FINAL REPORT
January 2003
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Fecal Coliform TMDL for Hickahala Creek

Yazoo River Basin

Panola and Tate Counties Mississippi

Prepared By

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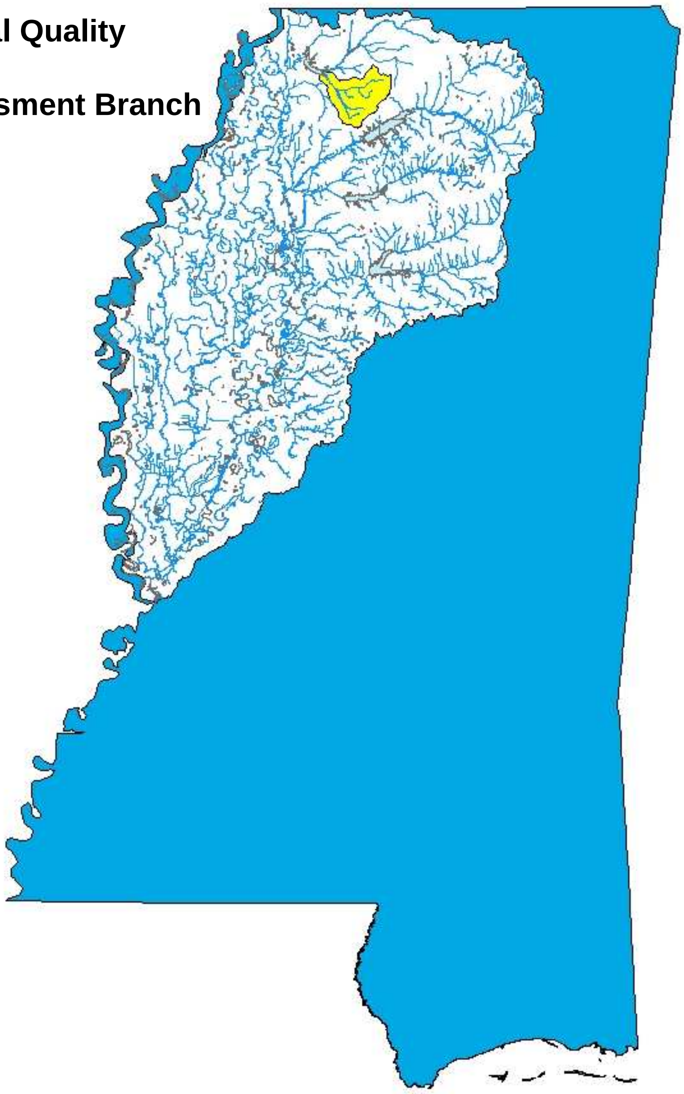

MISSISSIPPI DEPARTMENT OF ENVIRONMENTAL QUALITY

FOREWORD

This report has been prepared in accordance with the schedule contained within the federal consent decree dated December 22, 1998. The report contains one or more Total Maximum Daily Loads (TMDLs) for waterbody segments found on Mississippi's 1996 Section 303(d) List of Impaired Waterbodies. Because of the accelerated schedule required by the consent decree, many of these TMDLs have been prepared out of sequence with the State's rotating basin approach. The implementation of the TMDLs contained herein will be prioritized within Mississippi's rotating basin approach.

The amount and quality of the data on which this report is based are limited. As additional information becomes available, the TMDLs may be updated. Such additional information may include water quality and quantity data, changes in pollutant loadings, or changes in landuse within the watershed. In some cases, additional water quality data may indicate that no impairment exists.

Prefixes for fractions and multiples of SI units

Fraction	Prefix	Symbol	Multiple	Prefix	Symbol
10^{-1}	deci	d	10	deka	da
10^{-2}	centi	c	10^{2}	hecto	h
10^{-3}	milli	m	10^{3}	kilo	k
10^{-6}	micro	µ	10^{6}	mega	M
10^{-9}	nano	n	10^{9}	giga	G
10^{-12}	pico	p	10^{12}	tera	T
10^{-15}	femto	f	10^{15}	peta	P
10^{-18}	atto	a	10^{18}	exa	E

Conversion Factors

To convert from	To	Multiply by	To Convert from	To	Multiply by
Acres	Sq. miles	0.0015625	Days	Seconds	86400
Cubic feet	Cu. Meter	0.028316847	Feet	Meters	0.3048
Cubic feet	Gallons	7.4805195	Gallons	Cu feet	0.133680555
Cubic feet	Liters	28.316847	Hectares	Acres	2.4710538
cfs	Gal/min	448.83117	Miles	Meters	1609.344
cfs	MGD	.6463168	Mg/l	ppm	1
Cubic meters	Gallons	264.17205	µg/l * cfs	Gm/day	2.45

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TMDL INFORMATION PAGE

i. Listing Information

Name	ID	County	HUC	Cause	Mon/Eval
Hickahala Creek seg 2	MS305M2	Tate	08030204	Pathogens	Monitored
Near Independence: From headwaters near Wyatte including Bad Branch Creek to confluence with James Wolf Creek					
Hickahala Creek seg 4	MS303M4	Tate	08030204	Pathogens	Monitored
From Senatobia POTW South to watershed 381 boundary					
James Wolf Creek	MS305M1	Tate	08030204	Pathogens	Monitored
Near Looxahoma: From headwaters between Aiken and Tyro to mouth at Hickahala Creek					
Senatobia Creek seg 1	MS304M1	Panola Tate	08030204	Pathogens	Monitored
Near Como: From headwaters below pipeline including parts of tributaries to confluence with Mattie Creek					
Senatobia Creek seg 2	MS304M2	Tate	08030204	Pathogens	Monitored
Near Senatobia: From confluence with Mattie Creek to confluence with Old Senatobia Canal					

ii. Water Quality Standard

Parameter	Beneficial use	Water Quality Criteria
Fecal Coliform	Secondary Contact	May - October: Fecal coliform colony counts not to exceed a geometric mean of 200 per 100ml, nor shall more than 10 percent of samples examined during any month exceed a colony count of 400 per 100ml. November – April: Fecal coliform colony counts shall not exceed a geometric mean of 2000 per 100 ml, nor shall more than 10 percent of the samples examined during any month exceed a colony count of 4000 per 100 ml.

iii. NPDES Facilities

NPDES ID	Facility Name	Subwatershed	Receiving Water
MS0028070	Baptist Children's Village	08030204022	Bad Branch
MS0054801	Bartlett Subdivision	08030204022	Hickahala Creek
MS0051217	East Tate Elementary School	08030204022	Hickahala Creek
MS0032573	Tyro-East Headstart	08030204022	Wolf Creek
MS0032689	Royal Heights Subdivision	08030204022	Senatobia River
MS0033162	Back Acres Subdivision	08030204021	Senatobia River
MS0050768	Delta Rain Utility Company, Inc.	08030204021	Hickahala Creek
MS0052221	City of Senatobia	08030204020	Hickahala Creek

iv. Total Maximum Daily Load

Segment	WLA (Counts/Day)	LA (Counts/Day	MOS	TMDL Percent Reduction
MS303M4	1.7E+10	Varies with flow	Explicit	71
MS305M2	8.33E+08		Explicit	50
MS305M1	2.27E+08		Explicit	70
MS304M1	8.14E+08		Explicit	60
MS304M2			Explicit	76

