Total Maximum Daily Load

Evaluation

for

Nineteen Stream Segments

in the

Tennessee River Basin

for

Fecal Coliform

Submitted to:
The U.S. Environmental Protection Agency
Region 4
Atlanta, Georgia

Submitted by:
The Georgia Department of Natural Resources
Environmental Protection Division
Atlanta, Georgia

January 2004

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EXECUTIVE SUMMARY

The State of Georgia assesses its water bodies for compliance with water quality standards criteria established for their designated uses as required by the Federal Clean Water Act (CWA). Assessed water bodies are placed into one of three categories with respect to designated uses: 1) supporting, 2) partially supporting, or 3) not supporting. These water bodies are found on Georgia's 305(b) list as required by that section of the CWA that defines the assessment process, and are published in *Water Quality in Georgia* every two years (GA EPD 2000-2001).

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

The State of Georgia has identified nineteen (19) stream segments located in the Tennessee River Basin as water quality limited due to fecal coliform. A stream is placed on the partial support list if more than 10% of the samples exceed the fecal coliform criteria and on the not support list if more than 25% of the samples exceed the standard. Water quality samples collected within a 30-day period that have a geometric mean in excess of 200 counts per 100 milliliters during the period May through October, or in excess of 1000 counts per 100 milliliters during the period November through April are in violation of the bacteria water quality standard. There is also a single sample maximum criteria (4000 counts per 100 milliliters) for the months of November through April. The water use classifications of all of the impacted streams are Fishing, or Recreation.

An important part of the TMDL analysis is the identification of potential source categories. Sources are broadly classified as either point or nonpoint sources. A point source is defined as a discernable, confined, and discrete conveyance from which pollutants are or may be discharged to surface waters. Nonpoint sources are diffuse, and generally, but not always, involve accumulation of fecal coliform bacteria on land surfaces that wash off as a result of storm events.

The process of developing fecal coliform TMDLs for the Tennessee River Basin listed segments includes the determination of the following:

- The current critical fecal coliform load to the stream under existing conditions;
- The TMDL for similar conditions under which the current load was determined; and
- The percent reduction in the current critical fecal coliform load necessary to achieve the TMDL.

The calculation of the fecal coliform load at any point in a stream requires the fecal coliform concentration and stream flow. The availability of water quality and flow data varies considerably among the listed segments. Two different approaches were used depending on data availability: Loading Curve Approach and Equivalent Site Approach. The fecal coliform loads and required reductions for each of the listed segments are summarized in the table below.

Fecal Loads and Required Fecal Load Reductions

Stream Segment	Current Load (counts/ 30 days)	TMDL Components					Percent Reduction
		WLA (counts/ 30 days)	WLAsw (counts/ 30 days)	LA (counts/ 30 days)	MOS (counts/ 30 days)	TMDL (counts/ 30 days)	
Butternut Creek	5.36E+12	5.73E+10		1.35E+12	1.57E+11	1.57E+12	71
Chattanooga Creek - High Point to Flintstone	1.08E+13		2.22E+11	2.27E+12	2.76E+11	2.76E+12	74
Chattanooga Creek - Flintstone to Stateline	1.05E+13		2.93E+11	3.34E+12	4.04E+11	4.04E+12	61
Dry Creek	9.59E+12		5.78E+11	3.56E+11	1.04E+11	1.04E+12	89
East Chickamauga Creek	1.74E+13		1.65E+11	3.53E+12	4.11E+11	4.11E+12	76
Fightingtown Creek	6.41E+13			1.75E+13	1.95E+12	1.95E+13	70
Hemptown Creek	2.13E+13			4.76E+12	5.28E+11	5.28E+12	75
Little Tennessee River	4.14E+13	1.00E+10		1.17E+13	1.30E+12	1.30E+13	69
Lookout Creek	1.10E+13	5.01E+10		6.16E+12	6.90E+11	6.90E+12	37
McFarland Branch	1.98E+13		6.51E+10	8.36E+10	1.65E+10	1.65E+11	99
Nottely River - Right/Left Forks to US Hwy 19	1.97E+13			3.07E+12	3.41E+11	3.41E+12	83
Nottely River - US Hwy 19 to Lake Nottely	3.34E+13			8.92E+12	9.91E+11	9.91E+12	70
Peavine Creek	1.22E+13		6.67E+11	2.90E+12	3.96E+11	3.96E+12	68
South Chickamauga Creek	6.04E+13	1.51E+11	1.22E+12	1.44E+13	1.75E+12	1.75E+13	71
Tiger Creek	7.05E+12		7.26E+10	2.17E+12	2.50E+11	2.50E+12	65
Toccoa River	3.00E+14	1.62E+11		4.59E+13	5.12E+12	5.12E+13	83
West Chickamauga Creek - Mill Creek to Crawfish Creek	4.72E+16	2.69E+11	4.33E+13	3.10E+15	3.49E+14	3.49E+15	93
West Chickamauga Creek - Hwy 2 to Stateline	2.74E+14		6.45E+12	3.93E+13	5.08E+12	5.08E+13	81
Youngcane Creek	6.25E+12			1.52E+12	1.69E+11	1.69E+12	73

Management practices that may be used to help reduce fecal coliform source loads include:

- Compliance with NPDES permit limits and requirements;
- Adoption of NRCS Conservation Practices; and
- Application of Best Management Practices (BMPs) appropriate to reduce nonpoint sources.

The amount of fecal coliform delivered to a stream is difficult to determine. However, by requiring and monitoring the implementation of these management practices, their effects will improve stream water quality, and represent a beneficial measure of TMDL implementation.

1.0 INTRODUCTION

1.1 Background

The State of Georgia assesses its water bodies for compliance with water quality standards criteria established for their designated uses as required by the Federal Clean Water Act (CWA). Assessed water bodies are placed into one of three categories with respect to designated uses: 1) supporting, 2) partially supporting, or 3) not supporting. These water bodies are found on Georgia's 305(b) list as required by that section of the CWA that addresses the assessment process, and are published in *Water Quality in Georgia* every two years (GA EPD, 2000-2001).

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

The Environmental Protection Agency (EPA) Region 4 approved Georgia's final 2002 303(d) list on April 30, 2002. The list identifies the waterbodies as either partially supporting or not supporting their designated use classifications, due to exceedances of water quality standards for fecal coliform bacteria. Fecal coliform bacteria are used as an indicator of the potential presence of pathogens in a stream. Table 1 presents the streams of the Tennessee River Basin included on the 303(d) list for exceedances of the fecal coliform standard criteria. A total of 13 stream segments were listed as partially supporting their designated use, and 6 stream segments were listed as not supporting their designated use.

1.2 Watershed Description

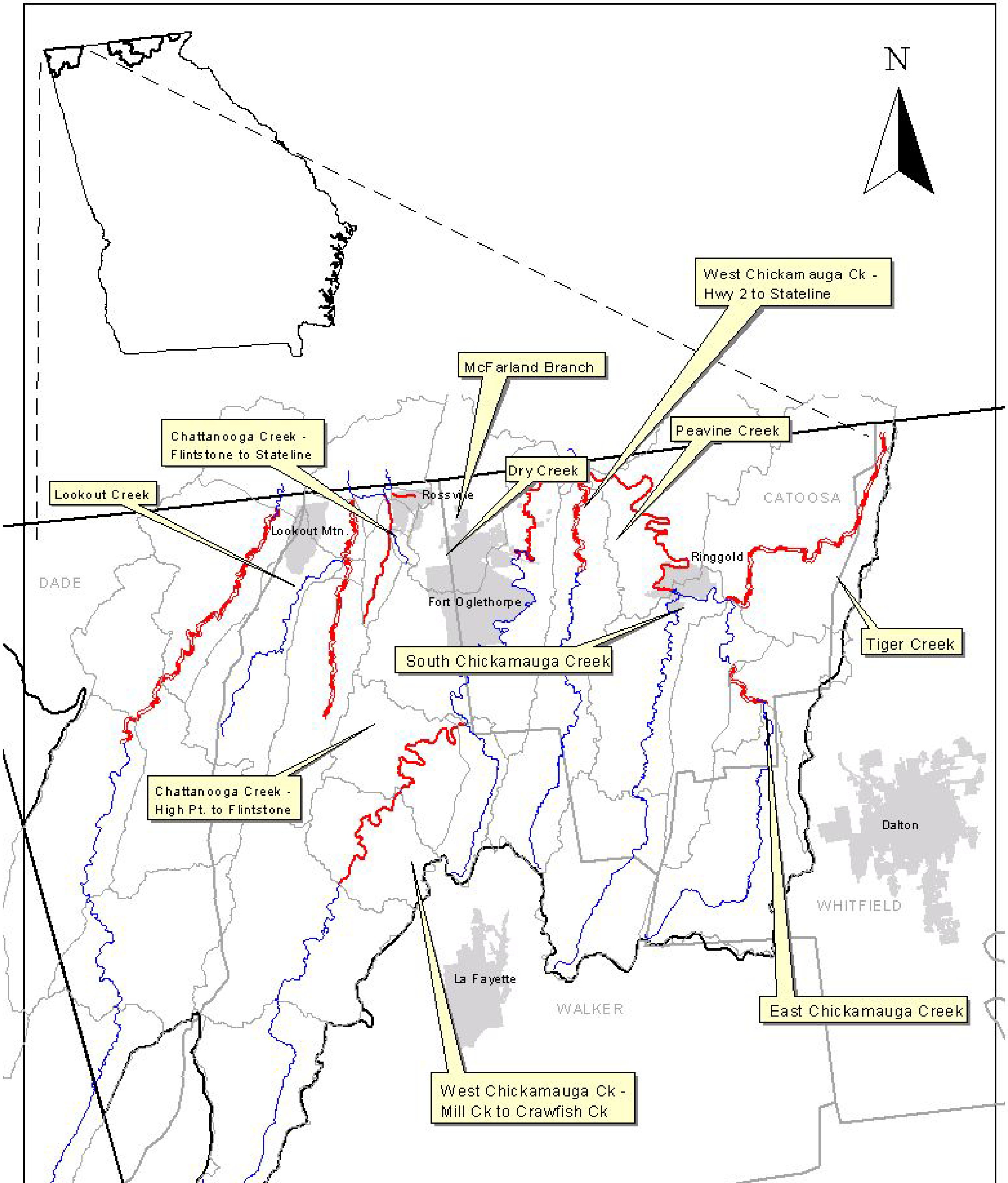
The Tennessee River originates in southwest Virginia and flows southwest across Tennessee and through Chattanooga, just north of the Georgia-Tennessee state line. It then continues into Alabama. Major tributaries of the Tennessee River are located in north Georgia. Lookout Creek, West Chickamauga Creek and Little Chickamauga Creek originate in the northwest corner of Georgia. Lookout Creek flows north into Tennessee and joins the Tennessee River in southwest Chattanooga. West Chickamauga Creek and Little Chickamauga Creek merge near the Georgia-Tennessee border, forming Chickamauga Creek, which continues north and flows into the Tennessee River in Chattanooga. Further east, the Toccoa River flows north from Georgia into Tennessee, where it is renamed the Ocoee River and continues north to the Tennessee River. The Nottely River and Brasstown Creek originate in Georgia and also flow north to the Tennessee River. The headwaters of the Little Tennessee River originate in the northeast corner of Georgia. The Little Tennessee flows north, then northwest where it joins the Tennessee River. The Tennessee River Basin contains parts of the Cumberland Plateau, Ridge and Valley, and Blue Ridge physiographic provinces that extend throughout the southeastern United States.

The USGS has divided the Georgia portion of the Tennessee basin into four sub-basins, or Hydrologic Unit Codes (HUCs). Figure 1 shows the location of the impaired stream segments and their associated watersheds in HUC 06020001, and Figure 2 shows the location of the impaired stream segments and associated watersheds in HUCs 06020002, 06020003, and 06010202.

Table 1. Water Bodies Listed for Fecal Coliform Bacteria in the Tennessee River Basin

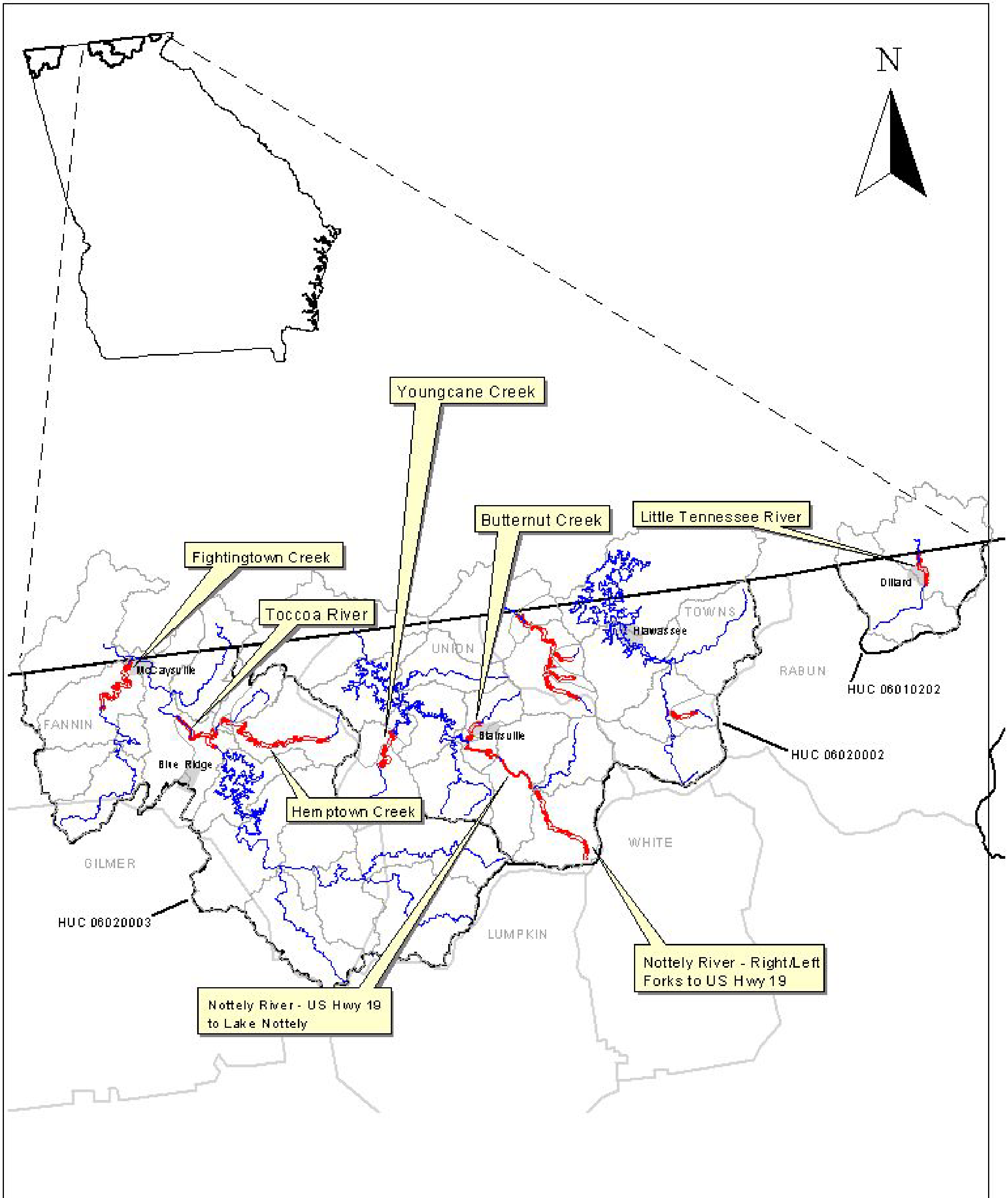
Stream Segment	Location	Segment Length (miles)	Designated Use	Listing
Butternut Creek	Blairsville (Union Co.)	2	Fishing	PS
Chattanooga Creek	High Point to Flintstone (Walker Co.)	7	Fishing	PS
Chattanooga Creek	Flintstone to Stateline (Walker Co.)	4	Fishing	PS
Dry Creek	Headwaters to State Line, Chattanooga Creek (Walker Co.)	5	Fishing	NS
East Chickamauga Creek	Tanyard Creek to Dry Creek (Catoosa Co.)	3	Fishing	PS
Fightingtown Creek	CR 159 to Stateline (Fannin Co.)	7	Fishing	PS
Hemptown Creek	Mitchell Branch to Young Stone Creek (Fannin Co.)	10	Fishing	PS
Little Tennessee River	Dillard to Stateline (Rabun Co.)	3	Fishing	PS
Lookout Creek	Trenton to Stateline (Dade Co.)	14	Fishing	PS
McFarland Branch	Rossville to Stateline (Walker Co.)	1	Fishing	NS
Nottely River	Right/Left Forks to US Hwy 19 (Union Co.)	6	Recreation	PS
Nottely River	US Hwy 19 to Lake Nottely (Union Co.)	8	Fishing	NS
Peavine Creek	Upstream South Chickamauga Creek (Catoosa Co.)	8	Fishing	PS
South Chickamauga Creek	Ringold to Stateline (Catoosa Co.)	15	Fishing	NS
Tiger Creek	Catoosa/Whitfield Counties	11	Fishing	PS
Toccoa River	Downstream Lake Blue Ridge (Fannin Co.)	7	Recreation	PS
West Chickamauga Creek	Mill Creek to Crawfish Creek (Walker Co.)	16	Fishing	NS
West Chickamauga Creek	Hwy 2 to Stateline (Catoosa Co.)	7	Fishing	NS
Youngcane Creek	Little Youngcane Creek to Nottely Lake (Union Co.)	4	Fishing	PS

Notes:
PS = Partially Supporting designated uses
NS = Not Supporting designated uses



TMDL Evaluation - Fecal Coliform
Tennessee River Basin

Figure 1. Impaired Stream Segments in HUC 06020001



TMDL Evaluation - Fecal Coliform Tennessee River Basin	Figure 2. Impaired Stream Segments in HUCs 06020002, 06020003, and 06010202

The land use characteristics of the Tennessee River Basin watersheds were determined using data from Georgia's National Land Cover Dataset (NLCD). This coverage was produced from Landsat Thematic Mapper digital images developed in 1995. Land use classification is based on a modified Anderson level one and two system. Table 2 lists the watershed land coverage distribution of the 19 stream segments on the 303(d) list.

1.3 Water Quality Standard

The water use classifications for the listed stream segments in the Tennessee River Basin are Recreation or Fishing. The criterion violated is listed as fecal coliform. The potential cause(s) listed include urban runoff and nonpoint sources. The use classification water quality standards for fecal coliform bacteria, as stated in *Georgia's Rules and Regulations for Water Quality Control*, Chapter 391-3-6-.03(6)(b), and 391-3-6-.03(6)(c), are:

(b) Recreation: General recreational activities such as water skiing, boating, and swimming, or for any other use requiring water of a lower quality, such as recreational fishing. These criteria are not to be interpreted as encouraging water contact sports in proximity to sewage or industrial waste discharges regardless pf treatment requirements:
(i) Bacteria: Fecal coliform not to exceed the following geometric means based on at least four samples collected from a given sampling site over a 30-day period at intervals not less than 24 hours
(1) Coastal waters 100 per 100 ml
(2) All other recreational waters 200 per 100 ml
(3) Should water quality and sanitary studies show natural fecal coliform levels exceed 200/100 ml (geometric mean) occasionally in high quality recreational waters, then the allowable geometric mean fecal coliform level shall not exceed 300 per 100 ml in lakes and reservoirs and 500 per 100 ml in free flowing fresh water streams.

(c) Fishing: Propagation of Fish, Shellfish, Game and Other Aquatic Life; secondary contact recreation in and on the water; or for any other use requiring water of a lower quality:
(iii) Bacteria: For the months of May through October, when water contact recreation activities are expected to occur, fecal coliform not to exceed a geometric mean of 200 per 100 ml based on at least four samples collected from a given sampling site over a 30-day period at intervals not less than 24 hours. Should water quality and sanitary studies show fecal coliform levels from non-human sources exceed 200/100 ml (geometric mean) occasionally, then the allowable geometric mean fecal coliform shall not exceed 300 per 100 ml in lakes and reservoirs and 500 per 100 ml in free flowing freshwater streams. For the months of November through April, fecal coliform not to exceed a geometric mean of 1,000 per 100 ml based on at least four samples collected from a given sampling site over a 30-day period at intervals not less than 24 hours and not to exceed a maximum of 4,000 per 100 ml for any sample. The State does not encourage swimming in surface waters since a number of factors which are beyond the control of any State regulatory agency contribute to elevated levels of fecal coliform. For waters designated as approved shellfish harvesting waters by the appropriate State agencies, the requirements will be consistent with those established by the State and Federal agencies responsible for the National Shellfish Sanitation Program. The requirements are found in the National Shellfish Sanitation Program Manual of Operation, Revised 1988, Interstate Shellfish Sanitation Conference, U. S. Department of Health and Human Services (PHS/FDA), and the Center for Food Safety and Applied Nutrition. Streams designated as generally supporting shellfish are listed in Paragraph 391-3-6-.03(14).

Table 2. Tennessee River Basin Land Coverage

Stream/Segment	Landuse Categories - Acres (Percent)													
	Open Water	Low Intensity Residential	High Intensity Residential	High Intensity Commercial, Industrial, Transportation	Bare Rock, Sand, Clay	Quarries, Strip Mines, Gravel Pits	Transitional	Forest	Row Crops	Pasture, Hay	Other Grasses (Urban, recreational; e.g. parks, lawns)	Woody Wetlands	Emergent Herbaceous Wetlands	Total	Landuse Source
Butternut Creek	2	0	131	183	0	1	0	6272	133	718	54	0	0	7,494	NLCD
	(0.0)	(0.0)	(1.7)	(2.4)	(0.0)	(0.0)	(0.0)	(83.7)	(1.8)	(9.6)	(0.7)	(0.0)	(0.0)	(100.0)	
Chattanooga Creek High Point to Flintstone	27	0	262	35	0	0	12	11,252	270	1,834	141	0	0	13,833	NLCD
	(0.2)	(0.0)	(1.9)	(0.3)	(0.0)	(0.0)	(0.1)	(81.3)	(2.0)	(13.3)	(1.0)	(0.0)	(0.0)	(100.0)	
Chattanooga Creek Flintstone to Stateline	44	0	587	132	0	0	14	29,109	526	2,466	260	0	0	33,138	NLCD
	(0.1)	(0.0)	(1.8)	(0.4)	(0.0)	(0.0)	(0.0)	(87.8)	(1.6)	(7.4)	(0.8)	(0.0)	(0.0)	(100.0)	
Dry Creek	13	0	629	52	0	98	1	2,300	132	475	191	0	0	3,891	NLCD
	(0.3)	(0.0)	(16.2)	(1.3)	(0.0)	(2.5)	(0.0)	(59.1)	(3.4)	(12.2)	(4.9)	(0.0)	(0.0)	(100.0)	
East Chickamauga Creek	133	0	572	349	0	16	669	33,186	1,141	8,660	262	208	4	45,201	NLCD
	(0.3)	(0.0)	(1.3)	(0.8)	(0.0)	(0.0)	(1.5)	(73.4)	(2.5)	(19.2)	(0.6)	(0.5)	(0.0)	(100.0)	
Fightingtown Creek	7	0	145	36	0	0	163	43,466	68	1,744	49	0	0	45,679	NLCD
	(0.0)	(0.0)	(0.3)	(0.1)	(0.0)	(0.0)	(0.4)	(95.2)	(0.1)	(3.8)	(0.1)	(0.0)	(0.0)	(100.0)	
Hemptown Creek	17	0	34	115	0	0	29	24,066	259	1,683	7	0	0	26,210	NLCD
	(0.1)	(0.0)	(0.1)	(0.4)	(0.0)	(0.0)	(0.1)	(91.8)	(1.0)	(6.4)	(0.0)	(0.0)	(0.0)	(100.0)	
Little Tennessee River	31	0	67	120	0	141	27	31,991	463	2,624	27	1	0	35,492	NLCD
	(0.1)	(0.0)	(0.2)	(0.3)	(0.0)	(0.4)	(0.1)	(90.1)	(1.3)	(7.4)	(0.1)	(0.0)	(0.0)	(100.0)	
Lookout Creek	156	0	675	806	0	15	1,331	95,153	3,944	7,975	324	48	0	110,426	NLCD
	(0.1)	(0.0)	(0.6)	(0.7)	(0.0)	(0.0)	(1.2)	(86.2)	(3.6)	(7.2)	(0.3)	(0.0)	(0.0)	(100.0)	
McFarland Branch	2	161	53	111	0	0	0	181	12	10	27	9	0	566	NLCD
	(0.4)	(28.4)	(9.4)	(19.6)	(0.0)	(0.0)	(0.0)	(32.0)	(2.1)	(1.8)	(4.8)	(1.6)	(0.0)	(100.0)	
Nottely River Right/Left Forks to US Hwy 19	2	0	3	1	0	0	9	17,247	95	354	0	0	0	17,711	NLCD
	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.1)	(97.4)	(0.5)	(2.0)	(0.0)	(0.0)	(0.0)	(100.0)	
Nottely River US Hwy 19 to Lake Nottely	32	0	51	33	0	69	9	50,500	453	2,632	5	0	0	53,784	NLCD
	(0.1)	(0.0)	(0.1)	(0.1)	(0.0)	(0.1)	(0.0)	(93.9)	(0.8)	(4.9)	(0.0)	(0.0)	(0.0)	(100.0)	
Peavine Creek	27	0	534	225	0	0	125	14,149	954	5,767	181	0	0	21,962	NLCD
	(0.1)	(0.0)	(2.4)	(1.0)	(0.0)	(0.0)	(0.6)	(64.4)	(4.3)	(26.3)	(0.8)	(0.0)	(0.0)	(100.0)	
South Chickamauga Creek	182	0	2672	1065	0	2	2,000	113,090	6,257	35,675	761	74	1	161,779	NLCD
	(0.1)	(0.0)	(1.7)	(0.7)	(0.0)	(0.0)	(1.2)	(69.9)	(3.9)	(22.1)	(0.5)	(0.0)	(0.0)	(100.0)	
Tiger Creek	104	0	534	354	2	0	1,287	52,931	2,345	15,199	215	44	0	73,015	NLCD
	(0.1)	(0.0)	(0.7)	(0.5)	(0.0)	(0.0)	(1.8)	(72.5)	(3.2)	(20.8)	(0.3)	(0.1)	(0.0)	(100.0)	

Stream/Segment	Landuse Categories - Acres (Percent)														
	Open Water	Low Intensity Residential	High Intensity Residential	High Intensity Commercial, Industrial, Transportation	Bare Rock, Sand, Clay	Quarries, Strip Mines, Gravel Pits	Transitional	Forest	Row Crops	Pasture, Hay	Other Grasses (Urban, recreational; e.g. parks, lawns)	Woody Wetlands	Emergent Herbaceous Wetlands	Total	Landuse Source
Toccoa River	52	0	226	376	0	0	29	39,428	453	2,416	86	0	5	43,071	NLCD
	(0.1)	(0.0)	(0.5)	(0.9)	(0.0)	(0.0)	(0.1)	(91.5)	(1.1)	(5.6)	(0.2)	(0.0)	(0.0)	(100.0)	
West Chickamauga Creek	67	0	60	62	0	0	368	47,988	1,764	14,224	46	114	6	64,700	NLCD
Mill Creek to Crawfish Creek	(0.1)	(0.0)	(0.1)	(0.1)	(0.0)	(0.0)	(0.6)	(74.2)	(2.7)	(22.0)	(0.1)	(0.2)	(0.0)	(100.0)	
West Chickamauga Creek	167	0	1674	476	0	41	416	69,008	3,520	21,870	824	132	6	98,134	NLCD
Hwy 2 to Stateline	(0.2)	(0.0)	(1.7)	(0.5)	(0.0)	(0.0)	(0.4)	(70.3)	(3.6)	(22.3)	(0.8)	(0.1)	(0.0)	(100.0)	
Youngcane Creek	4	0	2	39	0	0	0	15,562	243	2,459	0	0	0	18,309	NLCD
	(0.0)	(0.0)	(0.0)	(0.2)	(0.0)	(0.0)	(0.0)	(85.0)	(1.3)	(13.4)	(0.0)	(0.0)	(0.0)	(100.0)	

2.0 WATER QUALITY ASSESSMENT

Stream segments are placed on the 303(d) list as partially supporting or not supporting their water use classification based on water quality sampling data. A stream is placed on the partial support list if more than 10% of the samples exceed the fecal coliform criteria and on the not support list if more than 25% of the samples exceed the standard. Water quality samples collected within a 30-day period that have a geometric mean in excess of 200 counts per 100 milliliters during the period May through October, or in excess of 1000 counts per 100 milliliters during the period November through April, are in violation of the bacteria water quality standard. There is also a single sample maximum criterion (4000 counts per 100 milliliters) for the months of November through April.

