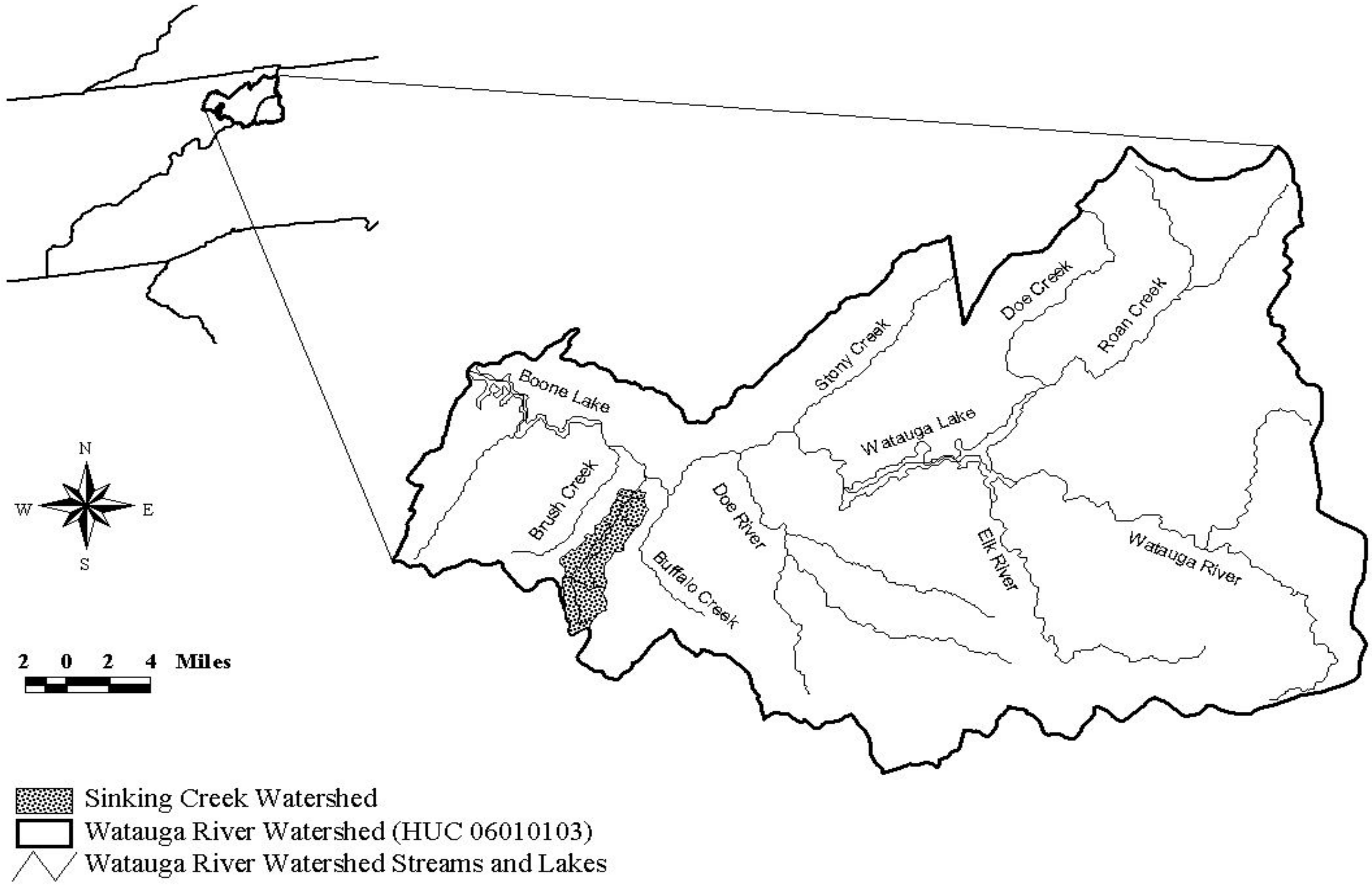

Figure 1. Location of the Watauga River and Sinking Creek watersheds.

Map Projection: Albers Equal Area
GRS 80

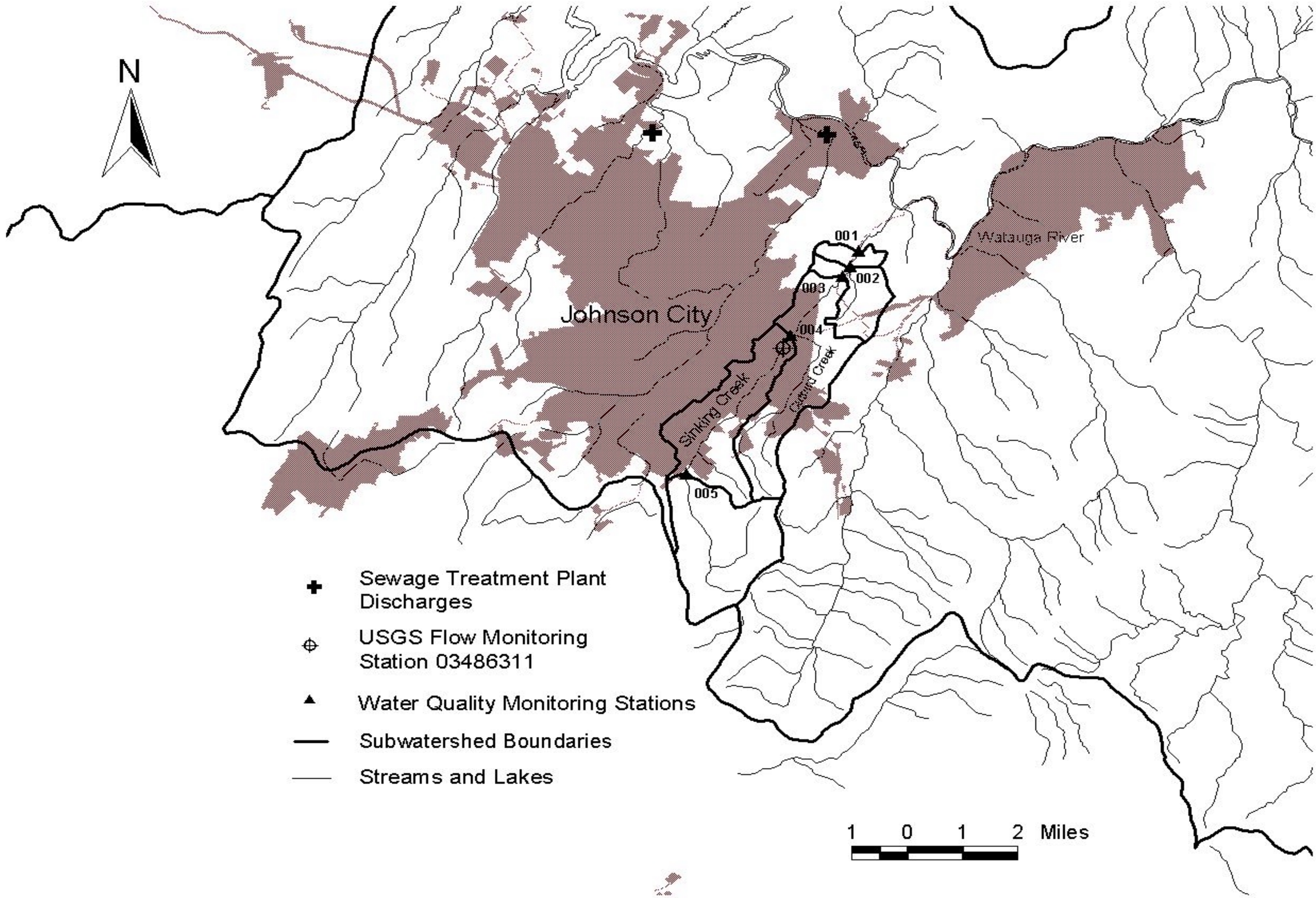

Figure 2. Sinking Creek watershed.

For the purposes of TMDL development, the most stringent of the applicable water quality criteria is designated as the water quality objective for impaired waters. The Recreation use classification is the most stringent for fecal coliform. Waters of this class must meet the following quality standards for fecal coliform:

> 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.

Table 1. MRLC Landuse Distribution by Subwatershed.

	001*		003		004		005		Watershed Totals	
Landuse	Area (ac)	%	Area (ac)	%	Area (ac)	%	Area (ac)	%	Area (ac)	%
Bare Rock/Sand/Clay	7	0.6	4	0.2	4	0.2	0	0.0	16	0.2
Deciduous Forest	232	21.1	899	35.9	698	31.6	1351	52.7	3180	38.0
Evergreen Forest	120	10.9	290	11.6	269	12.2	349	13.6	1027	12.3
High Intensity Commercial/Industrial/ Transportation	38	3.5	120	4.8	130	5.9	1	0.0	289	3.4
High Intensity Residential	2	0.2	82	3.3	83	3.7	0	0.0	167	2.0
Low Intensity Residential	206	18.8	600	24.0	592	26.8	9	0.3	1406	16.8
Mixed Forest	125	11.4	226	9.0	164	7.4	746	29.1	1262	15.1
Open Water	0	0.0	0	0.0	1	0.1	0	0.0	2	0.0
Other Grasses (Urban/recreational; e.g. parks, lawns)	68	6.2	95	3.8	81	3.7	5	0.2	248	3.0
Pasture/Hay	273	24.9	158	6.3	147	6.7	83	3.2	660	7.9
Row Crops	23	2.1	23	0.9	38	1.7	10	0.4	94	1.1
Transitional	0	0.0	0	0.0	0	0.0	4	0.2	4	0.1
Woody Wetlands	3	0.3	4	0.2	1	0.1	0	0.0	8	0.1
Total	1097	100	2501	100	2209	100	2558	100	8365	100

* Includes subwatershed 002.

1.3 Water Quality Target

A major component of the TMDL is the establishment of in-stream numeric endpoints, or targets, used to evaluate the attainment of water quality meeting designated use criteria. The target represents the restoration objective expected to be achieved by implementation of load reductions specified by the TMDL evaluation. In addition, the target serves to facilitate evaluation of progress toward attainment of water quality standards by allowing comparison to observed in-stream conditions. For this TMDL, the fecal coliform 30-day geometric mean standard for Recreation is the target level to evaluate impairment and establish the TMDL.

1.4 Water Quality Monitoring Program

Data from five water quality sampling sites on Sinking Creek (Appendix A) were used to determine water body impairment and for listing the water on the Tennessee 1998 303(d) list. Geometric means of monthly intensive fecal coliform samples, for the two periods 5/13-6/10/93 and 8/1-31/94, range from 44.0 to 1426 colonies per 100 ml. Concurrently, at the five sampling locations, 8% to 100% of samples had fecal coliform concentrations exceeding 200 colonies per 100 ml and 8% to 80% of samples had fecal coliform concentrations exceeding 1,000 colonies per 100 ml. Table 2 presents fecal coliform data statistics for the five water quality sampling sites.

Table 2. Water Quality Station Fecal Coliform Data Analysis.

Subwatershed[1]	Station	Samples (#)	Min (counts/100 ml)	Max (counts/100 ml)	Mean[2]	Median
001 (RM 0.6)	New Sinking Cr. Pump Sta.	38	200	14000	1357	835
002 (RM 1.1)	Bob Peoples Bridge	23	190	1700	752	610
003 (RM 1.5)	Sinking Creek Church	15	570	12000	2217	1150
004 (RM 2.9)	Orlando Drive	38	56	1700	507	340
005 (RM 7.3)	Jim McNeese Road	13	2	1190	132	28

[1] RM = Sinking Creek River Mile.
[2] Arithmetic mean.

2.0 SOURCE ASSESSMENT

Potential sources of fecal coliform are numerous and often occur in combination. Untreated or inadequately treated municipal sewage commonly constitutes a major source of fecal coliform in impaired surface waters. Urban stormwater runoff, sanitary and combined sewer overflows, and failing septic systems can be sources of fecal coliform. Rural stormwater runoff can contribute significant loads of fecal coliform from livestock pastures, animal feedlots, and cropland where manure application is practiced. Wildlife can also contribute fecal coliform. Sources of fecal coliform loads can be assigned to two broad classes: point source loads and nonpoint source loads. Point sources of fecal coliform are identified as entering a water body from discrete, identifiable locations, usually pipes. Nonpoint sources of fecal coliform are diffuse sources usually not identified as entering a water body at discrete locations. These sources generally involve land activities that contribute fecal coliform to streams during rainfall runoff events.

2.1 Point Source Assessment

One minor industrial National Pollutant Discharge Elimination System (NPDES) permitted facility, Bosch Braking System (TN0002500), is located in the Sinking Creek watershed. The facility has a permitted flow rate of 0.080 million gallons per day (MGD) (0.12 cubic feet per second [cfs]) and discharges to Sinking Creek in subwatershed 004, upstream from the Orlando Drive water quality sampling station. The facility is not permitted to discharge fecal coliforms and is not expected to contribute fecal coliform to Sinking Creek; therefore, it will not be considered in this TMDL in terms of fecal coliform loading.

Municipal Publicly Owned Treatment Works (POTWs) service urban areas located in the Sinking Creek watershed, including portions of east Johnson City, TN. These POTWs discharge to water bodies outside the Sinking Creek watershed (Figure 2) and therefore are not a consideration for the Sinking Creek TMDL evaluation.

Unidentified point sources (e.g., illicit connections to the storm sewer system and straight pipes to the stream) are considered to be potential contributors of fecal coliform loading in the Sinking Creek watershed. These have been considered in the TMDL analysis.

2.2 Nonpoint Source Assessment

In the absence of permitted point source dischargers contributing fecal coliform loading to Sinking Creek, nonpoint sources are believed to be the primary source of fecal coliform contamination. Land use in the watershed (in 1990-1993) consisted of approximately 25.3% urban, 9.0% agricultural (primarily pasture), and 65.5% forested. Nonpoint sources of fecal coliform loading contributing to water quality impairment in the Sinking Creek watershed are largely attributable to direct inputs to the waterbody (including septic systems, cattle in streams, and undefined sources) and urban runoff/stormwater.

2.2.1 Wildlife

Deer population data were provided by the Tennessee Wildlife Resources Agency (TWRA) for the state of Tennessee. However, no county-specific data were available for east Tennessee counties nor were statistics available for other animals. Therefore, deer were assumed to populate the Sinking Creek watershed according to the state average of 23 per square mile. In addition, in order to account for other wildlife sources of fecal coliform in the watershed, the number of deer per square mile was increased to 25 for water quality model simulations. 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.

2.2.2 Livestock Estimates

Table 3 shows agricultural livestock distribution in the watershed. The livestock data are based on the 1997 Agricultural Census compiled and reported by county and distributed to the subwatersheds based on the percentages of agricultural areas in each subwatershed classified as pasture/hay. Therefore, in a small watershed such as Sinking Creek, the level of uncertainty in livestock distribution on the basis of county populations is high.

Table 3. Livestock Distribution by Subwatershed.

Livestock (individuals)	Beef Cows	Dairy Cows	Total Cattle	Chickens (Layers)	Hogs	Sheep
001	76	15	91	0	0	1
002	104	18	122	0	0	1
003	122	25	147	0	0	1
004	146	34	180	0	1	1
005	89	0	89	0	0	1

2.2.3 Land Application of Agricultural Manure

Processed agricultural manure from confined hog, dairy cattle, and poultry operations is generally collected in lagoons and applied to land surfaces. There are no poultry operations in the Sinking Creek watershed and, according to county census data and subwatershed areas, proportionally, there is only one hog and it is located in subwatershed 004. In addition, dairy cattle account for less than 15% of the total cattle in the watershed. It is assumed that dairy cattle are kept in feedlots; therefore, 100% of dairy cattle waste is collected and applied equally to pasture and cropland in the watershed. No Natural Resources Conservation Service (NRCS)-supplied application schedules have been provided as of this writing so application rates were assumed to be uniform over all months of the year. This will provide for the smallest average error of assumption.

2.2.4 Grazing Animals

Beef cattle spend time grazing on pastureland and depositing manure onto the land. During rainfall runoff events, this manure is available for washoff and is transported to surface streams. It is assumed that animal access to the pastures is unlimited year-round, resulting in uniform fecal coliform loading rates throughout the year. The percentage of manure deposited during grazing on the land versus access to streams is used to estimate the fecal coliform loading rates from pastureland.

Grazing cattle usually have direct access to streams flowing through pastures as a drinking water source. Manure deposited in these streams by grazing animals is considered a direct point source in the water quality model. The input is considered as a constant flow and concentration according to the percentage of time spent in-stream.

2.2.5 Failing Septic Systems

Table 4 shows estimates from county census data of people in the Sinking Creek watershed on septic systems. In the Johnson City area, there are approximately 2.3 people per household on septic systems. However, the census data do not delineate between urban (Johnson City) and non-urban (Washington and Carter counties) areas. The majority of the population within the city limits is on city sewer service while virtually all of the population outside city limits (in Washington and Carter counties) is on septic systems. Assumed septic failure rates vary from 10 to 50%, in part to account for discrepancies in the census data. Failing septic systems are represented in the water quality model as point sources (summed by subwatershed) having constant flow and concentration.

Table 4. Septic Systems in the Sinking Creek Watershed.

Subwatershed	Septic Systems	Population Served	Failing Septic Systems*
001	15	35	3
002	107	247	21
003	344	792	172
004	340	783	68
005	7	17	1

* Estimated/assumed.

2.2.6 Urban Development

Fecal coliform loading from urban areas is potentially attributable to multiple sources including stormwater runoff, leaks and overflows from the sanitary sewer system, illicit discharges of sanitary waste, runoff from improper disposal of waste materials, and domestic animals. Urban runoff and stormwater processes are considered to be significant contributors to fecal coliform impairment in Sinking Creek. Unidentified (unverified) urban sources with direct input to the stream (e.g., leaking sanitary collection lines, illicit discharges, straight pipe connections to the stream) are included as point source inputs in water quality model simulations. Overflowing sanitary sewers, leaking collection lines, and straight pipe (illicit) connections to the stream are considered as possible sources of fecal coliform bacteria in the Sinking Creek watershed. These sources have all been documented at various times in the Sinking Creek watershed in the past and some (e.g., overflows) are known to have been corrected.

3.0 MODELING APPROACH

Establishing the relationship between in-stream water quality and source loadings is an important component of TMDL development. It provides for the identification of sources and their relative contributions (links sources to impairment) and supports examination of potential water quality improvements resulting from various remediation scenarios designed to meet water quality criteria. For the Sinking Creek fecal coliform TMDL evaluation, a dynamic loading model was utilized to develop this relationship. Fecal coliform source delineation methodology and the modeling techniques used to simulate dynamic loading, transport, and fate in the Sinking Creek watershed follow.