EXECUTIVE SUMMARY

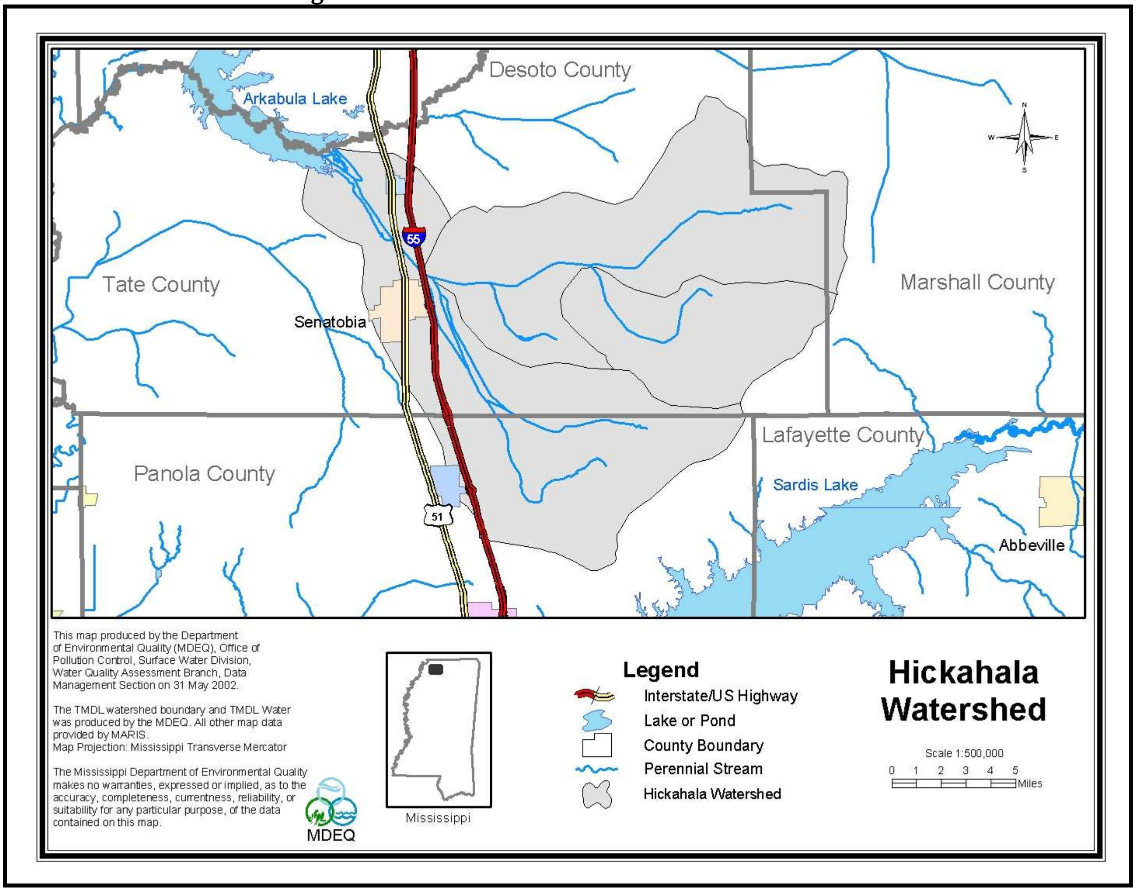
Segments of Hickahala Creek, James Wolf Creek, and Senatobia Creek have been placed on the Mississippi 1998 Section 303(d) List of Waterbodies as monitored waterbody segments, due to fecal coliform bacteria. The applicable state standard specifies that for the summer months, the maximum allowable level of fecal coliform shall not exceed a geometric mean of 200 colonies per 100 ml, nor shall more than ten percent of the samples examined during any month exceed a colony count of 400 per 100 ml. For the winter months, the maximum allowable level of fecal coliform shall not exceed a geometric mean of 2000 colonies per 100 ml, nor shall more than ten percent of the samples examined during any month exceed a colony count of 4000 per 100 ml.

Photo 1. Hickahala Creek

Hickahala Creek, photo 1, flows in a western direction from its headwaters near Wyatte, Mississippi to Arkabutla Lake. Arkabutla Lake is one of four major reservoirs in the Yazoo River Basin constructed in the 1940's for flood control purposes. This TMDL has been developed for two listed segments of Hickahala Creek, one listed segment of James Wolf Creek, and two listed segments of Senatobia Creek. Load duration curves, which compare the water quality data against a flow-varying allowable load, were used for developing the TMDL for these sections.

Although fecal coliform loadings from point and nonpoint sources in the watershed were not explicitly represented with a model, a source assessment was conducted for the Hickahala Creek Watershed. There are eight NPDES Permitted dischargers included in the waste load allocation (WLA). Nonpoint sources considered include wildlife, livestock, and urban development. Also considered were the nonpoint sources such as failing septic systems and other direct inputs to tributaries of Hickahala Creek. The location of the Hickahala Creek watershed and the urban area of Senatobia are shown in Figure 1 below.

Figure 1. Location of Hickahala Creek Watershed



Most of the permitted facilities currently have requirements in their NPDES Permits that require disinfection to meet water quality standards for pathogens at the end of pipe. Therefore, no changes are required for those existing NPDES permits. However, this TMDL recommends that upon reissuance the other NPDES Permits be modified to require disinfection. Monitoring of the permitted facilities in the Hickahala Creek Watershed should continue to ensure that compliance with permit limits is consistently attained.

The seasonal variations in hydrology, climatic conditions, and watershed activities are represented through the use of a continuous flow gage to develop the acceptable load curve and the use of water quality data collected throughout the year. The critical period was determined to be the summer season of May through October. An explicit 50 percent margin of safety (MOS) was used to account for uncertainty in the load duration curve method.

Water quality data indicate frequent violations of the fecal coliform standard in the waterbody. The load duration curves provide a data-based method to estimate the reductions required to meet water quality standards in Hickahala Creek. Load duration curves and TMDLs were computed at two locations along Hickahala Creek, one location along James Wolf Creek, and two locations on Senatobia Creek, according to the location of monitoring stations and corresponding segment locations. The estimated reductions of fecal coliform bacteria required for the two segments of Hickahala Creek from upstream to downstream are 50 and 71 percent respectively. The estimated reduction of fecal coliform bacteria required for James Wolf Creek is 70 percent. The estimated reductions of fecal coliform bacteria for the two segments of Senatobia Creek from upstream to downstream are 60 and 76 percent respectively.