Fecal coliform data were collected during calendar years 2000 and 2001. Sources of these data include the following:

- United States Geological Survey (USGS) basin water quality data, 2001 and 2002; and
- Georgia Environmental Protection Division (GA EPD) Trend Monitoring data, 2001 and 2002.

These sources had enough information to calculate a 30-day geometric mean and the data used for these TMDLs are presented in Appendix A.

For Butternut Creek, available data were not sufficient to calculate a 30-day geometric mean. This stream segment had been placed on the 303(d) list as a result of data collected prior to 2000. These data were assembled from the Tennessee Valley Authority. A summary of these data is presented in Appendix B.

3.0 SOURCE ASSESSMENT

An important part of the TMDL analysis is the identification of potential source categories. Sources are broadly classified as either point or nonpoint sources. A point source is defined as a discernable, confined, and discrete conveyance from which pollutants are or may be discharged to surface waters. Nonpoint sources are diffuse, and generally, but not always, involve accumulation of fecal coliform bacteria on land surfaces that wash off as a result of storm events.

3.1 Point Source Assessment

Title IV of the Clean Water Act establishes the National Pollutant Discharge Elimination System (NPDES) permit program. Basically, there are two categories of NPDES permits: 1) municipal and industrial wastewater treatment facilities, and 2) regulated storm water discharges.

3.1.1 Wastewater Treatment Facilities

In general, industrial and municipal wastewater treatment facilities have NPDES permits with effluent limits. These permit limits are either based on federal and state effluent guidelines (technology-based limits) or on water quality standards (water quality-based limits).

The EPA has developed technology-based guidelines, which establish a minimum standard of pollution control for municipal and industrial discharges without regard for the quality of the receiving waters. These are based on Best Practical Control Technology Currently Available (BPT), Best Conventional Control Technology (BCT), and Best Available Technology Economically Achievable (BAT). The level of control required by each facility depends on the type of discharge and the pollutant.

The EPA and the states have also developed numeric and narrative water quality standards. Typically, these standards are based on the results of aquatic toxicity tests and/or human health criteria and include a margin of safety. Water quality-based effluent limits are set to protect the receiving stream. These limits are based on water quality standards that have been established for a stream based on its intended use and the prescribed biological and chemical conditions that must be met to sustain that use.

Municipal and industrial wastewater treatment facilities discharges may contribute fecal coliform to receiving waters. There are ten NPDES permitted discharges with effluent limits for fecal coliform bacteria identified in the Tennessee River Basin Watershed upstream from the listed segments. Table 3 provides the monthly average discharge flows and fecal coliform concentrations for the municipal and industrial treatment facilities, obtained from calendar year 2001 Discharge Monitoring Report (DMR) data. The permitted flow and fecal coliform concentrations for these facilities are also included in this table.

Combined sewer systems convey a mixture of raw sewage and storm water in the same conveyance structure to the wastewater treatment plant. These are considered a component of municipal wastewater treatment facilities. When the combined sewage exceeds the capacity of the wastewater treatment plant, the excess is diverted to a combined sewage overflow (CSO) discharge point. There are no permitted CSO outfalls in the Tennessee River Basin.

Table 3. NPDES Facilities Discharging Fecal Coliform in the Tennessee River Basin

Facility Name	NPDES Permit No.	Receiving Stream	Actual 2001 Discharge		NPDES Permit Limits		Number of Violations July 1998-June 2001
			Average Monthly Flow (MGD)[1]	Geometric Mean (No./ 100 mL)[2]	Average Monthly Flow (MGD)	Average Monthly FC (No./ 100 mL)	
Blairsville WPCP	GA0033375	Butternut Creek	0.27	26.0	0.4	200	0
Blue Ridge WPCP	GA0021075	Dry Creek Trib	0.37	7.6	0.62	200	0
Blue Ridge WPCP	GA0037583	Dry Creek Trib	0.37	7.7	1	200	0
Dillard WPCP	GA0047139	Little Tennessee River	0.04	3.6	0.1	200	0
DNR Vogel State Park	GA0031313	East Fork Wolf Creek trib	0.12	8.0	0.11	200	0
Hiawassee WPCP	GA0050181	Chatuge Lake	0.20	2.5	0.3	200	0
Ringgold WPCP	GA0025615	South Chickamauga Creek	0.64	27.5	0.7	200	0
Trenton WPCP	GA0026221	Lookout Creek	0.32	42.8	1	200	0
Walker Co WPCP	GA0020478	West Chickamauga Creek	1.32	46.3	3.5	200	0
Young Harris WPCP	GA0022462	Brasstown Creek	0.10	30.7	0.24	200	3

Source: EPA PCS Website (2001) and the GA EPD Regional Offices

Notes: [1] Values shown are the annual average of the monthly average flows.

[2] Values shown are the annual average of the monthly geometric means.

3.1.2 Regulated Storm Water Discharges

Some storm water runoff is covered under the NPDES Permit Program. It is considered a diffuse source of pollution. Unlike other NPDES permits that establish end-of-pipe limits, storm water NPDES permits establish controls "to the maximum extent practicable" (MEP). Currently, regulated storm water discharges that may contain fecal coliform bacteria consist of those associated with industrial activities including construction sites five acres or greater, and large and medium municipal separate storm sewer systems (MS4s) that serve populations of 100,000 or more.

Storm water discharges associated with industrial activities are currently covered under a General Storm Water NPDES Permit. This permit requires visual monitoring of storm water discharges, site inspections, implementation of Best Management Practices (BMPs), and record keeping.

Storm water discharges from MS4s are very diverse in pollutant loadings and frequency of discharge. All cities and counties within the state of Georgia that had a population of greater than 100,000 at the time of the 1990 Census, are permitted for their storm water discharge under Phase I. Phase I MS4 permits require the prohibition of non-storm water discharges (i.e., illicit discharges) into the storm sewer systems, and controls to reduce the discharge of pollutants to the maximum extent practicable, including the use of management practices, control techniques and systems, as well as design and engineering methods (Federal Register, 1990). A site-specific Storm Water Management Plan (SWMP) outlining appropriate controls is required by and referenced in the permit. There are no Phase I MS4 permits in the Tennessee River Basin.

On March 10, 2003, small MS4s serving urbanized areas were required to obtain a storm water permit under the Phase II storm water regulations. An urbanized area is defined as an entity with a residential population of at least 50,000 people and an overall population density of at least 1,000 people per square mile. It is estimated that 30 counties and 56 communities will be permitted under the Phase II regulations. Table 4 lists those counties and communities located in the Tennessee River Basin that will be covered by the Phase II General Storm Water Permit, GAG610000.

Table 4. Phase II Permitted MS4s in the Tennessee River Basin

Name	Watershed
Catoosa County	Tennessee
Chickamauga	Tennessee
Fort Oglethorpe	Tennessee
Lookout Mountain	Tennessee
Ringgold	Tennessee
Rossville	Tennessee
Tunnel Hill	Tennessee
Walker County	Coosa, Tennessee
Whitfield County	Coosa, Tennessee

Source: Nonpoint Source Permitting Program, GA DNR, 2003

3.1.3 Confined Animal Feeding Operations

Confined livestock and confined animal feeding operations (CAFOs) are characterized by high animal densities. This results in large quantities of fecal material contained within a limited area. Processed agricultural manure from confined hog, dairy cattle and some poultry operations is generally collected in lagoons. It is then applied to pastureland and cropland as a fertilizer during the growing season, at rates that often vary monthly.

In 1990, the State of Georgia began registering CAFOs. Many of the CAFOs were issued land application or NPDES permits for treatment of wastewaters generated from their operations. The type of permit issued depends on the operation size (number of animal units). Table 5 presents the dairy CAFO located in the Tennessee River Basin that is registered and has a land application permit.

Table 5. Registered CAFO in the Tennessee River Basin

Name	County	Type	Total No. of Animals	Permit No.
Sims Family Partners, LP	Catoosa	Dairy	620	GAU700000

Source: Permitting and Compliance Program, Environmental Protection Division, GA EPD, 2003

3.2 Nonpoint Source Assessment

In general, nonpoint sources cannot be identified as entering a waterbody through a discrete conveyance at a single location. Typical nonpoint sources of fecal coliform bacteria include:

- Wildlife
- Agricultural Livestock
  - Animal grazing
  - Animal access to streams
  - Application of manure to pastureland and cropland
- Urban Development
  - Leaking septic systems
  - Land Application Systems
  - Landfills

In urban areas, a large portion of storm water runoff may be collected to storm sewer systems and discharged through distinct outlet structures. For large urban areas, these storm sewer discharge points may be regulated as described in Section 3.1.2.

3.2.1 Wildlife

The importance of wildlife as a source of fecal coliform bacteria in streams varies considerably, depending on the animal species present in the subwatersheds. Based on information provided by the Wildlife Resources Division (WRD) of DNR, the animals that spend a large portion of their time in or around aquatic habitats are considered to be the most important wildlife sources of fecal coliform. Waterfowl, most notably ducks and geese, are considered to potentially be the greatest contributors of fecal coliform. This is because they are typically found on the water surface, often in large numbers, and deposit their feces directly into the water. Other potentially important animals regularly found around aquatic environments include racoons, beavers, muskrats, and to a lesser extent, river otters and minks. Population estimates of these animal species in Georgia are currently not available.

White-tailed deer have a significant presence throughout the Tennessee River Basin. The 2001 deer census for counties in the Tennessee River Basin is presented in Table 6. Fecal coliform bacteria contributions from deer to water bodies are generally considered less significant than that of waterfowl, racoon, and beaver. This is because a greater portion of their time is spent in terrestrial habitats. This also holds true for other terrestrial mammals such as squirrels and rabbits, and terrestrial birds (Georgia WRD, 2002). However, feces deposited on the land surface can result in the introduction of fecal coliform to streams during runoff events. It should be noted that between storm events, considerable decomposition of the fecal matter might occur, resulting in a decrease in the associated fecal coliform numbers. This is especially true in the warm, humid environments typical of the southeast.

Table 6. 2001 Deer Census Data in the Tennessee River Basin

County	Deer Density (number/sq mi)
Catoosa	25
Dade	40
Fannin	25
Gilmer	40
Lumpkin	25
Rabun	25
Towns	25
Union	25
Walker	40
Whitfield	25

Source: Wildlife Resource Division, GA DNR, 2001

3.2.2 Agricultural Livestock

Agricultural livestock are a potential source of fecal coliform to streams in the Tennessee River Basin. The animals grazing on pastureland deposit their feces onto land surfaces, where it can be transported during storm events to nearby streams. Animal access to pastureland varies monthly, resulting in varying fecal coliform loading rates throughout the year. Beef cattle spend all of their time in pastures, while dairy cattle and hogs are periodically confined. In addition, agricultural livestock will often have direct access to streams that pass through their pastures, and can thus impact water quality in a more direct manner (USDA, 2002).

Table 7 provides the estimated number of beef cattle, dairy cattle, swine, sheep, goats and horses reported by county. These data were provided by the Natural Resources Conservation Service (NRCS) and are based on 2001 data.

Table 7. Estimated Agricultural Livestock Populations in the Tennessee River Basin

County	Livestock							
	Beef Cattle	Dairy Cattle	Swine	Sheep	Horses	Goats	Chickens Layers	Chickens-Broilers Sold
Catoosa	3,200	900	-	-	115	-	40,000	2,073,600
Dade	3,600	-	300	40	800	250	190,000	892,000
Fannin	4,300	200	20	15	60	25	160,000	1,140,000
Gilmer	5,000	1,050	3,450	-	-	400	550,000	13,560,000
Lumpkin	3,610	200	175	20	185	75	730,000	3,808,000
Rabun	2,200	-	-	100	200	200	-	1,331,200
Towns	5,000	-	450	30	525	200	-	72,000
Union	4,015	350	100	40	1,000	350	750,000	50,000
Walker	12,800	900	200	40	1,110	450	30,000	2,364,000
Whitfield	15,000	320	-	10	1,825	200	40,000	2,704,000

Source: NRCS, 2001

3.2.3 Urban Development

Fecal coliform from urban areas are attributable to multiple sources, including: domestic animals, leaks and overflows from sanitary sewer systems, illicit discharges of sanitary waste, leaking septic systems, runoff from improper disposal of waste materials, and leachate from both operational and closed landfills.

Urban runoff can contain high concentrations of fecal coliform from domestic animals and urban wildlife. Fecal coliform enter streams by direct washoff from the land surface, or the runoff may be diverted to a storm water collection system and discharged through a discrete outlet structure. For larger urban areas (populations greater than 100,000), the storm water outlets are regulated under MS4 permits (see Section 3.1.2). For smaller urban areas, the storm water discharge outlets currently remain unregulated.

In addition to urban animal sources of fecal coliform, there may be illicit sanitary sewer connections to the storm sewer system. As part of the MS4 permitting program, municipalities are required to conduct dry-weather monitoring to identify and then eliminate these illicit discharges. Fecal coliform may also enter streams from leaky sewer pipes, or during storm events when the combined sewer overflows discharge.

3.2.3.1 Leaking Septic Systems

Some fecal coliform in the Tennessee River Basin may be attributed to failure of septic systems and illicit discharges of raw sewage. Table 8 presents the number of septic systems in each county of the Tennessee River Basin existing in 1990, based on U.S. 1990 Census Data, and the number existing in 2001, based on the Georgia Department of Human Resources, Division of Public Health data. In addition, an estimate of the number of septic systems repaired during the eleven-year period from 1990 to 2001 is given.

Table 8. Number of Septic Systems in the Tennessee River Basin

County	Total Septic Systems	No. of Septic Systems Installed 1990 to 2001	No. of Septic Systems Repaired 1990 to 2001
Catoosa	16,375	5,190	530
Dade	5,342	1,317	63
Fannin	11,999	5,086	402
Gilmer	12,538	6,730	120
Lumpkin	8,525	3,627	158
Rabun	10,713	4,150	294
Towns	6,817	2,760	0
Union	10,737	4,977	568
Walker	19,097	3,608	600
Whitfield	23,385	6,444	1,422

Source: 1990 Census Data, and the GA Dept. of Human Resources, Div. of Public Health, 2001

These data show that a substantial increase in the number of septic systems has occurred in several counties. This is generally a reflection of population increases outpacing the expansion of sewage collection systems during this period. Hence, a large number of septic systems are installed to contain and treat the sanitary waste. It is estimated that there are approximately 2.37 people per household on septic systems (EPA, personal communication).

3.2.3.2 Land Application Systems

Many smaller communities use land application systems (LASs) for treatment of their sanitary wastewaters. These facilities are required through LAS permits to treat all their wastewater by land application and are to be properly operated as non discharging systems that contribute no runoff to nearby surface waters. However, runoff during storm events may carry surface residual containing fecal coliform bacteria to nearby surface waters. Some of these facilities may also exceed the ground percolation rate when applying the wastewater, resulting in surface runoff from the field. If not properly bermed, this runoff, which likely contains fecal coliform bacteria, may discharge to nearby surface waters. There is one permitted LAS located in the Tennessee River Basin (Table 9).

Table 9. Permitted Land Application System in the Tennessee River Basin

LAS Name	County	Permit No.	Type
National Textiles, L.C.	Rabun	GAU010429	Industrial

Source: Permitting and Compliance Program, GA EPD, 2003

3.2.3.3 Landfills

Leachate from landfills may contain fecal coliform bacteria that may at some point discharge into surface waters. Sanitary (or municipal) landfills are the most likely to serve as a source of fecal coliform bacteria. These types of landfills receive household wastes, animal manure, offal, hatchery and poultry processing plant wastes, dead animals, and other types of wastes. Older sanitary landfills were not lined and most have been closed. Those that remain active and have not been lined operate as construction/demolition landfills. Currently active sanitary landfills are lined and have leachate collection systems. All landfills, except inert landfills, are now required to install environmental monitoring systems for groundwater sampling and methane. There are 26 known landfills in the Tennessee River Basin (Table 10). Of these, one is an active landfill and the others are inactive or closed. As shown in the Table 10, many of the older, inactive landfills were never permitted.

Table 10. Landfills in the Tennessee River Basin

Name	County	Permit No.	Type	Status
Catoosa Co. - SR 151 - S	Catoosa	023-002D	Not Applicable	No Record
Catoosa County - SR 151 site no. 2 MSWL	Catoosa	023-007D	Municipal Solid Waste Landfill	Active
Catoosa County - SR 151 W EXP (SL)	Catoosa	023-005D	Sanitary Landfill	Ceased Accepting Waste
E.R. Anderson	Catoosa		Not Applicable	No Record
Ed Winters	Catoosa		Not Applicable	No Record
Ft. Oglethorpe	Catoosa		Not Applicable	No Record
Oscar Reardon - Hwy 146	Catoosa		Not Applicable	No Record
Ringgold	Catoosa		Not Applicable	No Record
Back Valley Rd.	Dade	041-004D	Sanitary Landfill	Closed
Charlie Page	Dade		Not Applicable	No Record
Rising Fawn	Dade		Not Applicable	No Record
Fannin Co. - Barnes Chapel	Fannin		Not Applicable	No Record
Fannin Co. - Mercier Apple Rd.	Fannin	055-005D	Not Applicable	No Record
Fannin County - SR 5 PH2 SL	Fannin	055-007D	Sanitary Landfill	Closed
Towns Co. - Hwy 288	Towns	139-001D	Not Applicable	No Record
Towns County - SR 288 PH1 (SL)	Towns	139-002D	Sanitary Landfill	Ceased Accepting Waste
Union County - Haralson Memorial Dr. (SL)	Union	144-001D	Sanitary Landfill	Closed
Marble Top Rd. Areas 1 - 5	Walker	146-003D	Sanitary Landfill	Ceased Accepting Waste
Marble Top Rd. No. 2	Walker	146-015D	Municipal Solid Waste Landfill	Permit Issued
Mathis Bros - Chickamauga Rd.	Walker	146-006D	Not Applicable	No Record
Mathis Bros. - S. Marbletop Rd.	Walker	146-005D	Not Applicable	No Record
Standard Brands Chemical Ind. Inc.	Walker	146-004D	Not Applicable	No Record
Steele Bros. Landfill - SR341 (LI)	Walker	146-011D	Industrial Waste Landfill	Ceased Accepting Waste
Dalton - Rocky Face (WS) PH2	Whitfield	155-033D	Sanitary Landfill	Ceased Accepting Waste
West Side Rocky Face Ph. 2	Whitfield	155-015D	Not Applicable	No Record
West Side Rocky Face Ph. 2	Whitfield	155-024D	Not Applicable	No Record

Source: Land Protection Branch, GA DNR, 1999 (GA EPD, 2000)

4.0 ANALYTICAL APPROACH

The process of developing fecal coliform TMDLs for the Tennessee River Basin listed segments includes the determination of the following:

- The current critical fecal coliform load to the stream under existing conditions;
- The TMDL for similar conditions under which the current load was determined; and
- The percent reduction in the current critical fecal coliform load necessary to achieve the TMDL.

The calculation of the fecal coliform load at any point in a stream requires the fecal coliform concentration and stream flow. The availability of water quality and flow data varies considerably among the listed segments. A discussion of the available monitoring data was presented in Section 2.0. For the majority of listed segments, fecal coliform sampling data were sufficient to calculate at least one 30-day geometric mean to compare with the regulatory criteria (see Appendix A). Fecal coliform data for the remaining segments were limited (see Appendix B). Depending on the nature and availability of water quality data, different approaches were used to determine the current critical loads and TMDLs for the listed segments. These different approaches are outlined below.

4.1 Loading Curve Approach

For those segments in which sufficient water quality data were collected to calculate at least one 30-day geometric mean that was above the regulatory standard, the loading curve approach was used. This method involves comparing the current critical load to summer and winter seasonal TMDL curves.

As mentioned in Section 2.0, the USGS monitored many of the listed segments and collected stream flow information concurrently with water quality samples. Stream depths were measured and used to determine stream flows, based on rating curves developed by the USGS for each sampling location.

In cases where no stream flow measurements were available, flow on the day the fecal coliform samples were collected was estimated using data from a nearby gaged stream. The nearby stream had to have relatively similar watershed characteristics, including landuse, slope, and drainage area. The stream flows were estimated by multiplying the gaged flow by the ratio of the listed stream drainage area to the gaged stream drainage area. Table 11 lists those segments for which no flow data were available and indicates the gaged station that was used to estimate the flow. If a gaged stream was available within the same watershed, it was used.

Table 11. Monitoring Stations with Estimated Flow

Monitoring Station	USGS Station Name	Station No.
Chattanooga River at Hwy 341 near Flintstone	Mill Creek near Crandall, GA	02384540

The current critical loads were determined using fecal coliform data collected within a 30-day period to calculate the geometric means, and multiplying these values by the arithmetic means of the flows measured at the time the water quality samples were collected. Georgia's instream fecal coliform standards are based on a geometric mean of samples collected over a 30-day period, with samples collected at least 24 hours apart. To reflect this in the load calculation, the fecal coliform loads are expressed as 30-day accumulation loads with units of counts per 30 days. This is described by the equation below:

$$L_{critical} = C_{geomean} * Q_{mean}$$

Where:
$L_{critical}$ = current critical fecal coliform load
$C_{geomean}$ = fecal coliform concentration as a 30-day geometric mean
Q_{mean} = stream flow as arithmetic mean

The current estimated critical load is dependent on the fecal coliform concentrations and stream flows measured during the sampling events. The number of events sampled is usually 16 events per year. Thus, these loads do not represent the full range of flow conditions or loading rates that can occur. Therefore, it must be kept in mind that the current critical loads used only represent the worst-case scenario that occurred among the time periods sampled.

The maximum fecal load at which the instream fecal coliform criteria will be met can be determined using a variation of the equation above. By setting C equal to the seasonal, instream fecal coliform standards, the load will equal the TMDL. However, the TMDL is dependent on stream flow. Figures in Appendix A graphically illustrate that the TMDL is a continuum for the range of flows (Q) that can occur in the stream over time. There are two TMDL curves shown in these figures. One represents the summer TMDL for the period May through October when the 30-day geometric mean standard is 200 counts/ 100 mL. The second curve represents the winter TMDL for the period November through April when the 30-day geometric mean standard is 1000 counts/ 100 mL. The equations for these two TMDL curves are:

$$TMDL_{summer} = 200 \text{ counts (as a 30-day geometric mean)}/100 \text{ mL} * Q$$

$$TMDL_{winter} = 1000 \text{ counts (as a 30-day geometric mean)}/100 \text{ mL} * Q$$

The graphs show the relationship between the current critical load ($L_{critical}$) and the TMDL. The TMDL for a given stream segment is the load for the mean flow corresponding to the current critical load. This is the point where the current load most exceeds the TMDL curve. This critical TMDL can be represented by the following equation:

$$TMDL_{critical} = C_{standard} * Q_{mean}$$

Where:
$TMDL_{critical}$ = critical fecal coliform TMDL load
$C_{standard}$ = seasonal fecal coliform standard (as a 30-day geometric mean)
summer - 200 counts/100 mL
winter - 1000 counts/ 100 mL
Q_{mean} = stream flow as arithmetic mean (same as used for $L_{critical}$)

A 30-day geometric mean load that plots above the respective seasonal TMDL curve represents an exceedance of the instream fecal coliform standard. The difference between the current critical load and the TMDL curve represents the load reduction required for the stream segment to meet the appropriate instream fecal coliform standard. The load reduction can thus be expressed as follows:

$$\text{Load Reduction} = \frac{L_{critical} - TMDL_{critical}}{L_{critical}} * 100$$

4.2 Equivalent Site Approach

TMDLs must be developed for a number of listed segments for which sufficient data are not available to calculate the 30-day geometric mean fecal coliform concentrations. Although there may be sampling data for many of these streams, there are not enough data within a 30-day period to directly calculate geometric means. In these cases, an equivalent site approach is used to estimate the current and TMDL loads. This approach involves calculating loads for the stream segments that lack sufficient data based on a relationship to other, similar, equivalent site(s) that have data. This method provides estimates that can be refined in the future as additional data are collected.

Development of loads using the equivalent site approach addresses three key issues:

1. Site-specific monitoring data should be used, even if it is insufficient for direct estimation of geometric means. The site-specific and equivalent site monitoring data should be combined in a weighted approach that reflects the relative accuracy of information provided by each data source.

2. Equivalent site selection has a potential impact on the resulting load estimates. In the case where a TMDL has already been prepared for a downstream segment within the same watershed, the equivalent site selection is obvious. For other segments, multiple sites within the same general region may be available for use.

3. Different land uses result in different fecal coliform concentrations. An equivalent site with a perfect land use match is unlikely to be available. Differences in land uses among watersheds should be addressed through use of a regionalization model that identifies the extent to which variability in fecal coliform concentrations can be explained by changes in land use.

In translating data from an equivalent site to a listed segment, it is important to account for changes in fecal coliform runoff concentrations associated with different land uses, and for changes in flow associated with different drainage areas. The critical load at site *i* can be estimated in relations to the calculated critical loads at equivalent sites *j* using the following equation:

$$\text{Load}_{\text{critical}} = \frac{1}{n}\sum_{j=1}^{n}\left[A_{ij} \cdot C_j \cdot Q_{crit,j} \cdot \frac{DA_i}{DA_j}\right]$$

Where:
$L_{critical}$ = estimated critical fecal coliform load at site *i*
n = number of equivalent sites
A_{ij} = translation factor
C_j = fecal coliform concentration (as a 30-day geometric mean) at site(s) *j*
Q_j = stream flow (as an arithmetic mean) at site(s) *j*
DA_i = drainage area above site *i*
DA_j = drainage area above site *j*

The A_{ij} factor relates the geometric mean fecal coliform concentration at site *i* to that at site(s) *j.* It is expressed in log space, since a geometric mean is used. It is expected that this factor will vary with land use, but may exhibit strong site-specific characteristics. For example, a given site might exhibit higher fecal coliform concentrations relative to an equivalent site than are expected from land use differences alone.