3.1 Model Selection

The Nonpoint Source Model (NPSM) is a Windows and ArcView geographic information system (GIS) based interface to the EPA watershed model Hydrologic Simulation Program - Fortran (HSPF). HSPF is a spatially distributed, lumped parameter, continuous simulation model used to analyze the dynamic hydrologic and water quality characteristics of watersheds and river basins. HSPF calculates nonpoint source loadings of selected pollutants for specified land use categories in the watershed, represents subsequent pollutant runoff response to hydrologic influences (i.e., precipitation), simulates point sources as constant or variable flow and concentration, and simulates flow and pollutant routing through a stream network to the outlet at the pour point of the watershed. The NPSM/HSPF watershed model was utilized to link the sources of fecal coliform to impacts and to characterize the processes (loading, transport, decay) contributing to exceedances of fecal coliform concentrations in the Sinking Creek watershed.

In addition to the NPSM/HSPF, the Watershed Characterization System (WCS), a GIS tool, was used to display, analyze, and compile GIS information to support water quality model simulations for the Sinking Creek watershed. This information includes land use categories, point source dischargers, soil types and characteristics, population data (human and livestock), and stream characteristics. Results of the WCS characterization are input to a spreadsheet designed by EPA to estimate NPSM/HSPF input parameters associated with fecal coliform buildup (loading rates) and washoff from land surfaces. In addition, the spreadsheet estimates direct loadings to water bodies due to cattle in streams and septic system failures. Computed loading rates from the WCS and spreadsheet tools were used in the NPSM/HSPF to simulate the deposition and transport of fecal coliform and the resulting water quality response.

3.2 Model Setup

The Sinking Creek watershed was delineated into five subwatersheds (Figure 2), corresponding to the five water quality monitoring stations, in order to characterize the relative fecal coliform contributions from various land uses and point source-type discharges. Due to the relatively small size of contributing areas draining to the two most downstream water quality monitoring stations, subwatersheds 002 and 001 were combined to form a single simulation/calibration segment (subwatershed) for all model analyses. Subwatershed delineation was based on EPA's River Reach Files Version 3 (RF3) segmented stream coverage and elevation data (USEPA, 1998). This discretization allows for management and load reduction alternatives to be varied by subwatershed. Stream geometry and hydraulic characteristics data (hydrologic function table) from nearby Brush Creek (a stream of similar size, drainage area, and geology) were used in model simulations for streamflow routing. These detailed stream parameters are not available in the RF3 coverage. In addition, for a simplified approach to modeling landuse loading of fecal coliform, the MRLC landuse data were combined into the following five categories: urban, forest, cropland, pasture, and barren (Table 5).

A continuous simulation period from October 1, 1988 to September 30, 1998 (ten water years or hydrologic cycles) was used in the water quality analysis for Sinking Creek. Observed water quality data were available at the five water quality monitoring stations during the periods May 13 to June 10, 1993 and August 1-31, 1994. In addition, limited water quality data were available in the late summer of 1995 and the fall of 1996. Therefore, the model results had more than adequate simulation time to stabilize prior to the occurrence of available observed water quality data. The water quality simulation period encompassed the hydrologic calibration period and available observed water quality data. A ten year simulation period was chosen to identify the critical period from which to develop the TMDL (see Sect. 3.5).

Table 5. Land Use Distribution in the Sinking Creek Watershed.

Subwatershed	Urban		Forest		Pasture		Cropland		Barren		Total	
	acres	%	acres	%	acres	%	acres	%	acres	%	acres	%
001*	314	28.6	480	43.8	273	24.9	23	2.1	7	0.6	1097	13.1
003	897	35.9	1419	56.7	158	6.3	23	0.9	4	0.2	2501	29.9
004	886	40.1	1132	51.3	147	6.7	38	1.7	5	0.2	2208	26.4
005	19	0.7	2446	95.6	83	3.2	10	0.4	0	0	2558	30.6
Total	2116	25.3	5477	65.5	661	7.9	94	1.1	16	0.2	8364	100

* Includes subwatershed 002.

3.3 Fecal Coliform Source Representation

Both point and nonpoint sources are represented in the water quality model. A number of nonpoint source categories are not associated with land loading processes and are represented as direct, in-stream source contributions in the model. These include, but are not limited to, failing septic systems, cattle in streams, leaking sewer lines, and unknown sources. All other nonpoint sources are land loading sources and therefore rainfall runoff generated. These sources are only partially available to streams due to the mechanisms of washoff (efficiency), decay, and incorporation into soil (adsorption, absorption, filtering) before being transported to the stream. Therefore, land-loading nonpoint sources are represented as indirect contributions to the stream. Buildup, washoff, and die-off rates are dependent on seasonal and hydrologic processes. The following sections describe the assumptions used for the various sources described in Section 2.0.

3.3.1 NPDES Discharge

There is one NPDES discharger in the Sinking Creek watershed, Bosch Braking System (TN0002500). It is represented in model simulations as a point source in subwatershed 004. In this case, since the facility is not permitted to discharge fecal coliform to Sinking Creek, the point source is represented as constant flow only. A discharge flow rate of 0.050 MGD (0.077 cfs), equal to the average reported in the facility's monthly Discharge Monitoring Reports, was used in all model simulations.

3.3.2 Wildlife

Fecal coliform loading from wildlife is represented in water quality model simulations based on deer population. The state average deer population is 23 per square mile. No county deer population data were available for east Tennessee counties. In the model, deer are uniformly distributed to forest, pasture, cropland, and wetland areas at a density of 25 per square mile to account for other forms of wildlife other than deer. The fecal coliform loading rate applied for deer, 5.0E+08 counts/day/deer, was derived from the EPA spreadsheet described in Section 3.1.

3.3.3 Land Application of Agricultural Manure

Fecal coliform accumulation and buildup rates resulting from land application of hog and cattle manure can be represented in model simulations as monthly input values or constants when uniform loading rates are assumed year-round. As stated in Section 2.2.3, manure application rates were assumed to be uniform over all months of the year. Hog manure is assumed to be applied only to cropland. Dairy cattle manure is assumed to be applied equally and uniformly to pastureland and cropland. The animal fecal loading rates are: 1.08×10^{10} counts/day/hog (ASAE, 1997) and 1.83×10^{11} counts/day/dairy cow (ASAE, 1997).

3.3.4 Grazing Animals

Beef cattle deposit fecal coliform directly to pastureland during grazing. It is assumed there is no monthly variation in access to pastures; therefore, fecal coliform loading rates are considered to be uniform throughout the year. Contributions of fecal coliform from wildlife are included in the pasture loading rate. The animal fecal loading rates are: 5.71×10^{10} counts/day/beef cattle (ASAE, 1997) and 5.0E+08 counts/day/deer.

3.3.5. Urban Development

Urban areas are represented in the model as two components: pervious and impervious. Initially, a single area-weighted loading rate for urban areas, based on buildup and accumulation rates referenced in Horner (1992), was used in the model. However, urban loading rates were adjusted as primary calibration parameters in model simulations and were varied by subwatershed. Within each subwatershed, the loading rates were assumed constant throughout the year.

It was apparent, in calibrating the water quality model to reproduce existing conditions, that dry weather phenomenon (exclusive of rainfall runoff generated loading) were responsible for the critical conditions in the Sinking Creek watershed. Significant contributions to high concentrations of fecal coliform at low flows, from urban sources, are probable. These sources may include leaking sewer lines, illicit connections, and improper disposal of wastes. Point source loads were included for each subwatershed in model simulations to account for these direct in-stream sources. They are included with Cattle-in-Streams and other unknown sources.

3.3.6 Other Sources

The peak 30-day geometric mean fecal coliform concentration at the outlet of subwatershed 003 increased by a factor of nearly 2.5 relative to 004 and the influence from 003 was sustained down to the watershed outlet at subwatershed 001. Critical 30-day geometric mean concentrations occur during seasonal low flows in the summer and fall. Therefore, direct in-stream sources appear to be largely responsible for the high fecal coliform concentrations during low-flow conditions. A point source load was included in each subwatershed in model simulations to account for direct in-stream loading of fecal coliform including cattle in streams (see Sect. 2.2.4) and unidentified (unknown) sources (see Sect. 2.2.6).

3.4 Model Calibration

Calibration of a dynamic loading model involves both hydrologic and water quality components. The model must be calibrated to appropriately represent hydrologic response in the watershed before reasonable water quality simulations and subsequent calibration can be performed. The hydrologic calibration involves comparison of simulated streamflows to historic continuous streamflow data from a stream gaging station in the watershed. Simulated streamflows are generated from input and adjustment of model parameters, including meteorological (precipitation, evapotranspiration, temperature), physical (area, overland flowpath length, slopes, Manning's roughness coefficients, stream cross-sections), and hydrologic response (infiltration; upper zone, lower zone, and groundwater storage; recession and interflow parameters) to represent the hydrologic cycle. Parameters are adjusted according to and within reasonable constraints until an acceptable agreement is achieved between simulated and observed results. Hydrologic calibration of the Sinking Creek model was conducted utilizing continuous discharge data from the U. S. Geological Survey (USGS) station 03486311, in close proximity to the water quality monitoring station at Orlando Drive (subwatershed 004). The hydrologic calibration period consisted of the gaging station period of record for continuous streamflow data: 10/1/90 - 9/30/92. Precipitation data for hydrologic calibration was collected from the Bristol, TN (Tri-Cities) Airport located approximately 13 miles from the Sinking Creek watershed.

As a first approximation for hydrologic calibration of Sinking Creek, the HSPF Parameter Database (HSPFParm) (USEPA, 1999) was searched to identify the nearest previously-applied HSPF project. Input data from the White Oak Creek watershed project were extracted from HSPFParm using the UCI file format export utility. White Oak Creek is a 6.5 square mile watershed located in Roane and Anderson Counties in east Tennessee. The White Oak Creek input data produced an inadequate calibration for Sinking Creek. However, comparison of White Oak Creek and Sinking Creek final calibration results indicates that differences in most parameters are minor. The major exception is the DEEPFR parameter, which represents losses to deep groundwater. Sinking Creek is a losing reach (DEEPFR = 0.35), characterized by multiple sinkholes, and actually drains into a large sinkhole downstream from the monitoring station at the New Sinking Creek Pump Station (subwatershed 001). According to White Oak Creek's DEEPFR parameter value (0.00), it does not exhibit the same losing characteristics as Sinking Creek. Results of Sinking Creek's hydrologic calibration are presented in Appendix B.

Fecal coliform data are available from five water quality monitoring stations in the Sinking Creek watershed for two intensive monthly (summer) sampling periods (10 samples each) during each of years 1993 (5/13-6/10) and 1994 (8/1-31). A limited number of samples were also collected during 1995 and 1996 with additional intensive monitoring again in 1999. However, precipitation data were not available for 1999 in a usable format for NPSM/HSPF model input; therefore, these recent data could not be used for model calibration. Because no data were available during the winter wet season and few samples were collected during highflow conditions, the uncertainty of the model calibration increases. Graphical representation of model calibration results shows that the model adequately simulates baseflow concentrations and storm runoff response where samples are available for comparison. In addition, because there are multiple water quality stations on Sinking Creek, it can be demonstrated that the calibration is consistent from the headwaters to the outlet of the watershed.

It became clear from water quality model calibration simulations that sources in subwatershed 003 contribute significantly greater fecal coliform loading per unit flow than sources in the other subwatersheds. And, due to in-stream fecal coliform decay (die-off) processes in upstream subwatersheds (including 003), additional loading in subwatersheds 001 and 002 only marginally increases the maximum 30-day geometric mean concentration at the New Sinking Creek Pump Station water quality station at the outlet of the watershed (subwatershed 001) relative to the Sinking Creek Church water quality station at the outlet of subwatershed 003. Observed water quality data collected in August 1994 indicate that the 30-day geometric mean concentration is higher at 003 than at 001. A comparison of simulated water quality concentrations and observed concentrations for sampling stations in the watershed are included in Appendix C.

3.5 Critical Conditions

Fecal coliform contributions to Sinking Creek may be attributed exclusively to the nonpoint category of sources. There are no point source dischargers permitted to discharge fecal coliform in the Sinking Creek watershed. Critical conditions for waters impaired by nonpoint sources generally occur during periods of wet-weather storm runoff. However, among the categories of nonpoint sources to Sinking Creek are sources that have the potential to occur as direct input to the stream as well as sources whose primary transport mechanism is groundwater, thus being more significant, relative to flow, during dry-weather periods.

The critical condition for fecal coliform impairment from nonpoint, land-loading sources is a rainfall runoff (storm) event preceded by an extended period of dry weather. An extended period of dry weather on the order of nine days or more allows for the maximum buildup of fecal coliform on the land surface, according to Sinking Creek watershed water quality model analyses. This fecal coliform accumulated on the land is then available for washoff by precipitation events. Critical conditions for direct contributions to the stream, represented as point sources in model simulations, occur during low flow and subsequent reduced dilution of available fecal coliform. Both conditions are simulated in the NPSM/HSPF model.

Observed fecal coliform sample concentration versus flow analyses were conducted for all sampling locations on Sinking Creek. These analyses indicated that there were no significant correlations in the relationships at any of the sampling locations. This suggests that fecal coliform impairment is not strictly a storm runoff phenomenon. In fact, according to the water quality model calibration, the critical condition occurs during periods of dry weather low flow. The highest 30-day geometric mean concentrations of fecal coliform occur during the summer and fall at all water quality sampling locations on an annual basis. However, it is important to note that, according to modeling results, storm-driven processes contribute significantly to impairment and must be addressed in the allocation and subsequent reduction of fecal coliform loadings to Sinking Creek.

The ten-year simulation period from October 1, 1988 to September 30, 1998 was used to calibrate the water quality model and identify the critical conditions from which to base the fecal coliform TMDL. This ten-year period contained a range of hydrologic conditions including low and high streamflows. The range of hydrologic conditions was considered adequate to identify the conditions critical to fecal coliform in Sinking Creek as well as determining the 30-day geometric mean concentration and subsequent loading for TMDL calculation. The critical period was determined to be during seasonal low flows occurring in the summer and fall.

4.0 MODEL RESULTS

4.1 Existing Conditions

Model results indicate that the primary sources of fecal coliform contamination in the Sinking Creek watershed are urban sources (both runoff-generated and direct input to the stream) and direct input of fecal coliform to the stream from various sources (e.g., failing septic systems, cattle, illicit dischargers, other animals having access to streams, and other unknown sources) in non-urban areas.

4.2 Critical Conditions

Results of the ten-year simulation of the 30-day geometric mean concentration for existing conditions at the outlet of the Sinking Creek watershed (001) are shown in Figure 3. Critical conditions can be determined from this figure. The 30-day critical period, according to the model simulation, is the time period preceding and including the highest simulated exceedance of the 30-day geometric mean standard. Achieving the water quality criteria for this period ensures that water quality criteria will be achieved for the remainder of the ten-year period and suggests that water quality criteria will be achieved for a very high percentage of time beyond the simulation period. For Sinking Creek, the highest exceedance of the 30-day geometric mean fecal coliform concentration standard occurred on September 26, 1995 at all three impaired subwatersheds modeled. Therefore, the critical period is August 28, 1995 through September 26, 1995. Table 6 shows the maximum 30-day geometric mean fecal coliform concentrations at each of the four modeled segments/subwatersheds and the corresponding levels of reduction required to achieve the 30-day geometric mean standard of 200 counts/100 ml at each.

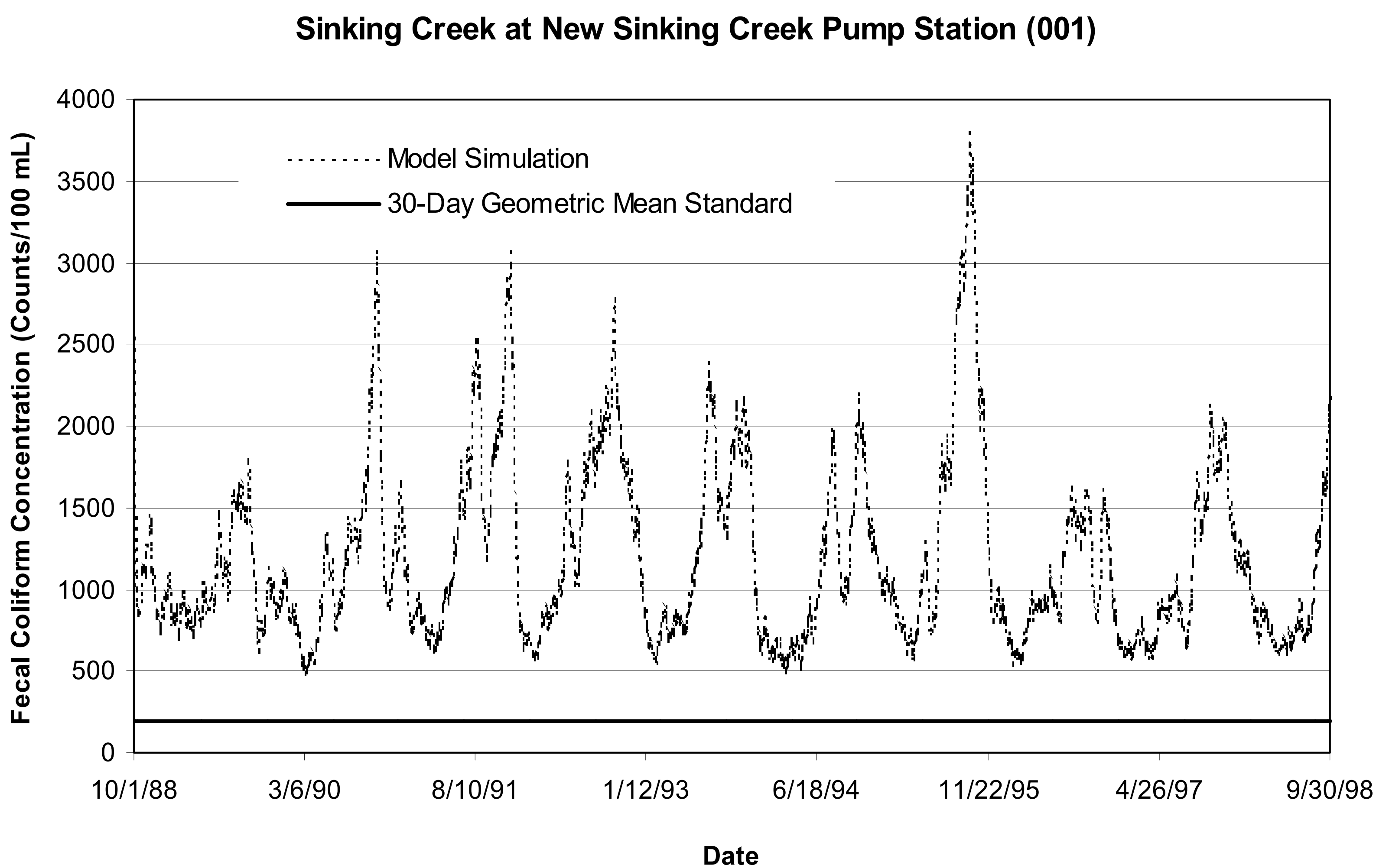

Figure 3. Sinking Creek model simulation of existing conditions (30-day geometric mean).