INTRODUCTION

1.1 Background

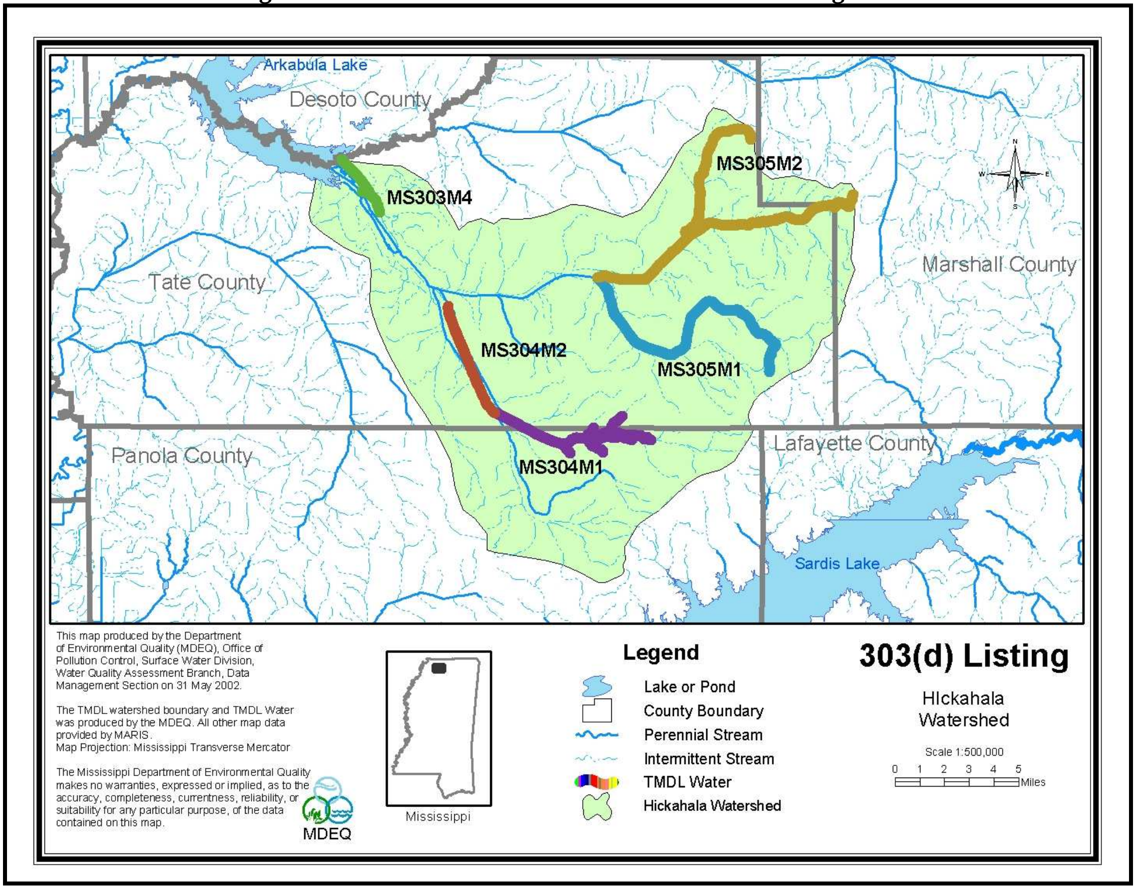
The identification of waterbodies not meeting their designated use and the development of total maximum daily loads (TMDLs) for those waterbodies are required by Section 303(d) of the Clean Water Act and the Environmental Protection Agency's (EPA) Water Quality Planning and Management Regulations (40 CFR part 130). The TMDL process is designed to restore and maintain the quality of those impaired waterbodies through the establishment of pollutant specific allowable loads. The pollutant of concern for this TMDL is fecal coliform. Fecal coliform bacteria are used as indicator organisms. They are readily identifiable and indicate the possible presence of other pathogenic organisms in the waterbody. The TMDL process can be used to establish water quality based controls to reduce pollution from nonpoint sources, maintain permit requirements for point sources, and restore and maintain the quality of water resources. This TMDL was developed for the 303(d) listed segments shown in Figure 2

The Hickahala Creek Drainage Area is in the Yazoo River Basin Hydrologic Unit Code (HUC) 08030204 in northwest Mississippi. The drainage area is approximately 149,190 acres; and lies within portions of Tate, Marshall, and Panola Counties. The watershed is rural. Forest and pasture are the dominant landuses within the watershed. The land distribution is shown in Table 1.

Table 1. Landuse Distribution for the Hickahala Creek Watershed

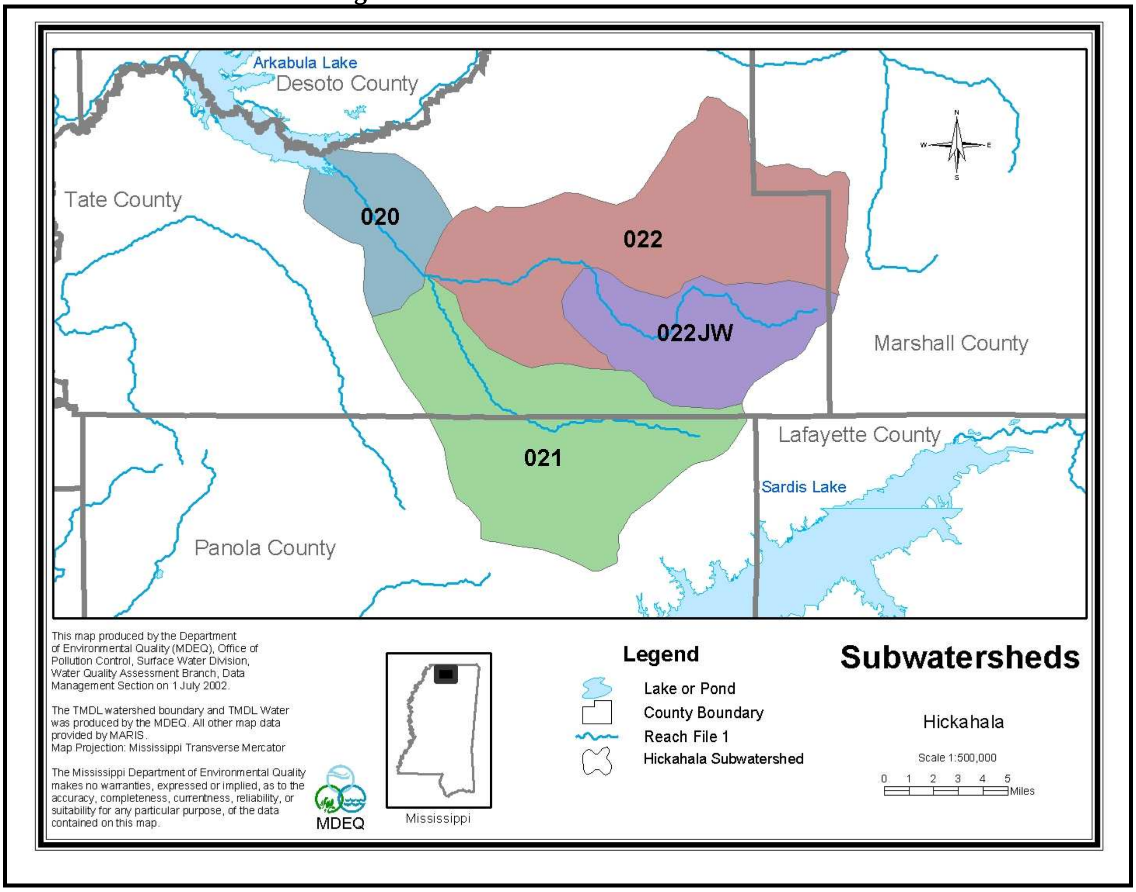
	Urban	Forest	Cropland	Pasture	Barren	Wetland	Aquaculture	Water	Total
Area (acres)	3,101	21,808	30,830	87,775	0	3,993	82	1,601	149,190
% Area	2%	15%	21%	59%	0%	3%	0%	1%	100%

Figure 2. Hickahala Creek Watershed 303d Listed Segment



The drainage area, or watershed of Hickahala Creek, has been divided into 4 subwatersheds based on the major tributaries and topography. Figure 3 shows the subwatersheds with a three-digit Reach File 1 segment identification number. Each subwatershed is assigned a corresponding identification number, which is a combination of the eight-digit HUC and the three-digit Reach File 1 segment identification number.

Figure 3. Hickahala Creek Subwatersheds



1.2 Applicable Waterbody Segment Use

The water use classification for the listed segment of the Hickahala Creek, as established by the State of Mississippi in the *Water Quality Criteria for Intrastate, Interstate and Coastal Waters* regulation, is Fish and Wildlife Support. The designated beneficial uses for the Hickahala Creek are Secondary Contact and Aquatic Life Support.