A method is needed that provides an appropriate weighing between limited site-specific data and a land use based regression of equivalent sites. An empirical Bayes analysis is the mathematical technique ideally suited for this circumstance. This analysis combines two important concepts: maximum likelihood techniques for combining data sources, and hierarchical regionalization techniques. The data combination step assumes that both equivalent site data and site-specific data provide information on the true local geometric mean. The two data sources are weighted in accordance with their degree of precision or accuracy. The regionalization step assumes that the true mean at any site is a result of random variability and a regional regression model on land use. Empirical Bayes techniques provide statistically optimal methods for computing both the data combination and regionalization steps from observed data.

In the empirical Bayes analysis, it is assumed that the long-term geometric mean fecal coliform concentration at a given site is a function of watershed landuse and site-specific factors that are represented by random noise. A sample realization of the geometric mean at site *i*, X_i, is assumed to be normally distributed about a true mean, Θ_i, with standard error of the estimate given by σ_ι. In statistical notation:

$$X_i \sim N(\Theta_i, \sigma_\iota^2)$$

The desired translation factor is then: $A_c = \Theta_i / \Theta_j$. Full technical details on the implementation of the empirical Bayes approach are provided in Appendix C. Table 12 list the equivalent sites used for the listed segments that did not have sufficient data to calculate a 30-day geometric mean.

Table 12. List of Equivalent Sites

Limited-Data Site	Equivalent Sites
Butternut Creek	Youngcane Creek near Youngcane
	Nottley River at Hwy 180
	Nottley River near Blairsville
	Chattahoochee River at Nacoochee

The estimated TMDL for the stream segments with insufficient data can be calculated using the following equation:

$$TMDL = \frac{1}{n} \sum_{j=1}^{n} \left[C_{STANDARD} \bullet Q_j \bullet \frac{DA_i}{DA_j} \right]$$

Where:

TMDL = fecal coliform TMDL load at site *i*
n = number of equivalent sites
$C_{STANDARD}$ = seasonal fecal coliform standard (as a 30-day geometric mean)
summer - 200 counts/100 mL
winter - 1000 counts/ 100 mL
Q_j = stream flow (as an arithmetic mean) at site(s) *j* (cfs)
DA_i = drainage area above site *i* (acres)
DA_j = drainage area above site *j* (acres)

The DA_i / DA_j ratio, as mentioned in the previous section, adjusts the flow from site *j* to site *i*. In the case where flow data are available, the actual arithmetic mean flow associated with the estimated 30-day geometric mean fecal coliform concentration can be used.

As in the loading curve approach, the estimated percent load reduction needed at site *i* can be expressed as follows:

$$\text{Load Reduction} = \frac{L_{critical} - TMDL}{L_{critical}} * 100$$

5.0 TOTAL MAXIMUM DAILY LOADS

A Total Maximum Daily Load (TMDL) is the amount of a pollutant that can be assimilated by the receiving waterbody without exceeding the applicable water quality standard; in this case, the seasonal fecal coliform standards. A TMDL is the sum of the individual waste load allocations (WLAs) from point sources and load allocations (LAs) for nonpoint sources , as well as the natural background (40 CFR 130.2) for a given waterbody. The TMDL must also include a margin of safety (MOS), either implicitly or explicitly, that accounts for the uncertainty in the relationship between pollutant loads and the water quality response of the receiving water body. TMDLs can be expressed in terms of either mass per time, toxicity, or other appropriate measures. For fecal coliform bacteria, the TMDLs are expressed as counts per 30 days as a geometric mean.

A TMDL is expressed as follows:

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

The TMDL calculates the WLAs and LAs with margins of safety to meet the stream's water quality standards. The allocations are based on estimates that use the best available data and provide the basis to establish or modify existing controls so that water quality standards can be achieved. In developing a TMDL, it is important to consider whether adequate data are available to identify the sources, fate, and transport of the pollutant to be controlled.

TMDLs may be developed using a phased approach. Under a phased approach, the TMDL includes: 1) WLAs that confirm existing limits and controls or lead to new limits, and 2) LAs that confirm existing controls or include implementing new controls (USEPA, 1991). A phased TMDL requires additional data be collected to determine if load reductions required by the TMDL are leading to the attainment of water quality standards.

The TMDL Implementation Plan establishes a schedule or timetable for the installation and evaluation of point and nonpoint source control measures, data collection, assessment of water quality standard attainment, and if needed, additional modeling. Future monitoring of the listed segment water quality will then be used to evaluate this phase of the TMDL, and if necessary, to reallocate the loads.

The fecal coliform loads calculated for each listed stream segment include the sum of the total loads from all point and nonpoint sources for the segment. The load contributions to the listed segment from unlisted upstream segments are represented in the background loads, unless the unlisted segment contains point sources that had permit violations for fecal coliform. In these cases, the upstream point sources are included in the wasteload allocations for the listed segment. In situations where two or more adjacent segments are listed, the fecal coliform loads to each segment are individually evaluated on a localized watershed basis. Point source loads originating in upstream segments are included in the background loads of the downstream segment. The following sections describe the various fecal coliform TMDL components.

5.1 Waste Load Allocations

The waste load allocation is the portion of the receiving water's loading capacity that is allocated to existing or future point sources. WLAs are provided to the point sources from municipal and industrial wastewater treatment systems that have NPDES effluent limits. There are seven active NPDES permitted facilities with fecal coliform permit limits in the Tennessee River Basin watershed that discharge into listed segments or have permit violations upstream of a listed segment. The maximum allocated fecal coliform loads for these municipal wastewater treatment facilities are given in Table 13. These WLA loads were calculated from the permitted or design flows and permitted fecal coliform concentrations. If the permit had no fecal coliform limit, a concentration of 200 counts/100 mL was used. The WLAs were expressed as accumulated loads over a 30-day period, and presented in units of counts per 30 days. If a facility expands its capacity and the permitted flow increases, the wasteload allocation for the facility would increase in proportion to the flow.

Table 13. WLAs for the Tennessee River Basin

Facility Name	Permit No.	Receiving Stream	Listed Stream Segment	WLA (counts/30 days)
Blairsville WPCP	GA0033375	Butternut Creek	Butternut Creek	9.10E+10
Blue Ridge WPCP	GA0021075	Dry Creek Tributary	Toccoa River D/S Lake Blue Ridge	1.41E+11
Blue Ridge WPCP	GA0037583	Dry Creek Tributary	Toccoa River D/S Lake Blue Ridge	2.28E+11
Dillard WPCP	GA0047139	Little Tennessee River	Little Tennessee River	2.28E+10
Ringgold WPCP	GA0025615	South Chickamauga Creek	South Chickamauga Creek	1.59E+11
Trenton WPCP	GA0026221	Lookout Creek	Lookout Creek	2.28E+11
Walker Co WPCP	GA0020478	West Chickamauga Creek	West Chickamauga Creek Hwy 2 to Stateline	7.96E+11

State and Federal Rules define storm water discharges covered by NPDES permits as point sources. However, storm water discharges are from diffuse sources and there are multiple storm water outfalls. Storm water sources (point and nonpoint) are different than traditional NPDES permitted sources in four respects: 1) they do not produce a continuous (pollutant loading) discharge; 2) their pollutant loading depends on the intensity, duration, and frequency of rainfall events, over which the permittee has no control; 3) the activities contributing to the pollutant loading may include the various allowable activities of others, and control of these activities is not solely within the discretion of the permittee; and 4) they do not have wastewater treatment plants that control specific pollutants to meet numerical limits.

The intent of storm water NPDES permits is not to treat the water after collection, but to reduce the exposure of storm water to pollutants by implementing various controls. It would be infeasible and prohibitively expensive to try to control pollutant discharges from each storm water outfall. Therefore, storm water NPDES permits require the establishment of controls or BMPs to reduce the pollutants entering the environment.

The waste load allocations from storm water discharges associated with MS4s (WLAsw) are estimated based on the percentage of urban area in each watershed covered by the MS4 storm water permit. At this time, the portion of each watershed that goes directly to the permitted storm sewer and that which goes through non-permitted point sources, or is sheet flow or agricultural runoff, has not been clearly defined. Thus, it is assumed that approximately 70 percent of the storm water runoff from the regulated urban area is collected by the municipal separate storm sewer systems.

There is one permitted CAFO in the Tennessee River Basin. However, this facility discharges no wastewater and is therefore not provided a WLA.

This TMDL will use an iterative approach. Future phases of TMDL development will attempt to further define the sources of pollutants and the portion that enters the permitted storm sewer systems. As more information is collected and these TMDLs are implemented, it will become clearer as to which BMPs are needed and how the water quality standards can be achieved.

5.2 Load Allocations

The load allocation is the portion of the receiving water's loading capacity that is attributed to existing or future nonpoint sources or to natural background sources. Nonpoint sources are identified in 40 CFR 130.6 as follows:

- Residual waste,
- Land disposal,
- Agricultural and silvicultural,
- Mines,
- Construction,
- Saltwater intrusion, and
- Urban storm water (non-permitted).

The LA is calculated as the remaining portion of the TMDL load available, after allocating the WLA and the MOS, using the following equation:

$$\Sigma \text{LA} = \text{TMDL} - (\Sigma \text{WLA} + \Sigma \text{WLAsw} + \Sigma \text{MOS})$$

As described above, there are two types of load allocations: 1) loads to the stream independent of precipitation, including sources such as failing septic systems, leachate from landfills, animals in the stream, and leaking sewer system collection lines or background loads; and 2) loads associated with fecal coliform accumulation on land surfaces that is washed off during storm events, including runoff from saturated LAS fields. At this time, it is not possible to partition the various sources of load allocations. Table 14 presents the total load allocation expressed as counts per 30 days, or as winter instantaneous maximum counts, for the 303(d) listed streams located in the Tennessee River Basin for the current critical condition. In the future, after additional data has been collected, it may be possible to partition the load allocation by source.

5.3 Seasonal Variation

The Georgia fecal coliform criteria are seasonal. One set of criteria applies to the summer season, while a different set applies to the winter season. To account for seasonal variations, the critical loads for each listed segment were determined from sampling data obtained during both summer and winter seasons, when possible. However, in some cases, the available data was limited to a single season for the calculation of the critical load. The TMDL and percent reduction given in Table 14 for each listed segment was based on the season in which the critical load occurred. The TMDLs for each season, for any given flow, are presented as equations in Section 5.5.

Analyses of the available fecal coliform data and corresponding flows were performed to determine if the fecal coliform violations occurred during wet weather (high flow) or dry weather (low flow) conditions. The flow data from each sampling site were normalized by dividing the measured flow by the product of the average annual runoff (cfs/ sq mile), published in Open-File Report 82-577, and the appropriate drainage area (Carter, 1982). Plots of the normalized flows (Q/Q_o) versus fecal coliform are shown in Appendix D. The plots do not show a consistent relationship between fecal coliform concentrations and flow. The summer and winter plots show that the fecal coliform violations occur during both high (wet weather) and low (dry weather) flow conditions.

5.4 Margin of Safety

The MOS is a required component of TMDL development. There are two basic methods for incorporating the MOS: 1) implicitly incorporate the MOS using conservative assumptions to develop allocations; or 2) explicitly specify a portion of the TMDL as the MOS and use the remainder for allocations. For this TMDL, an explicit MOS of 10 percent of the TMDL was used. The MOS values are presented in Table 14.

5.5 Total Fecal Coliform Load

The fecal coliform TMDL for the listed stream segment is dependent on the time of year and the stream flow. In the Tennessee River Basin, there are streams included on Georgia's 305(b)/303(d) list for violations of the fecal coliform standards that flow directly into North Carolina or Tennessee. Fecal coliform TMDLs were developed for these streams so that the fecal coliform standards of the respective state would be met.

The maximum seasonal fecal loads for Georgia are given below:

$TMDL_{summer}$ = 200 counts (as a 30-day geometric mean)/100 mL * Q

$TMDL_{winter}$ = 1000 counts (as a 30-day geometric mean)/100 mL * Q

$TMDL_{winter}$ = 4000 counts (instantaneous) /100 mL * Q

For purposes of determining necessary load reductions required to meet the instream water quality criteria, the current critical TMDL was determined. This load is the product of the applicable seasonal fecal coliform standard and the mean flow used to calculate the current critical load. It represents the sum of the allocated loads from point and nonpoint sources located within the immediate drainage area of the listed segment, the NPDES-permitted point discharges with recorded fecal coliform violations from the nearest upstream subwatersheds, and a margin of safety (MOS). For these calculations, the fecal load contributed by each facility to the WLA was not the maximum presented in Table 14, but rather was the product of the fecal coliform permitted limit and the average monthly discharge at the time of the critical load. The current critical loads and corresponding TMDLs, WLAs, LAs, MOSs, and percent load reductions for the Tennessee River Basin 303(d) listed streams are presented in Table 14.

The relationships of the current critical loads to the current critical TMDLs are shown graphically in Appendix A. The vertical distance between the two values represents the load reductions necessary to achieve the TMDLs. If no TMDL or Critical Load is given on the graphs in Appendix A, the current critical TMDL given in Table 14 is based on the instantaneous maximum standard. As a consequence of the localized nature of the load evaluations, the calculated fecal load reductions pertain to point and nonpoint sources occurring within the immediate drainage area of the listed segment. These current critical values represent a worst-case scenario for the limited set of data. Thus, the load reductions required are conservative estimates, and should be sufficient to prevent exceedances of the instream fecal coliform standard for a wide range of conditions.

Evaluation of the relationship between instream water quality and the potential sources of pollutant loading is an important component of TMDL development, and is the basis for later implementation of corrective measures and BMPs. For the current TMDLs, the association between fecal coliform loads and the potential sources occurring within the subwatersheds of each segment was examined on a qualitative basis.

Table 14. Fecal Loads and Required Fecal Load Reductions

Stream Segment	Current Load (counts/ 30 days)	TMDL Components					Percent Reduction
		WLA (counts/ 30 days)[1]	WLAsw (counts/ 30 days)	LA (counts/ 30 days)	MOS (counts/ 30 days)	TMDL (counts/ 30 days)	
Butternut Creek	5.36E+12	5.73E+10		1.35E+12	1.57E+11	1.57E+12	71
Chattanooga Creek - High Point to Flintstone	1.08E+13		2.22E+11	2.27E+12	2.76E+11	2.76E+12	74
Chattanooga Creek - Flintstone to Stateline	1.05E+13		2.93E+11	3.34E+12	4.04E+11	4.04E+12	61
Dry Creek	9.59E+12		5.78E+11	3.56E+11	1.04E+11	1.04E+12	89
East Chickamauga Creek	1.74E+13		1.65E+11	3.53E+12	4.11E+11	4.11E+12	76
Fightingtown Creek	6.41E+13			1.75E+13	1.95E+12	1.95E+13	70
Hemptown Creek	2.13E+13			4.76E+12	5.28E+11	5.28E+12	75
Little Tennessee River	4.14E+13	1.00E+10		1.17E+13	1.30E+12	1.30E+13	69
Lookout Creek	1.10E+13	5.01E+10		6.16E+12	6.90E+11	6.90E+12	37
McFarland Branch	1.98E+13		6.51E+10	8.36E+10	1.65E+10	1.65E+11	99
Nottely River - Right/Left Forks to US Hwy 19	1.97E+13			3.07E+12	3.41E+11	3.41E+12	83
Nottely River - US Hwy 19 to Lake Nottely	3.34E+13			8.92E+12	9.91E+11	9.91E+12	70
Peavine Creek	1.22E+13		6.67E+11	2.90E+12	3.96E+11	3.96E+12	68
South Chickamauga Creek	6.04E+13	1.51E+11	1.22E+12	1.44E+13	1.75E+12	1.75E+13	71
Tiger Creek	7.05E+12		7.26E+10	2.17E+12	2.50E+11	2.50E+12	65
Toccoa River	3.00E+14	1.62E+11		4.59E+13	5.12E+12	5.12E+13	83
West Chickamauga Creek - Mill Creek to Crawfish Creek	4.72E+16	2.69E+11	4.33E+13	3.10E+15	3.49E+14	3.49E+15	93
West Chickamauga Creek - Hwy 2 to Stateline	2.74E+14		6.45E+12	3.93E+13	5.08E+12	5.08E+13	81
Youngcane Creek	6.25E+12			1.52E+12	1.69E+11	1.69E+12	73

Note: [1] The assigned fecal coliform load from each NPDES permitted facility for WLA was determined as the product of the fecal coliform permit limit and the facility average monthly discharge at the time of the critical load.

6.0 RECOMMENDATIONS

The TMDL process consists of an evaluation of the 303(d) listed stream segments subwatersheds to identify, as best as possible, the sources of the fecal coliform loads causing the stream to exceed instream standard criteria. The TMDL analysis was performed using the best available data to specify WLAs and LAs that will meet fecal coliform water quality criteria so as to support the use classification specified for each listed segment.

This TMDL represents the first phase of a long-term process to reduce fecal coliform loading to meet water quality standards in the Coosa River Basin. Implementation strategies will be reviewed and the TMDLs will be refined as necessary in the next phase (next five-year cycle). The phased approach will support progress toward water quality standards attainment in the future. In accordance with USEPA TMDL guidance, these TMDLs may be revised based on the results of future monitoring and source characterization data efforts. The following recommendations emphasize further source identification and involve the collection of data to support the current allocations and subsequent source reductions.

6.1 Monitoring

Water quality monitoring is conducted at a number of locations across the state each year. The GA EPD has adopted a basin approach to water quality management that divides Georgia's major river basins into five groups. This approach provides for additional sampling work to be focused on one of the five basin groups each year and offers a five-year planning and assessment cycle. The Coosa, Tallapoosa, and Tennessee River Basins were the subjects of focused monitoring in 2001 and will again receive focused monitoring in 2006.

The TMDL Implementation Plan will outline an appropriate water quality monitoring program for the listed streams in the Tennessee River Basin. The monitoring program will be developed to help identify the various fecal coliform sources. This will be especially valuable for those segments where no data, old data, or spill data resulted in the listing. The monitoring program should include scheduled quarterly geometric mean sampling to evaluate listed waters and to determine if there has been improvement in the water quality of the listed stream segments.

6.2 Fecal Coliform Management Practices

Based on the findings of the source assessment, NPDES point source fecal coliform loads from wastewater treatment facilities do not significantly contribute to the impairment of the listed stream segments. This is because these facilities are required to treat to levels corresponding to instream water quality criteria. Fecal coliform loads from NPDES permitted MS4 areas may be significant, but these sources cannot be easily segregated from other storm water runoff. Other sources of fecal coliform in urban areas include wastes that are attributable to domestic animals, leaks and overflows from sanitary sewer systems, illicit discharges of sanitary waste, leaking septic systems, runoff from improper disposal of waste materials, and leachate from both operational and closed landfills. In agricultural areas, potential sources of fecal coliform may include CAFOs, animals grazing in pastures, dry manure storage facilities and lagoons, chicken litter storage areas, and direct access of livestock to streams. Wildlife and waterfowl can be an important source of fecal coliform bacteria.

Management practices are recommended to reduce fecal coliform source loads to the listed 303(d) stream segments, with the result of achieving the instream fecal coliform standard criteria. These recommended management practices include:

- Compliance with NPDES permit limits and requirements,
- Adoption of NRCS Conservation Practices, and
- Application of Best Management Practices (BMPs) appropriate to agricultural or urban land uses, whichever applies.

6.2.1 Point Source Approaches

Point sources are defined as discharges of treated wastewater or storm water into rivers and streams at discrete locations. The NPDES permit program provides a basis for municipal, industrial and storm water permits, monitoring and compliance with limitations, and appropriate enforcement actions for violations.

In accordance with GA EPD rules and regulations, all discharges from point source facilities are required to be in compliance with the conditions of their NPDES permit at all times. In the future, all municipal and industrial wastewater treatment facilities with the potential for the occurrence of fecal coliform in their discharge will be given end-of-pipe limits equivalent to the water quality standard of 200 counts/100 ml or less.

6.2.2 Nonpoint Source Approaches

The GA EPD is responsible for administering and enforcing laws to protect the waters of the State. The GA EPD is the lead agency for implementing the State's Nonpoint Source Management Program. Regulatory responsibilities that have a bearing on nonpoint source pollution include establishing water quality standards and use classifications, assessing and reporting water quality conditions, and regulating land use activities that may affect water quality. Georgia is working with local governments, agricultural and forestry agencies such as the Natural Resources Conservation Service, the Georgia Soil and Water Conservation Commission, and the Georgia Forestry Commission, to foster the implementation of BMPs to address nonpoint source pollution. In addition, public education efforts are being targeted to individual stakeholders to provide information regarding the use of BMPs to protect water quality. The following sections describe, in more detail, recommendations to reduce nonpoint source loads of fecal coliform bacteria in Georgia's surface waters.

6.2.2.1 Agricultural Sources

The GA EPD should coordinate with other agencies that are responsible for agricultural activities in the state to address issues concerning fecal coliform loading from agricultural lands. It is recommended that information (e.g., livestock populations by subwatershed, animal access to streams, manure storage and application practices, etc.) be periodically reviewed so that watershed evaluations can be updated to reflect current conditions. It is also recommended that BMPs be utilized to reduce the amount of fecal coliform bacteria transported to surface waters from agricultural sources to the maximum extent practicable.

The following three organizations have primary responsibility for working with farmers to promote soil and water conservation, and to protect water quality:

- The University of Georgia (UGA) - Cooperative Extension Service,
- Georgia Soil and Water Conservation Commission (GSWCC), and
- Natural Resources Conservation Service (NRCS).

The UGA has faculty, County Cooperative Extension Agents, and technical specialists who provide services in several key areas relating to agricultural impacts on water quality.

The GA EPD designated the GSWCC as the lead agency for agricultural Nonpoint Source Management in the State. The GSWCC develops nonpoint source management programs and conducts educational activities to promote conservation and protection of land and water devoted to agricultural uses.

The NRCS works with federal, state, and local governments to provide financial and technical assistance to farmers. The NRCS develops standards and specifications for BMPs that are to be used to improve, protect, or maintain our state's natural resources. In addition, every five years, the NRCS conducts the National Resources Inventory (NRI). The NRI is a statistically based sample of land use and natural resource conditions and trends that covers non-federal land in the United States.

The NRCS is also providing technical assistance to the GSWCC and the GA EPD with the Georgia River Basin Planning Program. Planning activities associated with this program will describe conditions of the agricultural natural resource base once every five years. It is recommended that the GSWCC and the NRCS continue to encourage BMP implementation, education efforts, and river basin surveys with regard to River Basin Planning.

6.2.2.2 Urban Sources

Both point and nonpoint sources of fecal coliform bacteria can be significant in the Tennessee River Basin urban areas. Urban sources of fecal coliform can best be addressed using a strategy that involves public participation and intergovernmental coordination to reduce the discharge of pollutants to the maximum extent practicable. Management practices, control techniques, public education, and other appropriate methods and provisions may be employed. In addition to water quality monitoring programs, discussed in Section 6.1, the following activities and programs conducted by cities, counties, and state agencies are recommended:

- Uphold requirements that all new and replacement sanitary sewage systems be designed to minimize discharges into storm sewer systems;

- Further develop and streamline mechanisms for reporting and correcting illicit connections, breaks, surcharges, and general sanitary sewer system problems;

- Sustained compliance with storm water NPDES permit requirements; and

- Continue efforts to increase public awareness and education towards the impact of human activities in urban settings on water quality, ranging from the consequences of industrial and municipal discharges to the activities of individuals in residential neighborhoods.

6.3 Reasonable Assurance

Permitted discharges will be regulated through the NPDES permitting process described in this report. Georgia is working with both federal and state agencies, such as the NRCS and the GSWCC, and with local governments, to foster the implementation of BMPs to address nonpoint sources. In addition, public education efforts will be targeted at individual stakeholders to provide information regarding the use of BMPs to protect water quality.

6.4 Public Participation

A thirty-day public notice will be provided for this TMDL. During this time, the availability of the TMDL will be public noticed, a copy of the TMDL will be provided upon request, and the public will be invited to provide comments on the TMDL.

7.0 INITIAL TMDL IMPLEMENTATION PLAN

The GA EPD has coordinated with EPA to prepare this Initial TMDL Implementation Plan for this TMDL. GA EPD has also established a plan and schedule for development of a more comprehensive implementation plan after this TMDL is established. GA EPD and EPA have executed a Memorandum of Understanding that documents the schedule for developing the more comprehensive plans. This Initial TMDL Implementation Plan includes a list of best management practices and provides for an initial implementation demonstration project to address one of the major sources of pollutants identified in this TMDL while State and/or local agencies work with local stakeholders to develop a revised TMDL implementation plan. It also includes a process whereby GA EPD and/or Regional Development Centers (RDCs) or other GA EPD contractors (hereinafter, "GA EPD Contractors") will develop expanded plans (hereinafter, "Revised TMDL Implementation Plans").

This Initial TMDL Implementation Plan, written by GA EPD and for which GA EPD and/or the GA EPD Contractor are responsible, contains the following elements.

1. EPA has identified a number of management strategies for the control of nonpoint sources of pollutants, representing some best management practices. The "Management Measure Selector Table" shown below identifies these management strategies by source category and pollutant. Nonpoint sources are the primary cause of excessive pollutant loading in most cases. Any wasteload allocations for wastewater treatment plant facilities will be implemented in the form of water-quality based effluent limitations in NPDES permits. Any wasteload allocations for regulated storm water will be implemented in the form of best management practices in the NPDES permits. NPDES permit discharges are a secondary source of excessive pollutant loading, where they are a factor, in most cases.

2. GA EPD and the GA EPD Contractor will select and implement one or more best management practice (BMP) demonstration projects for each River Basin. The purpose of the demonstration projects will be to evaluate by River Basin and pollutant parameter the site-specific effectiveness of one or more of the BMPs chosen. GA EPD intends that the BMP demonstration project be completed before the Revised TMDL Implementation Plan is issued. The BMP demonstration project will address the major category of contribution of the pollutant(s) of concern for the respective River Basin as identified in the TMDLs of the stream segments in the River Basin. The demonstration project need not be of a large scale, and may consist of one or more measures from the Table or equivalent BMP measures proposed by the GA EPD Contractor and approved by GA EPD. Other such measures may include those found in EPA's "Best Management Practices Handbook", the "NRCS National Handbook of Conservation Practices, or any similar reference, or measures that the volunteers, etc., devise that GA EPD approves. If for any reason the GA EPD Contractor does not complete the BMP demonstration project, GA EPD will take responsibility for doing so.

3. As part of the Initial TMDL Implementation Plan the GA EPD brochure entitled "Watershed Wisdom -- Georgia's TMDL Program" will be distributed by GA EPD to the GA EPD Contractor for use with appropriate stakeholders for this TMDL, and a copy of the video of that same title will be provided to the GA EPD

Contractor for its use in making presentations to appropriate stakeholders, on TMDL Implementation plan development.

4. If for any reason a GA EPD Contractor does not complete one or more elements of a Revised TMDL Implementation Plan, GA EPD will be responsible for getting that (those) element(s) completed, either directly or through another contractor.

5. The deadline for development of a Revised TMDL Implementation Plan, is the end of December 2005.

6. The GA EPD Contractor helping to develop the Revised TMDL Implementation Plan, in coordination with GA EPD, will work on the following tasks involved in converting the Initial TMDL Implementation Plan to a Revised TMDL Implementation Plan:
   A. Generally characterize the watershed;
   B. Identify stakeholders;
   C. Verify the present problem to the extent feasible and appropriate, (e.g., local monitoring);
   D. Identify probable sources of pollutant(s);
   E. For the purpose of assisting in the implementation of the load allocations of this TMDL, identify potential regulatory or voluntary actions to control pollutant(s) from the relevant nonpoint sources;
   F. Determine measurable milestones of progress;
   G. Develop monitoring plan, taking into account available resources, to measure effectiveness; and
   H. Complete and submit to GA EPD the Revised TMDL Implementation Plan.