Table 6. Sinking Creek watershed simulated maximum 30-day geometric mean fecal coliform concentrations for existing (1988-1998) conditions.

Subwatershed	Max. 30-day Geometric Mean Fecal Coliform Concentration (Counts/100 ml)	Percent Reduction Required to Achieve Water Quality Standard
005	68.4	NA[1]
004	1519	86.8
003	3779	94.7
001[2]	3795	94.7

[1] Subwatershed/Reach 005 is unimpaired.
[2] Includes subwatershed 002.

5.0 ALLOCATION

5.1 Total Maximum Daily Load

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

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

The objective of a TMDL is to allocate loads among all of the known pollutant sources throughout a watershed so that appropriate control measures can be implemented and water quality standards achieved. 40 CFR §130.2 (I) states that TMDLs can be expressed in terms of mass per time (e.g., pounds per day), toxicity, or other appropriate measure. For fecal coliform, TMDLs are expressed as counts per 30 days to be consistent with the water quality standard. Therefore, the TMDL represents the maximum fecal coliform load that can be assimilated by the stream during the critical 30-day period while maintaining the fecal coliform water quality standard of 200 counts/100 ml.

The total maximum daily load of fecal coliform was determined by adding the WLA and the LA. The MOS was implicitly included in the TMDL analysis (as described in Sect. 3.5) and does not factor directly in the TMDL equation as shown above. The TMDL was summarized in the Summary Sheet at the front of this document. The TMDL for Sinking Creek at the New Sinking Creek Pump Station (most downstream monitored point in the watershed) is 1.212×10^{12} counts per 30 days.

5.2 Waste Load Allocations

Since there are no NPDES fecal coliform-permitted discharges in the Sinking Creek watershed, the WLA for Sinking Creek is zero. All future NPDES facilities will be required to meet end-of-pipe criteria for fecal coliform discharge.

5.3 Load Allocations

Modeling results indicate dual impacts to fecal coliform loading in the Sinking Creek watershed. Urban sources provide the greatest source contribution in the winter wet season when storm runoff events dominate streamflow. Direct in-stream sources (failing septic systems, leaking sewer lines, cattle in streams, and other animals and unknown sources) provide the greatest source contribution during the summer dry season when seasonal low flow dominates and dilution of direct sources is minimized. Direct in-stream sources are the most significant in terms of contribution to exceedances of water quality criteria.

Reducing loading from agricultural practices in the Sinking Creek watershed had a limited impact in allocation modeling simulations (what-if scenarios). In fact, the difference between a 100% reduction and a 100% increase in agricultural loading, exclusive of direct in-stream loading by cattle (and other sources), was approximately 25 counts per 100 ml. Since the maximum simulated 30-day geometric mean fecal coliform concentration, for existing conditions, was on the order of 3795 counts/100 ml at the watershed outlet (001), impacts from agricultural land use loading are considered to be negligible and reductions are unnecessary. In addition, no loading reduction was considered for forested land.

The allocation strategy for Sinking Creek nonpoint source load reduction consisted of applying reductions to fecal coliform loading to all impaired subwatersheds (004, 003, and 001/002) until subwatershed 004 (with the most upstream impaired stream reach) was adjusted to meet water quality standards. Next, further reductions were applied to subwatersheds 003 and 001/002 until their concentrations approached water quality standards. Lastly, it became apparent that additional reductions were needed to the direct in-stream sources in subwatershed 003 because it exhibited higher direct in-stream loading. Because loading to 003 contributes to 001/002 downstream, the final adjustments to 003 achieved water quality standards in reaches 003 and 001/002. The headwaters of Sinking Creek (subwatershed 005) was unimpaired; therefore, no reductions were applied to loading in that segment.

Allocation modeling scenarios were investigated in order to meet fecal coliform Recreational Use in-stream water quality criteria at all water quality monitoring locations in Sinking Creek. The final allocation scenario included nonpoint source loading reductions to urban land use loading and direct in-stream sources. Reductions to loading were not applied uniformly to all land uses in all subwatersheds. Reductions applied to sources in the subwatersheds varied and consisted of the following ranges: 90-97.5% reduction in urban land use loading rates and 75-99.25% reduction in direct in-stream loading (75-90% reduction in failing septic systems and 86.9-99.25% reduction to loading from cattle in streams and other/unknown direct in-stream sources). The lower rates of reduction were generally for subwatershed 004 and the higher rates were generally for downstream subwatersheds where impairment is greatest. In many cases, subwatershed 003 required the greatest levels of reduction because of the higher source term in that subwatershed. See Appendix D for detailed allocation information by subwatershed.

5.4 Seasonal Variation

Seasonal variation is accounted for in the dynamic water quality model by simulations covering ten hydrologic cycles (equivalent to ten years). Changes in meteorologic inputs and hydrology indicate distinctive seasonal changes and variability in modeled watershed response. In addition, different sources dominate water quality during different seasons (see Sect. 5.3, paragraph 1, above).

5.5 Margin of Safety

The MOS is a required component of TMDL development. There are two basic methods for incorporating the MOS (USEPA, 1991): 1) implicitly incorporate the MOS using conservative model assumptions to develop allocations, or 2) explicitly specify a portion of the total TMDL as the MOS and use the remainder for allocations. For the Sinking Creek fecal coliform TMDL, the MOS was implicitly incorporated into the modeling analysis by use of conservative model assumptions. This was accomplished by selection of conservative model input parameters and incorporation of the critical period based on the results of a ten-year simulation including extreme wet and dry periods.

6.0 IMPLEMENTATION STRATEGY

The TMDL analysis was performed using the best data available to specify Load Allocations that will meet the water quality criteria for fecal coliform in Sinking Creek so as to support its designated use classifications. The following recommendations and strategies are targeted toward source delineation, collection of data to support additional modeling and evaluation, and subsequent reduction in sources causing impairment of water quality.

6.1 Monitoring

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

Continued monitoring of the fecal coliform concentration at multiple water quality sampling points in the watershed is critical in characterizing sources of fecal coliform contamination and documenting future reduction of loading. Historical monitoring methodology has focused on intensive sampling for one month (10 samples in 30 days) each summer. This type of sampling supports stream posting for water quality impairment and, according to model simulations, correctly targets the critical low flow season. 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 Sinking Creek watershed includes monthly grab samples and intensive sampling for one month during the wet season (January-March). In addition, monitoring efforts may be refined and enhanced in order to characterize dry and wet season baseflow conditions (concentrations) and promote selective storm response (hydrograph) characterization. Lastly, stream discharge should be measured with the collection of each fecal coliform sample in order to characterize the dynamics of fecal coliform transport within the surface-water system. Consideration should be given to reactivating the USGS continuous stream gage at station 03486311 to support improved model calibration. This gage could serve as an index site for all water quality monitoring stations in the Sinking Creek watershed. This information will support future dynamic modeling efforts yielding meaningful results and reduced uncertainty.

6.2 Field Surveys

Many of the model input parameters utilized in dynamic water quality simulations in support of this TMDL development were based on estimations and assumptions. Therefore, a significant component of the implementation strategy for addressing fecal coliform exceedances in Sinking Creek is collection of data by field reconnaissance. Information on current manure management methods in the watershed is needed to verify the modeling assumptions or to adjust simulations accordingly. Input in this area should be coordinated with the Tennessee Department of Agriculture (TDA), University of Tennessee Agricultural Extension Service, and the NRCS.

In addition, a number of field surveys are recommended to verify or refine estimates of sources of fecal coliform to Sinking Creek. Efforts supported by the City of Johnson City, County Health Departments (Washington and Carter), the Tennessee Department of Environment and Conservation (TDEC), TDA, TWRA, NRCS, and others should be initiated for collecting these data and conducting the following surveys:

1. Septic system data (population serviced by, age of, proximity to stream, etc.) including failure rates by county or subwatershed

2. Cattle access to streams (and other agricultural animals, feeding operations, etc.)

3. Livestock populations by subwatersheds (including horses, sheep, and other agricultural animals)

4. Unknown sources: domestic animals, leaking sewer lines, illicit discharges, improper waste disposal, etc.

5. Wildlife population estimates by county (in east Tennessee) or subwatershed (deer, waterfowl, etc.)

6.3 Phase 2 NPDES Stormwater Permit and Storm Water Management Plan

The City of Johnson City, TN will be issued an NPDES Phase 2 Stormwater permit by the State of Tennessee, Department of Environment and Conservation (TDEC). Applications are due by March 10, 2003. In accordance with the permit, the City of Johnson City must develop a Storm Water Quality Management Program (SWQMP). The management program will cover the duration of the permit (5-year renewable) and will comprise 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. Components of the SWQMP will include, but will not be limited to, the following (USEPA, 2000):

Public Education and Outreach: Distributing educational materials and performing outreach to inform citizens about the impacts polluted stormwater runoff discharges can have on water quality.

Public Participation/Involvement: Providing opportunities for citizens to participate in program development and implementation, including effectively publicizing public hearings and/or encouraging citizen representatives on a stormwater management panel.

Illicit Discharge Detection and Elimination: Developing and implementing a plan to detect and eliminate illicit discharges to the storm sewer system (includes developing a system map and informing the community about hazards associated with illegal discharges and improper disposal of waste).

Post-Construction Runoff Control: Developing, implementing, and enforcing a program to address discharges of post-construction stormwater runoff from new development and redevelopment areas. Applicable controls could include preventative actions such as protecting sensitive areas (e.g., wetlands) or the use of structural BMP's such as grassed swales or porous pavement.

Pollution Prevention/Good Housekeeping: Developing and implementing a program with the goal of preventing or reducing pollutant runoff from municipal operations. The program must include municipal staff training on pollution prevention measures and techniques (e.g., regular street sweeping, reduction in the use of pesticides or street salt, or frequent catch basin cleaning.

Additional activities and programs conducted by city, county, and state agencies are recommended to support the SWQMP: field screening and monitoring programs to identify the types and extent of fecal coliform water quality problems, relative degradation or improvement over time, areas of concern, and source identification; requirements that all new and replacement sanitary sewage systems be designed to minimize discharges from the system into the storm sewer system; and mechanisms for reporting illicit connections, breaks, surcharges, and general sanitary sewer system problems with potential to release to the storm sewer system.

6.4 Future Efforts

This TMDL represents the first phase of a long-term restoration project to reduce fecal coliform loading to acceptable levels (meeting water quality standards) in the Sinking 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 nonpoint 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.

7.0 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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APPENDIX A

WATER QUALITY DATA

Table A1. Sinking Creek Water Quality (Fecal Coliform) Data.

Subwatershed[1]	Date	FC[2]	FC (30-d GM)[3]
001	5/13/93	14000	
001	5/17/93	1500	
001	5/20/93	1700	
001	5/24/93	580	
001	5/27/93	2100	
001	6/2/93	780	
001	6/3/93	680	
001	6/7/93	900	
001	6/9/93	1400	
001	6/10/93	1200	1426
001	7/18/94	1050	
001	7/20/94	3300	
001	7/25/94	1070	
001	8/1/94	1180	
001	8/4/94	960	
001	8/8/94	1060	
001	8/10/94	1500	
001	8/15/94	1290	
001	8/22/94	1000	
001	8/23/94	830	
001	8/25/94	690	
001	8/29/94	1000	
001	8/31/94	2300	1118
001	8/22/95	2100	
001	9/05/95	1200	
001	10/28/96	440	
001	10/30/96	550	
001	11/4/96	230	
001	11/5/96	840	
001	11/6/96	270	
001	8/18/99	200	
001	8/19/99	650	
001	8/24/99	590	
001	8/26/99	400	
001	8/31/99	430	
001	9/2/99	530	
001	9/7/99	510	
001	9/9/99	550	
002	5/20/93	1400	
002	5/24/93	1300	
002	5/27/93	200	
002	6/2/93	600	
002	6/3/93	670	
002	6/7/93	1200	
002	6/9/93	1700	

Subwatershed[1]	Date	FC[2]	FC (30-d GM)[3]
002	6/10/93	1500	904
002	8/22/95	1100	
002	9/5/95	1300	
002	10/28/96	610	
002	10/30/96	400	
002	11/4/96	190	
002	11/5/96	190	
002	11/6/96	210	
002	8/18/99	920	
002	8/19/99	540	
002	8/24/99	840	
002	8/26/99	280	
002	8/31/99	560	
002	9/2/99	520	
002	9/7/99	680	
002	9/9/99	390	
003	5/13/93	12000	
003	5/17/93	1600	
003	7/18/94	1030	
003	7/20/94	3500	
003	7/25/94	2000	
003	8/1/94	1150	
003	8/4/94	1060	
003	8/8/94	810	
003	8/10/94	3500	
003	8/15/94	1110	
003	8/22/94	1340	
003	8/23/94	1500	
003	8/25/94	570	
003	8/29/94	1200	
003	8/31/94	890	1167
004	5/13/93	1600	
004	5/17/93	870	
004	5/20/93	470	
004	5/24/93	320	
004	5/27/93	420	
004	6/2/93	240	
004	6/3/93	750	
004	6/7/93	1400	
004	6/9/93	1000	
004	6/10/93	700	659
004	718/94	160	
004	7/20/94	360	
004	7/25/94	340	
004	8/1/94	230	

Subwatershed[1]	Date	FC[2]	FC (30-d GM)[3]
004	8/4/94	970	
004	8/8/94	90	
004	8/10/94	270	
004	8/15/94	620	
004	8/22/94	270	
004	8/23/94	480	
004	8/25/94	110	
004	8/29/94	1370	
004	8/31/94	1700	403
004	8/22/95	910	
004	9/5/95	690	
004	10/28/96	620	
004	10/30/96	260	
004	11/4/96	110	
004	11/5/96	190	
004	11/6/96	370	
004	8/18/99	122	
004	8/19/99	56	
004	8/24/99	126	
004	8/26/99	130	
004	8/31/99	140	
004	9/2/99	178	
004	9/7/99	86	
004	9/9/99	530	
005	7/18/94	10	
005	7/20/94	10	
005	7/25/94	10	
005	8/1/94	48	
005	8/4/94	10	
005	8/8/94	16	
005	8/10/94	2	
005	8/15/94	1190	
005	8/22/94	162	
005	8/23/94	108	
005	8/25/94	40	
005	8/29/94	76	
005	8/31/94	28	44

[1] 001 = New Sinking Creek Pump Station
002 = Bob Peoples Bridge
003 = Sinking Creek Church
004 = Orlando Drive
005 = Jim McNeese Road
[2] Fecal Coliform Concentration (Counts/100 ml)
[3] Fecal Coliform 30-day Geometric Mean Concentration (Counts/100 ml)

APPENDIX B

HYDROLOGIC CALIBRATION

Table B1. NPSM/HSPF Hydrology Parameters and Value Ranges

			Range of Values							
			Typical		Possible		White Oak Cr.	Sinking Creek		
Name	Definition	Units	Min	Max	Min	Max	Starter	Calibration	Function of:	Comments
PWAT-PARM2										
FOREST	Fraction forest cover	none	0	0.5	0	0.95	0.1	0.284-0.394	Forest cover	% evergreen (forest land use only)
LZSN	Lower zone nominal soil moisture storage	inches	3	8	2	15	7	5	Soils, climate	Calibration
INFILT	Index to infiltration capacity of the soil	in/hr	0.01	0.25	0.001	0.5	0.08	0.05	Soils, land use	Calibration, divides surface/subsurface flow
LSUR	Length of overland flow plane	feet	200	500	100	700	1440	500	Topography	Estimate from maps or GIS
SLSUR	Slope of overland flow plane	none	0.01	0.15	0.001	0.3	0.14	0.029-0.15	Topography	Estimate from maps or GIS
KVARY	GW recession flow parameter	1/inches	0	3	0	5	0	0	Baseflow recession variation	Used when recession rate varies w/ GW levels
AGWRC	Basic GW recession rate	none	0.92	0.99	0.85	0.999	0.99	0.98	Baseflow recession	Calibration
PWAT-PARM3										
PETMAX	Temperature below which ET is reduced	deg. F	35	45	32	48	40	40	Climate, vegetation	Reduces ET near freezing, when SNOW is active
PETMIN	Temperature below which ET is set to zero	deg. F	30	35	30	40	35	35	Climate, vegetation	Reduces ET near freezing, when SNOW is active
INFEXP	Exponent in infiltration equation	none	2	2	1	3	2	2	Soils variability	Usually default to 2.0
INFILD	Ratio of max/mean infiltration capacities	none	2	2	1	3	2	2	Soils variability	Usually default to 2.0
DEEPFR	Fraction of GW inflow to deep recharge	none	0	0.2	0	0.5	0	0.35	Geology, GW recharge	Calibration: Sinking Creek is losing reach (sinkholes)
BASETP	Fraction of remaining ET from baseflow	none	0	0.05	0	0.2	0	0	Riparian vegetation	Direct ET from riparian vegetation
AGWETP	Fraction of remaining ET from active GW	none	0	0.05	0	0.2	0	0	Marsh/wetlands extent	Direct ET from shallow GW
PWAT-PARM4										
CEPSC	Interception storage capacity	inches	0.03	0.2	0.01	0.4	monthly	monthly	Vegetation type/density, land use	Monthly values usually used
UZSN	Upper zone nominal soil moisture storage	inches	0.1	1	0.05	2	0.8	0.7	Surface soil conditions, land use	Accounts for near surface retention
NSUR	Manning's n (roughness) for overland flow	none	0.15	0.35	0.1	0.5	0.3	0.3	Surface conditions, land use	Monthly values often used for croplands
INTFW	Interflow inflow parameter	none	1	3	1	10	4	5	Soils, topography, land use	Calibration, based on hydrograph separation
IRC	Interflow recession parameter	none	0.5	0.7	0.3	0.85	0.3	0.5	Soils, topography, land use	Often start with a value of 0.7, then adjust
LZETP	Lower zone ET parameter	none	0.2	0.7	0.1	0.9	monthly	monthly	Vegetation type/density, root depth	Monthly values usually used
MON-INTERCEPT	Monthly interception storage capacity	inches	0.03	0.2	0.01	0.4			Vegetation type/density, land use	Monthly values usually used
	January						0.01	0.01		
	February						0.01	0.01		
	March						0.03	0.03		
	April						0.08	0.08		
	May						0.12	0.12		
	June						0.12	0.12		
	July						0.12	0.12		
	August						0.12	0.12		
	September						0.12	0.12		
	October						0.06	0.06		
	November						0.03	0.03		
	December						0.01	0.01		
MON-LZETPARM	Monthly lower zone ET parameter	none	0.2	0.7	0.1	0.9			Vegetation type/density, root depth	Monthly values usually used
	January						0.2	0.2		
	February						0.2	0.2		
	March						0.2	0.2		
	April						0.3	0.3		