1.3 Applicable Waterbody Segment Standard

The water quality standard applicable to the use of the waterbody and the pollutant of concern is defined in the *State of Mississippi Water Quality Criteria for Intrastate, Interstate, and Coastal Waters*. The standard states that for the summer months the fecal coliform colony counts shall not exceed a geometric mean of 200 per 100 ml, nor shall more than ten percent of the samples examined during any month exceed a colony count of 400 per 100 ml. For the winter months, the maximum allowable level of fecal coliform shall not exceed a geometric mean of 2000 colonies per 100 ml, nor shall more than ten percent of the samples examined during any month exceed a colony count of 4000 per 100 ml. The water quality standard was used to assess the data to determine impairment in the waterbody. The instantaneous, summer portion of the water quality standard, 400 counts per 100 ml, was used as the targeted endpoint to establish these TMDLs using the load duration curve method.

TMDL ENDPOINT AND WATER QUALITY ASSESSMENT

2.1 Selection of a TMDL Endpoint and Critical Condition

One of the major components of a TMDL is the establishment of instream numeric endpoints, which are used to evaluate the attainment of acceptable water quality. Instream numeric endpoints, therefore, represent the water quality goals that are to be achieved by implementing the load and waste load reductions specified in the TMDL. The endpoints allow for a comparison between observed instream conditions and conditions that are expected to restore designated uses. The instream fecal coliform target for this TMDL is 400 colony counts per 100 ml with an explicit MOS of 50 percent, which reduces the target to 200 colony counts per 100 ml.

While the endpoint of a TMDL calculation is similar to a standard for a pollutant, the endpoint is not the standard. Currently MDEQ's standard for fecal coliform states that for the summer months the fecal coliform colony counts shall not exceed a geometric mean of 200 per 100 ml, nor shall more than ten percent of the samples examined during any month exceed a colony count of 400 per 100 ml. For the winter months, the maximum allowable level of fecal coliform shall not exceed a geometric mean of 2000 colonies per 100 ml, nor shall more than ten percent of the samples examined during any month exceed a colony count of 4000 per 100 ml. For these TMDLs, MDEQ considered the instantaneous portion of the standard when looking at the data for assessment of impairment, setting the target, and calculating the TMDL. The geometric mean portion of the standard is not appropriate as a target for use with load duration curves at this time because the data available at stations with the appropriate flow information are instantaneous. Data appropriate for the calculation of geometric means have been recently collected on Hickahala Creek and are provided in Section 2.2. Additional monitoring of water quality for use in the calculation of geometric means and flow measurement at those stations is ongoing. Assessment of the geometric mean standard will be more fully evaluated upon completion of the monitoring project.

Because fecal coliform bacteria may be attributed to both nonpoint and point sources, the critical condition used for the evaluation of stream response was derived by a multi-year period. Critical conditions for waters impaired by nonpoint sources generally occur during periods of wet-weather and high surface runoff. But, critical conditions for point source dominated systems generally occur during low-flow, low-dilution conditions. The 1988-2001 period for which the water quality data exists represents both low-flow conditions as well as wet-weather conditions and encompasses a range of wet and dry seasons. Therefore, the 13-year period was used to find the critical conditions associated with all potential sources of fecal coliform bacteria within the watershed. The summer condition was chosen as the critical condition because the water quality standards are more stringent during this period. The 400 counts per 100 ml standard was applied to all of the data in the load duration curves.

2.2 Discussion of Instream Water Quality

There are six ambient stations on the listed segments operated by USGS that collected fecal coliform monitoring data during the 14-year modeling period. Monitoring for flow and fecal coliform was performed on a routine basis on Hickahala Creek at station 07277700 located on a County Road 1.7 miles east of Senatobia, MS. Two additional monitoring stations were located on Hickahala Creek, 07277520, near Independence MS and 07277530 near Looxahoma, MS. There was one monitoring station located on James Wolf Creek, 07277548 near Looxahoma, MS. Monitoring from flow and fecal coliform bacteria was conducted at station 07277730 near Senatobia, MS. An additional monitoring station was located on Senatobia Creek, 07277715 near Como, MS. These stations, however, are no longer routinely monitored for fecal coliform bacteria. In order to collect fecal coliform data, MDEQ now goes to monitoring stations six times within a 30-day period. These data are used to calculate the geometric mean for the waterbody. Several stations on Otoucalofa Creek were recently included in this type of monitoring.

2.2.1 Inventory of Available Water Quality Monitoring Data

Fecal coliform monitoring data collected at the monitoring stations form are included in the Tables A-1 through A-5 in Appendix A. Flow measurements are also given in the tables along with the fecal coliform data. Data collected from the geometric mean study from 2001 are shown below in Tables 1 through 5.

Table 2. Fecal Coliform Data reported in Hickahala Creek, Station 6 Coldwater-Arkabutla Road
September 2001 to December 2001

Date	Tape Down Measurement	Fecal Coliform (counts/100ml)	Geometric Mean
9/26/2001 13:30	27.11	220	59
10/2/2001 13:00	27.77	400	
10/8/2001 13:35	28.17	40	
10/10/2001 12:45	28.33	2	
10/17/2001 11:50	19.50	82	
10/23/2001 12:45	19.93	70	
11/13/2001 11:45	23.88	90	444
11/19/2001 12:55	25.86	92	
11/26/2001 10:40	28.16	240	
11/28/2001 12:05	25.26	2100	
12/5/2001 11:45	10.69	390	
12/10/2001 12:10	10.50	4700	

Table 3. Fecal Coliform Data reported in Senatobia Creek, Station 7 Unnamed Road off of Springfield Road
September 2001 to December 2001

Date	Tape Down Measurement	Fecal Coliform (counts/100ml)	Geometric Mean
9/27/2001 13:00	30.23	66	115
10/2/2001 10:55	30.16	240	
10/8/2001 11:55	30.00	184	
10/10/2001 11:05	30.12	80	
10/17/2001 10:30	30.45	148	
10/23/2001 10:50	30.44	66	
11/13/2001 10:35	30.29	84	250
11/19/2001 10:50	30.30	76	
11/26/2001 9:35	30.40	450	
11/28/2001 10:35	29.80	560	
12/5/2001 10:40	30.42	900	
12/10/2001 11:05	30.24	168	

Table 4. Fecal Coliform Data reported in Senatobia Creek, Station 8, Hwy 4
September 2001 to December 2001

Date	Tape Down Measurement	Fecal Coliform (counts/100ml)	Geometric Mean
9/27/2001 13:40	26.71	60	122
10/2/2001 11:55	26.73	76	
10/8/2001 12:50	26.80	72	
10/10/2001 11:55	26.77	120	
10/17/2001 11:25	26.50	450	
10/23/2001 11:35	26.63	184	
11/13/2001 11:20	26.65	24	285
11/19/2001 11:45	26.63	78	
11/26/2001 10:20	26.65	470	
11/28/2001 11:25	25.82	4300	
12/5/2001 11:25	26.70	250	
12/10/2001 11:42	26.43	570	

Table 5. Fecal Coliform Data reported in James Wolf Creek, Station 9, Hwy 4
September 2001 to December 2001

Date	Tape Down Measurement	Fecal Coliform (counts/100ml)	Geometric Mean
9/26/2001 12:25	26.80	370	180
10/2/2001 11:35	26.76	164	
10/8/2001 12:30	26.71	40	
10/10/2001 11:35	26.79	208	
10/17/2001 11:05	26.80	340	
10/23/2001 11:20	26.66	200	
11/13/2001 11:05	26.68	78	503
11/19/2001 11:25	26.70	72	
11/26/2001 10:05	26.66	240	
11/28/2001 11:08	26.28	6000	
12/5/2001 11:10	26.61	490	
12/10/2001 11:30	26.54	4100	