7. The public will be provided an opportunity to participate in the development of the Revised TMDL Implementation Plan and to comment on it before it is finalized.

8. The Revised TMDL Implementation Plan will supersede this Initial TMDL Implementation Plan when GA EPD approves the Revised TMDL Implementation Plan.

Management Measure Selector Table

Land Use	Management Measures	*Fecal Coliform*	*Dissolved Oxygen*	*pH*	*Sediment*	*Temperature*	*Toxicity*	*Mercury*	*Metals (copper, lead, zinc, cadmium)*	*PCBs, toxaphene*
Agriculture	1. Sediment & Erosion Control	_	_		_	_				
	2. Confined Animal Facilities	_	_							
	3. Nutrient Management	_	_							
	4. Pesticide Management		_							
	5. Livestock Grazing	_	_		_	_				
	6. Irrigation		_		_	_				
Forestry	1. Preharvest Planning				_	_				
	2. Streamside Management Areas	_	_		_	_				
	3. Road Construction & Reconstruction		_		_	_				
	4. Road Management		_		_	_				
	5. Timber Harvesting		_		_	_				
	6. Site Preparation & Forest Regeneration		_		_	_				
	7. Fire Management	_	_	_	_	_				
	8. Revegetation of Disturbed Areas	_	_	_	_	_				
	9. Forest Chemical Management		_			_				
	10. Wetlands Forest Management	_	_	_		_		_		

Land Use	Management Measures	*Fecal Coliform*	*Dissolved Oxygen*	*pH*	*Sediment*	*Temperature*	*Toxicity*	*Mercury*	*Metals (copper, lead, zinc, cadmium)*	*PCBs, toxaphene*
Urban	1. New Development	–	–		–	–			–	
	2. Watershed Protection & Site Development	–	–		–	–		–	–	
	3. Construction Site Erosion and Sediment Control		–		–	–				
	4. Construction Site Chemical Control		–							
	5. Existing Developments	–	–		–	–			–	
	6. Residential and Commercial Pollution Prevention	–	–							
Onsite Wastewater	1. New Onsite Wastewater Disposal Systems	–	–							
	2. Operating Existing Onsite Wastewater Disposal Systems	–	–							
Roads, Highways and Bridges	1. Siting New Roads, Highways & Bridges	–	–		–	–			–	
	2. Construction Projects for Roads, Highways and Bridges		–		–	–				
	3. Construction Site Chemical Control for Roads, Highways and Bridges		–							
	4. Operation and Maintenance-Roads, Highways and Bridges	–	–			–			–	

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Appendix A

30-day Geometric Mean Fecal Coliform Monitoring Data

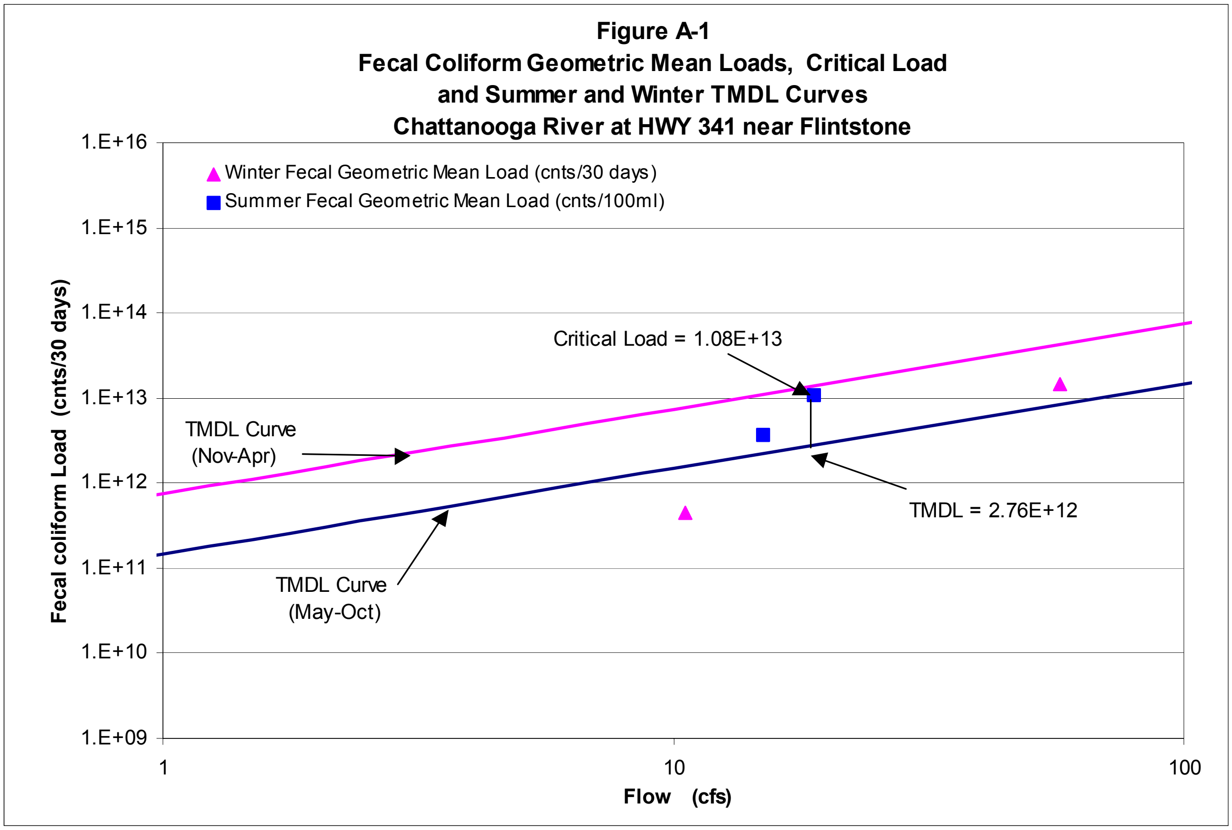

Table A-1. Data for Figure A-1, including: observed fecal coliform, instantaneous flow fecal coliform load, fecal coliform geometric mean, mean flow, fecal coliform geometric mean load.

Date	Observed Fecal Coliform (counts/100 ml)	Estimated Instantaneous Flow On Sample Day (cfs)	Geometric Mean (cnts/100 ml)	Mean Flow (cfs)	Geometric Mean Fecal Coliform Loading (cnts/30 days)	Geometric Mean TMDL Fecal Coliform Loading (cnts/30 days)
21-Feb-01	490	39.60				
27-Feb-01	90	39.60				
6-Mar-01	330	74.90				
13-Mar-01	940	74.90	342	57	1.44E+13	4.20E+13
16-May-01	330	7.50				
22-May-01	330	8.40				
30-May-01	4900	35.20				
12-Jun-01	700	24.20	782	19	1.08E+13	2.76E+12
21-Aug-01	190	12.30				
30-Aug-01	2400	7.70				
5-Sep-01	1300	28.60				
11-Sep-01	20	11.20	330	15	3.62E+12	2.19E+12
6-Nov-01	130	6.60				
14-Nov-01	20	6.60				
28-Nov-01	20	12.10				
4-Dec-01	220	17.00	58	11	4.51E+11	7.76E+12

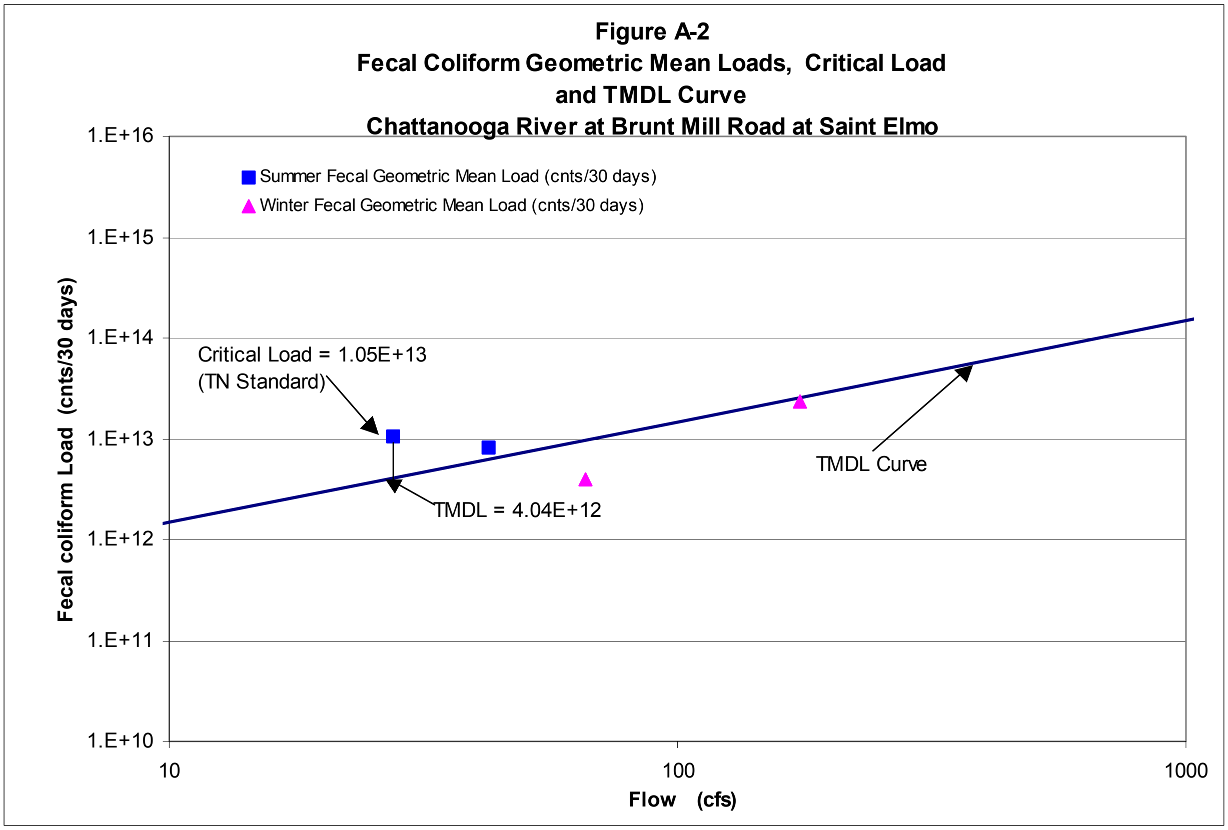

Table A-2. Data for Figure A-2, including: observed fecal coliform, instantaneous flow fecal coliform load, fecal coliform geometric mean, mean flow, fecal coliform geometric mean load.

Date	Observed Fecal Coliform (counts/100 ml)	Estimated Instantaneous Flow On Sample Day (cfs)	Geometric Mean (cnts/100 ml)	Mean Flow (cfs)	Geometric Mean Fecal Coliform Loading (cnts/30 days)	Geometric Mean TMDL Fecal Coliform Loading (cnts/30 days)
21-Feb-01	80	150.00				
27-Feb-01	230	217.00				
6-Mar-01	50	112.00				
13-Mar-01	1300	217.00	186	174	2.38E+13	2.55E+13
16-May-01	140	27.00				
22-May-01	330	22.00				
30-May-01	1300	57.00				
12-Jun-01	80	64.00	263	43	8.21E+12	6.24E+12
21-Aug-01	270	25.00				
30-Aug-01	790	17.00				
5-Sep-01	1700	47.00				
11-Sep-01	200	21.00	519	28	1.05E+13	4.04E+12
6-Nov-01	50	53.00				
14-Nov-01	20	47.00				
28-Nov-01	20	93.00				
4-Dec-01	2200	70.00	81	66	3.93E+12	9.65E+12

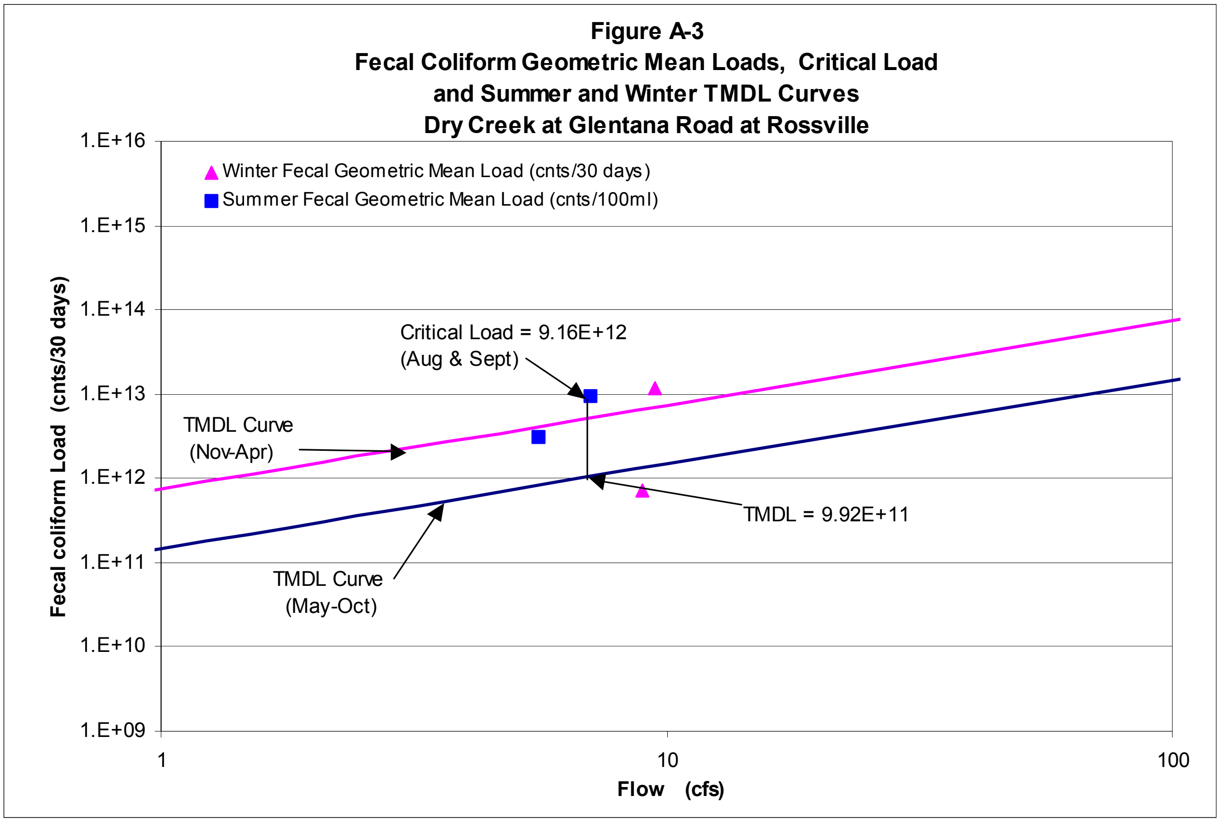

Table A-3. Data for Figure A-3, including: observed fecal coliform, instantaneous flow fecal coliform load, fecal coliform geometric mean, mean flow, fecal coliform geometric mean load.

Date	Observed Fecal Coliform (counts/100 ml)	Estimated Instantaneous Flow On Sample Day (cfs)	Geometric Mean (cnts/100 ml)	Mean Flow (cfs)	Geometric Mean Fecal Coliform Loading (cnts/30 days)	Geometric Mean TMDL Fecal Coliform Loading (cnts/30 days)
21-Feb-01	1700	6.80				
27-Feb-01	170	10.00				
6-Mar-01	1300	7.00				
13-Mar-01	22000	14.00	1696	9	1.18E+13	6.94E+12
16-May-01	1700	5.60				
22-May-01	700	4.80				
30-May-01	330	6.40				
12-Jun-01	790	5.50	746	6	3.05E+12	8.18E+11
21-Aug-01	2200	6.50				
30-Aug-01	4900	5.80				
5-Sep-01	2200	9.60				
11-Sep-01	490	6.40	1846	7	9.59E+12	1.04E+12
6-Nov-01	490					
14-Nov-01	20					
28-Nov-01	20	10.00				
4-Dec-01	790	7.90	112	9	7.33E+11	6.57E+12

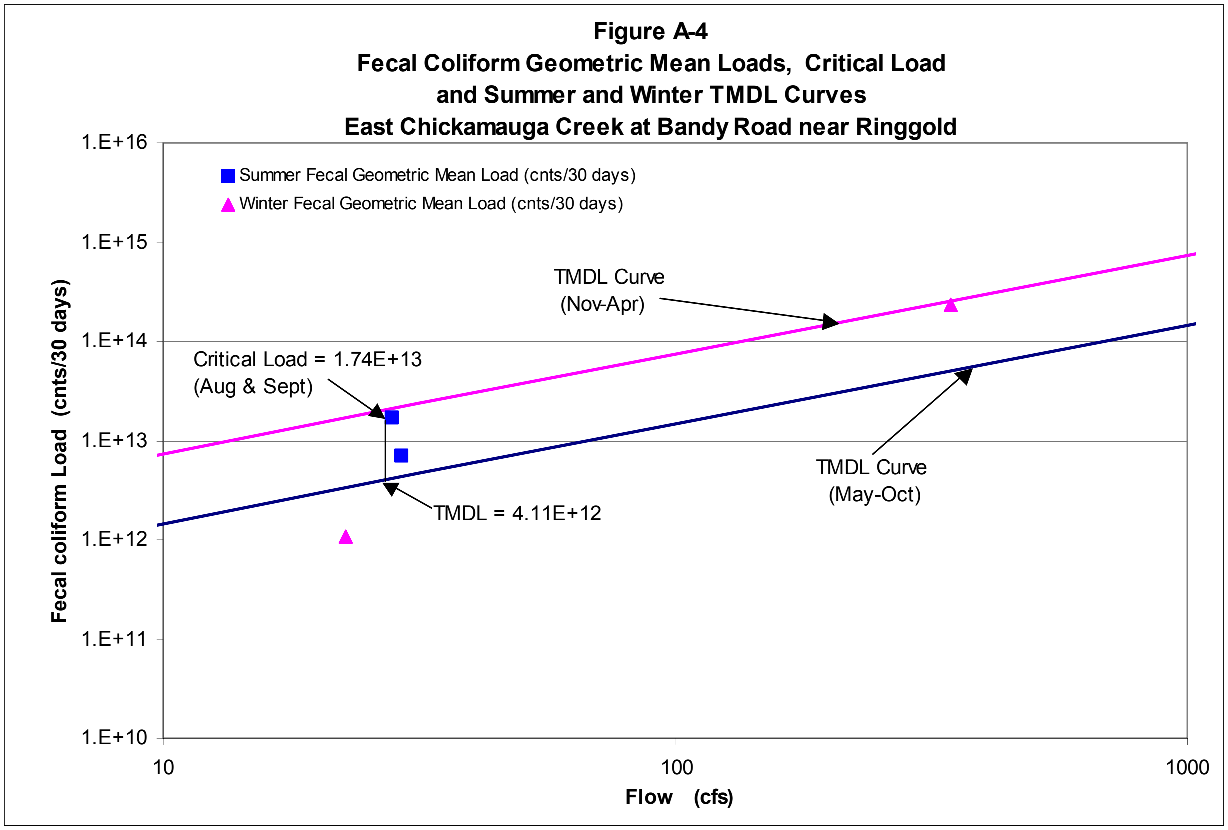

Table A-4. Data for Figure A-4, including: observed fecal coliform, instantaneous flow fecal coliform load, fecal coliform geometric mean, mean flow, fecal coliform geometric mean load.

Date	Observed Fecal Coliform (counts/100 ml)	Estimated Instantaneous Flow On Sample Day (cfs)	Geometric Mean (cnts/100 ml)	Mean Flow (cfs)	Geometric Mean Fecal Coliform Loading (cnts/30 days)	Geometric Mean TMDL Fecal Coliform Loading (cnts/30 days)
22-Feb-01	3500	376.00				
28-Feb-01	290	92.00				
7-Mar-01	80	62.00				
15-Mar-01	9200	855.00	930	346	2.36E+14	2.54E+14
15-May-01	20	27.00				
23-May-01	230	27.00				
31-May-01	3300	33.00				
9-Jul-01	790	30.00	331	29	7.10E+12	4.29E+12
20-Aug-01	22000	30.00				
29-Aug-01	170	23.00				
4-Sep-01	1700	36.00				
13-Sep-01	80	23.00	845	28	1.74E+13	4.11E+12
8-Nov-01	260	24.00				
15-Nov-01	20	23.00				
27-Nov-01	20	21.00				
3-Dec-01	170	23.00	65	23	1.08E+12	1.67E+13

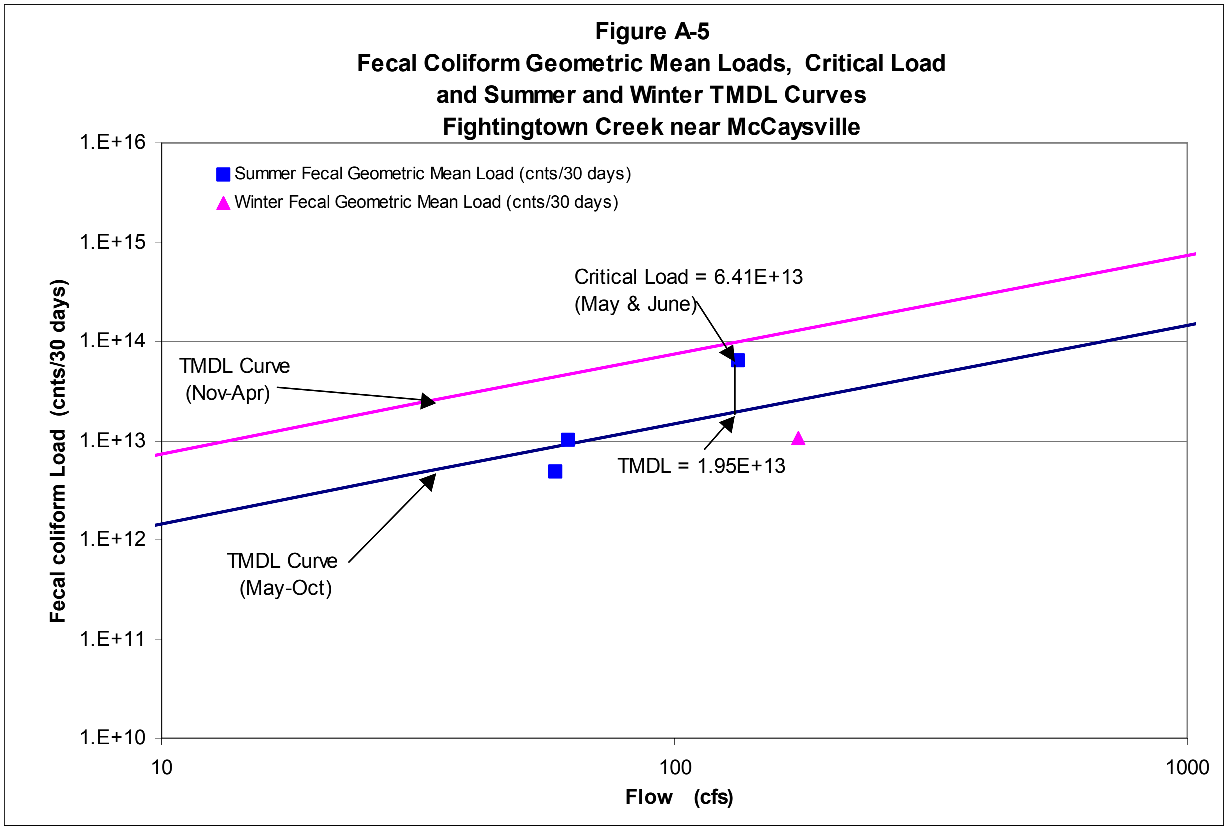

Table A-5. Data for Figure A-5, including: observed fecal coliform, instantaneous flow fecal coliform load, fecal coliform geometric mean, mean flow, fecal coliform geometric mean load.

Date	Observed Fecal Coliform (counts/100 ml)	Estimated Instantaneous Flow On Sample Day (cfs)	Geometric Mean (cnts/100 ml)	Mean Flow (cfs)	Geometric Mean Fecal Coliform Loading (cnts/30 days)	Geometric Mean TMDL Fecal Coliform Loading (cnts/30 days)
16-Jan-01	50	68.00				
23-Jan-01	50	189.00				
30-Jan-01	230	332.00				
6-Feb-01	80	109.00	82	175	1.05E+13	1.28E+14
7-May-02	1300	153.00				
14-May-02	140	104.00				
21-May-02	130	77.00				
4-Jun-02	7900	197.00	658	133	6.41E+13	1.95E+13
28-Aug-02	140	64.00				
10-Sep-02	330	64.00				
18-Sep-02	170	54.00				
27-Sep-02	330	66.00	226	62	1.03E+13	9.10E+12
2-Oct-02	50	54.00				
9-Oct-02	50	51.00				
15-Oct-02	1300	77.00				
23-Oct-02	50	53.00	113	59	4.87E+12	8.62E+12

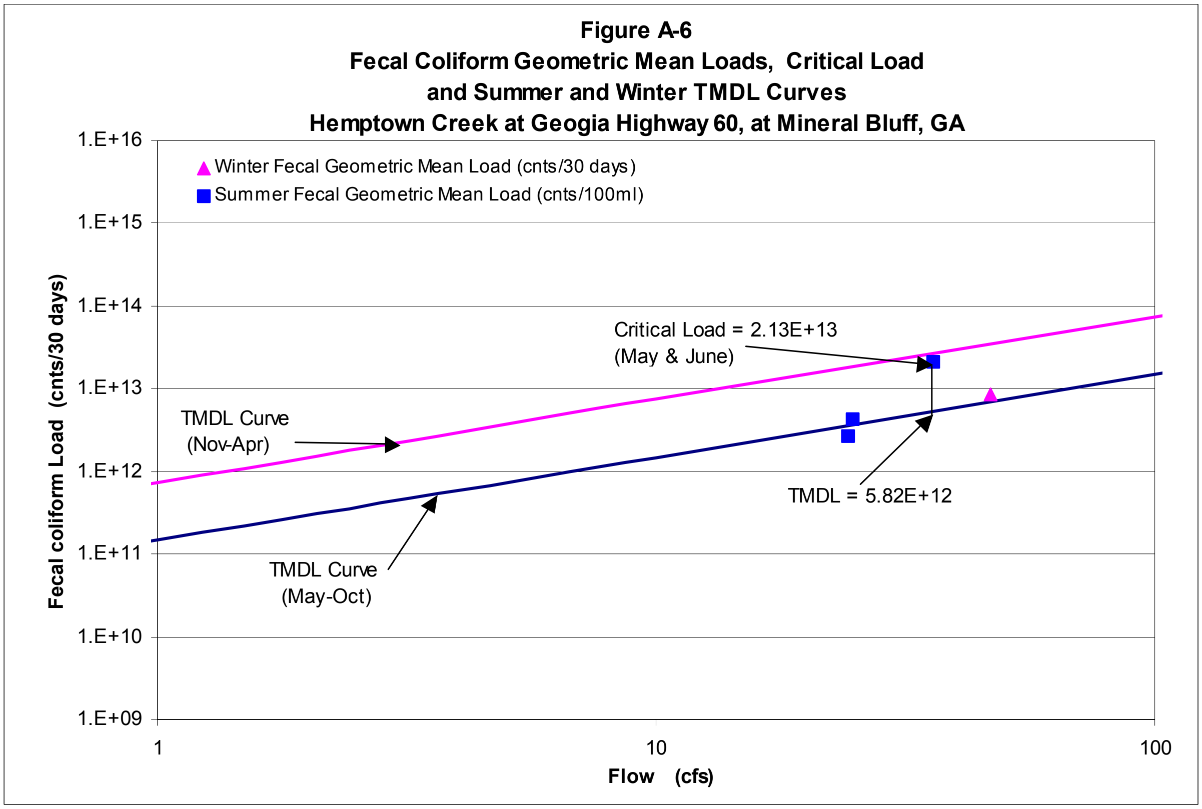

Table A-6. Data for Figure A-6, including: observed fecal coliform, instantaneous flow fecal coliform load, fecal coliform geometric mean, mean flow, fecal coliform geometric mean load.