	May							0.4	0.4		
	June							0.4	0.4		
	July							0.4	0.4		
	August							0.3	0.3		
	September							0.3	0.3		
	October							0.2	0.2		
	November							0.2	0.2		
	December							0.2	0.2		

GW = groundwater
ET = evapotranspiration

Table B2. Sinking Creek Hydrologic Calibration Analysis

Simulation Name:	Sinking Creek (Sink15)	**Simulation Period:**	10/1/1991 - 9/30/1992
		Watershed Area (ac):	4767.00
Total Simulated In-Stream Flow:	**12.36**	Total Observed In-stream Flow:	**13.08**
Total of Highest 10% Flows:	**5.05**	Total of Observed Highest 10% Flows:	**4.70**
Total of Lowest 50% Flows:	**2.23**	Total of Observed Lowest 50% Flows:	**2.11**
Simulated Summer Flow Volume (months 7-9):	**1.46**	Observed Summer Flow Volume (7-9):	**1.77**
Simulated Fall Flow Volume (months 10-12):	**3.69**	Observed Fall Flow Volume (10-12):	**2.11**
Simulated Winter Flow Volume (months 1-3):	**4.32**	Observed Winter Flow Volume (1-3):	**4.36**
Simulated Spring Flow Volume (months 4-6):	**2.89**	Observed Spring Flow Volume (4-6):	**4.83**
Total Simulated Storm Volume:	**10.56**	Total Observed Storm Volume:	**12.49**
Simulated Summer Storm Volume (7-9):	**1.01**	Observed Summer Storm Volume (7-9):	**1.62**
Errors (Simulated-Observed)		*Recommended Criteria*	
Error in Total Volume:	**-5.48**	10	
Error in 50% Lowest Flows:	**5.74**	10	
Error in 10% Highest Flows:	**7.42**	15	
Seasonal Volume Error - Summer:	**-17.36**	30	
Seasonal Volume Error - Fall:	**74.50**	30	
Seasonal Volume Error - Winter:	**-0.93**	30	
Seasonal Volume Error - Spring:	**-40.25**	30	
Error in Storm Volumes:	**-15.43**	20	
Error in Summer Storm Volumes:	**-60.55**	50	

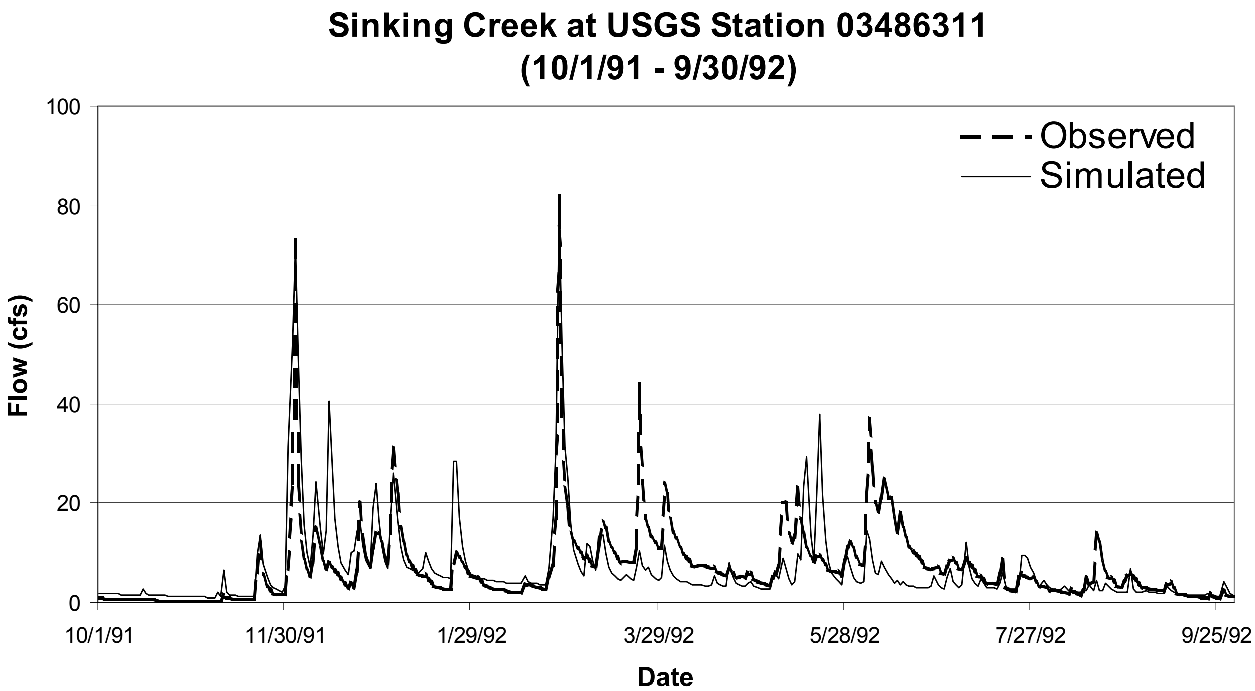

Figure B1. Sinking Creek hydrologic model simulation of flow versus observed data.

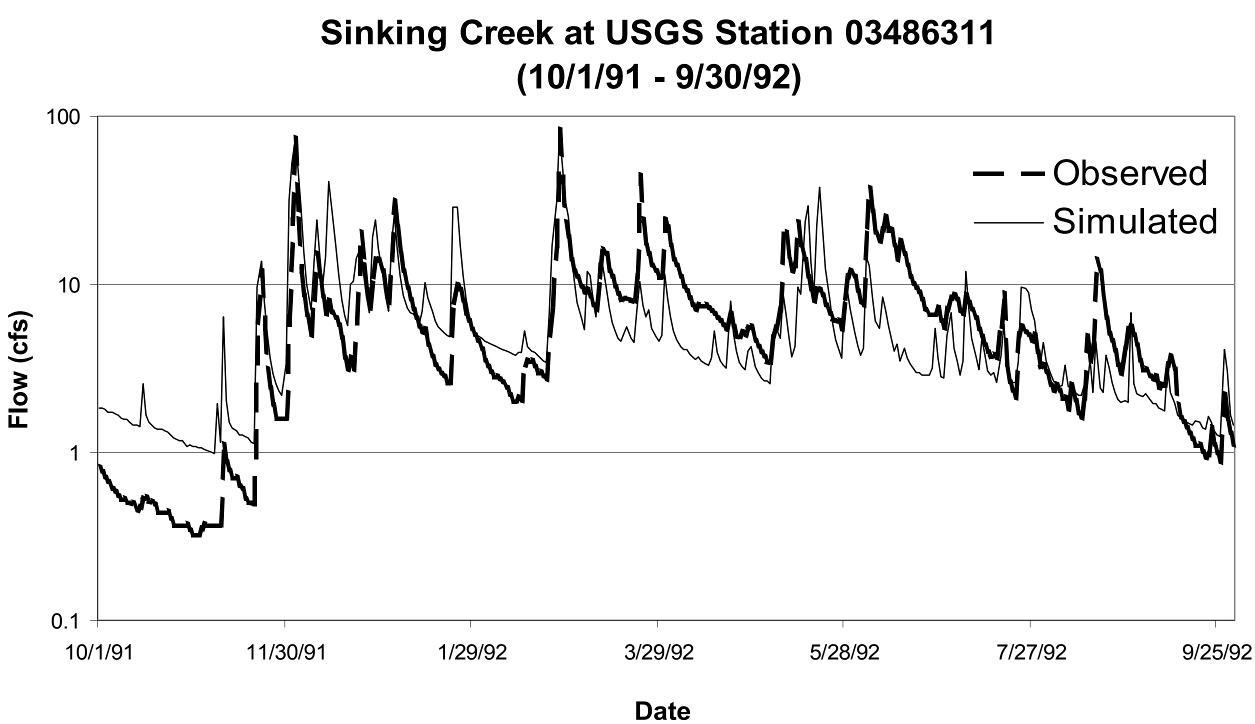

Figure B2. Sinking Creek hydrologic model simulation of flow versus observed data (log scale).

APPENDIX C

WATER QUALITY CALIBRATION

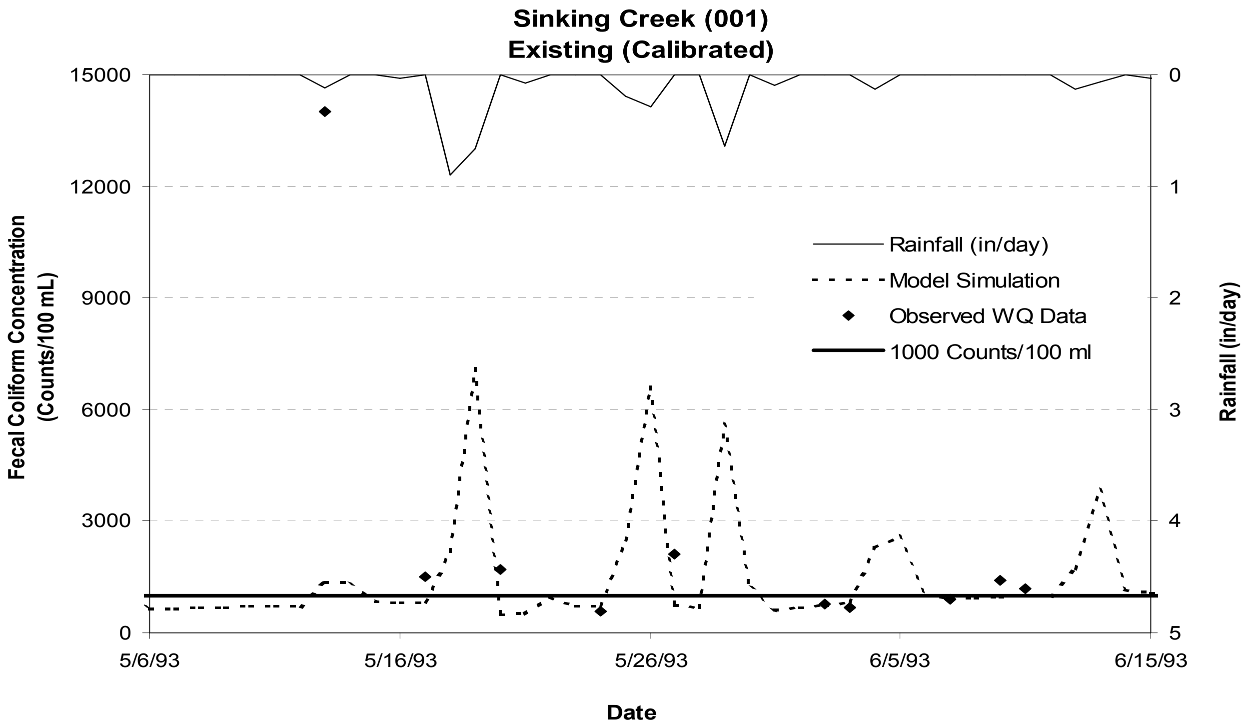

Figure C1. Sinking Creek water quality model simulation of fecal coliform concentration versus observed data at New Sinking Creek Pump Station (001), May-June, 1993.

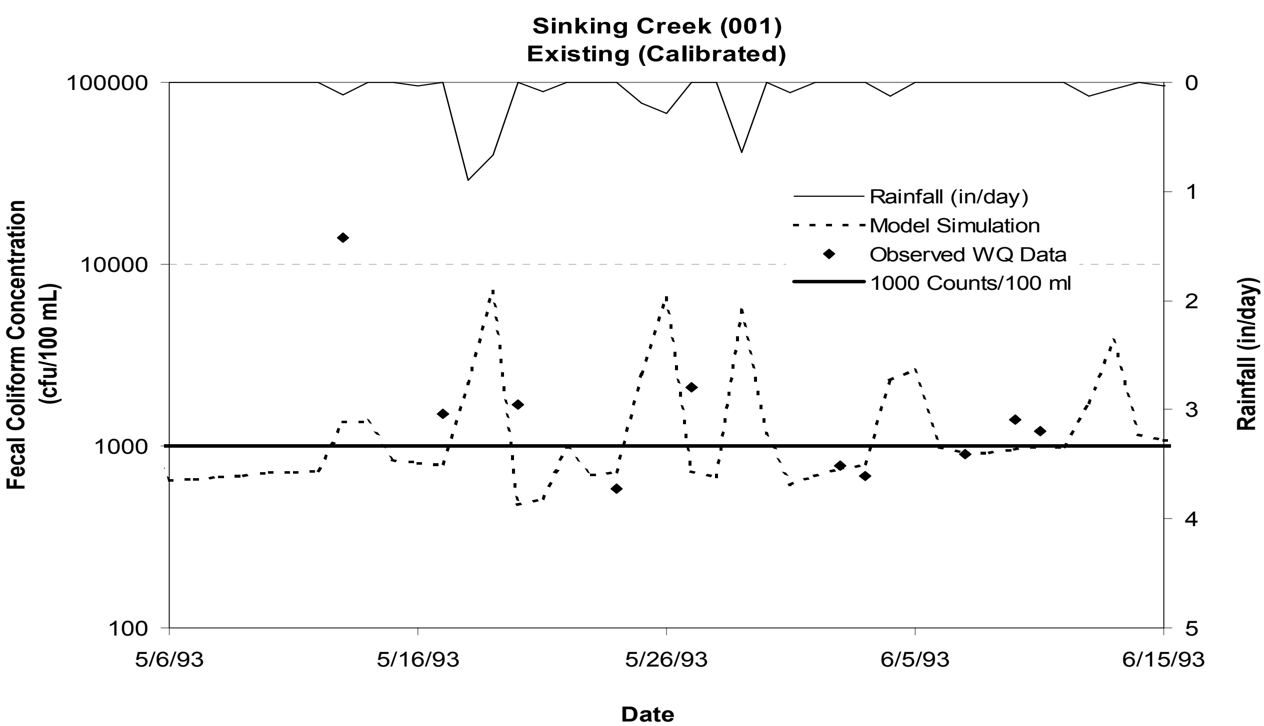

Figure C2. Sinking Creek water quality model simulation of fecal coliform concentration versus observed data (log scale) at New Sinking Creek Pump Station (001), May-June, 1993.

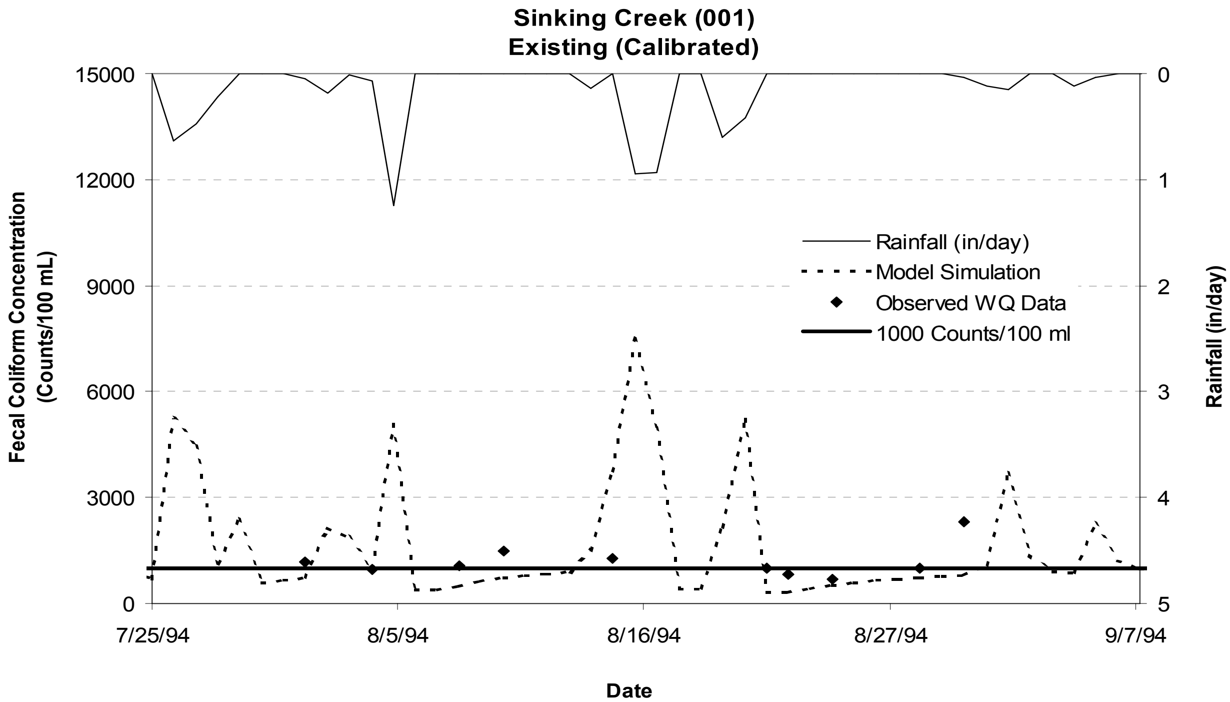

Figure C3. Sinking Creek water quality model simulation of fecal coliform concentration versus observed data at New Sinking Creek Pump Station (001), August 1994.