Table 6. Fecal Coliform Data reported in Hickahala Creek, Station Hwy 305
September 2001 to December 2001

Date	Tape Down Measurement	Fecal Coliform (counts/100ml)	Geometric Mean
9/26/2001 12:05	25.24	240	189
10/2/2001 11:15	25.31	156	
10/8/2001 12:15	25.24	18	
10/10/2001 11:20	24.24	106	
10/17/2001 10:50	25.45	6000	
10/23/2001 11:10	25.31	106	
11/13/2001 10:55	25.45	48	210
11/19/2001 11:15	25.30	50	
11/26/2001 9:55	25.34	4200	
11/28/2001 10:55	24.39	520	
12/5/2001 11:00	25.22	88	
12/10/2001 11:20	25.06	184	

2.2.2 Analysis of Instream Water Quality Monitoring Data

Historically, MDEQ only had data appropriate to compare all of the samples to the instantaneous portion of the standard, which is no more than 10% greater than the instantaneous maximum standard of 400 counts per 100 ml for the summer months and 4000 counts per 100 ml for the winter months. The geometric mean portion of the current fecal coliform standard was not used in assessment due to lack of appropriate data at that time. MDEQ's new method of collecting data six times at a site during a 30-day period must be assessed for both parts of the standard. Tables 7 and 8 show the statistical summary of the recent monitoring data, which is part of an ongoing project. The data are provisional data and clearly verify impairment indicated by previous assessments.

Table 7. Summer Statistical Summaries of Water Quality Data

Station Number	Number of Samples	Geometric Mean	Standard Violation (200/100 ml)	Percent Instantaneous Exceedance	Standard Violation (400 counts/100 ml)
6	6	59	No	17%	Yes
7	6	115	No	17%	Yes
8	6	122	No	17%	Yes
9	6	180	No	50%	Yes
10	6	189	No	33%	Yes

Table 8. Winter Statistical Summaries of Water Quality Data

Station Number	Number of Samples	Geometric Mean	Standard Violation (2000 counts/100 ml)	Percent Instantaneous Exceedance	Standard Violation (4000 counts/100 ml)
6	6	444	No	33%	Yes
7	6	250	No	0%	No
8	6	285	No	17%	Yes
9	6	503	No	33%	Yes
10	6	210	No	17%	Yes

SOURCE ASSESSMENT

The TMDL evaluation summarized in this report examined all known potential fecal coliform sources in the Hickahala Creek Watershed. The source assessment was developed to provide an indication of which sources might be reduced to reach the reduction goals outlined in this report. In evaluation of the sources, loads were characterized by the best available information, monitoring data, literature values, and local management activities. This section documents the available information and interpretation for the analysis.

3.1 Assessment of Point Sources

Point sources of fecal coliform bacteria have their greatest potential impact on water quality during periods of low flow. Thus, a careful evaluation of point sources that discharge fecal coliform bacteria was necessary in order to quantify the degree of impairment present during the low flow, critical condition period. The eight-wastewater treatment plants discharging into the Hickahala Creek Watershed serve several areas including the City of Senatobia, some small subdivisions, a utility company, and two schools.

Once the permitted discharger was located, the effluent was characterized based on all available monitoring data including permit limits, discharge monitoring reports, and information on treatment types. Discharge monitoring reports (DMRs) were the best data source for characterizing effluent because they report measurements of flow and fecal coliform present in effluent samples. DMRs from 1994 through 2001 were analyzed and no violations were found. The facility's permit limits were used as input in the model. The facilities are shown below.

Table 9. Inventory of Point Source Dischargers

NPDES ID	Facility Name	Subwatershed	Receiving Water	Flow (mgd)	Fecal Coliform Concentration (counts/100 ml)
MS0028070	Baptist Children's Village	08030204022	Bad Branch	.010	200
MS0054801	Bartlett S/D	08030204022	Hickahala Creek	.084	200
MS0051217	East Tate Elementary School	08030204022	Hickahala Creek	.012	200
MS0032573	Tyro-East Headstart	08030204022	Wolf Creek	.002	200
MS0032689	Royal Heights S/D	08030204022	Senatobia River	.030	200
MS0033162	Back Acres S/D	08030204021	Senatobia River	.070	200
MS0050768	Delta Rain Utility Company, Inc.	08030204021	Hickahala Creek	.040	200
MS0052221	City of Senatobia	08030204020	Hickahala Creek	2.0	200

3.2 Assessment of Nonpoint Sources

There are many potential nonpoint sources of fecal coliform bacteria for the Hickahala Creek, including:

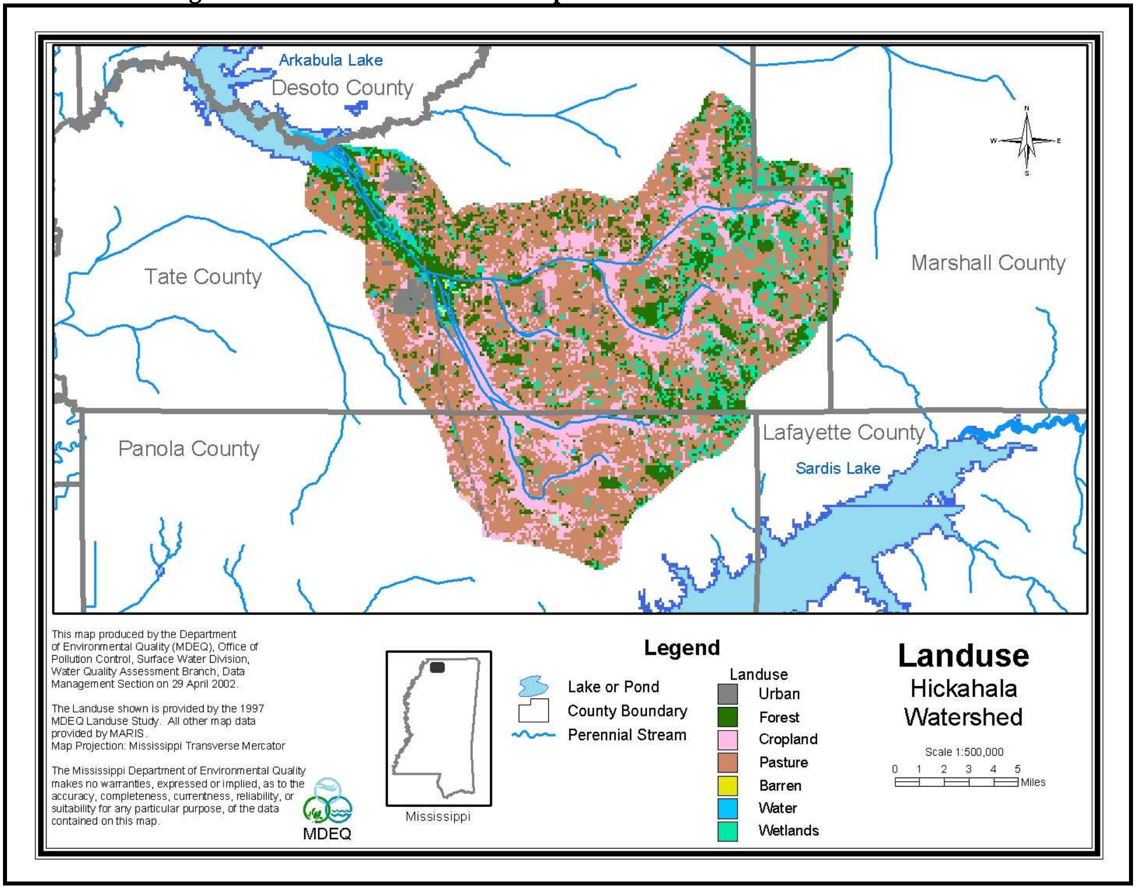
- Failing septic systems
- Wildlife
- Other Direct Inputs
- Urban development

The 149,910 acre drainage area of the Hickahala Creek contains many different landuse types, including urban, forest, cropland, pasture, barren, and wetlands. The modeled landuse information for the watershed is based on the State of Mississippi's Automated Resource Information System (MARIS), 1997. This data set is based Landsat Thematic Mapper digital images taken between 1992 and 1993. The MARIS data are classified on a modified Anderson level one and two system with additional level two wetland classifications. For modeling purposes the landuse categories were grouped into the landuses of urban, forest, cropland, pasture, barren, and wetlands. The landuse distribution is shown in Table 10 and Figure 4.