Date	Observed Fecal Coliform (counts/100 ml)	Estimated Instantaneous Flow On Sample Day (cfs)	Geometric Mean (cnts/100 ml)	Mean Flow (cfs)	Geometric Mean Fecal Coliform Loading (cnts/30 days)	Geometric Mean TMDL Fecal Coliform Loading (cnts/30 days)
16-Jan-01	210	33.00				
23-Jan-01	110	50.00				
30-Jan-01	2200	71.00				
6-Feb-01	80	33.00	253	47	8.66E+12	3.43E+13
7-May-02	4900	40.00				
14-May-02	330	20.00				
21-May-02	330	22.00				
4-Jun-02	790	62.00	806	36	2.13E+13	5.28E+12
28-Aug-02	70	25.00				
10-Sep-02	700	26.00				
18-Sep-02	270	23.00				
27-Sep-02	220	25.00	232	25	4.22E+12	3.63E+12
2-Oct-02	220	24.00				
9-Oct-02	140	21.00				
15-Oct-02	790	28.00				
23-Oct-02	20	24.00	149	24	2.64E+12	3.56E+12

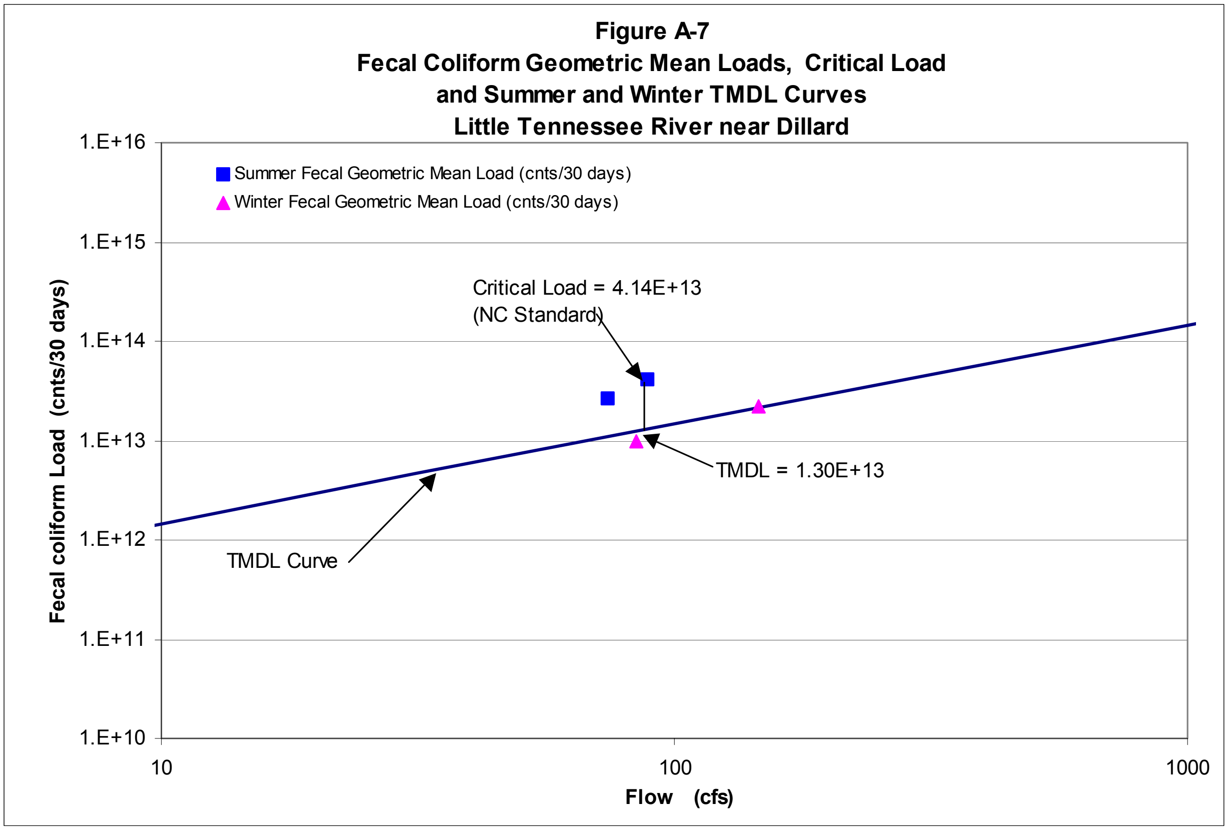

Table A-7. Data for Figure A-7, including: observed fecal coliform, instantaneous flow fecal coliform load, fecal coliform geometric mean, mean flow, fecal coliform geometric mean load.

Date	Observed Fecal Coliform (counts/100 ml)	Estimated Instantaneous Flow On Sample Day (cfs)	Geometric Mean (cnts/100 ml)	Mean Flow (cfs)	Geometric Mean Fecal Coliform Loading (cnts/30 days)	Geometric Mean TMDL Fecal Coliform Loading (cnts/30 days)
12-Feb-01	110	94.00				
20-Feb-01	220	87.00				
26-Feb-01	230	268.00				
5-Mar-01	330	133.00	207	146	2.21E+13	2.14E+13
30-May-01	330	79.00				
5-Jun-01	260	85.00				
11-Jun-01	790	71.00				
20-Jun-01	790	62.00	481	74	2.62E+13	1.09E+13
10-Jul-01	130	84.00				
18-Jul-01	290	65.00				
25-Jul-01	4600	98.00				
1-Aug-01	940	108.00	635	89	4.14E+13	1.30E+13
8-Nov-01	170	79.00				
15-Nov-01	20	71.00				
26-Nov-01	260	100.00				
6-Dec-01	770	86.00	162	84	9.96E+12	1.23E+13

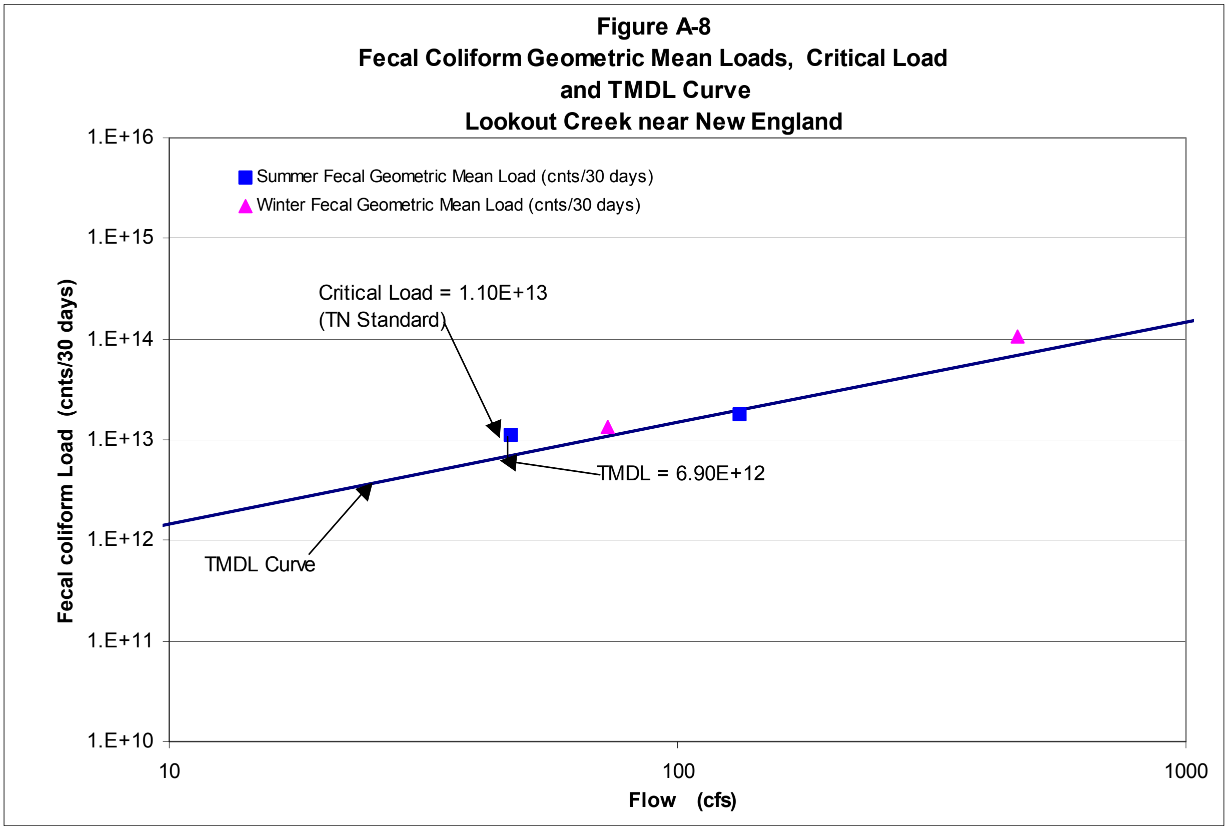

Table A-8. Data for Figure A-8, including: observed fecal coliform, instantaneous flow fecal coliform load, fecal coliform geometric mean, mean flow, fecal coliform geometric mean load.

Date	Observed Fecal Coliform (counts/100 ml)	Estimated Instantaneous Flow On Sample Day (cfs)	Geometric Mean (cnts/100 ml)	Mean Flow (cfs)	Geometric Mean Fecal Coliform Loading (cnts/30 days)	Geometric Mean TMDL Fecal Coliform Loading (cnts/30 days)
21-Feb-01	170	385.00				
27-Feb-01	490	542.00				
6-Mar-01	230	269.00				
13-Mar-01	460	666.00	306	466	1.05E+14	6.83E+13
16-May-01	110	52.00				
22-May-01	20	44.00				
30-May-01	1100	194.00				
12-Jun-01	490	238.00	186	132	1.80E+13	1.94E+13
21-Aug-01	220	51.00				
30-Aug-01	330	30.00				
5-Sep-01	1100	69.00				
11-Sep-01	130	38.00	319	47	1.10E+13	6.90E+12
6-Nov-01	490	24.00				
14-Nov-01	170	25.00				
28-Nov-01	460	142.00				
4-Dec-01	110	100.00	255	73	1.36E+13	1.07E+13

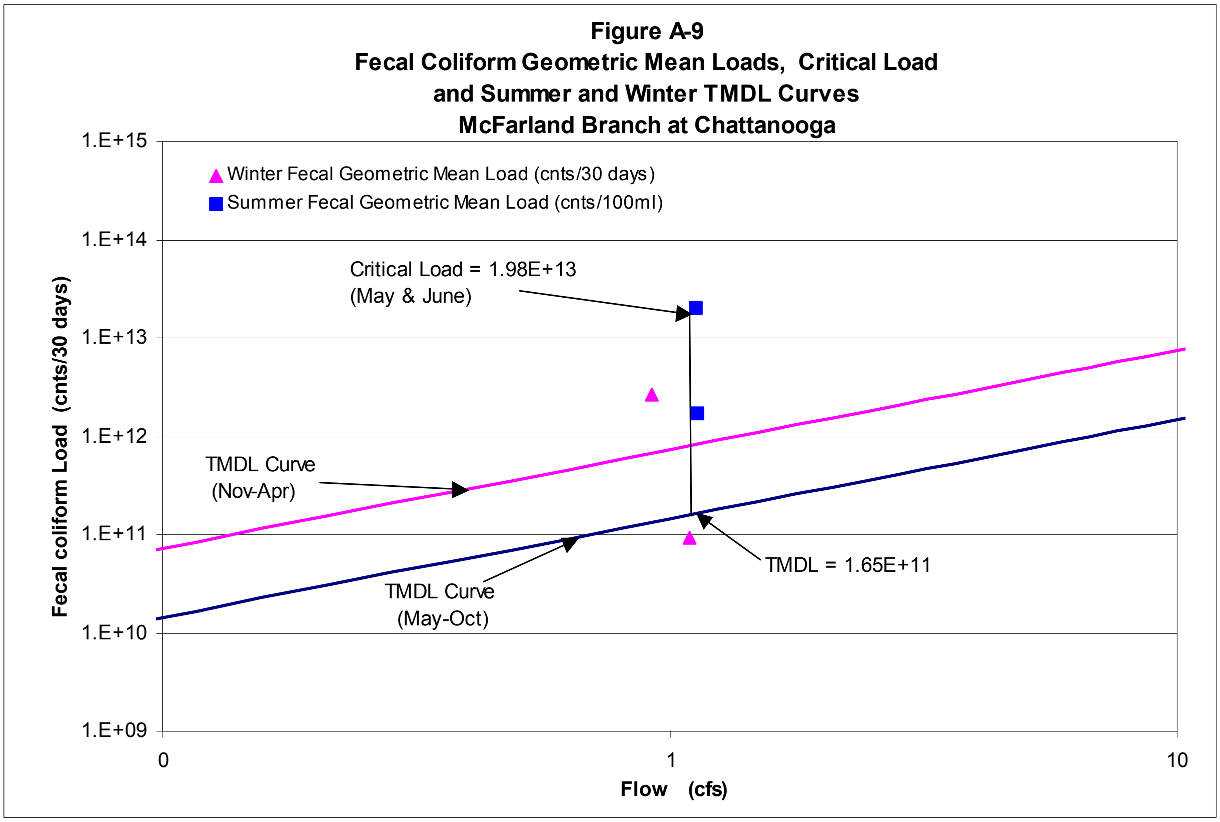

Table A-9. Data for Figure A-9, including: observed fecal coliform, instantaneous flow fecal coliform load, fecal coliform geometric mean, mean flow, fecal coliform geometric mean load.

Date	Observed Fecal Coliform (counts/100 ml)	Estimated Instantaneous Flow On Sample Day (cfs)	Geometric Mean (cnts/100 ml)	Mean Flow (cfs)	Geometric Mean Fecal Coliform Loading (cnts/30 days)	Geometric Mean TMDL Fecal Coliform Loading (cnts/30 days)
21-Feb-01	1700	1.10				
27-Feb-01	3100	1.10				
6-Mar-01	790	1.10				
13-Mar-01	54000	0.38	3872	0.9	2.61E+12	6.75E+11
16-May-01	24000	1.00				
22-May-01	24000	1.30				
30-May-01	24000	1.10				
12-Jun-01	24000	1.10	24000	1.1	1.98E+13	1.65E+11
21-Aug-01	4900	0.82				
30-Aug-01	2200	0.82				
5-Sep-01	4900	1.80				
11-Sep-01	330	1.10	2043	1.1	1.70E+12	1.67E+11
6-Nov-01	490	0.98				
14-Nov-01	40	1.40				
28-Nov-01	20	1.00				
4-Dec-01	490	0.98	118	1.1	9.42E+10	8.00E+11

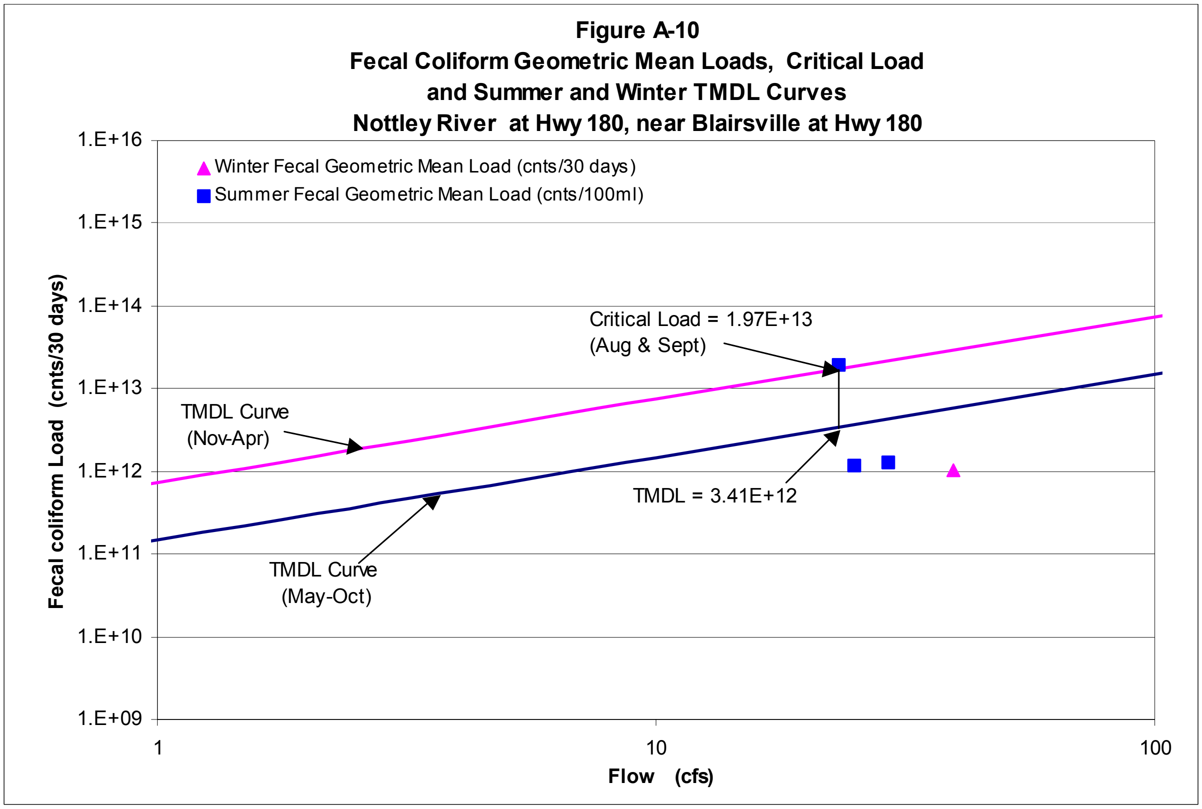

Table A-10. Data for Figure A-10, including: observed fecal coliform, instantaneous flow fecal coliform load, fecal coliform geometric mean, mean flow, fecal coliform geometric mean load.

Date	Observed Fecal Coliform (counts/100 ml)	Estimated Instantaneous Flow On Sample Day (cfs)	Geometric Mean (cnts/100 ml)	Mean Flow (cfs)	Geometric Mean Fecal Coliform Loading (cnts/30 days)	Geometric Mean TMDL Fecal Coliform Loading (cnts/30 days)
18-Jan-01	80	40.00				
25-Jan-01	20	43.00				
1-Feb-01	50	41.00				
8-Feb-01	20	34.00	36	40	1.03E+12	2.90E+13
9-May-01	20	30.00				
16-May-01	80	37.00				
23-May-01	130	24.00				
6-Jun-01	60	26.00	59	29	1.28E+12	4.29E+12
30-Aug-01	490	19.00				
12-Sep-01	1400	20.00				
20-Sep-01	3300	28.00				
26-Sep-01	790	26.00	1156	23	1.97E+13	3.41E+12
4-Oct-01	130	19.00				
11-Oct-01	170	23.00				
18-Oct-01	40	28.00				
25-Oct-01	20	30.00	65	25	1.19E+12	3.67E+12

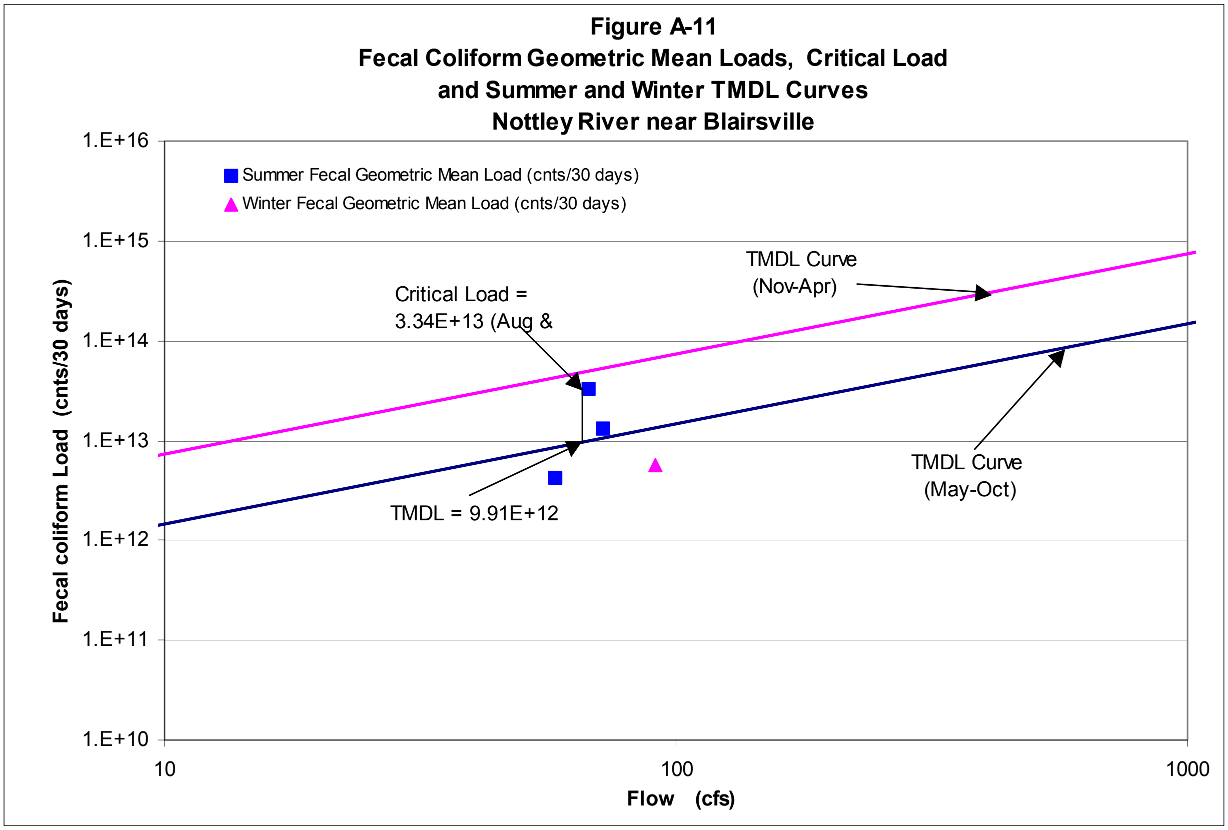

Table A-11. Data for Figure A-11, including: observed fecal coliform, instantaneous flow fecal coliform load, fecal coliform geometric mean, mean flow, fecal coliform geometric mean load.

Date	Observed Fecal Coliform (counts/100 ml)	Estimated Instantaneous Flow On Sample Day (cfs)	Geometric Mean (cnts/100 ml)	Mean Flow (cfs)	Geometric Mean Fecal Coliform Loading (cnts/30 days)	Geometric Mean TMDL Fecal Coliform Loading (cnts/30 days)
17-Jan-02	170	61.00				
24-Jan-02	20	120.00				
31-Jan-02	130	106.00				
7-Feb-02	110	78.00	84	91	5.59E+12	6.70E+13
9-May-02	170	70.00				
15-May-02	40	57.00				
22-May-02	790	57.00				
5-Jun-02	700	104.00	248	72	1.31E+13	1.06E+13
29-Aug-02	700	50.00				
11-Sep-02	790	63.00				
19-Sep-02	340	46.00				
25-Sep-02	1100	111.00	674	68	3.34E+13	9.91E+12
3-Oct-02	170	51.00				
10-Oct-02	230	52.00				
17-Oct-02	130	71.00				
24-Oct-02	20	58.00	100	58	4.27E+12	8.51E+12

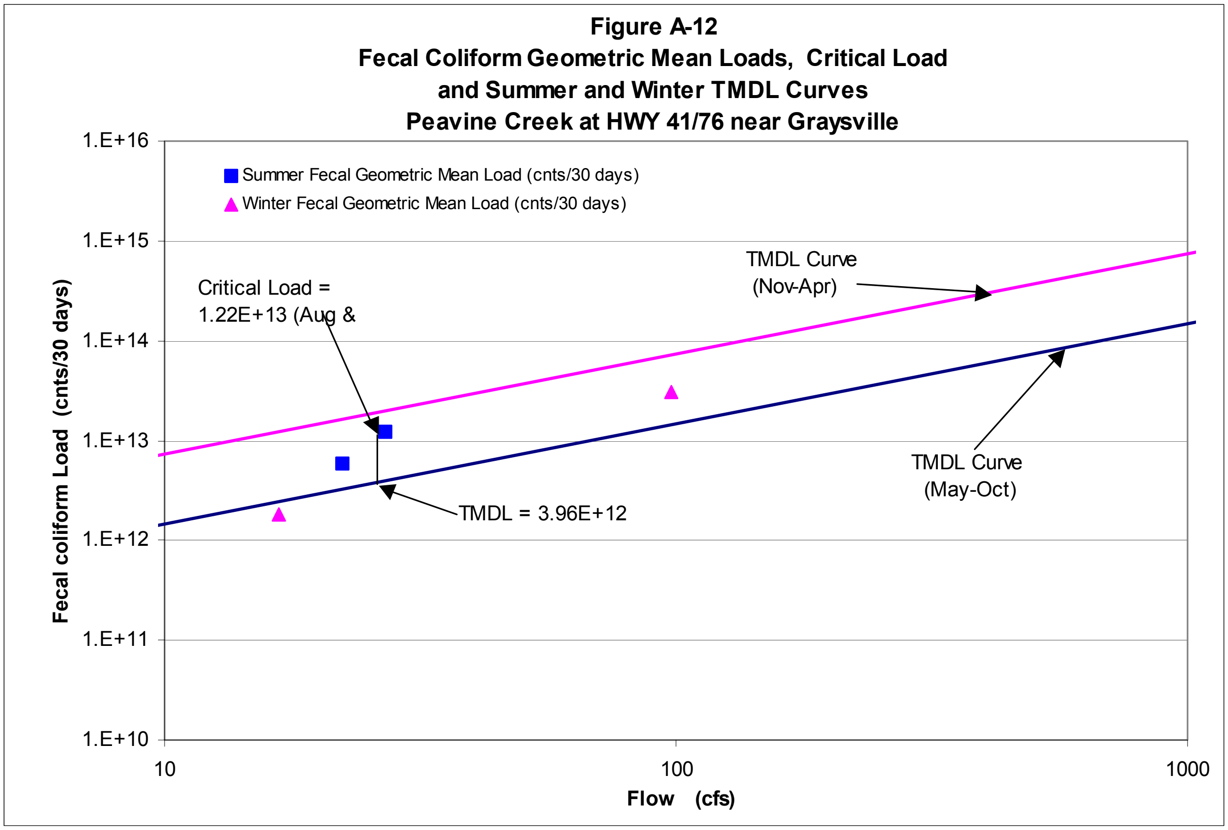

Table A-12. Data for Figure A-12, including: observed fecal coliform, instantaneous flow fecal coliform load, fecal coliform geometric mean, mean flow, fecal coliform geometric mean load.