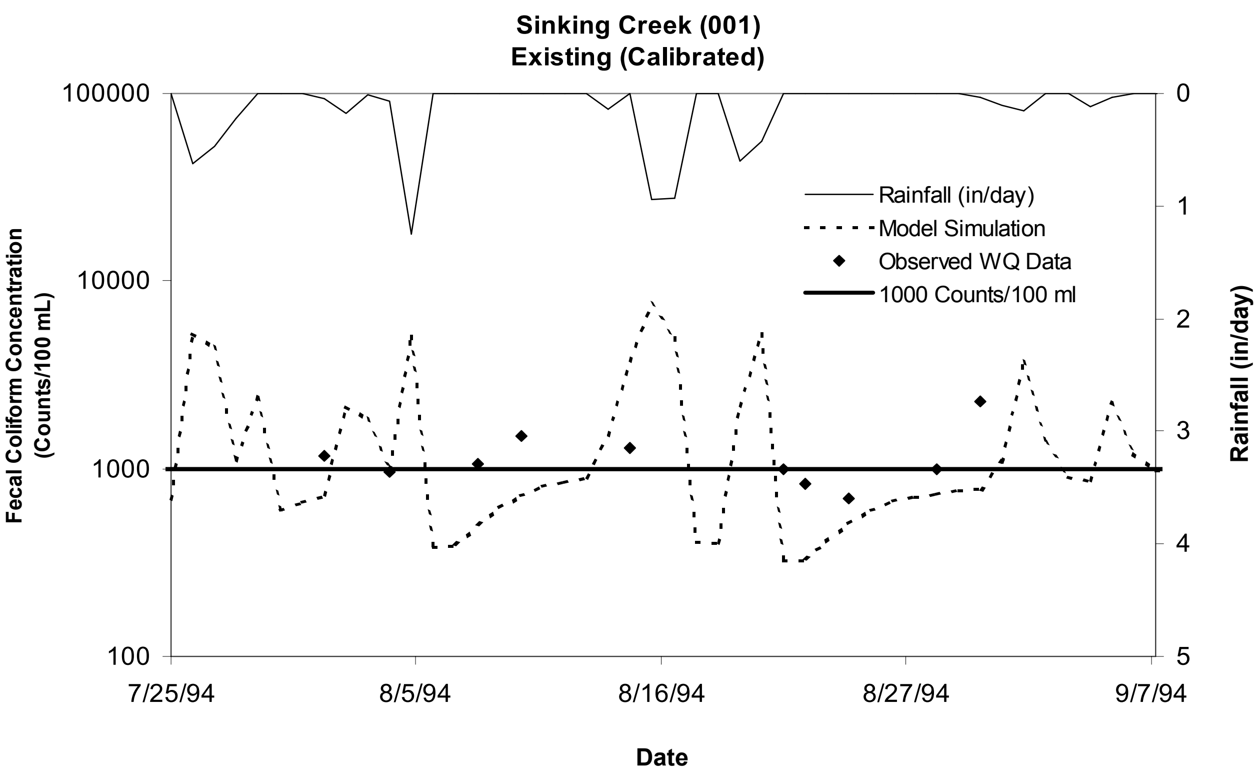

Figure C4. Sinking Creek water quality model simulation of fecal coliform concentration versus observed data (log scale) at New Sinking Creek Pump Station (001), August 1994.

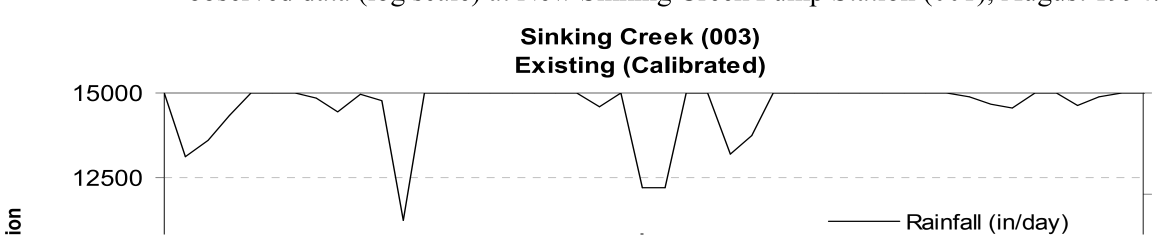

Figure C5. Sinking Creek water quality model simulation of fecal coliform concentration versus observed data at Sinking Creek Church (003), August 1994.

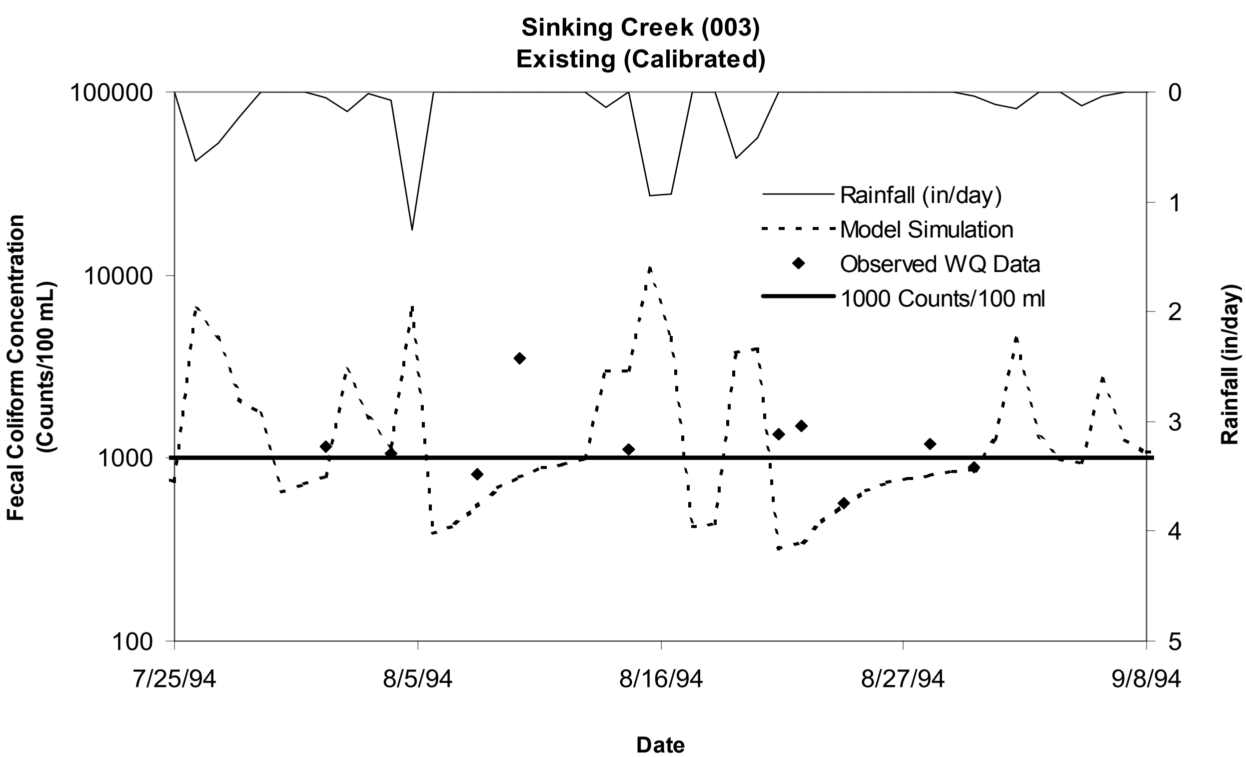

Figure C6. Sinking Creek water quality model simulation of fecal coliform concentration versus observed data (log scale) at Sinking Creek Church (003), August 1994.

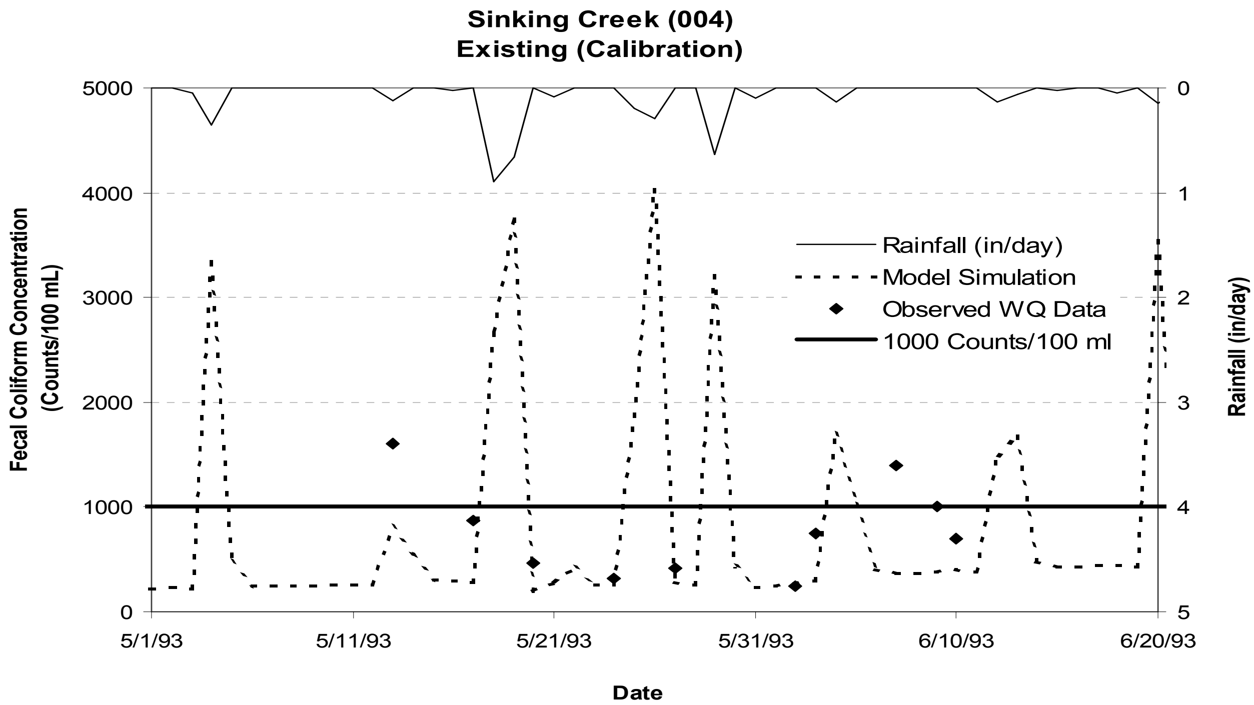

Figure C7. Sinking Creek water quality model simulation of fecal coliform concentration versus observed data at Orlando Drive (004), May-June, 1993.

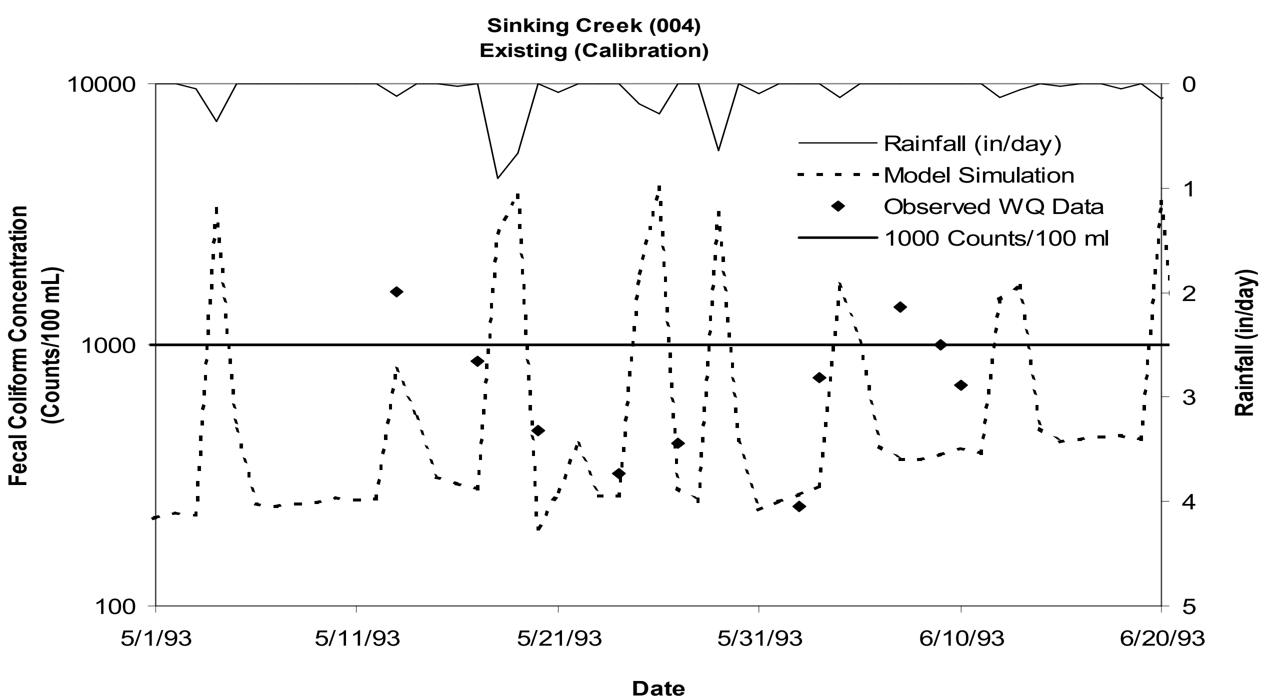

Figure C8. Sinking Creek water quality model simulation of fecal coliform concentration versus observed data (log scale) at Orlando Drive (004), May-June, 1993.

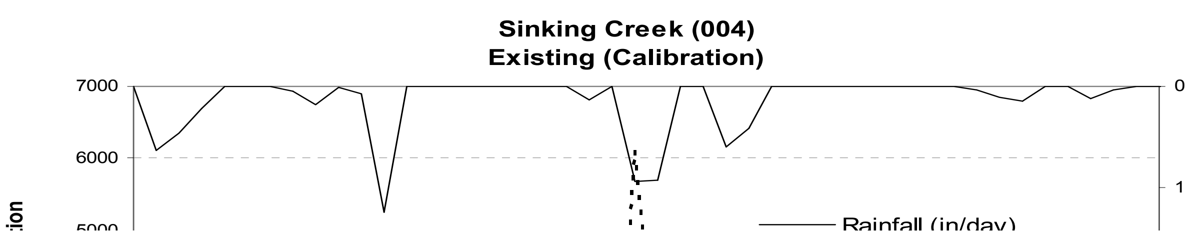

Figure C9. Sinking Creek water quality model simulation of fecal coliform versus observed data at Orlando Drive (004), August 1994.

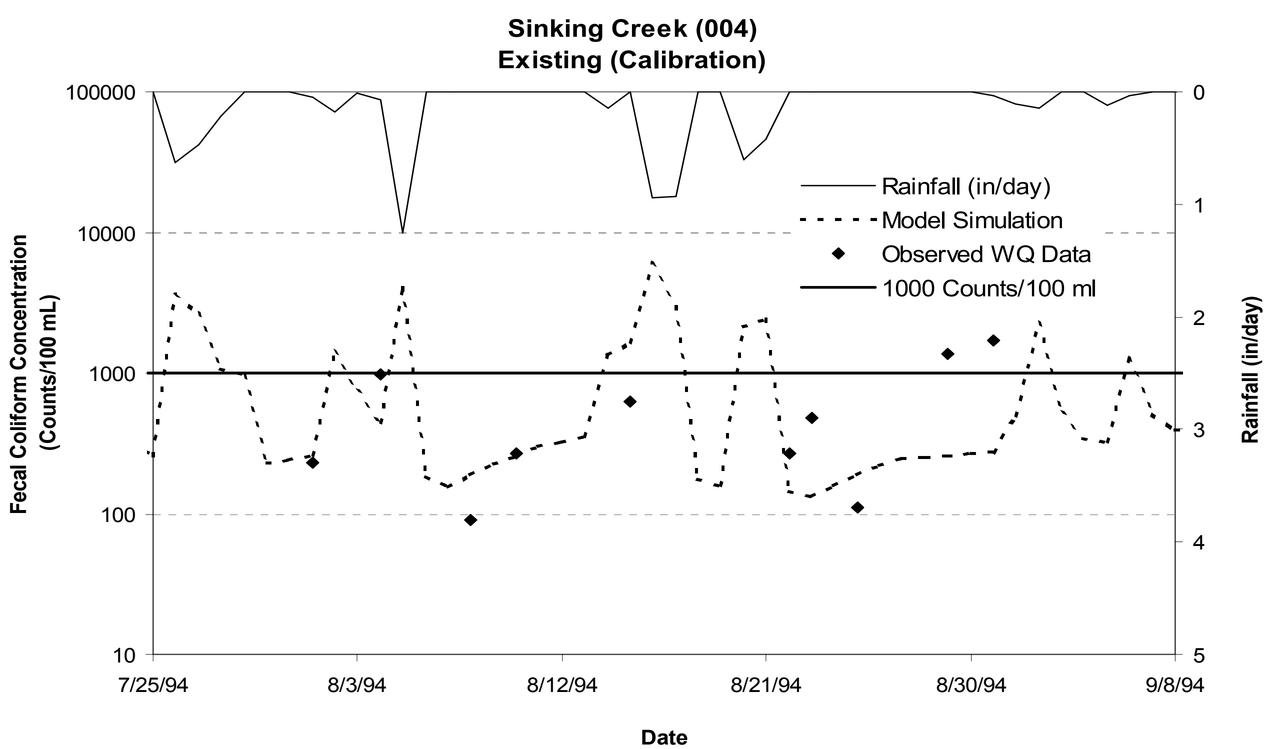

Figure C10. Sinking Creek water quality model simulation of fecal coliform versus observed data (log scale) at Orlando Drive (004), August 1994.

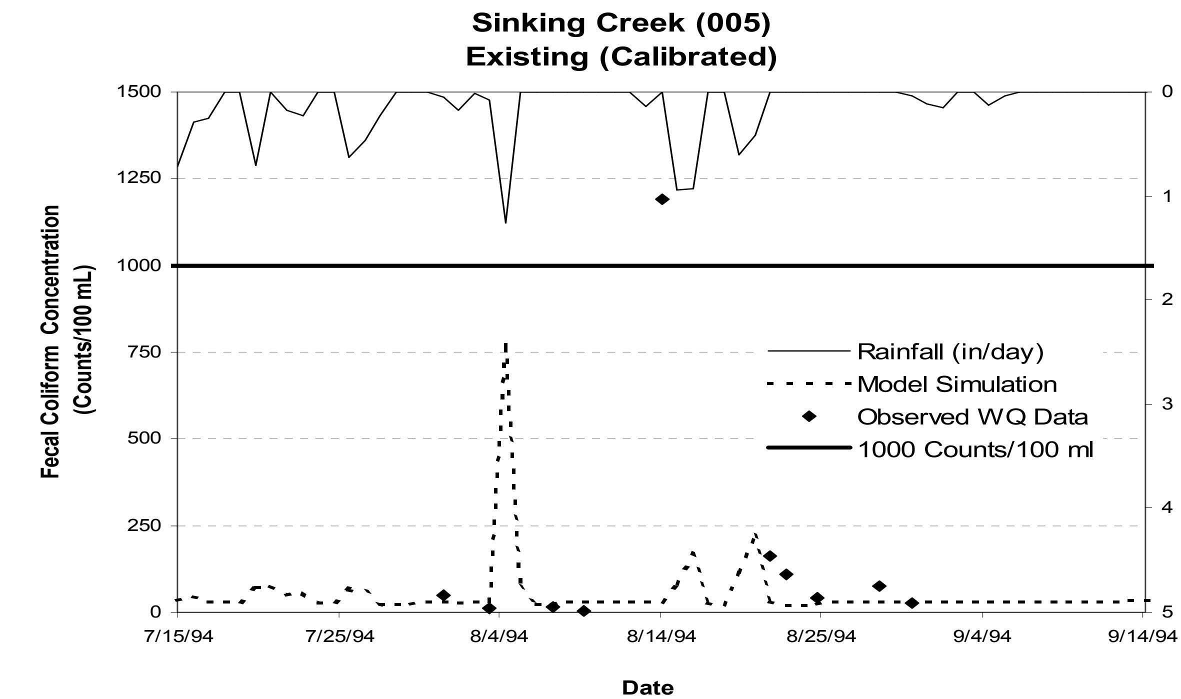

Figure C11. Sinking Creek water quality model simulation of fecal coliform concentration versus observed data at Jim McNeese Road (005), August 1994.