Table 10. Landuse Distribution for Each Subwatershed (acres)

Subwatershed	Urban	Forest	Cropland	Pasture	Barren	Wetland	Aquaculture	Water	Total
08030204020	1,344	2,675	1,374	6,112	0	3,300	0	1,127	15,931
08030204021	1,358	4,855	14,206	30,845	0	404	82	187	51,937
08030204022	327	9,731	10,209	34,900	0	276	0	265	55,709
080302040JW	72	4,547	5,041	15,918	0	12	0	22	25,613
Total	3,101	21,808	30,830	87,775	0	3,993	82	1,601	149,190
Percent	2%	15%	21%	59%	0%	3%	0%	1%	100%

Figure 4. Landuse Distribution Map for the Hickahala Creek Watershed



3.2.1 Failing Septic Systems

Septic systems have a potential to deliver fecal coliform bacteria loads to surface waters due to malfunctions, failures, and direct pipe discharges. Properly operating septic systems treat wastewater and dispose of the water through a series of underground field lines. The water is applied through these lines into a rock substrate, thence into underground absorption. The systems can fail when the field lines are broken, or when the underground substrate is clogged or flooded. A failing septic system's discharge can reach the surface, where it becomes available for wash-off into the stream. Another potential problem is a direct bypass from the system to a stream. In an effort to keep the water off the land, pipes are occasionally placed from the septic tank or the field lines directly to the creek.

Another consideration is the use of individual onsite wastewater treatment plants. These treatment systems are in wide use in Mississippi. They can adequately treat wastewater when properly maintained. However, these systems may not receive the maintenance needed for proper, long-term operation. These systems require some sort of disinfection to properly operate. When this expense is ignored, the water does not receive adequate disinfection prior to release.

Septic systems have the greatest impact on nonpoint source fecal coliform impairment in the Yazoo Basin. The best management practices needed to reduce this pollutant load need to prioritize elimination of septic tank loads from failures and improper use of individual onsite treatment systems.

3.2.2 Wildlife

Wildlife present in the Hickahala Creek Watershed contributes to fecal coliform bacteria on the land surface. No attempts were made in this TMDL to quantify the number and location of animals or amount of bacteria washed into Hickahala Creek due to wildlife contributions.

3.2.3 Other Direct Inputs

Other direct inputs of fecal coliform includes all animal access to streams (domestic and wild), illicit discharges of fecal coliform bacteria, dump sites, and leaking sewer collection lines.

3.2.4 Urban Development

Urban areas include land classified as urban and barren. The only urban area in the Hickahala Creek watershed is in the City of Senatobia. Even though only a small percentage of the watershed is classified as urban, the contribution of the urban areas to fecal coliform loading in the Hickahala Creek Watershed was considered. Fecal coliform contributions from urban areas may come from storm water runoff, failing sewer pipes, and runoff contribution from improper disposal of materials such as litter.

LOAD DURATION CURVE PROCEDURE

The estimated reductions required for this TMDL were developed using load duration curves. The methodology outlined in a paper completed to explore the use of load duration curves for data analysis applications for streams in the Yazoo River Basin in Mississippi was followed in the development of the load duration curves for this TMDL (Sheely, 2002). Load duration curves were developed as a method in which TMDLs applicable to all hydrological conditions could be calculated. Prior to the introduction of this method, many TMDLs were developed to address a single flow condition such as the 7Q10 (7-day, 10-year low flow) or average flow. This new method allows for the development of TMDLs that addressed more than just a single flow condition. Because these curves include the entire range of flow conditions, pollutant sources of all types can be considered in the TMDLs. The methods used to develop both the flow and load duration curves will be described.

4.1 Development of Flow Duration Curves

The first step in the development of load duration curves is to create flow duration curves using continuous flow or stage data. There are two continuous flow gages in the Hickahala Creek Watershed maintained by the USGS. Gage 07277700 is located on Hickahala Creek near Senatobia, MS on a county road. Continuous from data for the period of February 1986 through September 2000 were available for this station. Gage 07277730 located on Senatobia Creek on Highway 4. Continuous flow data for the period of October 1995 through September 2000 were available for this station.

The flow data are used to create flow duration curves, which display the cumulative frequency distribution of the daily flow data over the period of record. The flow duration curve relates flow values measured at the monitoring station to the percent of time that those values are met or exceeded. Flows are ranked from extremely low flows, which are exceeded nearly 100 percent of the time, to extremely high flows, which are rarely exceeded. Flow duration curves were developed for several locations on Hickahala Creek and for Senatobia Creek. The flow duration curves for two locations on Hickahala Creek were developed using the data from gage 07277700. The first flow duration curve developed was for the water quality monitoring station that was located at the same location as the flow gage. This flow duration curve is shown on a semi-log plot in Figure 5. Flow duration curves for the other water quality monitoring station location on Hickahala Creek, and an additional water quality monitoring station located on James Wolf Creek, were developed using a ratio of the drainage areas of the flow gage station and the monitoring station. The use of this method assumes that the hydrological characteristics of the watersheds would be similar. This is a valid assumption because the stations are located within the same watershed. Flow duration curves were developed for Senatobia Creek using the data from gage 07277730. Water quality monitoring station 07277730 is located at the same location as the flow gauge. A drainage area ratio was used to develop a flow duration curve for water quality monitoring station 07277715 on Senatobia Creek.