Date	Observed Fecal Coliform (counts/100 ml)	Estimated Instantaneous Flow On Sample Day (cfs)	Geometric Mean (cnts/100 ml)	Mean Flow (cfs)	Geometric Mean Fecal Coliform Loading (cnts/30 days)	Geometric Mean TMDL Fecal Coliform Loading (cnts/30 days)
22-Feb-01	5400	234.00				
28-Feb-01	330	55.00				
7-Mar-01	80	35.00				
15-Mar-01	230	67.00	426	98	3.05E+13	7.17E+13
15-May-01	20	21.00				
23-May-01	330	17.00				
31-May-01	4900	27.00				
9-Jul-01	490	24.00	355	22	5.79E+12	3.27E+12
20-Aug-01	490	20.00				
29-Aug-01	130	20.00				
4-Sep-01	2400	50.00				
13-Sep-01	940	18.00	616	27	1.22E+13	3.96E+12
8-Nov-01	330	13.00				
15-Nov-01	230	13.00				
27-Nov-01	20	21.00				
3-Dec-01	330	20.00	150	17	1.84E+12	1.23E+13

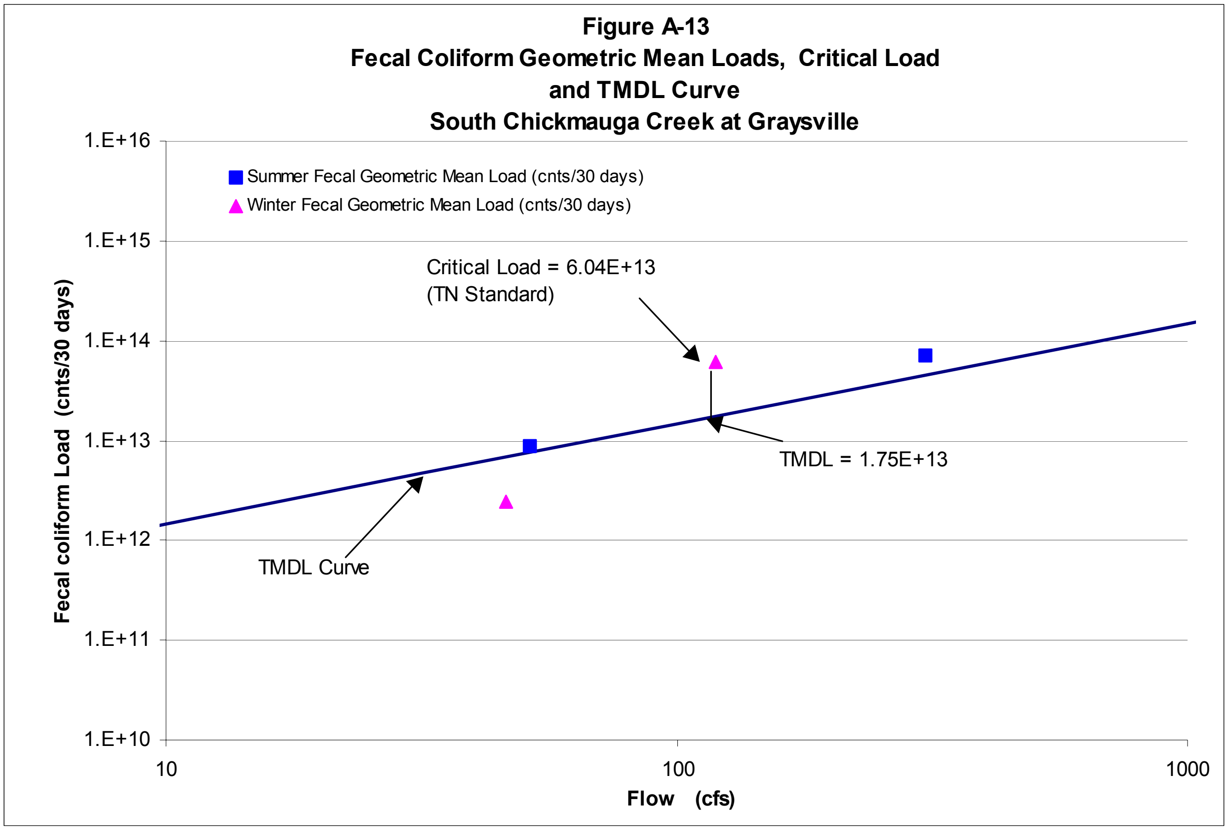

Table A-13. Data for Figure A-13, including: observed fecal coliform, instantaneous flow fecal coliform load, fecal coliform geometric mean, mean flow, fecal coliform geometric mean load.

Date	Observed Fecal Coliform (counts/100 ml)	Estimated Instantaneous Flow On Sample Day (cfs)	Geometric Mean (cnts/100 ml)	Mean Flow (cfs)	Geometric Mean Fecal Coliform Loading (cnts/30 days)	Geometric Mean TMDL Fecal Coliform Loading (cnts/30 days)
22-Feb-01	2400	77.00				
28-Feb-01	330	143.00				
7-Mar-01	170	165.00				
15-Mar-01	1700	91.00	692	119	6.04E+13	1.75E+13
15-May-01	20	159.00				
23-May-01	790	779.00				
31-May-01	1300	198.00				
13-Jun-01	490	93.00	317	307	7.14E+13	4.51E+13
23-Aug-01	270	44.00				
29-Aug-01	110	34.00				
4-Sep-01	1300	71.00				
13-Sep-01	80	57.00	236	52	8.91E+12	7.56E+12
8-Nov-01	50	36.00				
15-Nov-01	80	38.00				
27-Nov-01	20	50.00				
3-Dec-01	330	61.00	72	46	2.43E+12	6.79E+12

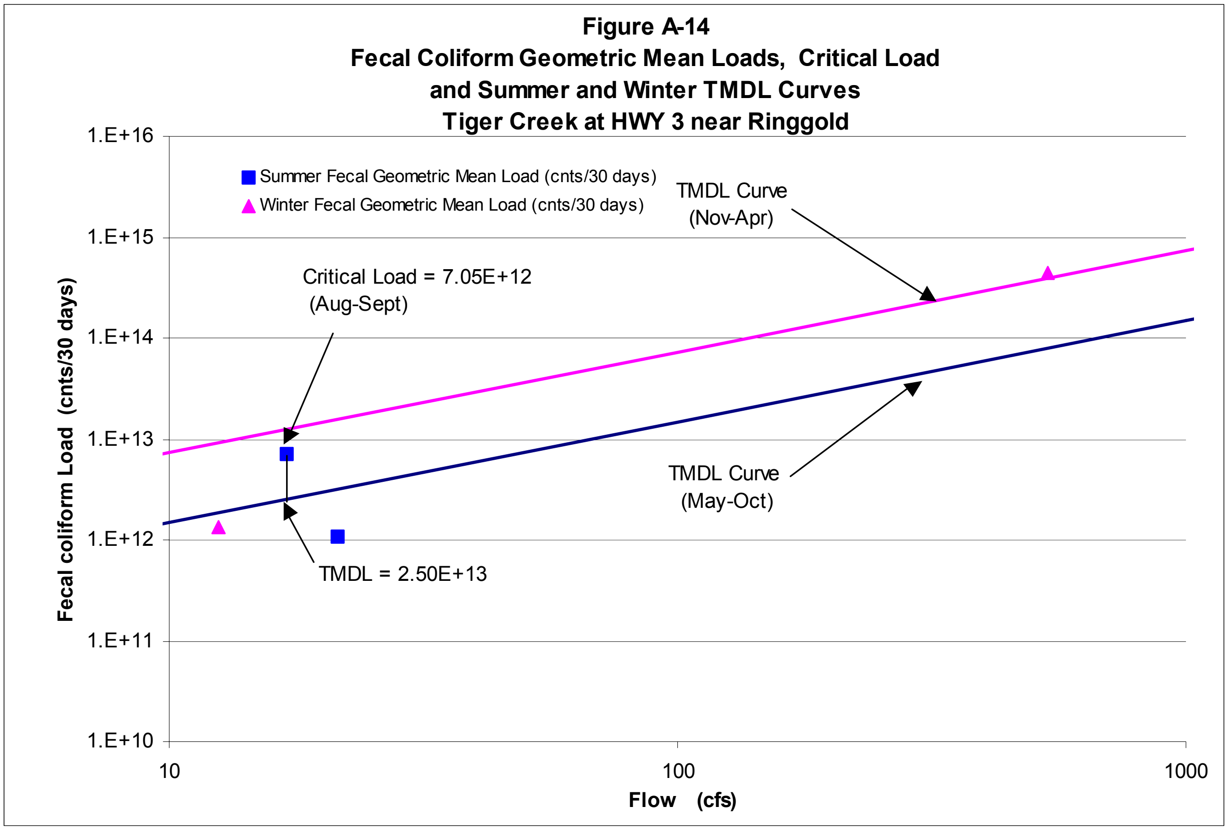

Table A-14. Data for Figure A-14, including: observed fecal coliform, instantaneous flow fecal coliform load, fecal coliform geometric mean, mean flow, fecal coliform geometric mean load.

Date	Observed Fecal Coliform (counts/100 ml)	Estimated Instantaneous Flow On Sample Day (cfs)	Geometric Mean (cnts/100 ml)	Mean Flow (cfs)	Geometric Mean Fecal Coliform Loading (cnts/30 days)	Geometric Mean TMDL Fecal Coliform Loading (cnts/30 days)
22-Feb-01	11000	848.00				
28-Feb-01	790	131.00				
7-Mar-01	20	64.00				
15-Mar-01	9400	1090.00	1131	533	4.43E+14	3.91E+14
15-May-01	20	18.00				
23-May-01	30	17.00				
31-May-01	110	24.00				
9-Jul-01	330	27.00	68	22	1.08E+12	3.16E+12
20-Aug-01	1100	15.00				
29-Aug-01	700	12.00				
4-Sep-01	270	29.00				
13-Sep-01	490	12.00	565	17	7.05E+12	2.50E+12
8-Nov-01	20	13.00				
15-Nov-01	60	12.00				
27-Nov-01	3300	11.00				
3-Dec-01	110	14.00	144	13	1.33E+12	9.18E+12

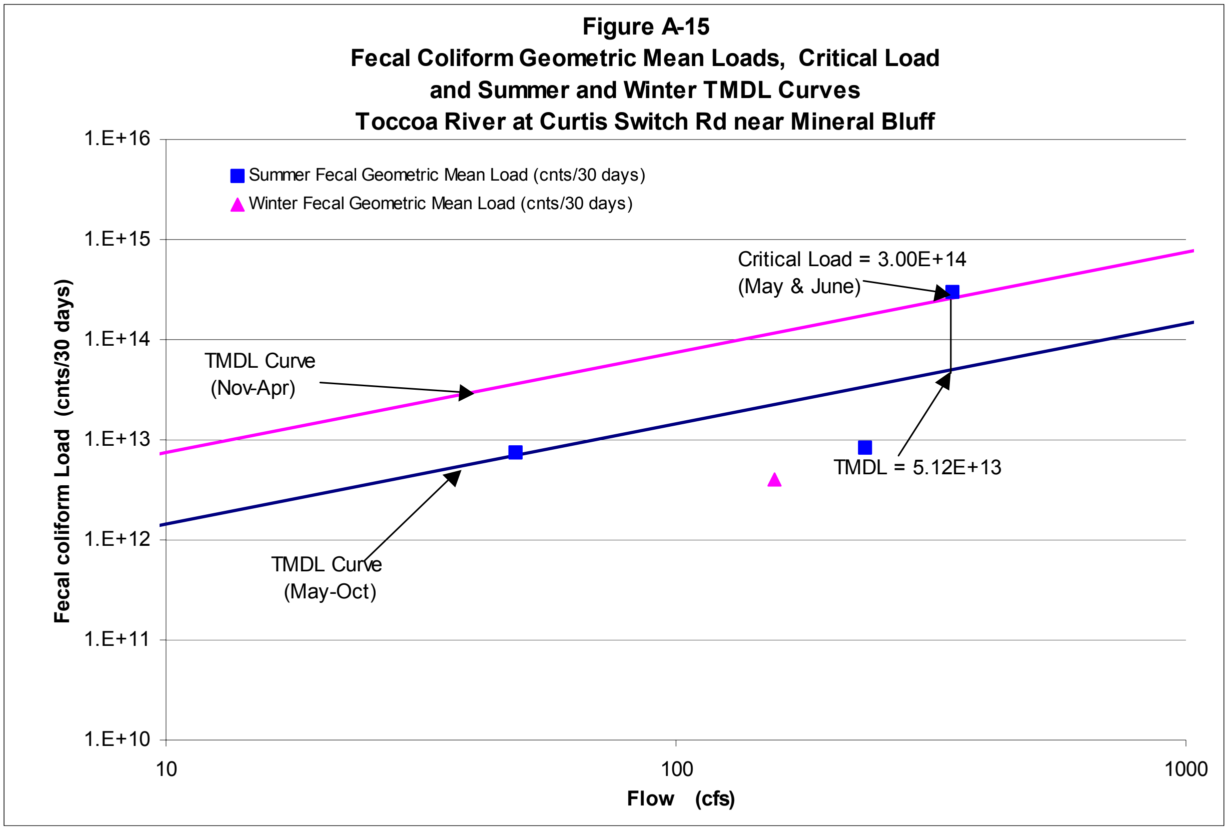

Table A-15. Data for Figure A-15, including: observed fecal coliform, instantaneous flow fecal coliform load, fecal coliform geometric mean, mean flow, fecal coliform geometric mean load.

Date	Observed Fecal Coliform (counts/100 ml)	Estimated Instantaneous Flow On Sample Day (cfs)	Geometric Mean (cnts/100 ml)	Mean Flow (cfs)	Geometric Mean Fecal Coliform Loading (cnts/30 days)	Geometric Mean TMDL Fecal Coliform Loading (cnts/30 days)
16-Jan-01	20	94.00				
23-Jan-01	20	168.00				
30-Jan-01	80	251.00				
6-Feb-01	50	111.00	36	156	4.07E+12	1.15E+14
7-May-02	490	230.00				
14-May-02	4900	660.00				
21-May-02	1700	372.00				
4-Jun-02	460	133.00	1171	349	3.00E+14	5.12E+13
28-Aug-02	430	45.00				
10-Sep-02	130	24.00				
18-Sep-02	130	82.00				
27-Sep-02	260	43.00	208	49	7.42E+12	7.12E+12
2-Oct-02	50	31.00				
9-Oct-02	20	25.00				
15-Oct-02	20	605.00				
23-Oct-02	270	277.00	48	235	8.30E+12	1.72E+14

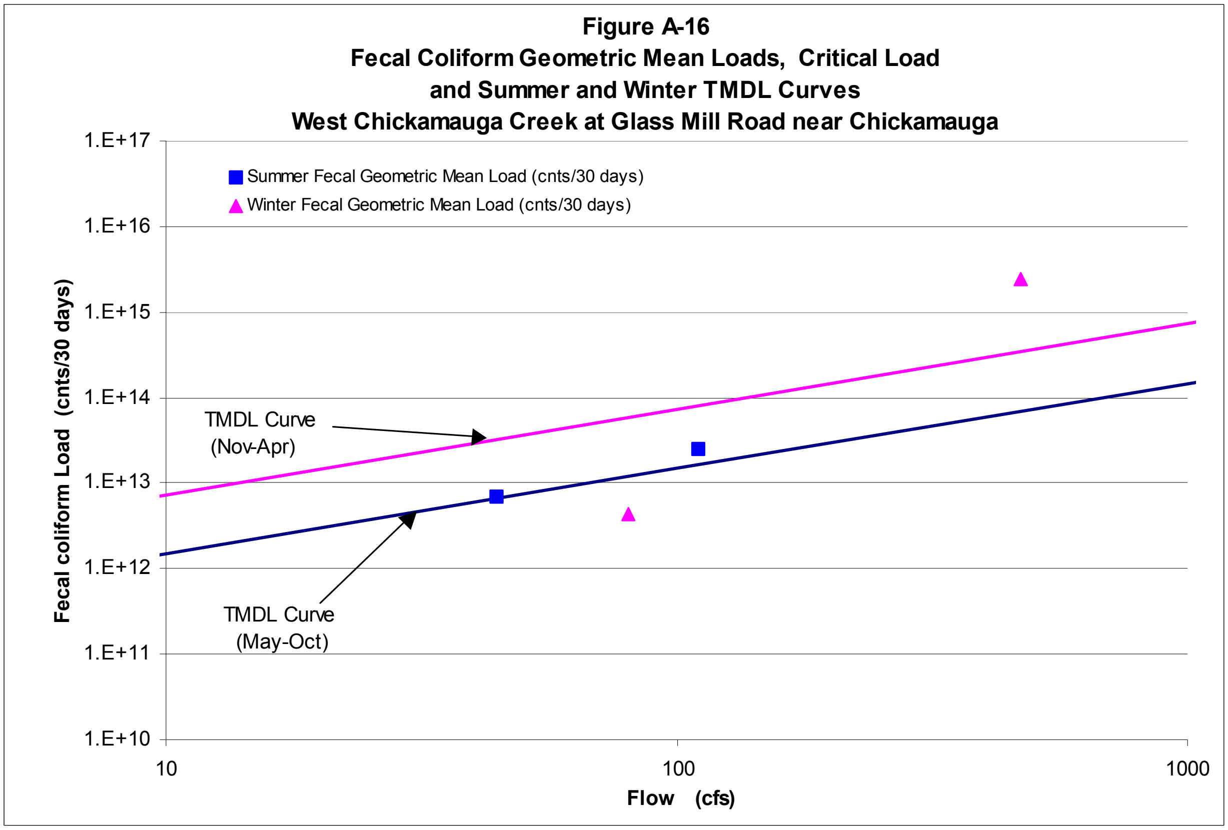

Table A-16. Data for Figure A-16, including: observed fecal coliform, instantaneous flow fecal coliform load, fecal coliform geometric mean, mean flow, fecal coliform geometric mean load.

Date	Observed Fecal Coliform (counts/100 ml)	Estimated Instantaneous Flow On Sample Day (cfs)	Geometric Mean (cnts/100 ml)	Mean Flow (cfs)	Geometric Mean Fecal Coliform Loading (cnts/30 days)	Geometric Mean TMDL Fecal Coliform Loading (cnts/30 days)
21-Feb-01	740	187.00				
26-Feb-01	24000	327.00				
5-Mar-01	2400	187.00				
13-Mar-01	54000	1190.00	6926	473	2.40E+15	3.47E+14
17-May-01	230	46.00				
22-May-01	50	43.00				
29-May-01	2400	275.00				
11-Jul-01	330	76.00	309	110	2.49E+13	1.61E+13
21-Aug-01	170	42.00				
29-Aug-01	80	38.00				
5-Sep-01	700	65.00				
12-Sep-01	220	32.00	214	44	6.95E+12	6.50E+12
6-Nov-01	110	47.00				
14-Nov-01	20	49.00				
28-Nov-01	20	104.00				
4-Dec-01	700	121.00	74	80	4.39E+12	5.89E+13

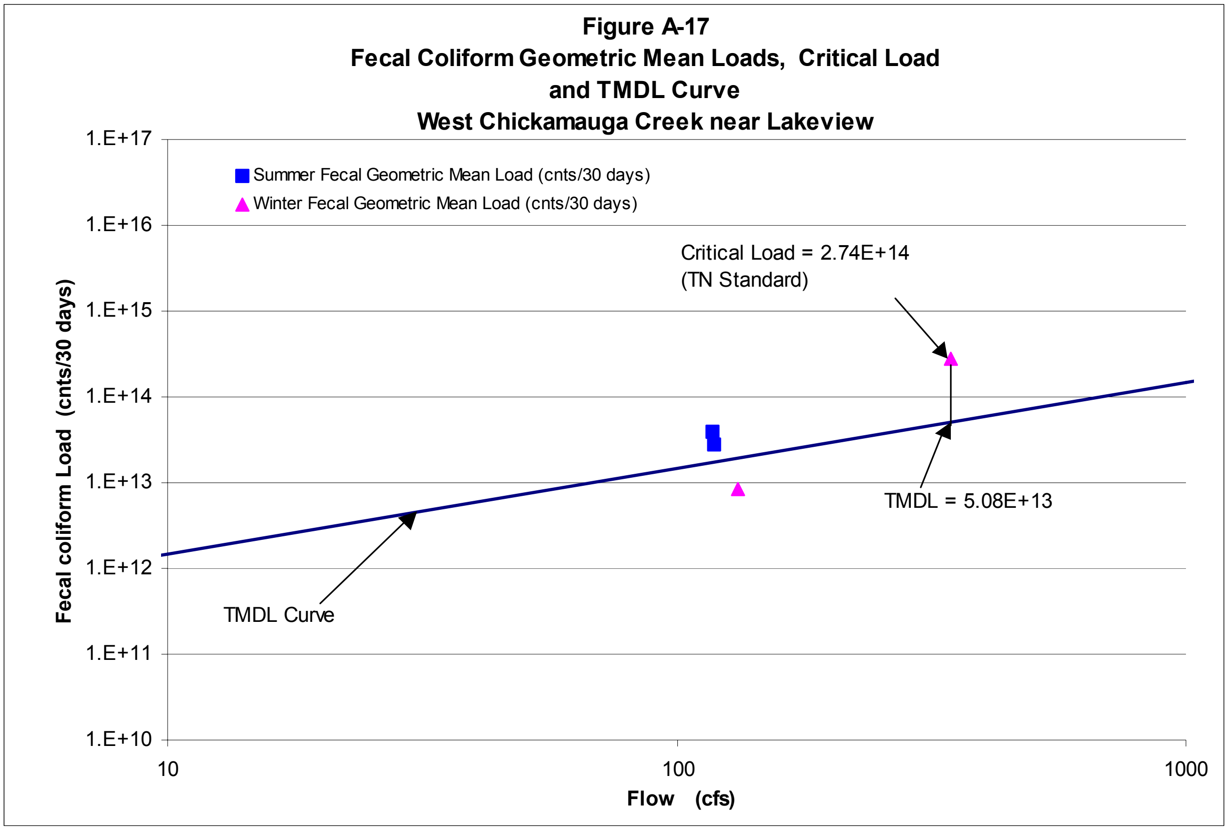

Table A-17. Data for Figure A-17 including: observed fecal coliform, instantaneous flow fecal coliform load, fecal coliform geometric mean, mean flow, fecal coliform geometric mean load.

Date	Observed Fecal Coliform (counts/100 ml)	Estimated Instantaneous Flow On Sample Day (cfs)	Geometric Mean (cnts/100 ml)	Mean Flow (cfs)	Geometric Mean Fecal Coliform Loading (cnts/30 days)	Geometric Mean TMDL Fecal Coliform Loading (cnts/30 days)
22-Feb-01	2400	342.00				
28-Feb-01	490	321.00				
7-Mar-01	330	232.00				
15-Mar-01	3500	489.00	1080	346	2.74E+14	5.08E+13
15-May-01	270	86.00				
23-May-01	110	81.00				
31-May-01	1100	184.00				
9-Jul-01	330	123.00	322	119	2.80E+13	1.74E+13
20-Aug-01	330	88.00				
29-Aug-01	230	83.00				
4-Sep-01	3300	224.00				
13-Sep-01	170	76.00	454	118	3.93E+13	1.73E+13
8-Nov-01	170	68.00				
15-Nov-01	20	67.00				
27-Nov-01	20	224.00				
3-Dec-01	790	168.00	86	132	8.28E+12	1.93E+13

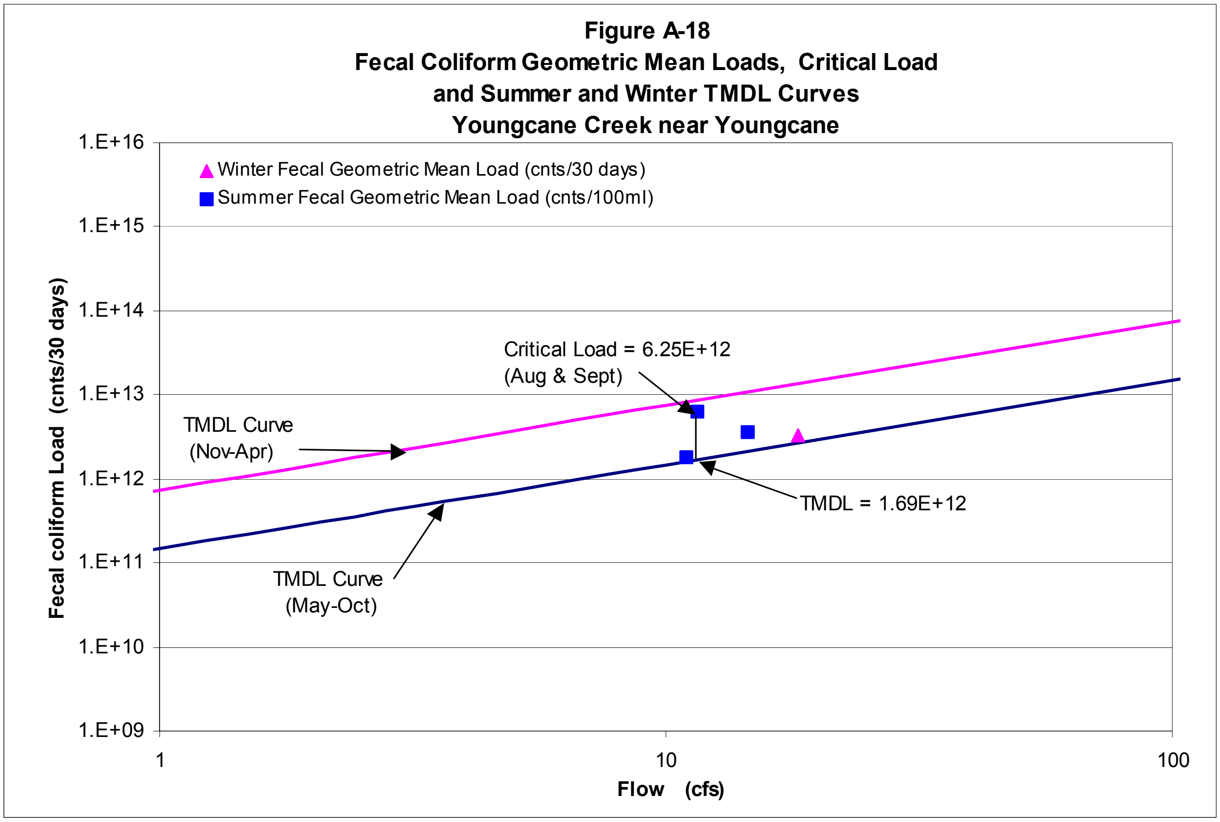

Table A-18. Data for Figure A-18, including: observed fecal coliform, instantaneous flow fecal coliform load, fecal coliform geometric mean, mean flow, fecal coliform geometric mean load.