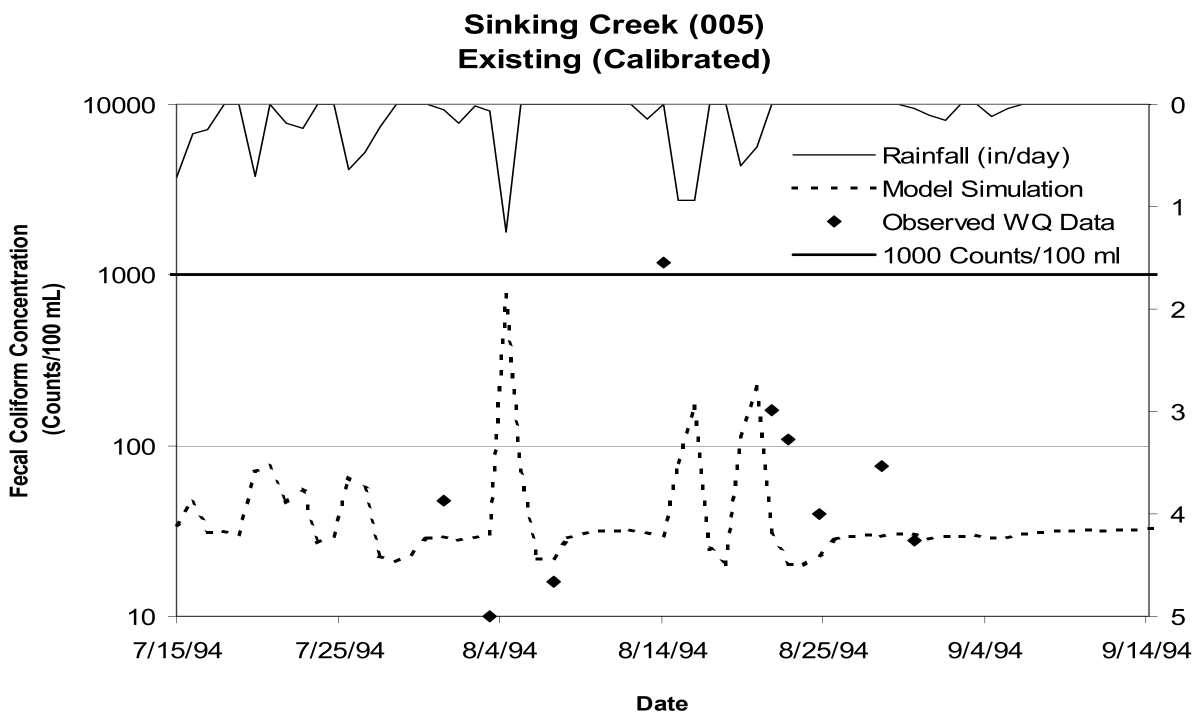

Figure C12. Sinking Creek water quality model simulation of fecal coliform concentration versus observed data (log scale) at Jim McNeese Road (005), August 1994.

APPENDIX D

TMDL ALLOCATION RESULTS

Table D1. Sinking Creek Water Quality Allocation Analysis

Calibrated Water Quality model parameters:

SW#	% SSF	% OIS	Urb (Perv) SQO/ACQOP	Urb (Perv) SQOLIM	Urb (Imp) SQO/ACQOP	Urb (Imp) SQOLIM	Urb. IOQC/AOQC	Ag. SQO/ACQOP	Ag. SQOLIM	Ag. IOQC/AOQC	Calibrated model max. 30-d geo. mean
005	10	0.0	7.18E+06	1.15E+07	7.18E+06	1.15E+07	9300	5.416E+10	8.666E+10	14900	68.4
004	20	0.175	1.08E+10	1.73E+10	1.08E+10	1.73E+10	93000	6.570E+10	1.051E+11	29800	**1519**
003	50	1.0	2.025E+10	3.25E+10	2.025E+10	3.25E+10	175000	5.394E+10	8.631E+10	29800	**3779**
002	20	0.175	1.08E+10	1.73E+10	1.08E+10	1.73E+10	93000	4.599E+10	7.358E+10	29800	
001	20	0.175	1.08E+10	1.73E+10	1.08E+10	1.73E+10	93000	4.904E+10	7.847E+10	29800	**3795**

Allocation Water Quality model parameters:

SW#	% SSF	% OIS	Urb (Perv) SQO/ACQOP	Urb (Perv) SQOLIM	Urb (Imp) SQO/ACQOP	Urb (Imp) SQOLIM	Urb. IOQC/AOQC	Ag. SQO/ACQOP	Ag. SQOLIM	Ag. IOQC/AOQC	Allocated model max. 30-d geo. mean
005											68.4
004	5	0.023	5.400E+08	8.650E+08	5.400E+08	8.650E+08	9300				**197.6**
003	5	0.0075	5.063E+08	8.100E+08	5.063E+08	8.100E+08	9300				**197.3**
002	5	0.0025	5.400E+08	8.650E+08	5.400E+08	8.650E+08	9300				
001	5	0.0025	5.400E+08	8.650E+08	5.400E+08	8.650E+08	9300				**198.2**

Note: only parameter values that have been adjusted are listed (i.e., parameter values not listed were not adjusted)

Allocation Water Quality model; **Percent Reductions** (relative to calibrated model) to meet criteria:

SW#	% SSF	% OIS	Urb (Perv) SQO/ACQOP	Urb (Perv) SQOLIM	Urb (Imp) SQO/ACQOP	Urb (Imp) SQOLIM	Urb. IOQC/AOQC	Ag. SQO/ACQOP	Ag. SQOLIM	Ag. IOQC/AOQC	% Reduction*
005	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
004	75	86.9	95	95	95	95	90	0.0	0.0	0.0	**86.8**
003	90	99.25	97.5	97.5	97.5	97.5	94.7	0.0	0.0	0.0	**94.7**
002	75	98.6	95	95	95	95	90	0.0	0.0	0.0	94.7
001	75	98.6	95	95	95	95	90	0.0	0.0	0.0	**94.7**

* Percent reduction at subwatershed outlet required to meet criteria (30-day geometric mean less than or equal to 200 counts/100 ml) according to calibrated model 30-day geometric mean concentration.

SW# = Subwatershed number
SSF = Septic System Failure
OIS = Other direct In-Stream sources (including unknown and unidentified sources)
Urb = Urban
Perv = Pervious
Imp = Impervious
Ag = Agricultural

Table D2. Sinking Creek Water Quality Loading Analysis: Existing Conditions

Subwatershed #	Land Loading (Counts/30 days)		Direct In-Stream Loading (Counts/30 days)		
	Pervious	Impervious	Septic Systems	OIS[1]	Total (Counts/30 days)
005	3.109E+10	3.297E+07	1.325E+09	0.000E+00	3.245E+10
004	1.191E+11	8.086E+12	1.246E+11	4.385E+11	8.768E+12
003	1.800E+11	1.467E+13	3.146E+11	2.095E+12	1.726E+13
002	5.402E+10	1.653E+12	3.924E+10	3.118E+11	2.058E+12
001	2.500E+10	1.891E+11	5.587E+09	2.275E+11	4.472E+11
Total	4.092E+11	2.460E+13	4.854E+11	3.073E+12	**2.857E+13**

[1] OIS = Other direct In-Stream sources (including unknown and unidentified sources)

Table D3. Sinking Creek Water Quality Loading Analysis: TMDL Allocation

Subwatershed #	Land Loading (Counts/30 days)		Direct In-Stream Loading (Counts/30 days)		Total (Counts/30 days)	TMDL (Counts/30 days)
	Pervious	Impervious	Septic Systems	OIS[1]		
005	3.109E+10	3.297E+07	6.631E+08	0.000E+00	3.179E+10	3.179E+10
004	5.566E+10	4.125E+11	3.110E+10	5.766E+10	5.569E+11	5.887E+11
003	4.784E+10	3.611E+11	3.146E+10	1.571E+10	4.561E+11	1.045E+12
002	3.238E+10	8.434E+10	9.792E+09	4.454E+09	1.310E+11	1.176E+12
001	2.183E+10	9.647E+09	1.397E+09	3.250E+09	3.612E+10	**1.212E+12**
Total	1.888E+11	8.676E+11	7.442E+10	8.107E+10	1.212E+12	

[1] OIS = Other direct In-Stream sources (including unknown and unidentified sources)

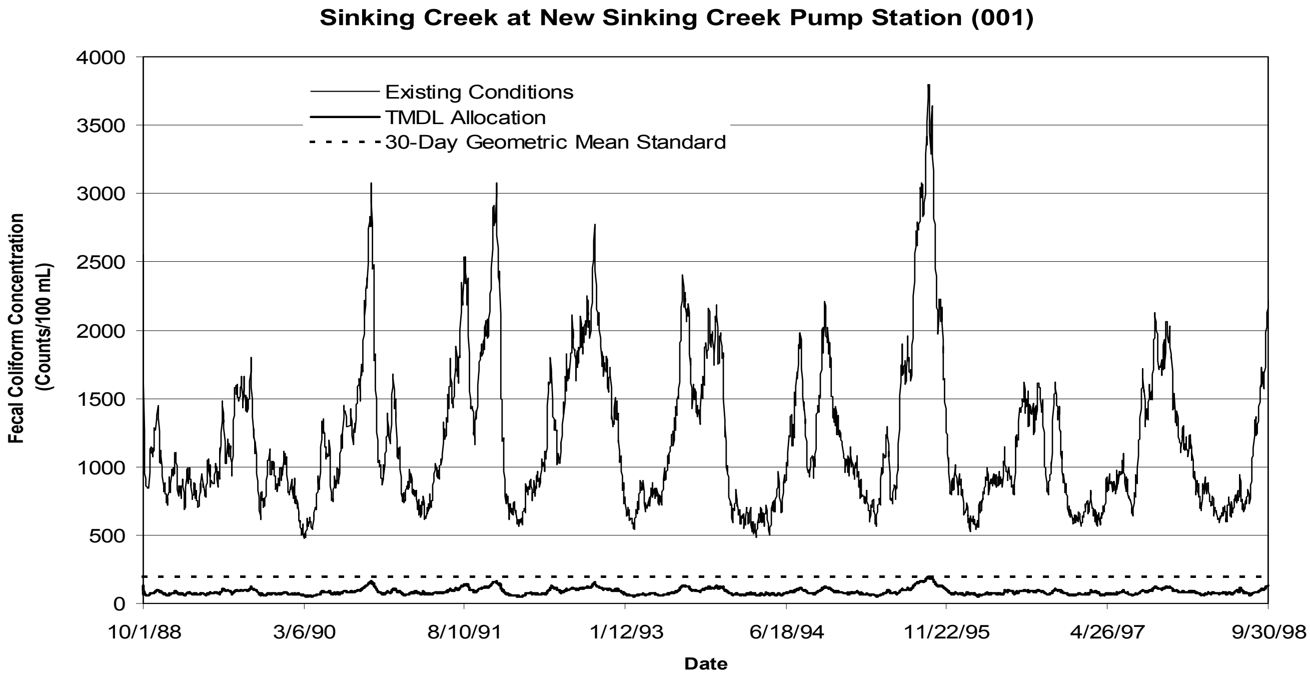

Figure D1. Sinking Creek model simulation of existing conditions versus TMDL allocation at New Sinking Creek Pump Station (001), (30-day geometric means).

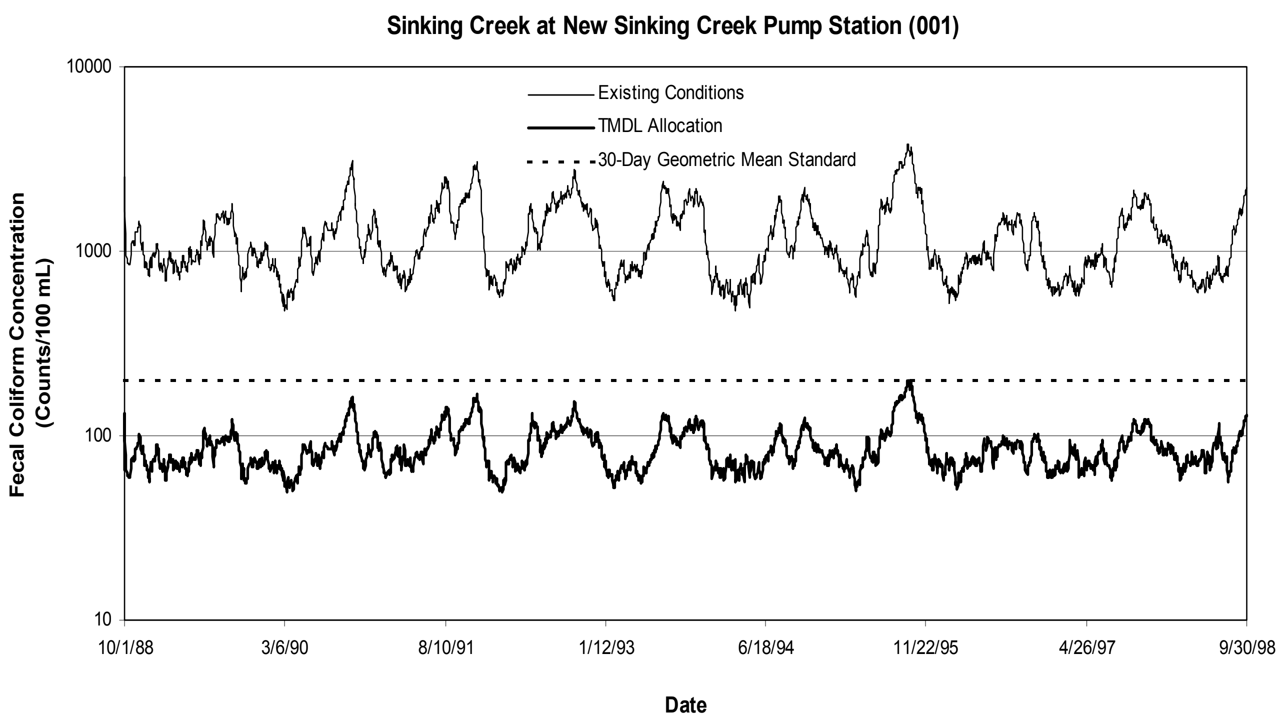

Figure D2. Sinking Creek model simulation of existing conditions versus TMDL allocation (log scale) at New Sinking Creek Pump Station (001), (30-day geometric means).

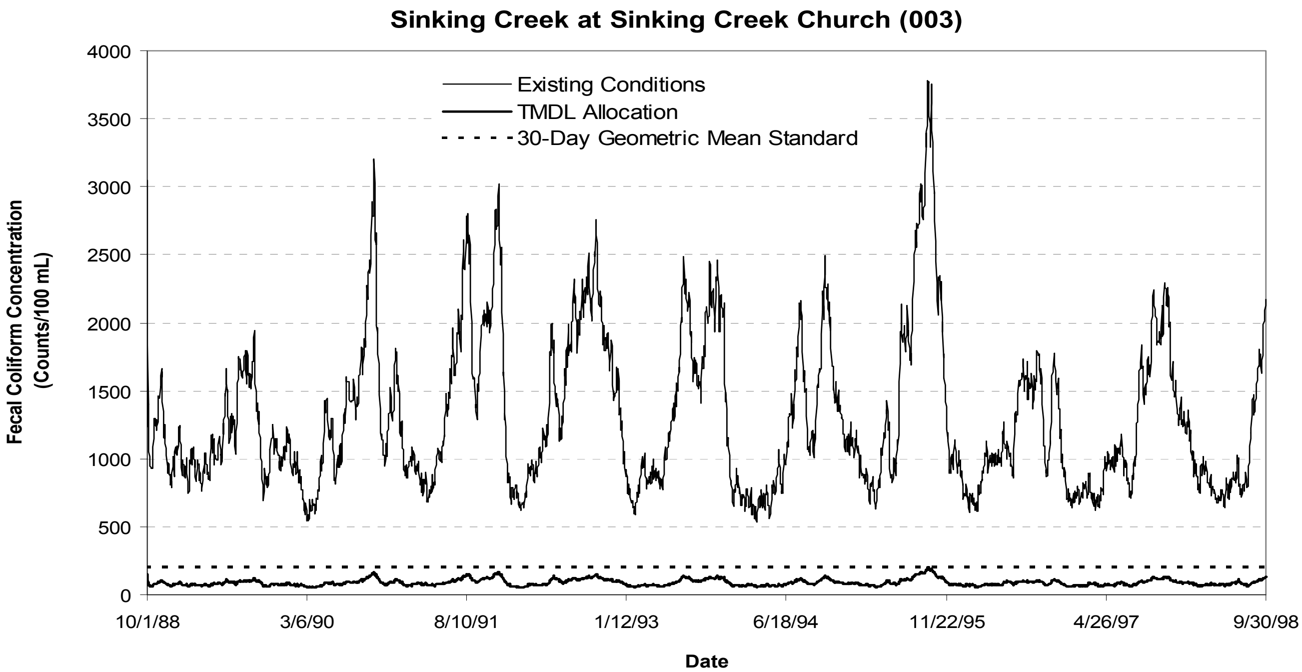

Figure D3. Sinking Creek model simulation of existing conditions versus TMDL allocation at Sinking Creek Church (003), (30-day geometric means).