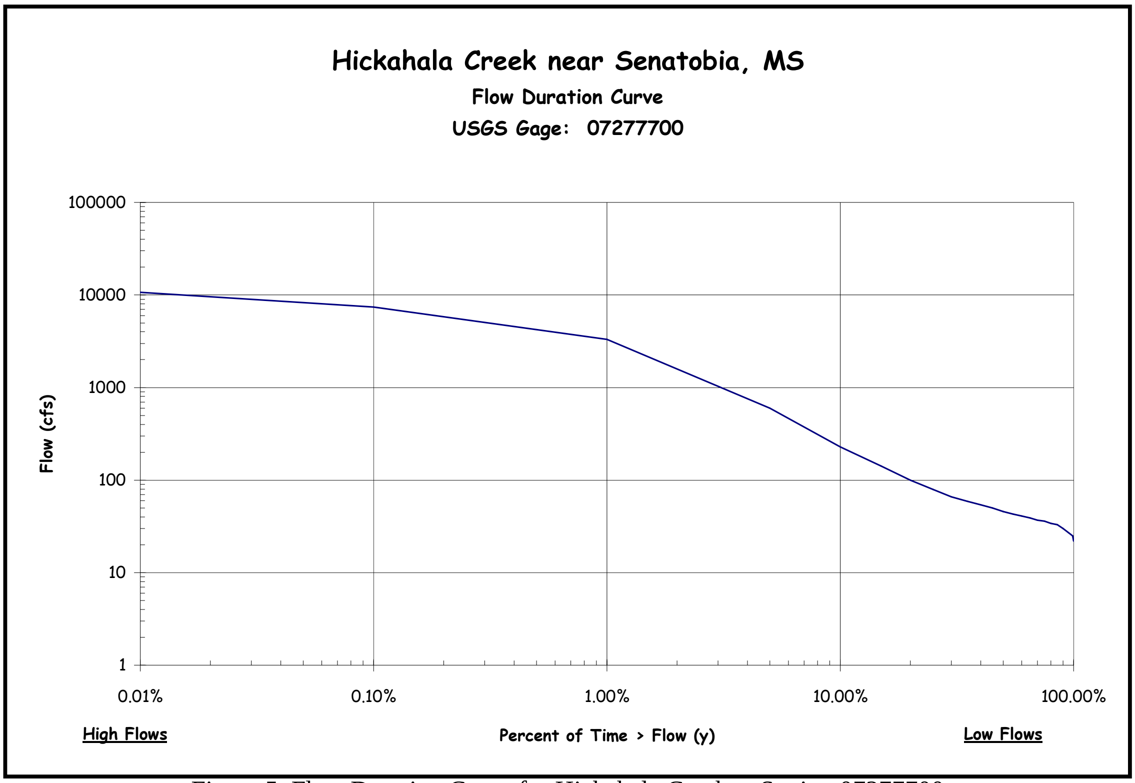


Figure 5. Flow Duration Curve for Hickahala Creek at Station 07277700

4.2 Load Duration Curves

Flow duration curves are then transformed into load duration curves by multiplying the flow values along the curve by applicable water quality criteria values for pathogens and appropriate conversion factors. The load duration curves are conceptually similar to the flow duration curves, in that the x-axis represents the flow recurrence interval. The y-axis is transformed to represent the allowable load of the water quality parameter. The curve representing the allowable load of fecal coliform was calculated using the instantaneous, summer water quality criteria of 400 counts per 100 ml and the flow associated with each flow recurrence interval. Load duration curves were developed for each of the five 303(d) listed segments in the Hickahala Creek Watershed. Although there was more than one monitoring location in some of the 303(d) listed segments, only one load duration curve was developed for each segment. The monitoring station that had sufficient monitoring data and was located at the farthest downstream point within each segment was selected for development of the load duration curve. The load duration curves developed for the five segments are included in Appendix B.

4.3 Comparison of Monitoring Data and Water Quality Criteria

The final step in the development of load duration curves was to add the monitoring data to the curves. Pollutant loads were estimated from the data as the product of the pollutant concentrations, instantaneous flows measured at the time of sample collection, and appropriate conversion factors. In order to identify the plotting position of each calculated load, the recurrence interval of each instantaneous flow measurement was defined. Water quality monitoring data are plotted on the same graph as the load duration curve. The load duration curves, which are shown in Appendix B, provide a graphical display of the water quality conditions in the waterbody. The monitoring data points that plot above the target line exceed the water quality target, while those that plot below meet the target.

4.4 Source Identification

The position at which the monitoring data exceed the target gives an indication of the potential sources and delivery mechanisms of the pollutants. Violations that occur on the right side of the curve, during low-flow conditions, indicate the presence of continuous pollutant sources, such as NPDES permitted discharges and failing septic tanks. Violations that occur on the left side of the curve, during higher flows, indicate intermittent sources that appear in response to rain events. Monitoring data that exceed water quality criteria in the mid-range flow indicate that pollutants are most likely due to a combination of these sources. The load duration curves in Appendix B show that water quality data exceeds the target during all flow conditions at all stations. The interpretation of these curves indicate that both point and nonpoint sources are present in the Hickahala Creek Watershed. However, the highest concentration of fecal coliform bacteria and the greatest frequency of violations occurs during high flow conditions.

Using load duration curves for data analysis is different from the methods typically used in that the frequency of attainment or violation of a particular water quality criteria is stressed rather than the absolute values of the monitoring data. One of the strengths of this method is that it can be used to interpret possible delivery mechanisms of pollutants. Load duration curves have been shown to be influenced by the landuse distribution in their watersheds (Sheely, 2002). Because of this, load duration curves have the potential to be used as a method for targeting pollution reduction efforts in watersheds that are impaired and require TMDL development.

4.5 Stream Characteristics

The stream characteristics given below describe the most downstream reach of the listed drainage area of the Hickahala Creek. The channel geometry and lengths for the Hickahala Creek are based on data available within the BASINS modeling system. The characteristics of the modeled section of the Hickahala Creek are as follows.

- Length 45.5 miles
- Average Depth 0.2 ft
- Average Width 14.9 ft
- Average Flow 178.7 cubic ft per second
- Mean Velocity 1.0 ft per second
- 7Q10 Flow 6.5 cubic ft per second
- Slope 0.0014 ft per ft

4.6 Selection of Representative Period

The period of record for flow data ranged from 1986 to 2000. The period of record for water quality data used to develop the load duration curves ranged from 1988 to 1995. Seasonality and critical conditions are accounted for during the extended time frame of the data represented in the load duration curves.

The critical condition for fecal coliform impairment from nonpoint source contributors occurs after a heavy rainfall that is preceded by several days of dry weather. The dry weather allows a build up of fecal coliform bacteria, which is then washed off the ground by a heavy rainfall. By using the extended time period, many such occurrences should be captured in the data results. Critical conditions for point sources, which occur during low-flow and low-dilution conditions, are considered as well.

4.7 Existing Loading

An additional set of load duration curves showing the target of 200 counts per 100 ml with a 50 percent MOS was developed, Appendix C. Only the monitoring data points that exceed the target of 200 counts per 100 ml are shown on these curves. The curves in Appendix C also include a regression line drawn through the data points that exceed the 200 counts per 100 ml target. The regression line represents the best fit of the existing loading in the five segments of Hickahala Creek and Senatobia Creek.

ALLOCATION

In accordance with 40 CFR section130.2, which states, "TMDLS can be expressed in terms of either mass per time, toxicity, or other appropriate measure," this TMDL is expressed as a percent reduction of load in order to retain the benefit of utilizing various flow conditions to develop the load duration curve. The use of a single TMDL number would effectively return to the choice of just one flow condition for TMDL development. This method uses the difference between the regression line through the exceeding points (the existing loading) and the load duration target curve to calculate the appropriate percent reduction necessary for the TMDL. The only allocation included in this TMDL is the wasteload allocation for point sources.

5.1 Wasteload Allocations

The wasteload allocation is based on the existing point sources in the Hickahala Creek Watershed. The WLA is represented on the load duration curves in Appendix C as a horizontal line with a constant load appropriate for each segment. Segment MS304M1 is located upstream of the point source discharger, thus the line representing the WLA is set at zero for these segments. The zero WLA line for this segment, however, will not prevent the addition of new point source dischargers within this segment in the future. However, it will be required that any future discharger within any of the segments of Hickahala Creek, James Wolf or Senatobia Creek will be required to disinfect their effluent so that the effluent consistently meets water quality standards. The point sources and their allocated loads are shown in Table 11. The point sources that are recommended for permit modification to include fecal coliform limits and disinfection are also indicated in Table 11.