Date	Observed Fecal Coliform (counts/100 ml)	Estimated Instantaneous Flow On Sample Day (cfs)	Geometric Mean (cnts/100 ml)	Mean Flow (cfs)	Geometric Mean Fecal Coliform Loading (cnts/30 days)	Geometric Mean TMDL Fecal Coliform Loading (cnts/30 days)
17-Jan-02	130	16.00				
24-Jan-02	230	20.00				
31-Jan-02	700	20.00				
7-Feb-02	170	17.00	244	18	3.27E+12	1.34E+13
8-May-02	790	18.00				
15-May-02	40	12.00				
22-May-02	130	14.00				
5-Jun-02	3300	14.00	341	15	3.63E+12	2.13E+12
29-Aug-02	330	11.00				
11-Sep-02	330	12.00				
19-Sep-02	790	10.00				
25-Sep-02	3500	13.00	741	12	6.25E+12	1.69E+12
3-Oct-02	1700	10.00				
10-Oct-02	330	11.00				
17-Oct-02	230	11.00				
24-Oct-02	20	12.00	225	11	1.82E+12	1.61E+12

Appendix B

Summary of Limited Fecal Coliform Monitoring Data

Summary of Limited Fecal Coliform Monitoring Data

Listed Segment	Number of Observations	Total Geometric Mean (counts/100 mL)	Data Source
Butternut Creek	15	127	TVA

Appendix C

Technical Details for Estimating TMDLs for Limited-Data Sites

Conceptual Approach

The approach to estimating fecal coliform bacteria TMDLs for the waterbodies lacking 30-day geometric mean data relies on a relationship to other similar or "equivalent" waterbodies that do have 30-day geometric mean data. This provides an estimated TMDL that can be refined in the future as additional site-specific data are collected.

Development of the TMDLs via an "equivalent" site approach needed to address three important issues:

1. Any site-specific monitoring data for a waterbody should also be incorporated, even if it is not sufficient for direct estimation of 30-day geometric means.

2. Differences in land use will result in different fecal coliform bacteria concentrations. An equivalent waterbody that provides a perfect match in landuse to a subject site is unlikely to be available.

3. The selection of an equivalent waterbody is likely to have a strong impact on the resulting TMDL estimates for a subject waterbody

Consideration of these three issues led to a corresponding set of objectives for the approach:

1. Site-specific and equivalent site data should be combined in a weighted approach that reflects the relative accuracy of information provided by each data source.

2. Differences in land use among watersheds should be addressed through use of a regionalization model that identifies the extent to which changes in geometric mean fecal coliform concentrations can be explained by changes in land use.

3. The influence of equivalent waterbody selection should be minimized through the use of multiple equivalent waterbodies for each subject waterbody.

These three objectives may be met through use of an Empirical Bayes regionalization analysis. This method combines two important concepts: Bayesian maximum likelihood techniques for combining sources of data (local and regional), and hierarchical regionalization techniques. The data combination step assumes that both the regional or equivalent site information and the available site-specific data provide information on the true, local geometric mean. The two sources of data should be combined or weighted in accordance with the degree of precision or accuracy in each source. The regionalization step assumes that the true mean at any site is a result of random variability and a regression model on land use. Empirical Bayes techniques provide statistically optimal methods for computing both the data combination and regionalization steps from observed data.

Technical Basis

In the TMDL Curve method, the needed reductions for a given waterbody, and thus the allocations, are determined by the ratio

$$\text{Reduction} = \frac{\text{TMDL Curve Point}}{\text{Critical Load}} \quad (1)$$

where the critical load is the estimated 30-day fecal coliform load most exceeding the TMDL curve, and the TMDL curve point is calculated as the geometric mean water quality standard for fecal coliform bacteria times the 30-day average flow corresponding to the critical load estimate. Both the numerator and denominator of this equation can be written in terms of a critical geometric mean, G_{cri} and a corresponding critical flow, $Q_{crit:}$

$$\text{TMDL Curve Point} = WQS \cdot Q_{crit} \quad (2)$$
$$\text{Critical Load} = G_{crit} \cdot Q_{crit}$$

Sites for which sufficient 30-day geometric means have not been collected, an estimate of G_{crit} is not available. For many waterbodies, some to many scattered observations are available, even though 30-day geometric means cannot be estimated. For other waterbodies, no site-specific data are available. In most cases, site-specific flow gaging is also not available. The approach estimates the TMDL for the sites without geometric mean data by adjusting the critical load, and thus the reduction estimate, from one or more equivalent sites that do have data. In this way, appropriate 30-day geometric mean data are “translated” to the limited-data sites to provide an estimate of load reduction needed to achieve the TMDL.

In translating from an equivalent site to a subject site, it is important to account for changes in runoff concentrations associated with differences in land use, and for changes in flow associated with different basin size. The critical load at limited-data site *i* can be estimated in relation to calculated critical loads at *n* other sites *j* through

$$\text{Critical Load}_{\text{i}} = \frac{1}{n}\sum_{j=1}^{n}\left[A_{ij} \cdot G_{crit,j} \cdot Q_{crit,j} \cdot \frac{DA_i}{DA_j}\right] \quad (3)$$

in which A_{ij} is a factor (based on land use) that relates the expected fecal coliform concentration at site *i* to that at site *j*, expressed in log space since a geometric mean is used to determine compliance), and *DA* represents the drainage area above the sample site.

The ratio DA_i/DA_j adjusts the estimated critical flow from site *j* to site *i*. In the case where gage data are available, actual mean flows rather than drainage areas can be used for the ratio. Equation (3) thus translates both the critical geometric mean concentration and the associated critical flow to provide a new estimate of critical load at site *i*. Averaging over estimates obtained from *n* equivalent sites, the estimated reduction needed at site *i* is then, from (1):

$$\text{Reduction}_{\text{i}} = \sum_{\text{j=1}}^{\text{n}} \frac{\left[WQS \cdot Q_{crit,j} \cdot \frac{DA_i}{DA_j}\right]}{\left[A_{ij}\ G_j \cdot Q_{crit,j} \cdot \frac{DA_i}{DA_j}\right]} \quad (4)$$

The key task for completing this effort is determining the translation factor, A_{ij}, which relates the expected concentrations at site *i* to those at site *j*. It is assumed that the critical 30-day geometric mean concentration at site *i* is related to that at site *j* by the same proportionality observed between the long-term geometric means of the full data at sites *i* and *j*. The factor A_{ij} can reasonably be assumed to vary with land use, but also to exhibit strong site-specific characteristics. For instance, a given site might tend to exhibit higher concentrations relative to an equivalent site than are expected from consideration of land use differences alone.

So, what is needed is a method that provides an appropriate weighting between limited site-specific data and a landuse-based regression on equivalent sites. This situation is ideally suited for an empirical Bayes analysis (Berger, 1985; Morris, 1983). This is a technique for Bayesian updating that is based entirely on observed data (thus, “empirical”).

It is assumed that the long-term geometric mean fecal coliform concentration at a given site (expressed in log space) is a function of underlying properties of land use in the watershed plus site-specific factors that are represented by random noise. A sample realization of the (log space) long-term geometric mean at site *i*, x_i is assumed to be normally distributed about a true mean, 2_i, with standard error of the estimate given by Φ_i. In statistical notation this may be written as:

$$x_i \sim \mathrm{N}\left(\theta_i, \sigma_i^2\right) \qquad (5)$$

The desired translation factor for use in Equations (3) and (4) above is then

$$A_{ij} = e^{\theta_i} \big/ e^{\theta_j} \qquad (6)$$

In a regional context, we assume that each of the true (but unknown) local site long-term geometric means arises from a regional regression on land characteristics, such that

$$\theta_i = \boldsymbol{y}_i^t \cdot \beta + \varepsilon_i \qquad (7)$$

where $\boldsymbol{y}$ is a vector of land use characteristics, **ß** is a vector of regression coefficients, and γ_i is a normally-distributed error term, such that

$$\varepsilon_i \sim \mathrm{N}\left(0, \sigma_\pi^2\right) \qquad (8)$$

Equations (7) and (8) constitute a standard linear regression model, written in vector notation. (Note that the vector **ß** includes an intercept value, in addition to coefficients on the regressors, and the first item in the vector $\boldsymbol{y}$ is a 1 corresponding to the intercept value.) The regionalization is accomplished by estimating **ß** and Φ_B from the data, i.e., across multiple sites. To simplify the mathematics, it is assumed that the Φ_i are known from the sample data, and uncertainty in the estimation of the Φ_i is ignored (Berger, 1985).

The desired maximum likelihood estimate of a geometric mean associated with a given site should range between the regression estimate, $\boldsymbol{y}_i^t$ **ß**, and the at-site observed long-term geometric mean, x_i. If there are no monitoring data at a given site, the best estimator is simply the regression estimator; on the other hand, if there are sufficient data at a given site, it is appropriate to use the observed geometric mean without regionalization. Weighting between these two end-members depends on the relative magnitudes of Φ_i and Φ_B, which express, respectively, the degree of uncertainty associated with the local and regional estimators. In a

Bayesian sense, the best estimate is provided by the posterior distribution, incorporating the regional regression (as a prior distribution estimated *prior* to incorporating the site data) and the likelihood function of observed site data.

In a standard Bayes approach, the prior distribution should be independent of the data used to form the likelihood function. Morris (1983) developed Empirical Bayes approximations to the posterior means and variances that take into account the errors introduced by estimating **ß** and Φ_B from the data. The maximum likelihood Empirical Bayes estimator of 2 is given by $:_i^{EB}$, with variance V_i^{EB}. These are estimated through the equations

$$E(\theta_i) \quad = \quad \mu_i^{EB} = \quad x_i - \hat{B}_i \cdot \left(x_i - \boldsymbol{y}_i^t \hat{\beta}\right) \qquad (9)$$

and

$$V_i^{EB} = \sigma_i^2 \cdot \left[1 - \frac{\left(p - \hat{l}_i\right)}{p} \hat{B}_i\right] + \frac{2}{p - l - 2} \hat{B}_i^2 \left(\frac{\hat{\sigma}_p^2 + \hat{\sigma}_\pi^2}{\sigma_i^2 + \hat{\sigma}_\pi^2}\right) \left(x_i - \boldsymbol{y}_i^t \hat{\beta}\right)^2 \qquad (10)$$

In these equations, the parameter B_i is a Bayes factor that weights between the regional and local estimates. The x_I and Φ_i are, as noted above, the observed mean and variance of the logarithms of fecal coliform concentration data at site *i*. When no observations are available at a site, Φ_I^2 is assumed to be equal to the mean variance across all sites with data.

The vector of regression parameters, **ß**, is estimated by the standard least squares regression equation, written in matrix notation as

$$\hat{\beta} = \left(\boldsymbol{y}^t \boldsymbol{V}^{-1} \boldsymbol{y}\right)^{-1} \left(\boldsymbol{y}^t \boldsymbol{V}^{-1} \boldsymbol{x}\right) \qquad (11)$$

where $\boldsymbol{y}$, representing the observed land characteristics, is a $(p \times l)$ matrix of l regressors at p sites, $\boldsymbol{x}$ is the $(p \times 1)$ vector of observed means at the *p* sites, and $\boldsymbol{V}$ is a $(p \times p)$ diagonal matrix with diagonal elements $V_{ii} = \Phi_i^2 + \Phi_B^2$. The regional variance is in turn estimated as

$$\hat{\sigma}_\pi^2 = \frac{\sum_{i=1}^{p} \left\{ \left[\left(p / (p - l)\right) \left(x_i - \boldsymbol{y}_i^t \hat{\beta}\right)^2 - \sigma_i^2 \right] / \left[\sigma_i^2 + \hat{\sigma}_\pi^2\right]^2 \right\}}{\sum_{i=1}^{p} \left(\sigma_i^2 + \hat{\sigma}_\pi^2\right)^{-2}} \qquad (12)$$

and the remaining factors are

$$\hat{B}_i = \frac{(p - l - 2)}{(p - l)} \cdot \frac{\sigma_i^2}{\sigma_i^2 + \hat{\sigma}_\pi^2} \qquad (13)$$

$$\hat{l}_i = p \left[\boldsymbol{y} \left(\boldsymbol{y}^t \boldsymbol{V}^{-1} \boldsymbol{y}\right)^{-1} \boldsymbol{y}^t \right]_{ii} / \left(\sigma_i^2 + \hat{\sigma}_\pi^2\right) \qquad (14)$$

and

$$\hat{\sigma}_p^2 = \frac{\sum_{i=1}^{p} \sigma_i^2 / \left(\sigma_i^2 + \hat{\sigma}_\pi^2\right)}{\sum_{i=1}^{p} 1/\left(\sigma_i^2 + \hat{\sigma}_\pi^2\right)} \tag{15}$$

These equations do not provide a closed form solution, as **ß** is involved in the equation for Φ_B, while Φ_B is required in the equation for **ß**. The equations must thus be solved by iteration: Start with a guess for Φ_B and use it to calculate **ß**, then use the estimate of **ß** to recalculate Φ_B. Convergence is usually rapid, with the proviso that if Φ_B converges to a negative number, zero replaces it. All the necessary calculations have been incorporated into a spreadsheet.

Development of Regionalization Format

The technical approach can be applied to any type of linear regional regression model. Some experimentation was needed to determine the appropriate independent variables for use in the regression equation. Results of Atlanta-area studies such as the Atlanta Regional Stormwater Characterization Study (Quasenbarth, 1993; CDM, 1996; CH2M HILL, 1999) suggested that the most relevant information for urban areas is likely to be percent of the watershed area in residential and commercial/industrial/office land uses.

Data to support the regionalization were obtained from GA EPD via the Water Resources Database (WRDB) and supplemented by local (county and municipal) data. Though some of the data sources extend back as far as 1968, the regionalization was restricted to data from the last ten years (1992-2002). Land use data were aggregated to the scale of 12-digit hydrologic unit codes with some further delineation based on reach monitoring locations such that only upstream land use is tabulated for the regionalization. The smaller sub-watersheds were assigned 13 digit alphanumeric codes. These 12 or 13 digit watersheds will be referred to simply as watersheds in the following discussion.

This approach was previously applied to the Chattahoochee and Flint River basins. Particularly in the Chattahoochee basin the availability of data is much more extensive, largely as a result of monitoring conducted as part of the Chattahoochee River Modeling Project. In addition, observations are available from a wider range of land use fractions in these basins than are available for the Coosa and Tennessee basin sites. As a result, the regionalization data were pooled for the Coosa, Tennessee, Chattahoochee, and Flint basins to improve estimation.

For each watershed the mean and variance of the long-term fecal coliform data were calculated in log space. The log-space means were then plotted against the fraction of the local watershed in agricultural, rural, urban, or single family residential land use. Single independent variable regressions on fractions in individual land uses had poor explanatory power and high standard errors; however, there was a positive correlation between coliform concentration and urban land uses. Correlation against the total agricultural land use fraction was weakly negative. Multiple regressions provided better results, and the final exploratory model used fraction of land in single family residential and urban land uses. This model has an adjusted R^2 of 40 percent for the Coosa and Tennessee basin sites, as shown in Figure 1, with both coefficients statistically significant. (The adjusted R^2 is an unbiased estimate of the explanatory power of the model after correcting for potential correlation among multiple regression coefficients that can lead to an over-estimate of the un-adjusted R^2.)

In sum, the exploratory regression indicates a statistically significant relationship between the long-term geometric mean of observed fecal coliform data and land use. This model then provides the format for the empirical Bayes regional regression. As expected, the regional regression information provides some useful information, but is not in itself sufficient to provide an accurate estimate of observations. For this reason the weighting of regional and local data based on relative precision, as is done in the Bayes approach, is particularly important.

It should be noted that the long-term geometric mean data from sites is used only in the estimation of the parameters for the regional regression. These estimates are not used for assessing compliance with the 30-day geometric mean criterion, which would be inappropriate.

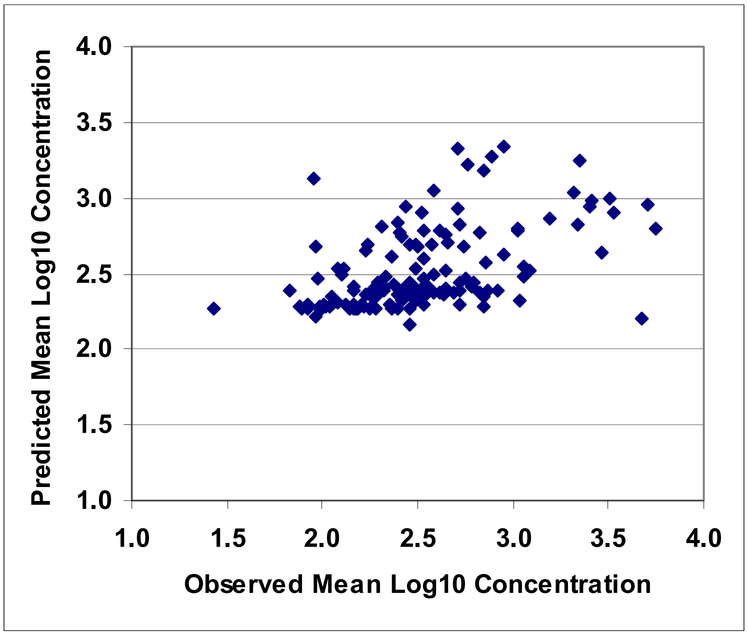

Figure 1. Predicted versus Observed Geometric Mean Fecal Coliform Bacteria Concentrations based on Land Use, Coosa and Tennessee Sites

Method Implementation

The methods described above were implemented in Excel spreadsheets, using built-in matrix/array functions. The process consists of two general steps: determination of the regionalization parameters, and combination of site and regional data to estimate individual-site results.

The regionalization problem was broken into two sets. One set included the data from the Atlanta metropolitan area, the other set included sites outside the Atlanta metropolitan area. There are two reasons for taking this approach. First, there are likely to be systematic differences in the sources of bacterial pollution in this highly developed area. Second, the land use coverage for the Atlanta metropolitan area is obtained from the Atlanta Regional Commission (ARC) ESDIS system, which combines a variety of sources of high-accuracy information, including aerial photography interpretation, and is likely to differ in quality from the satellite imagery-derived National Land Cover Database (NLCD) data available for the remainder of the state.

Within both the ARC and NLCD areas the regional regression used fraction urban area and fraction single family residential area as independent variables. In both cases, only the local land use within the 12+-digit HUC watershed corresponding to the listed segment was used in the regression, and not the entire upstream area land use, as concentrations are believed to be most strongly associated with local inputs. In three cases where the listed segment includes two or more 12+-digit HUCs, the land use distribution in the HUCs associated with the listed segment was combined for the purposes of the regression. The land use fractions associated with each site are shown in Table 1a (ARC area) and Table 1b (NLCD area). Site fecal coliform data used in the regionalization consisted of the post-1992 data collected for the "limited-data" TMDL sites, plus data provided by GA EPD for the sites at which TMDLs were estimated from valid 30-day geometric means using the TMDL Curve method.

Selection of Equivalent Sites

Selection of equivalent sites proceeded with the following rules:

1. In the case where valid 30-day geometric mean data are available for a downstream segment within the same watershed, this site (or sites) would be used as the equivalent site (this case does not occur among the Coosa/Tennessee basin sites).

2. The total pool of equivalent sites available consisted of all the sites with completed TMDL estimates provided by GA EPD. Potential equivalent sites for segments within the Atlanta Metropolitan area were selected from other sites in the metropolitan area; the pool for sites outside the metropolitan area was composed of other sites outside the metro area (NLCD sites).

3. Where an equivalent site was not already present in a downstream segment, up to 5 equivalent sites were selected from within an approximately 10 mile radius, depending on availability. If the subject site is a headwater basin, preference was given to selection of equivalent sites that were also headwater basins, as these should have similar flow regimes.

4. Sites known to be influenced by local point source discharges were omitted from the pool of potential equivalent sites for limited-data sites impacted by nonpoint sources only.

5. If no equivalent sites were present within a 10 mile radius of the subject site, 1 or 2 equivalent sites were picked from the general pool of sites that had similar land use and drainage area size.

Selected equivalent sites for each limited-data site are identified in Table 2. This table also shows the estimated TMDL reduction percentages calculated by GA EPD for each of the equivalent sites.

Table 1a. Data for Sites used for Empirical Bayes Regionalization, ARC Landuse Area

Site	Location	Watershed ID	Basin	Fraction Urban	Fraction Single Family Residential	Sample Count	Long-term Geometric Mean (cts/100 ml)	Data Source
Anneewakee Creek	House Creek to Lake Monroe (Douglas Co.)	031300020304A	Chattahoochee	0.0037	0.3000	73	170	CRMP(1992-1996)
Arrow Creek	Atlanta (Fulton Co.)	031300011201B	Chattahoochee	0.6500	0.3000	21	1096	DeKalb County-94/95
Ball Mill Creek	Fulton/DeKalb Counties	031300010907B	Chattahoochee	0.0700	0.8500	23	513	DeKalb County-94/95, CRMP-92/96
Big Creek	Hwy 400 to Chattahoochee River (Fulton Co.)	031300011004A	Chattahoochee	0.5600	0.2900	141	1047	CRMP(1992-1996)
Bubbling Creek	DeKalb County	031300011203B	Chattahoochee	0.6600	0.2900	23	708	DeKalb County-94/95, ARC stormwater data
Burnt Fork Creek	DeKalb County	031300011202D	Chattahoochee	0.3600	0.5700	23	891	DeKalb County-94/95
Buttermilk Creek	Cobb County	031300020208C	Chattahoochee	0.2000	0.5900	103	380	Cobb County-90/05
Camp Creek	Fulton County	031300020302	Chattahoochee	0.0800	0.2900	53	525	CRMP(1992-1996)
Chattahoochee River	Morgan Falls Dam to Peachtree Creek (Fulton/Cobb Co.)	031300011101A	Chattahoochee	0.1800	0.6100	16	91	WRDB(1998-2000)
Chattahoochee River	Headwaters to Chattahoochee River (Cobb Co.)	031300011103A	Chattahoochee	0.0900	0.8000	54	1047	WRDB(1998-2000)
Chattahoochee River	Utoy Creek to Pea Creek (Fulton/Douglas Co.)	031300020301	Chattahoochee	0.0400	0.1400	16	417	WRDB(1998-2000)
Chattahoochee River	Pea Creek to Wahoo Creek (Fulton Co.)	031300020307	Chattahoochee	0.0200	0.0800	17	110	WRDB(1998-2000)
Johns Creek	Headwaters to Chattahoochee River (Fulton Co.)	031300010906	Chattahoochee	0.1000	0.6600	56	891	CRMP(1992-1996)
Level Creek	Headwaters to Chattahoochee River (Gwinnett Co.)	031300010902B	Chattahoochee	0.0500	0.4900	36	457	CRMP(1992-1996)
Level Creek	Tributary to Chattahoochee River (Gwinnett Co.)	031300010907C	Chattahoochee	0.6000	0.2600	72	1230	CRMP(1992-1996)
Long Island Creek	Headwaters to Chattahoochee River (Fulton Co.)	031300011105B	Chattahoochee	0.1700	0.7900	53	575	CRMP(1992-1996)
Lullwater Creek	DeKalb County	031300011202C	Chattahoochee	0.1500	0.6700	23	3388	DeKalb County-94/95

Site	Location	Watershed ID	Basin	Fraction Urban	Fraction Single Family Residential	Sample Count	Long-term Geometric Mean (cts/100 ml)	Data Source
March Creek	Fulton County	031300011101B	Chattahoochee	0.2700	0.6100	38	5623	CRMP(1992-1996)
Mud Creek	Ga.Hwy 120 to Noses Creek (Cobb Co.)	031300020206C	Chattahoochee	0.0200	0.5900	94	275	Cobb County-90/02
Nancy Creek	Headwaters to Peachtree Creek, Atlanta (DeKalb/Fulton Co.)	031300011203A	Chattahoochee	0.2500	0.6500	55	1148	CRMP(1992-1996)
Nickajack Creek	Headwaters to Chattahoochee River (Cobb Co.)	031300020102	Chattahoochee	0.1500	0.6100	57	513	CRMP(1992-1996)
Olley Creek	Cobb County	031300020207	Chattahoochee	0.2300	0.5400	140	447	Cobb County-90/02
Pea Creek	Fulton County	031300020305	Chattahoochee	0.0013	0.1100	12	245	CRMP(1992-1996)
Peachtree Creek	I-85 to Chattahoochee River Atlanta (Fulton Co.)	031300011204A	Chattahoochee	0.2700	0.6700	124	4786	CRMP(1992-1996)
Peavine Creek	DeKalb County	031300011202B	Chattahoochee	0.2200	0.7500	46	2570	DeKalb County-94/95
Proctor Creek	Headwaters to Chattahoochee River, Atlanta (Fulton Co.)	031300020101C	Chattahoochee	0.4100	0.4300	72	5129	CRMP(1992-1996)
Rottenwood Creek	Headwaters to Chattahoochee River (Cobb Co.)	031300011104A	Chattahoochee	0.6700	0.1400	88	2089	CRMP(1992-1996)
S Fk Peachtree Creek	Atlanta (Fulton Co.)	031300011202A	Chattahoochee	0.2600	0.6400	52	2239	DeKalb County-94/95, ARC stormwater data, NAWQUA
S Fk Peachtree Creek	Atlanta (Fulton Co.)	031300011202E	Chattahoochee	0.3600	0.4900	33	2512	DeKalb County-94/95, ARC stormwater data, NAWQUA
Sandy Creek	I-285 to Chattahoochee River (Fulton Co.)	031300020101B	Chattahoochee	0.1800	0.6300	56	3236	CRMP(1992-1996)
Sewell Mill Creek	Cobb County	031300011103D	Chattahoochee	0.0500	0.8800	96	204	Sanitary survey (93), Cobb County-90/02, NAWQUA
Sweetwater Creek	U/S Pine Valley Rd. to Noses Creek (Paulding/Cobb Co.)	031300020208A	Chattahoochee	0.1300	0.4400	125	257	CRMP(1992-1996)

Site	Location	Watershed ID	Basin	Fraction Urban	Fraction Single Family Residential	Sample Count	Long-term Geometric Mean (cts/100 ml)	Data Source
Sweetwater Creek	U/S Pine Valley Rd. to Noses Creek (Paulding/Cobb Co.)	031300020208B	Chattahoochee	0.2000	0.3100	17	229	WRDB(1998-2000)
Utoy Creek	Atlanta (Fulton Co.)	031300020103A	Chattahoochee	0.1800	0.4200	92	2884	CRMP(1992-1996)
Ward Creek	Cobb County	031300020205B	Chattahoochee	0.1300	0.7100	90	550	Cobb County-90/01
White Oak Creek	Fulton County	031300020312B	Chattahoochee	0.0000	0.0600	55	339	CRMP(1992-1996)
Willeo Creek	Cobb/Fulton Counties	031300011102	Chattahoochee	0.0500	0.8600	54	288	CRMP(1992-1996)
Butler Creek	Cobb County	031501040902B	Coosa	0.1125	0.6125	81	387	Cobb County-95/97
Little Allatoona Creek	Cobb County	031501040901A	Coosa	0.0377	0.3774	36	172	Cobb County-95/97
Little Noonday Creek	Cobb County	031501040808A	Coosa	0.1598	0.7539	37	293	Cobb County-95/97
Owl Creek	Lake Allatoona Tributary (Cherokee Co.)	031501041004A	Coosa	0.0952	0.6191	27	1555	Clean Lakes Study, Cherokee County Monitoring
Proctor Creek	Cobb County	031501040902C	Coosa	0.2273	0.4091	95	291	Cobb County-95/97
Pumpkinvine Creek	Little Pumpkinvine Creek to Etowah River (Paulding/Bartow Co.)	031501041105	Coosa	0.0309	0.1536	16	318	GA EPD
Rocky Creek	Fulton County	031501040804A	Coosa	0.0429	0.6286	13	261	Rocky Creek Fulton County-94/95
Rubes Creek	Cobb/Cherokee Counties	031501040806	Coosa	0.0720	0.6400	65	341	Cobb County-95/97
Trib. to Allatoona Creek	Cobb County	031501040901C	Coosa	0.0500	0.4500	13	120	Cobb County
Camp Creek	Headwaters to Flint River (Clayton Co.)	031300050102	Flint	0.1100	0.5800	16	195	WRDB(1998-2000)
Flint River	Hwy 138 to N. Hampton Road	031300050101A	Flint	0.1400	0.4300	29	91	WRDB(1998-2000)