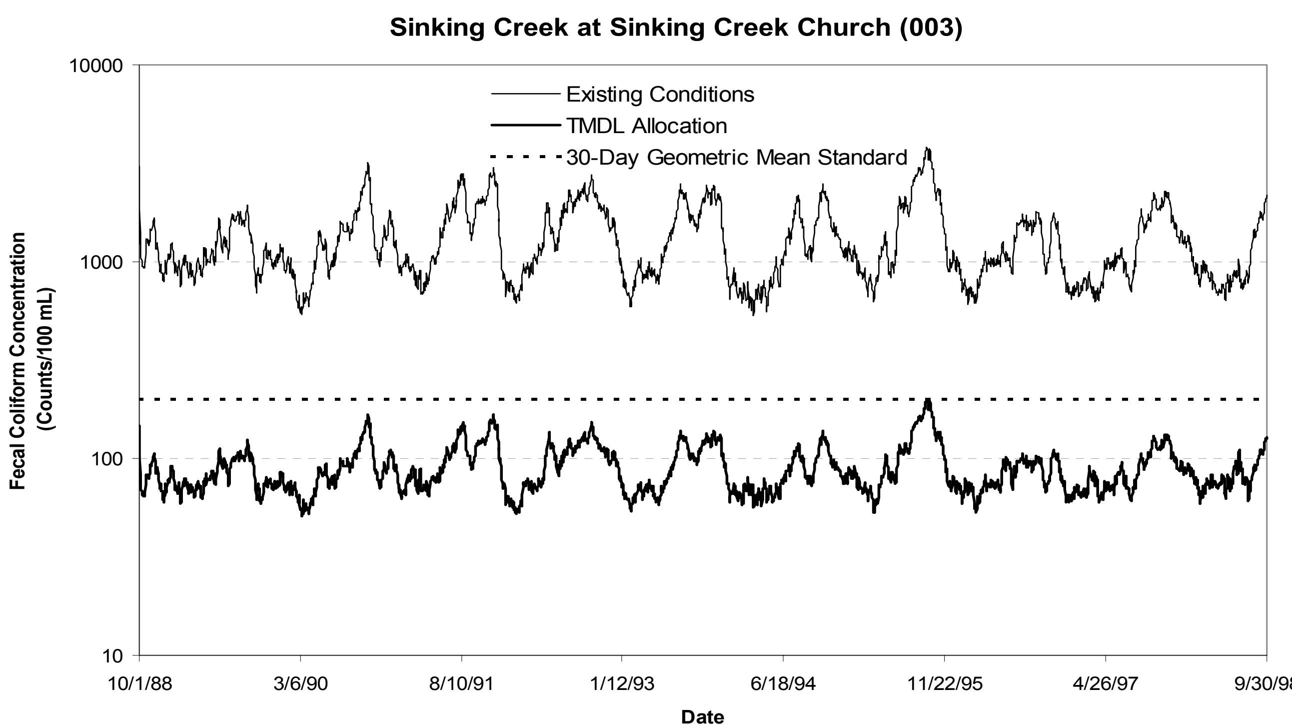

Figure D4. Sinking Creek model simulation of existing conditions versus TMDL allocation (log scale) at Sinking Creek Church (003), (30-day geometric means).

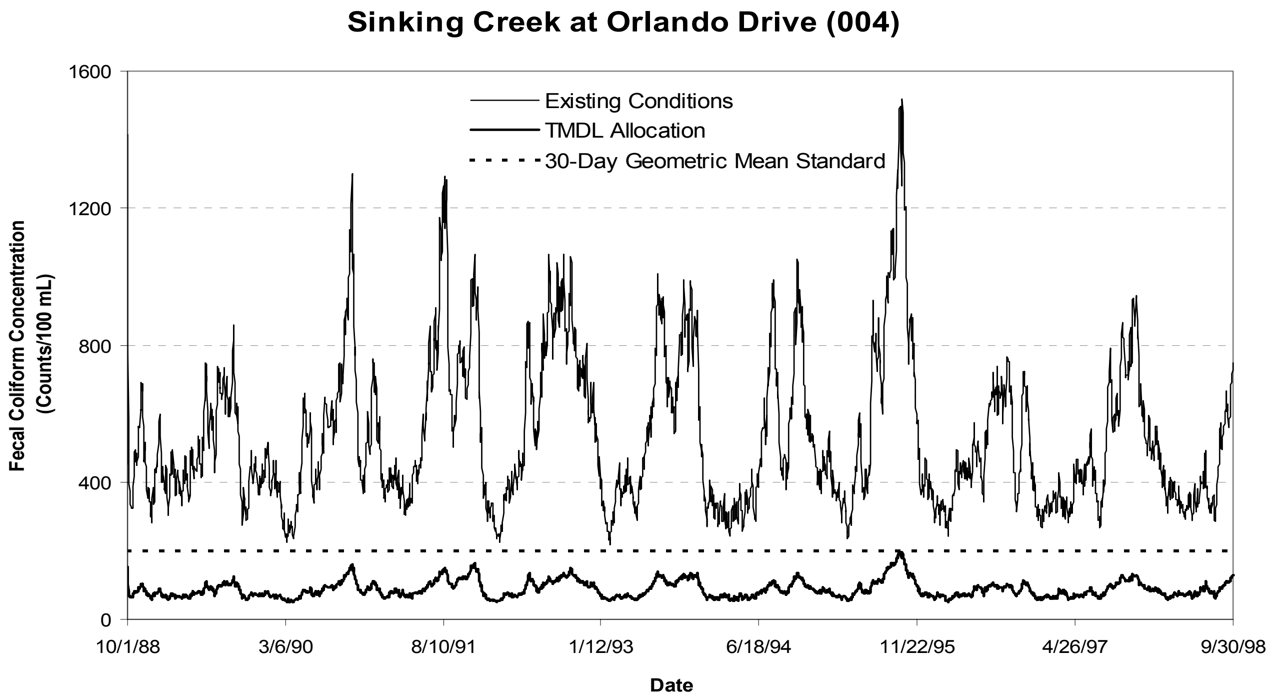

Figure D5. Sinking Creek model simulation of existing conditions versus TMDL allocation at Orlando Drive (004), (30-day geometric means).

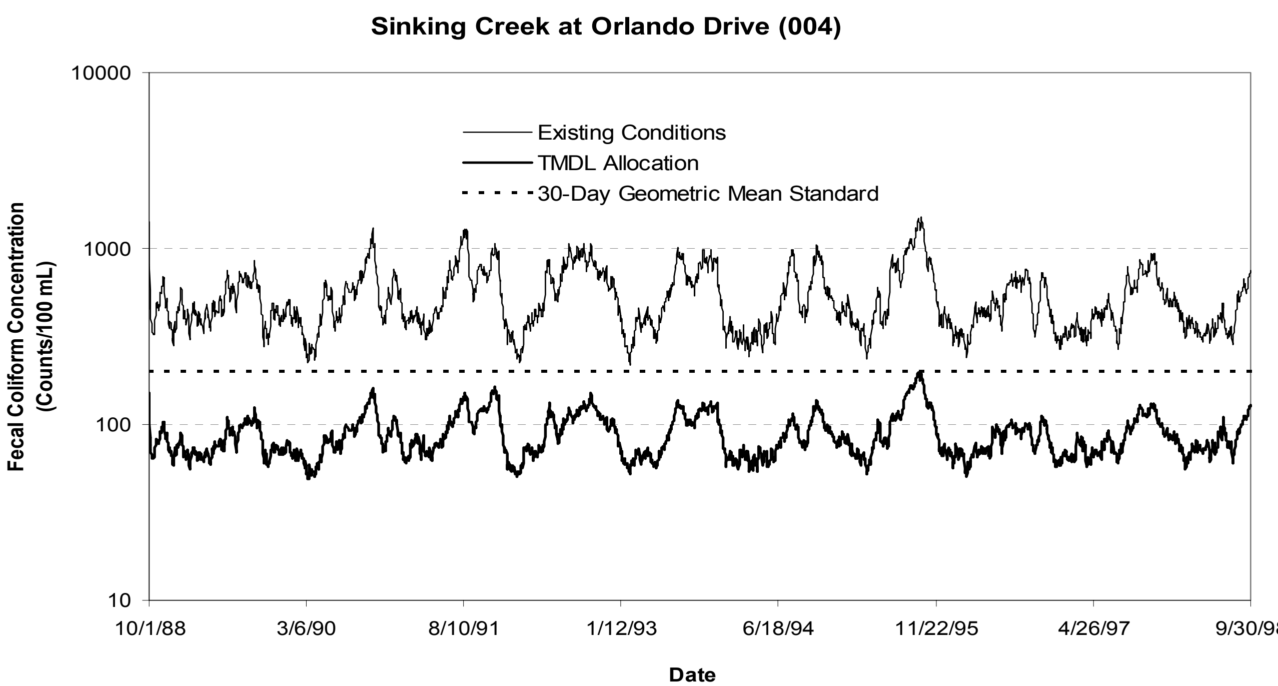

Figure D6. Sinking Creek model simulation of existing conditions versus TMDL allocation (log scale) at Orlando Drive (004), (30-day geometric means).

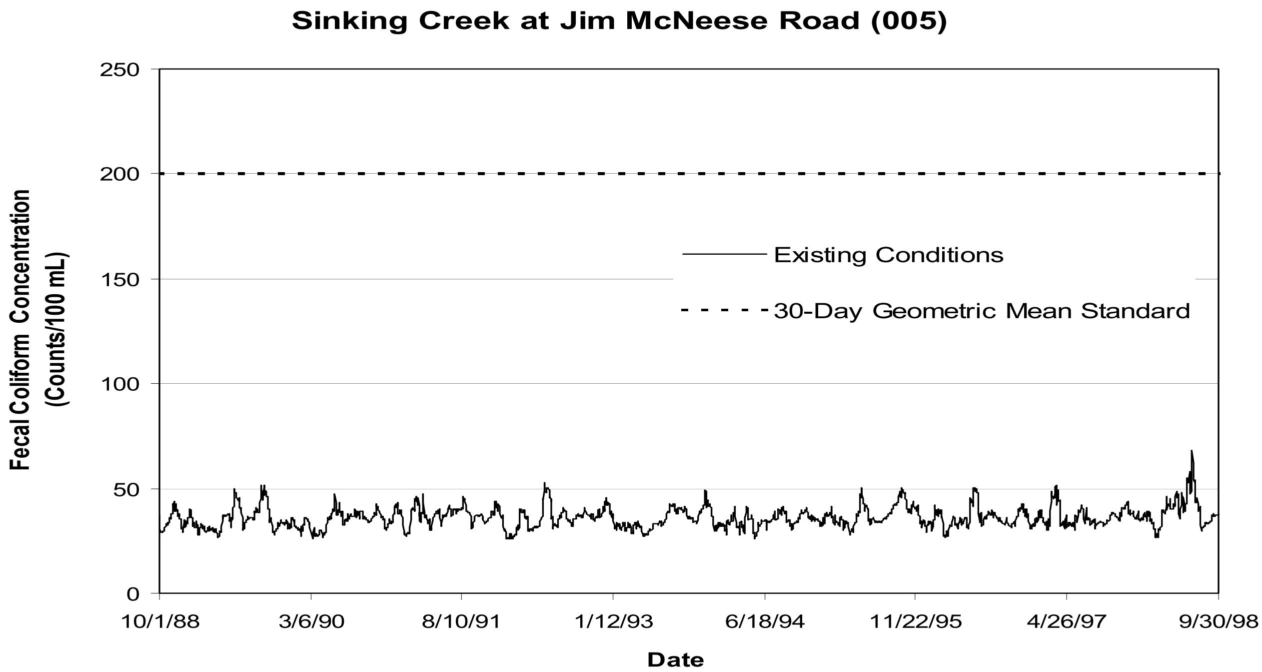

Figure D7. Sinking Creek model simulation of existing conditions at Jim McNeese Road (005), (30-day geometric means).

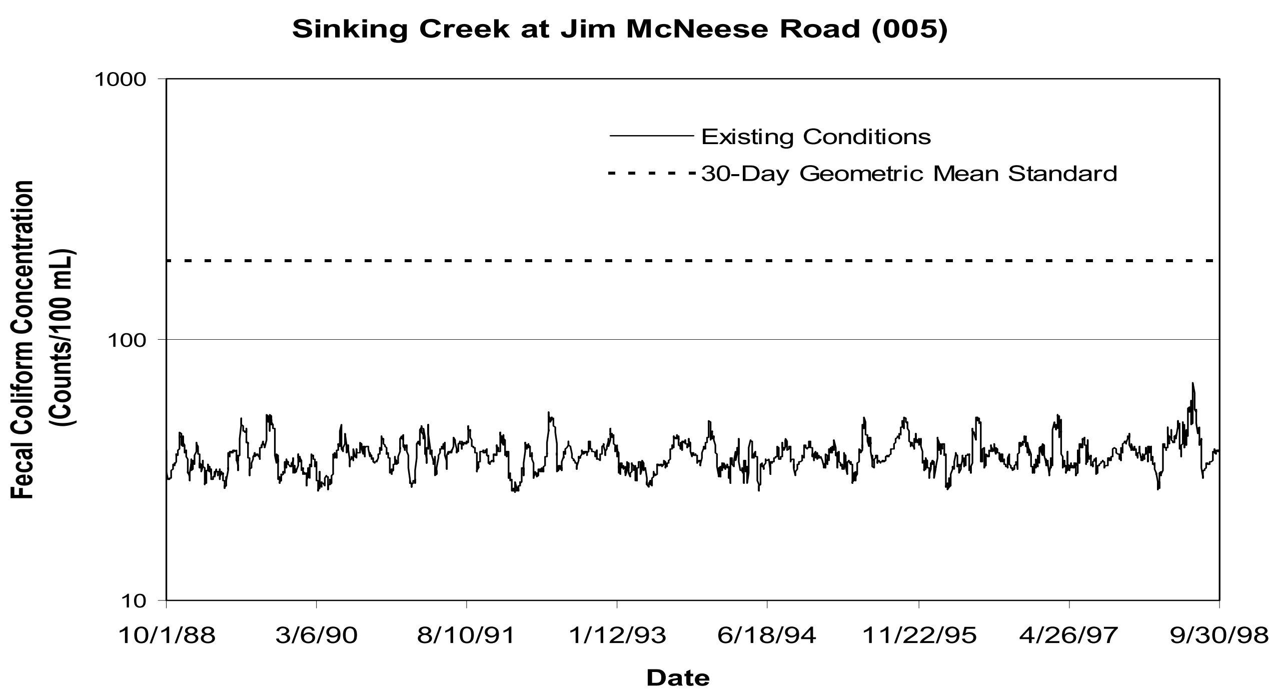

Figure D8. Sinking Creek model simulation of existing conditions (log scale) at Jim McNeese Road (005), (30-day geometric means).

APPENDIX E

PUBLIC NOTICE OF PROPOSED TOTAL MAXIMUM DAILY LOAD (TMDL) FOR FECAL COLIFORM IN SINKING CREEK

DIVISION OF WATER POLLUTION CONTROL

PUBLIC NOTICE OF AVAILABILITY OF FECAL COLIFORM TOTAL MAXIMUM DAILY LOAD (TMDL) FOR SINKING CREEK, WATAUGA RIVER WATERSHED (HUC 06010103), TENNESSEE

Announcement is hereby given of the availability of Tennessee's proposed total maximum daily load (TMDL) for fecal coliform for the Sinking Creek watershed, which drains to Watauga River at approximately river mile 19.9. 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.

Sinking Creek is listed on Tennessee's final 1998 303(d) list as not supporting its designated use classifications due, in part, to discharge of fecal coliforms resulting from Urban runoff/stormwater and Pastureland. The TMDL utilizes Tennessee's general water quality criteria, recently collected site specific water quality data, continuous flow data from a USGS discharge monitoring station located in the watershed, and a calibrated dynamic water quality model to establish allowable loadings of fecal coliform which will result in reduced in-stream concentrations and attainment of water quality standards. The TMDL requires reductions of approximately 95% for Sinking Creek.

The proposed Sinking Creek fecal coliform TMDL can be downloaded from the following 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:

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

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

Persons wishing to comment on the proposed TMDL are invited to submit their comments in writing no later than September 25, 2000 to:

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

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

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

APPENDIX F

RESPONSE TO PUBLIC COMMENTS FOR PROPOSED TOTAL MAXIMUM DAILY LOAD (TMDL) FOR FECAL COLIFORM IN SINKING CREEK

Comments received on the Proposed TMDL for Fecal Coliform in Sinking Creek

The following is an unedited electronic transmittal of the one set of comments received during the public notice period. The bolded, underlined numbers have been inserted as a guide to responses to the comments, which follow.

September 25, 2000

BY EMAIL AND U.S. MAIL

Sherry H. Wang, Ph.D.
Tennessee Department of Environment and Conservation
Division of Water Pollution Control
Watershed Management Section
7th Floor, L&C Annex
401 Church Street
Nashville, TN 37243-1534

Re: Sinking Creek TMDL

Dear Sherry,

I am writing to comment on the Sinking Creek TMDL located in the Watauga River watershed for fecal coliform, dated August 21, 2000. Despite some strong components in this TMDL-based watershed restoration plan, this TMDL (very similar to the Nonconnah TMDL issued last year) is not designed to attain compliance with water quality standards in Sinking Creek. Overall, I strongly urge TDEC to revise this TMDL so that it is designed with the goal of attaining compliance with the fecal coliform water quality standard in mind. This is not even a Phase One TMDL because there is no indication it is designed to come into compliance with the water quality standard for fecal coliform. It should be called something like a 'watershed characterization' which recognizes the need for additional monitoring before trying to fit it all together in an actual TMDL designed to achieve compliance with water quality standards.

I will provide some overall comments before specific comments on certain sections of the draft TMDL.

<u>1</u>)1. Overall the draft TMDL appears to be a good effort of modeling and attempts to address land use and identify most potential sources of fecal coliform.
<u>2</u>)2. There no mention of the Quality Assurance/Quality Control measures, such as holding times, labs, etc. utilized in collecting the water quality data. For example, the maximum six hour holding time was found to be a problem with the Nonconnah draft TMDL for fecal coliform.
<u>3</u>)3. There are documents that were either not referenced or used in this draft TMDL such as: an ETSU study mentioning improvements of the fecal problem; sampling information for "potential delisting, and a Boone Watershed report from March 1999 with data that appear to have not been used indicating some high fecal in water and sediments as well as a discussion of data and recommendation of use of optical brightner for determining fecal sources.
<u>4</u>)4. We should note that according to the fecal coliform data on Page 21, newer data (though it does not comply with the standard 10 samples/month) collected in 1994 AND 1999 indicates fewer violations. If the problems in this watershed have decreased or no longer meet criteria for listing on the 303(d) list, this needs to be clarified.
<u>5</u>)5. TCWN would also like to clarify that this TMDL addresses both the 200 standard as well as the 1000 chronic standard for fecal coliform.

Our specific concerns are outlined below.

Executive Summary
6)1. We are pleased by the inclusion of the Executive Summary that is very helpful to providing an overview of a fairly technical document that follows. TCWN suggest the following improvements be made to the Executive Summary to enable citizens and local governments to better understand the general findings and conclusions of the TMDL. In general, many citizens will not have the time to review the entire TMDL and the Executive Summary will serve as the primary overview of the document.

* Subheadings within the Executive Summary would be helpful such as: What is a TMDL?, About Sinking Creek, The Fecal Coliform Standard, How TDEC Analyzed the Fecal Coliform Problem in Sinking Creek, Our Results, Sources of Contribution, Reductions Need From Sources to Meet Water Quality Standards, Recommended Strategies.