Table 1b. Data for Sites used for Empirical Bayes Regionalization, NLCD Landuse Area

Site	Location	HUC	Basin	Fraction Urban	Fraction Single Family Residential	Sample Count	Long-term Geometric Mean (cts/100 ml)	Data Source
Chattahoochee River	Ga. Hwy 17, Helen to SR255 (White/ Habersham Co.)	031300010102	Chattahoochee	0.0029	0.0012	16	76	WRDB(1998-2000)
Chattahoochee River	SR255 to Soquee River (White/Habersham Co.)	031300010106	Chattahoochee	0.0015	0.0017	16	151	WRDB(1998-2000)
Soquee River	Goshen Creek to SR 17, Clarkesville (Habersham Co.)	031300010202	Chattahoochee	0.0004	0.0005	16	102	WRDB(1998-2000)
Tesnatee Creek	Cleveland (White Co.)	031300010504	Chattahoochee	0.0137	0.0080	16	166	WRDB(1998-2000)
Amicalola Creek	Headwaters near Hwy 52 to Etowah River (Dawson Co.)	031501040204	Coosa	0.0487	0.0019	16	185	GA EPD
Armuchee Creek	Oostanaula River Tributary (Floyd Co.)	031501030507	Coosa	0.0412	0.0051	16	302	GA EPD
Big Dry Creek	Rome (Floyd Co.)	031501030604A	Coosa	0.1097	0.0583	30	1127	Rome WPCP Monitoring
Cane Creek	Dry Creek to Chattooga River (Walker/Chattooga Co.)	031501050407	Coosa	0.0611	0.0200	16	146	GA EPD
Cartecay River	Owltown Creek to Coosawattee River (Gilmer Co.)	031501020106	Coosa	0.0590	0.0275	33	254	GA EPD, Carter's Lake WPMP-96
Cedar Creek	Polk County	031501050203	Coosa	0.0583	0.0257	17	832	GA EPD
Chattooga River 1	Cane Creek, Trion to Henry Branch (Chattooga Co.)	031501050501A	Coosa	0.0713	0.0269	16	210	GA EPD
Chattooga River 2	Henry Branch to Lyerly (Chattooga Co.)	031501050504A	Coosa	0.0666	0.0253	16	293	GA EPD
Coahulla Creek	Below 728 Road to Mill Creek (Whitfield Co.)	031501010307	Coosa	0.0351	0.0299	16	267	GA EPD
Conasauga River 1	Hwy 286 to Holly Creek (Whitfield/Murray Co.)	031501010207	Coosa	0.0289	0.0074	16	311	GA EPD
Conasauga River 2	Holly Creek to Oostanaula River (Murray/Gordon Co.)	031501010501	Coosa	0.0581	0.0293	16	380	GA EPD
Coosa River	Rome to Hwy 100 (Floyd Co.)	031501041607	Coosa	0.0658	0.0301	17	302	GA EPD
Coosawattee River	Confluence with Ellijay River to Mountaintown Creek (Gilmer Co.)	031501020401	Coosa	0.0622	0.0291	16	520	GA EPD
Ellijay River	Upstream Coosawattee River (Gilmer Co.)	031501020205	Coosa	0.0669	0.0315	33	440	GA EPD, Carter's Lake WPMP-96

Site	Location	HUC	Basin	Fraction Urban	Fraction Single Family Residential	Sample Count	Long-term Geometric Mean (cts/100 ml)	Data Source
Etowah River 1	Clear Creek to Forsyth County Line (Dawson Co.)	031501040105	Coosa	0.0450	0.0020	16	283	GA EPD
Etowah River 2	Clear Creek to Forsyth County Line (Dawson Co.)	031501040306A	Coosa	0.0515	0.0308	16	193	GA EPD
Etowah River 4	Lake Allatoona to Richland Creek (Bartow Co.)	031501041304	Coosa	0.0670	0.0604	16	202	GA EPD
Etowah River 5	Rome to Hwy 100 (Floyd Co.)	031501041607	Coosa	0.0705	0.0486	16	329	GA EPD
Euharlee Creek	Hills Creek to upstream Plant Bowen	031501041407A	Coosa	0.0647	0.0161	16	329	GA EPD
Flat Creek	Upstream Coosawattee River (Gilmer Co.)	031501020402A	Coosa	0.0895	0.0755	17	528	Carter's Lake WPMP-96
Holly Creek	Rock Creek to Conasauga River (Murray Co.)	031501010406A	Coosa	0.0604	0.0210	16	368	GA EPD
Long Swamp Creek	Hwy 53 to Etowah River, near Ball Ground (Pickens/ Cherokee Co.)	031501040404	Coosa	0.0822	0.0619	16	235	GA EPD
Mountain Town Creek	Hwy 282 to Coosawattee River (Gilmer Co.)	031501020305A	Coosa	0.0360	0.0098	33	186	GA EPD, Carter's Lake WPMP-96
Oostanaula River	Hwy 140 to Coosa River (Floyd Co.)	031501030103	Coosa	0.0649	0.0241	16	309	GA EPD
Pine Log Creek	Cedar Creek to Salacoa Creek (Gordon Co.)	031501020706	Coosa	0.0601	0.0049	16	745	GA EPD
Raccoon Creek 502	U/S Chattooga River, Berryton (Chattooga Co.)	031501050502	Coosa	0.0579	0.0194	16	490	GA EPD
Sharp Mtn Creek	Rock Creek to Etowah River (Cherokee Co.)	031501040506	Coosa	0.0858	0.0529	16	203	GA EPD
Silver Creek	Rome (Floyd Co.)	031501041606	Coosa	0.1354	0.0620	16	448	GA EPD
Spring Creek 1603	Etowah River Tributary (Floyd Co.)	031501041603	Coosa	0.0519	0.0207	16	411	GA EPD
Spring Creek 0403	Walker/Chattooga County	031501050403	Coosa	0.0415	0.0012	16	312	GA EPD
Tails Creek	Hwy 282 to Carters Lake (Gilmer Co.)	031501020403A	Coosa	0.0446	0.0113	33	170	GA EPD, Carter's Lake WPMP-96
Talking Rock Creek1	GA Hwy 136 to Pickens/Gilmer Co. Line (Pickens Co.)	031501020505	Coosa	0.0625	0.0189	16	303	GA EPD
Tanyard Creek	White Lake to Lake Allatoona (Cobb Co.)	031501040903A	Coosa	0.2323	0.2707	39	306	Cobb County-95/97

Site	Location	HUC	Basin	Fraction Urban	Fraction Single Family Residential	Sample Count	Long-term Geometric Mean (cts/100 ml)	Data Source
Trib. to Oothkalooga Creek	Peters Street to Oothkalooga Creek, Calhoun (Gordon County)	031501030203C	Coosa	0.2923	0.1925	42	330	Calhoun - Oothkalooga Creek Spill Data 1996
Trib to Pettit Creek	Cartersville (Bartow Co.)	031501041303C	Coosa	0.2640	0.0658	53	771	Cartersville - Pettit Creek Spill Data 1997
Two Run Creek	Clear Creek to Etowah River (Bartow Co.)	031501041504	Coosa	0.0655	0.0149	16	368	GA EPD
Woodward Creek	Oostanaula River Tributary (Floyd Co.)	031501030602	Coosa	0.0655	0.0121	16	444	GA EPD
Butternut Creek	Blairsville (Union Co.)	060200020804A	Tennessee	0.1234	0.0895	15	127	TVA
Fightingtown Creek	CR 159 to Stateline (Fannin Co.)	060200030206	Tennessee	0.0418	0.0129	16	193	GA EPD
Hemptown Creek	Mitchell Branch to Young Stone Creek (Fannin Co.)	060200030203A	Tennessee	0.0691	0.0111	16	289	GA EPD
Nottley Creek 1	Right/Left Forks to US Hwy 19 (Union Co.)	060200020801	Tennessee	0.0425	0.0001	16	112	GA EPD
Nottley Creek 2	US Hwy 19 to Lake Nottely (Union Co.)	060200020803	Tennessee	0.0501	0.0084	16	193	GA EPD
Youngcane Creek	Little Youngcane Creek to Nottely Lake (Union Co.)	060200020807A	Tennessee	0.0595	0.0136	16	343	GA EPD

Table 2. Equivalent Sites Selected for Each Limited-Data TMDL Site

Limited-Data Site	Equivalent Site	Watershed ID	Drainage Area (mi^2)	30-Day Critical Geometric Mean (cts/100 ml)	Percent Reduction for TMDL
Acworth Creek		031501040902A	0.16		
	Allatoona Creek at McClain Road near Acworth	031501040901B	18.60	826.1	75.8
	Level Creek	031300010902B	8.83	1392.9	85.6
	Willeo Creek	031300011102	16.67	255.3	21.7
	Kelly Mill Branch	031300011001D	3.85	205.4	2.6
	Mobley Creek	031300020309B	16.38	426.8	53.1
Big Dry Creek		031501030604A	17.00		
	Armuchee Creek at Old Dalton Road near Rome	031501030507	224.00	1323.2	84.9
	Woodward Creek at Bells Ferry Road near Rome	031501030602	26.20	672.1	70.2
	Silver Creek at Cresent Avenue near Rome	031501041606	37.40	608.7	67.1
	Spring Creek at GA Hwy 20 near Rome	031501041603	37.40	607.0	67.1
Butler Creek		031501040902B	9.00		
	Allatoona Creek at McClain Road near Acworth	031501040901B	18.60	826.1	75.8
	Level Creek	031300010902B	8.83	1392.9	85.6
	Willeo Creek	031300011102	16.67	255.3	21.7
	Kelly Mill Branch	031300011001D	3.85	205.4	2.6
	Mobley Creek	031300020309B	16.38	426.8	53.1
Flat Creek		031501020402A	7.00		
	Talking Rock Creek near Blaine	031501020505	78.10	428.2	53.3
	Tails Creek at GA Hwy 282 near Ellijay	031501020403A	7.70	348.1	42.5
	Ellijay River at US Hwy 76 at Ellijay	031501020205	87.70	1081.6	81.5
	Mountaintown Creek at GA Hwy282 near Ellijay	031501020305A	61.60	548.8	63.6
Lake Acworth		031501040902D	20.30		
	Allatoona Creek at McClain Road near Acworth	031501040901B	18.60	826.1	75.8
	Level Creek	031300010902B	8.83	1392.9	85.6
	Willeo Creek	031300011102	16.67	255.3	21.7
	Kelly Mill Branch	031300011001D	3.85	205.4	2.6
	Mobley Creek	031300020309B	16.38	426.8	53.1
Little Allatoona Creek		031501040901A	6.00		
	Allatoona Creek at McClain Road near Acworth	031501040901B	18.60	826.1	75.8
	Level Creek	031300010902B	8.83	1392.9	85.6
	Willeo Creek	031300011102	16.67	255.3	21.7
	Kelly Mill Branch	031300011001D	3.85	205.4	2.6
	Mobley Creek	031300020309B	16.38	426.8	53.1
Little Noonday Creek		031501040808A	7.00		
	Allatoona Creek at McClain Road near Acworth	031501040901B	18.60	826.1	75.8
	Level Creek	031300010902B	8.83	1392.9	85.6
	Willeo Creek	031300011102	16.67	255.3	21.7
	Kelly Mill Branch	031300011001D	3.85	205.4	2.6
	Mobley Creek	031300020309B	16.38	426.8	53.1
Owl Creek		031501041004A	2.00		
	Allatoona Creek at McClain Road near Acworth	031501040901B	18.60	826.1	75.8
	Level Creek	031300010902B	8.83	1392.9	85.6
	Willeo Creek	031300011102	16.67	255.3	21.7
	Kelly Mill Branch	031300011001D	3.85	205.4	2.6
	Mobley Creek	031300020309B	16.38	426.8	53.1
Proctor Creek		031501040902C	8.00		
	Allatoona Creek at McClain Road near Acworth	031501040901B	18.60	826.1	75.8
	Level Creek	031300010902B	8.83	1392.9	85.6
	Willeo Creek	031300011102	16.67	255.3	21.7
	Kelly Mill Branch	031300011001D	3.85	205.4	2.6
	Mobley Creek	031300020309B	16.38	426.8	53.1

Limited-Data Site	Equivalent Site	Watershed ID	Drainage Area (mi^2)	30-Day Critical Geometric Mean (cts/100 ml)	Percent Reduction for TMDL
Rocky Creek		031501040804A	8.00		
	Allatoona Creek at McClain Road near Acworth	031501040901B	18.60	826.1	75.8
	Level Creek	031300010902B	8.83	1392.9	85.6
	Willeo Creek	031300011102	16.67	255.3	21.7
	Kelly Mill Branch	031300011001D	3.85	205.4	2.6
	Mobley Creek	031300020309B	16.38	426.8	53.1
Rubes Creek		031501040806	15.00		
	Allatoona Creek at McClain Road near Acworth	031501040901B	18.60	826.1	75.8
	Level Creek	031300010902B	8.83	1392.9	85.6
	Willeo Creek	031300011102	16.67	255.3	21.7
	Kelly Mill Branch	031300011001D	3.85	205.4	2.6
	Mobley Creek	031300020309B	16.38	426.8	53.1
Tanyard Creek		031501040903A	3.00		
	Euharlee Creek near Stillsboro	031501041407A	158.00	868.1	77.0
	Spring Creek at GA Hwy 20 near Rome	031501041603	37.40	607.0	67.1
	Woodward Creek at Bells Ferry Road near Rome	031501030602	26.20	672.1	70.2
Trib to Allatoona		031501040901C	2.00		
	Allatoona Creek at McClain Road near Acworth	031501040901B	18.60	826.1	75.8
	Level Creek	031300010902B	8.83	1392.9	85.6
	Willeo Creek	031300011102	16.67	255.3	21.7
	Kelly Mill Branch	031300011001D	3.85	205.4	2.6
	Mobley Creek	031300020309B	16.38	426.8	53.1
Trib to Oothkalooga Creek		031501030203C	3.00		
	Oostanaula River near Calhoun	031501030103	1734.00	299.0	33.1
	Woodward Creek at Bells Ferry Road near Rome	031501030602	26.20	672.1	70.2
	Pine Log Creek at Sonoraville	031501020706	99.10	1028.3	80.6
Trib to Pettit Creek		031501041303C	2.00		
	Euharlee Creek near Stillsboro	031501041407A	158.00	868.1	77.0
	Spring Creek at GA Hwy 20 near Rome	031501041603	37.40	607.0	67.1
	Woodward Creek at Bells Ferry Road near Rome	031501030602	26.20	672.1	70.2
Butternut Creek		060200020804A	11.00		
	Youngcane Creek near Youngcane	060200020807A	22.40	740.8	73.0
	Nottley River at Hwy 180	060200020801	27.00	1156.4	82.7
	Nottley River near Blairsville	060200020803	74.80	674.4	70.3
	Chattahoochee River at Nacoochee	031300010102	50.93	303.7	51.9

The empirical Bayes implementation yields the regionalization parameters shown in Table 3. These parameters are then used in Equation 9 to maximum likelihood estimates of 2 for each site. This in turn allows calculation of the translation factors using Equation 6. The resulting TMDL estimates are provided in the main document.

Table 3. Regional Regression Parameter Estimates to Predict Long-Term Average Log base-10 Fecal Coliform Bacteria Concentration

Landuse Source	Intercept	Coefficient on fraction urban area	Coefficient on fraction single family residential
ARC	2.16	1.44	0.43
NLCD	2.31	4.15	-3.54

For both areas, the estimate of Φ_B is zero. This is a common occurrence in the method, and does not interfere with application. The implications are discussed by Berger (1985, p. 177) who states that the presence of a zero estimate of the regional or prior variance does not mean that there is no uncertainty in the estimate of the regional parameters. Rather, it implies a *lack* of information about Φ_B due to the fact that the likelihood function for Φ_B is quite flat.

The resulting empirical Bayes estimates of the individual limited-data site statistics are provided in Table 4.

Table 4. Empirical Bayes Sufficient Statistics for Limited Data Sites (Expressed as log base 10 of the long-term geometric mean concentration, cts/100 ml)

Site Name	Watershed ID	μ EB (Equation 9)	V EB (Equation 10)
Atlanta Metro Area (ARC) Sites			
Acworth Creek	031501040902A	3.007	0.063
Butler Creek	031501040902B	2.593	0.039
Lake Acworth	031501040902D	2.589	0.032
Little Allatoona	031501040901A	2.377	0.014
Little Noonday Creek	031501040808A	2.712	0.021
Owl Creek	031501041004A	2.597	0.033
Proctor Creek	031501040902C	2.661	0.042
Rocky Creek	031501040804A	2.496	0.015
Rubes Creek	031501040806	2.546	0.020
Trib. to Allatoona	031501040901C	2.418	0.018
Non-ARC (NLCD) Sites			
Big Dry Creek	031501030604A	2.580	0.044
Flat Creek	031501020402A	2.426	0.017
Tanyard Creek	031501040903A	2.322	0.039
Trib. to Oothkalooga Creek	031501030203C	2.825	0.024
Trib. to Pettit Creek	031501041303C	3.158	0.078
Butternut Creek	060200020804A	2.485	0.032

Translating Results to TMDLs

If a single equivalent site is used, estimation of the TMDL is straightforward. The procedure is the same as is used for the sites with valid geometric mean data, except that the estimates of critical load and associated flow would be obtained from the equivalent site using the methods described in this appendix. This situation (requiring a valid 30-day geometric mean estimate from a downstream segment) does not occur among the Coosa/Tennessee basin limited-data sites.

When multiple equivalent sites are used, the situation is somewhat more complicated, as each equivalent site may produce a different estimate of critical load and flow. The Bayes procedure described in this appendix is based, of necessity, on determining the relationship of long-term geometric means between sites. As a result, the primary output of this procedure is an estimate of the needed percent reduction, while the estimates of critical loads are less reliable because the regionalization reflects mean loads rather than critical loads. For this reason, the TMDL table entry for a limited-data site with multiple equivalent sites is filled in starting with the estimated percent reduction as the primary output and working backward to fill in the other entries. The estimate of the TMDL is set at the average of the TMDL curve points determined in relationship to each of the equivalent sites. The estimate of current critical load is then set to a value such that current load times percent reduction equals the TMDL. When more than one equivalent site is used, this procedure results in an estimate of current critical load that may differ somewhat from the average of the critical load estimates obtained from the equivalent sites, but is within the range of the critical load estimates from the equivalent sites.

The TMDL estimates calculated by this method are based on compliance with the seasonal geometric mean criteria. It is also necessary to check for compliance against the winter maximum concentration criterion of 4000 counts per 100 ml. Of the limited data sites addressed in this study, none had winter observations in excess of this criterion reported in recent data (1998-2002). Older data are not appropriate for comparison to the maximum concentration criterion as situations that lead to maxima in urban streams such as spills are modified over time. As a result, it is not necessary to do an alternate calculation of reductions based on this criterion.

The final TMDL estimates are reported in Table 14 in the main text.

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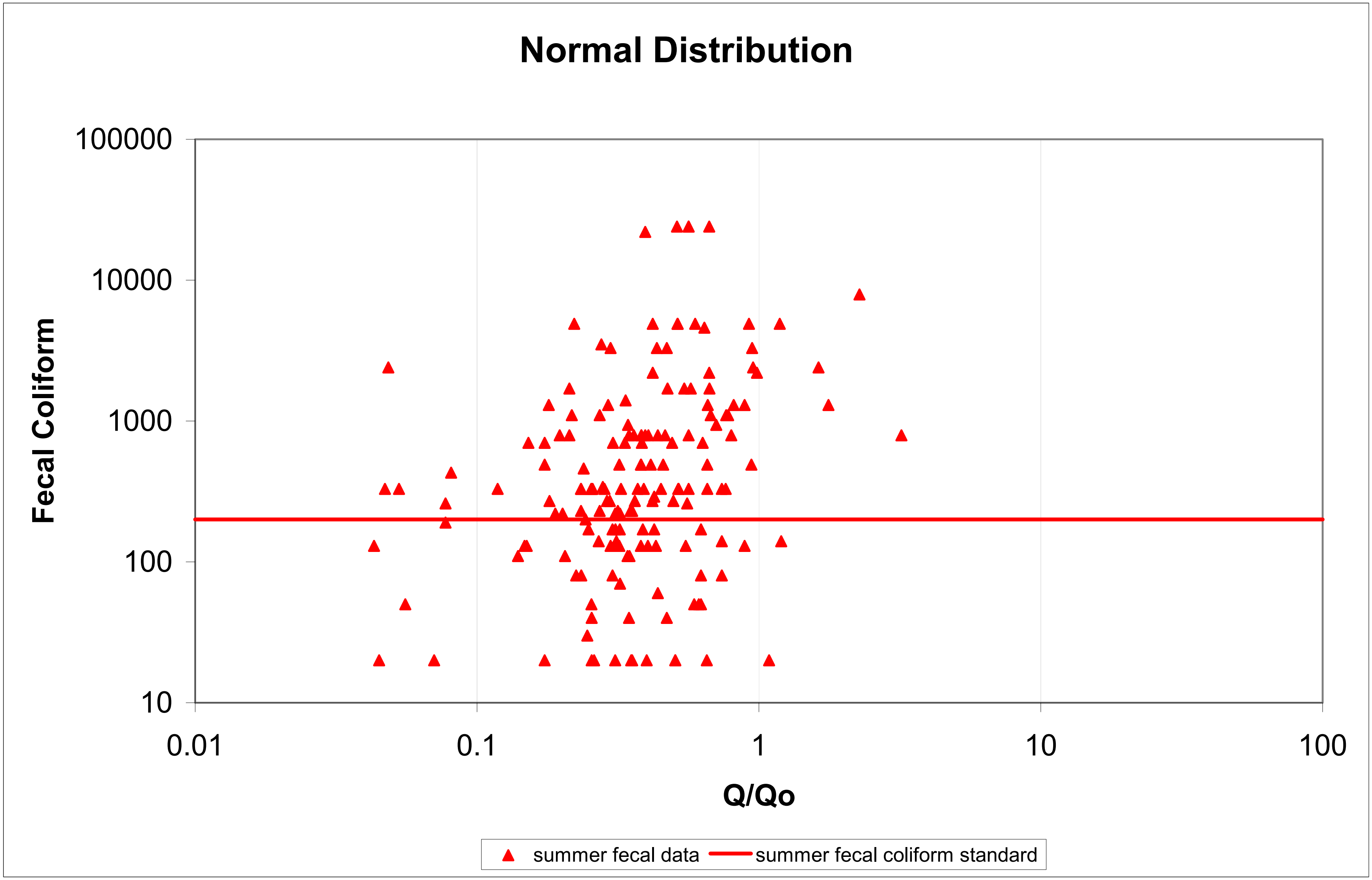
Appendix D

Normalized Flows Versus Fecal Coliform Plots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1
10
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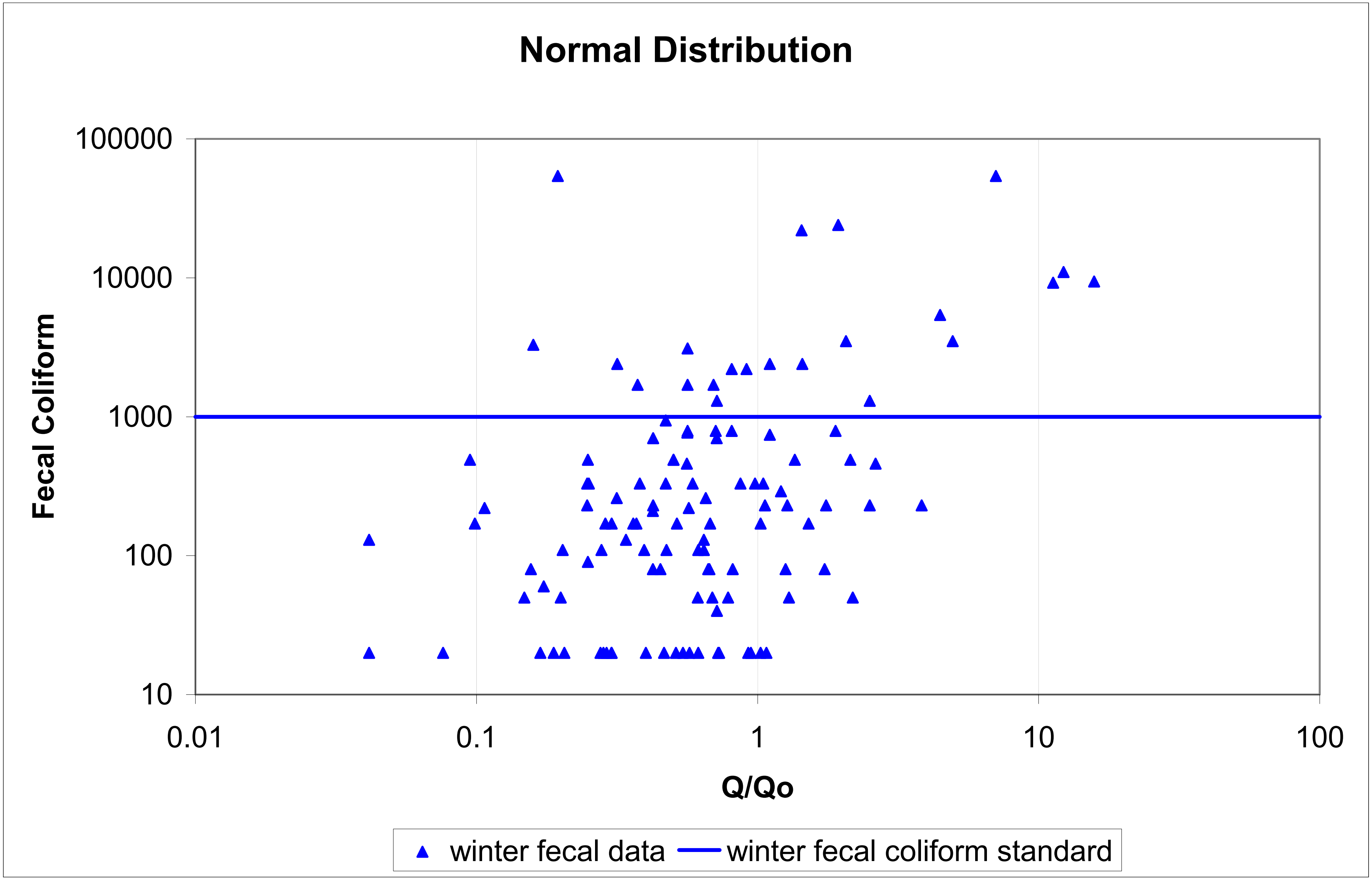
Q/Qo
summer fecal data
summer fecal coliform standard


Normal Distribution
Fecal Coliform
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10000
1000
100
10
0.01
0.1
1
10
100
Q/Qo
winter fecal data
winter fecal coliform standard