* The actual Total Maximum Daily Load for Sinking Creek needs to be included in the Executive Summary and highlighted

7)4. This TMDL addresses only fecal coliform (FC). There is no mention of how or whether this TMDL addresses Tennessee's E. Coli standard.

8)5. The land use data covering 1990-1993 is fairly old. It would appear that more updated information would be available or at least some ground-truthing of whether this land use data is still applicable.

9)6. There is mention in the Executive Summary of direct in-stream sources such as failing septic systems, leaking sewer lines, and straight pipes, but no apparent confirmation that they are actually contributing to the problem. TCWN would like TDEC to provide more information, to the extent available, about these sources. On page 6 of the draft TMDL, it states the following: "Unidentified point sources (e.g. illicit connections to the storm sewer system and straight pipes to the stream) are considered to be potential contributors of fecal coliform loading in the Sinking Creek watershed." Specifically, has TDEC or another agency/organization identified any specific sources? If so, why not eliminate these illicit connections immediately? Please provide any information collected about this source.

10)7. One NPDES permit has been identified in this TMDL, the Bosch Braking System (TN002500). According to the draft TMDL, "the facility is not permitting to discharge fecal coliform and is not expected to contribute fecal coliform to Sinking Creek; therefore, it will not be considered in this TMDL in terms of fecal coliform loading." Was it ever verified that this NPDES permittee does not discharge FC into Sinking Creek? Does TDEC know whether this sources has alternative means for disposing of its sewage?

11)8. There is no mention of past problems with the city's sewage pump stations in the area with respect to by-pass problems. It appears there is a New Sinking Creek Pump Station. Has this been fixed or still a possible source of FC?

Section 1.2

Maps (Figure 1 and 2)
12) We are pleased in the improvement in the maps provided by TDEC. We suggest that TDEC provide some other features provided on topographic maps such as roads so the public can better identify with the watershed. In addition, sewer pump stations should be included on the map as well.

Section 1.4

13) The water quality provided is a little old (1993-94). Newer data collected in 1999 is not enough to compare with standard since there were not 10 samples/month collected. In some cases, there was only two samples/month.

Table 2
14) This table shows a "mean" that does not indicate if it is a geometeric mean as required by the state standard (10 samples/month). If the table includes data that does not meet state standard requirement, this needs to be discussed and explained up front. TDEC could explain why they do not have adequate samples and that they are making some estimations. The reader, however, is left to figure out how TDEC has come up with the data provided in Table 2.

Section 2.1
15) Once again, has TDEC verified or made any analysis into whether pump stations and/or sewer leaks are sources of contribution in this watershed?

Section 2.2 Nonpoint Source Assessment
16)* While the data provided in subsections 1-4 is somewhat helpful, TCWN wonders whether TDEC has recently visited the watershed to determine whether these estimates essentially match the on-the-ground conditions. For example, TDEC estimates according to the 1997 agricultural census that there is only one hog in the entire watershed, 0 chickens, and 5 sheep according to estimates. How close are these estimations to reality?
17)* Are there any CAFOs in the area?
18)* TDEC even acknowledges that the "level of uncertainty in livestock distribution on the basis on county populations is high."
19)* The draft TMDL assumes that 100 percent of the dairy cattle waste is collected and applied equally to pasture and cropland in the watershed. This assumes no runoff during dry weather. Has that been confirmed? How about during wet weather?
20)* TCWN is similarly concerned with Section 2.2.5 "Failing Septic Systems." Has TDEC obtained any real information from the County Health Department as to the occurrence of septic tanks or are all of the numbers in Table 4 an estimate?
21)* Section 2.2.6 indicates that some overflowing sanitary sewer problems have been corrected. This indicates that some overflowing sanitary sewer problems have not been corrected, or is it just that straight pipes and leaking collection systems might not have been corrected?

Section 5.0 Allocation
22)* TDEC should clarify that the TMDL value is only for the geometric mean standard and not for the maximum standard.
23)* The TMDL should not only provide a value at the "bottom of the watershed" but also with the protection of standards upstream and its tributaries.

Section 5.3 Load Allocations
24) It is unclear what local allocation is given to illegal sources in this section. Illegal sources should get an allocation of zero. This needs to be clarified. Also, straight pipes might be better considered as point sources rather than as part of the non-point LA.

Section 5.5 Margin of Safety
25) An explicit Margin of Safety is needed in this TMDL or TDEC should better justify why they are using an implicit MOS. An explicit MOS should be established because TDEC did not use, or at least identify, conservative model assumptions to develop allocations. In other words, the draft TMDL for Sinking Creek was specifically designed to address critical conditions in the watershed. It cannot therefore be claimed as incorporating an MOS without specifically identifying them. On page 37, the "summary sheet" also indicates that "conservative modeling assumptions" were used to determine the implicit MOS. We do not believe this is supported in the document.

Section 6.0
26) As we suggested in our overall comments, this TMDL will not address the water quality problems in Sinking Creek. The implementation strategy following the TMDL is most certainly needed but more efforts must be made to directly address the water quality impairment issues.

Section 6.1 Monitoring
27) It is unclear in this section exactly when future water quality monitoring data will be collected according to the watershed cycle. This needs to be clarified.

28) In addition, the future monitoring plans are for monthly samples and one winter month of intensive sampling. This will not yield enough data for the geometric mean standard determination or for checking the critical summer condition. The water quality monitoring program should therefore be revised.

Section 6.3 Phase 2 Stormwater Permit
29) If the stormwater permit is a source of fecal coliform, then the source needs to be addressed before 2003. Real fecal coliform limits should be incorporated into this permit.

30) The implementation strategy for this TMDL would appear to rest entirely upon the development of the City of Johnson City Phase 2 Stormwater permit program. While it is entirely possible the Johnson City SWQMP could achieve a reduction in the discharge of fecal coliform to Sinking Creek, it is beyond belief that anyone could expect that reduction to amount to the 86-96% figure required by this TMDL.

Page 37
31) We appreciate the summary sheet and suggest that it be moved up to following the Executive Summary.

32) The TMDL (1.212 x 1012 counts per 30 days) given should indicated is the value for the geometric mean standards and not the maximum standard.

Conclusion
33) The draft TMDL, even if completely implemented, is not designed to comply with water quality standards. While there is some mention of a possible Stage II TMDL to address other contributing factors, the iterative or phased TMDL process is suitable only when the initial phase is designed to at least theoretically attain compliance with water quality standards. This approach is intended to allow for uncertainty in good faith efforts to attain compliance. It is not intended to justify the proposal of partial TMDLs that have no chance of reaching that goal. **34)**The first step in most TMDL-based recovery plans will be the collection of additional data to confirm an impairment, identify sources of pollutants and determine the extent of their contribution to the problem. that step was skipped in this instance, though the problem description based on existing data was commendable.

Thank you for the opportunity to submit these comments.

Sincerely,

Danielle Droitsch
Executive Director

DCD

cc:

Tony Able, EPA Region 4
Richard Parrish, Southern Environmental Law Center
Barry W. Sulkin, Tennessee Environmental Council
Sierra Club, Franklin Chapter

Response to Comments Received on the Proposed TMDL for Fecal Coliform in Sinking Creek

1. The Division acknowledges and appreciates the comment.

2. The six-hour holding time was not a problem with the Fecal Coliform TMDL for Nonconnah Creek. The original comment, as transcribed in abbreviated form in the summary of comments in the Division's formal submittal to EPA, dated October 12, 1999, is reiterated as follows: *"For the data for which documentation was available, there appear to be sampling protocol problems. For unrelated sites, some samples were held beyond allowable holding times. A few lab sheets faxed from the Memphis Field Office showed both the sample and analysis dates. Some samples were taken on one day and the test run on the next, thus exceeding the holding time and invalidating the results."* The Division's response to the aforementioned comment, included in the summary of comments in the formal submittal to EPA (October 12, 1999) stated, *"According to the Division of Water Pollution Control's Environmental Field Office Manager in Memphis, all water quality samples utilized in the TMDLs met sample holding times and sampling protocols were followed. In addition, according to personnel at the State Analytical Laboratory in Nashville, TN, the fecal coliform test is a 24-hour test. When the sample is received, a reagent is added and the sample is incubated for 24 hours prior to the analysis. Therefore, the test date must be 24 hours later than the collection and received (by Lab) dates for all samples which met holding times*." Likewise, according to the Division's Environmental Assistance Center Manager in Johnson City, all Sinking Creek fecal coliform samples met sample holding times and sampling protocols were followed.

3. The documents referred to, and the data contained therein, were evaluated as part of the Sinking Creek fecal coliform TMDL development. However, no significant findings resulted from this evaluation. Some of the reasons the documents were not referenced include the following:

   Monitoring sites were established by ETSU only in the upper reaches of Sinking Creek. The most downstream site in the ETSU study was approximately 1.5 miles upstream from the Orlando Drive monitoring station at the outlet of subwatershed 004. Therefore, most of the fecal coliform loading resulting in impairment of Sinking Creek was not represented by ETSU monitoring sites.

   The data "indicating some high fecal in water and sediments" were not contradictory to the data collected by the State of Tennessee and utilized for the TMDL. High fecal coliform concentrations are to be expected in sediments in the vicinity of chronically high fecal coliform concentrations in water due to the fact that there is significant uptake and release (exchange) between streambed sediments and the water column.

   The data did not show significant correlations between fecal coliform and optical brighteners at any of the ETSU Sinking Creek sampling sites (R^2 values range from 0.0071 to 0.1258); therefore, the results were inconclusive, at best.

   Lastly, at the three ETSU sampling sites on Sinking Creek, 25-80% of samples exceed 200 counts/100 ml and 12.5-50% of samples exceed 1000 counts/100 ml; therefore, the data do not support "potential delisting". In addition, the ETSU data were not collected with sufficient frequency to support the 30-day geometric mean standard of a minimum of 10 samples collected within a 30-day period to support posting or delisting of a waterbody.

4. The data collected in 1994 were utilized in the calibration of the water quality model and the TMDL evaluation. The watershed continues to meet the criteria for listing on the 303(d) list until it can be demonstrated that water quality does not violate water quality standards. As stated in Section 3.4, "precipitation data were not available for 1999 in a usable format for NPSM/HSPF model input; therefore, these recent data could not be used for model calibration." It is inconclusive whether problems in the watershed have decreased based on the 1999 data. This may be clarified in subsequent TMDL evaluations.

5. As stated in Section 1.3, "For this TMDL, the fecal coliform 30-day geometric mean standard for Recreation is the target level to evaluate impairment and establish the TMDL." This is in accordance with EPA's established

protocol for fecal coliform TMDLs. However, it remains a requirement to achieve the maximum level of 1000 counts/100 ml according to water quality standards.

6. The Division does not believe the incorporation of subheadings in the Executive Summary would significantly improve the public's level of understanding. However, the TMDL value will be included in the Executive Summary as requested.

7. To date, insufficient data have been collected to evaluate water quality with respect to E. coli in the Sinking Creek watershed. The State of Tennessee now routinely collects E. coli samples concurrently with fecal coliform and will consider both in future evaluations. Currently, evaluation of fecal coliform only is in accordance with EPA's guidance.

8. The land use data for the period 1990-1993 became available to the Division in GIS format in 1999. Until that time, land use data from the 1970s was the most recent available. The TMDL implementation plan calls for ground-truthing in terms of verification and refinement of source estimates. In addition, Section 6.2 states, "a significant component of the implementation strategy for addressing fecal coliform exceedances in Sinking Creek is collection of data by field reconnaissance."

9. Straight pipe connections to the stream have been identified and corrected. Other sources are suspected. A septic system survey, which has not been conducted, is recommended. In addition, the implementation plan calls for additional efforts to identify sources (see Section 6.2). The sources must be identified before they can be eliminated.

10. NPDES permit number TN002500 does not authorize discharge of fecal coliform to Sinking Creek or any other waterbody.

11. Historical problems and overflows have been documented at the old Sinking Creek Pump Station. The Division is not aware of similar problems with the New Sinking Creek Pump Station; however, leaking sewer lines are suspected and there remains at least the potential for overflows. In addition, bypass problems are not within the scope of this TMDL because sewage treatment plants are not located in, nor do they discharge to, the Sinking Creek watershed.

12. The comment has been duly noted and consideration will be given to providing further improvements to maps in subsequent TMDLs.

13. According to EPA's *Guidance for Water Quality-based Decisions: The TMDL Process*, *EPA 440/4-91-001, April 1991*, "Lack of information about certain types of pollution problems (for example, those associated with nonpoint sources or with certain toxic pollutants) should not be used as a reason to delay implementation of water quality-based controls." EPA's *Report of the Federal Advisory Committee on the Total Maximum Daily Load (TMDL) Program, EPA 100-R-98-006, July 1998*, states, "lack of certainty must not delay TMDL development". The implementation plan calls for additional and expanded monitoring to support refinements to the TMDL evaluation.

14. A footnote has been added to Table 2 to indicate that the mean is the arithmetic mean. The purpose of the table is to provide data statistics summarizing the actual data provided in Appendix A (as referenced in the first sentence of Section 1.4). The reader can examine the data in the Appendix A. In addition, geometric means have been included in Appendix A where adequate samples are available. Lastly, there are no estimations made or implied in the Table 2.

15. See response number 11, above.

16. Section 2.2.2 states, "in a small watershed such as Sinking Creek, the level of uncertainty in livestock distribution on the basis of county populations is high." The implementation plan, Section 6.2, calls for field surveys to verify or refine these estimates.

17. There are no permitted CAFOs in the Sinking Creek watershed.

18. Yes. See response number 16, above.

19. Runoff is generated by precipitation; therefore, by definition, runoff does not occur during dry weather. Unless manure is applied directly to a stream or it is conveyed (after application) by some other means (e.g., wind), it will not enter the stream during dry weather. During wet weather it is a potential source, particularly in close proximity to streams.

20. Section 2.2.5 states, "Table 4 shows **estimates** from county census data of people in the Sinking Creek watershed on septic systems." In addition, a footnote to the table states that the numbers reported for failing septic systems are "**Estimated/assumed**". To the Division's knowledge, the Washington and Carter County Health Departments and the State Division of Groundwater Protection have not conducted septic system surveys. The implementation plan recommends this in Section 6.2.

21. There is no intended implication that overflowing sanitary sewer problems have not been corrected. Section 2.2.6 uses the terms "potentially attributable" and "possible sources" to describe the three sources referred to in the reviewer's comment. Though some occurrences have been identified and corrected, some may not have been identified and/or corrected.

22. As stated in Section 1.3, "For this TMDL, the fecal coliform 30-day geometric mean standard for Recreation is the target level to evaluate impairment and establish the TMDL." This is in accordance with EPA's established protocol for fecal coliform TMDLs. However, it remains a requirement to achieve the maximum level of 1000 counts/100 ml according to water quality standards. In addition, see response number 32, below.

23. Table E2 has been split into two tables, E2 and E3. Table E3 presents the TMDL allocation water quality model results and has been expanded to provide a TMDL value at each monitored location on Sinking Creek.

24. Illegal sources are to be identified and eliminated. Therefore, the allocation is zero (0). If straight pipes were permitted to discharge fecal coliform to the stream, they would be allocated a load as Waste Load Allocation (WLA). However, they are required to be eliminated; therefore, their allocation would also be zero. Any future permitted point source discharges would be required to meet end-of-pipe criteria for fecal coliform.

25. Conservative model assumptions were used to develop the TMDL and subsequent allocations. The TMDL will be revised to more thoroughly describe the conservative model assumptions to support an implicit margin of safety.

26. As stated in number 9, above, the implementation plan calls for additional efforts to identify sources (see Section 6.2). The sources must be identified before they can be eliminated. According to EPA's *Water Quality Guidance for the Great Lakes System: Supplementary Information Document (SID), EPA-820-B-95-001, March 1995, Section VIII.C, Total Maximum Daily Loads*, "The phased approach to TMDL development is an iterative process that provides for pollution reduction while the regulatory agency collects and uses new monitoring data and the demonstrated performance of existing controls to evaluate the TMDL and revise it as necessary. TMDLs established using the phased approach are based on best available information, sound professional judgment, and a margin of safety to account for uncertainty in available data and the anticipated relationship between controls, loading reductions, and predicted changes in water quality."

27. Section 6.1 states, "a watershed TMDL is developed one or two years prior to commencement of the next cycle's monitoring period." For Sinking Creek, water quality data are scheduled to be collected in 2002 with additional data possibly to be collected in 2001 or 2003.

28. Section 6.1 states, "monitoring should be **expanded** to provide water quality information to characterize seasonal trends and refined source identification and delineation" and "Recommended monitoring for the Sinking Creek watershed **includes** monthly grab samples and intensive sampling for one month during the wet

season." This section describes efforts recommended in addition to current monitoring efforts; therefore, the geometric mean standard will continue to be supported and the critical summer condition will be monitored.

29. Section 6.2 addresses source identification by the city of Johnson City, among other agencies. City managers have the responsibility to address known problems resulting in contributions of pollutants to Sinking Creek. The Division has the authority to enforce this. Traditionally, NPDES permits in Tennessee do not contain storm water pollutant limits unless specified by an applicable section of 40 CFR effluent guidelines for a particular industry.

30. The city of Johnson City Phase 2 Stormwater permit will require a stormwater management program that does not cause or contribute to violations of State water quality standards of receiving streams and reduces the discharge of pollutants to the maximum extent practicable. Septic system failures and unidentified sources, mostly beyond the responsibility of the Johnson City Phase 2 Stormwater permit, are also significant contributors of fecal coliform to Sinking Creek and major components of the implementation strategy.

31. The Summary Sheet has been moved to the front of the document.

32. Section 1.3, Water Quality Target, states, "For this TMDL, the fecal coliform 30-day geometric mean standard for Recreation is the target level to evaluate impairment and establish the TMDL." Section 4.2, Critical Conditions, states, "Table 6 shows the maximum 30-day geometric mean fecal coliform concentrations at each of the four modeled segments/subwatersheds and the corresponding levels of reduction required to achieve the 30-day geometric mean standard of 200 counts/100 ml at each." In addition, Section 5.1, Total Maximum Daily Load, will be expanded to clarify that the TMDL value is for the 30-day geometric mean standard.

33. The TMDL represents the maximum fecal coliform load that can be assimilated by the stream during the critical 30-day period while maintaining the fecal coliform water quality standard of 200 counts/100 ml. The loading reductions specified are designed to bring Sinking Creek water quality into compliance with water quality standards at all times. See response number 26, above.

34. The items (step) described as missing by the reviewer, "collection of additional data to confirm an impairment, identify sources of pollutants and determine the extent of their contribution", are all included in the TMDL implementation plan.