Table 11. Wasteload Allocations

NPDES ID	Facility Name	Subwatershed Location	Allocated Load (counts/day)	Permit Modification Recommended
MS0028070	Baptist Children's Village	8030204022	7.57E+07	No
MS0054801	Bartlett S/D	8030204022	6.36E+08	No
MS0051217	East Tate Elementary School	8030204022	9.09E+07	No
MS0032573	Tyro-East Headstart	8030204022JW	1.14E+07	No
MS0032689	Royal Heights S/D	8030204022	2.27E+08	No
MS0033162	Back Acres S/D	8030204021	5.30E+08	No
MS0050768	Delta Rain Utility Company, Inc.	8030204021	3.03E+08	No
MS0052221	City of Senatobia	8030204020	1.51E+10	No

5.2 Load Allocations

The load allocation for this TMDL varies according to the flow conditions as represented graphically for each segment in graphs C-1 through C-5. In graphs C-1 through C-4 the load allocation is equal to the area of the load duration curve that is above the line representing the WLA and below the curve representing the TMDL. In graph C-5, where the waste load allocation is zero, the load allocation is represented as the entire area under the TMDL curve.

5.3 Incorporation of a Margin of Safety (MOS)

The two types of MOS development are to implicitly incorporate the MOS using conservative assumptions or to explicitly specify a portion of the total TMDL as the MOS. For this TMDL, the MOS is an explicit 50 percent reduction of the criteria of 400 counts per 100 ml to a target of 200 counts per 100 ml.

5.4 Calculation of the TMDL

Because the TMDL is variable depending on the recurrence interval of the appropriate flow, the TMDL is expressed as an average percent reduction of the load. The percent reduction necessary for the TMDL is the average of the differences between the existing load line and the target load curve at each recurrence interval. The regression line through the exceeding points represents the existing load. The target curve represents 200 counts per 100 ml at the various flows. Graphs C-1 through C-5 graphically represent the variable TMDL and LA, WLA, and MOS for each segment. The percent reduction of fecal coliform bacteria recommended for each segment in this TMDL is shown in Table 12. The units of counts per day are appropriate for this TMDL due to the use of the instantaneous standard as opposed to units of counts/per 30 days that are used in conjunction with the use of the geometric mean standard.

Table 12. TMDL Percent Reduction

Segment	WLA (counts/day)	MOS	TMDL Percent Reduction
MS303M4	1.70E+10	Explicit	71.3
MS305M2	8.33E+08	Explicit	49.7
MS305M1	2.27E+08	Explicit	70.2
MS304M2	8.14E+08	Explicit	76.3
MS304M1		Explicit	60.3

5.5 Seasonality

For many streams in the state, fecal coliform limits vary according to the seasons. This stream is designated for the use of secondary contact. For this use, the pollutant standard is seasonal. The criteria for the most critical season, which is the summer for Hickahala Creek, was used as the target for this TMDL. Because data were used throughout the year for several years at each monitoring station, seasonality was addressed. The extended period of record for the stage information allowed for representation of many different flow conditions, which is also relevant to seasonality.

5.6 Reasonable Assurance

This component of TMDL development does not apply to this TMDL Report. There are no point sources (WLA) requesting a reduction based on promised Load Allocation components and reductions. This TMDL will recommend that all point sources discharge treated and disinfected effluent that will be below the 200 colony counts per 100ml target at the end of the pipe.

CONCLUSION

The TMDL will not impact existing or future NPDES Permits as long as the effluent is disinfected to meet water quality standards for pathogens. MDEQ will not approve any NPDES Permit application that does not plan to meet water quality standards for disinfection. Education projects that teach best management practices should be used as a tool for reducing nonpoint source contributions. These projects may be funded by CWA Section 319 Nonpoint Source (NPS) Grants.

6.1 Future Monitoring

MDEQ has adopted the Basin Approach to Water Quality Management, a plan that divides Mississippi's major drainage basins into five groups. During each yearlong cycle, MDEQ resources for water quality monitoring will be focused on one of the basin groups. During the next monitoring phase in the Yazoo River Basin, the Hickahala Creek may receive additional monitoring to identify any change in water quality. MDEQ produced guidance for future Section 319 project funding will encourage NPS restoration projects that attempt to address TMDL related issues within Section 303(d)/TMDL watersheds in Mississippi.

Additional monitoring for fecal coliform bacteria will also continue for several stations in the Hickahala Creek Watershed as part of the geometric mean bacteria sampling project. Bacteria samples will be collected at two stations on Hickahala Creek, one station on James Wolf Creek, and two stations on Senatobia Creek during two thirty-day periods in fall of 2002 and spring of 2003.

6.2 Public Participation

This TMDL will be published for a 30-day public notice. During this time, the public will be notified by publication in the statewide newspaper and a newspaper in the area of the watershed. The public will be given an opportunity to review the TMDL and submit comments. MDEQ also distributes all TMDLs at the beginning of the public notice to those members of the public who have requested to be included on a TMDL mailing list. TMDL mailing list members may request to receive the TMDL reports through either, email or the postal service. Anyone wishing to be included on the TMDL mailing list should contact Linda Burrell at (601) 961-5062 or Linda_Burrell@deq.state.ms.us. At the end of the 30-day period, MDEQ will determine the level of interest in the TMDL and make a decision on the necessity of holding a public meeting.

All written comments received during the public notice period and at any public meeting become a part of the record of this TMDL. All comments will be considered in the ultimate completion of this TMDL for submission of this TMDL to EPA Region 4 for final approval.

DEFINITIONS

Ambient stations: a network of fixed monitoring stations established for systematic water quality sampling at regular intervals, and for uniform parametric coverage over a long-term period.

Assimilative capacity: the capacity of a body of water or soil-plant system to receive wastewater effluents or sludge without violating the provisions of the State of Mississippi Water Quality Criteria for Intrastate, Interstate, and Coastal Waters and Water Quality regulations.

Background: the condition of waters in the absence of man-induced alterations based on the best scientific information available to MDEQ. The establishment of natural background for an altered waterbody may be based upon a similar, unaltered or least impaired, waterbody or on historical pre-alteration data.

Calibrated model: a model in which reaction rates and inputs are significantly based on actual measurements using data from surveys on the receiving waterbody.

Critical Condition: hydrologic and atmospheric conditions in which the pollutants causing impairment of a waterbody have their greatest potential for adverse effects.

Daily discharge: the "discharge of a pollutant" measured during a calendar day or any 24-hour period that reasonably represents the calendar day for purposes of sampling. For pollutants with limitations expressed in units of mass, the "daily discharge" is calculated as the total mass of the pollutant discharged over the day. For pollutants with limitations expressed in other units of measurement, the "daily average" is calculated as the average.

Designated Use: use specified in water quality standards for each waterbody or segment regardless of actual attainment.

Discharge monitoring report: report of effluent characteristics submitted by a NPDES Permitted facility.

Effluent standards and limitations: all State or Federal effluent standards and limitations on quantities, rates, and concentrations of chemical, physical, biological, and other constituents to which a waste or wastewater discharge may be subject under the Federal Act or the State law. This includes, but is not limited to, effluent limitations, standards of performance, toxic effluent standards and prohibitions, pretreatment standards, and schedules of compliance.

Effluent: treated wastewater flowing out of the treatment facilities.

Fecal coliform bacteria: a group of bacteria that normally live within the intestines of mammals, including humans. Fecal coliform bacteria are used as an indicator of the presence of pathogenic organisms in natural water.

Geometric mean: the nth root of the product of n numbers. A 30-day geometric mean is the 30^{th} root of the product of 30 numbers.

Impaired Waterbody: any waterbody that does not attain water quality standards due to an individual pollutant, multiple pollutants, pollution, or an unknown cause of impairment.

Land Surface Runoff: water that flows into the receiving stream after application by rainfall or irrigation. It is a transport method for nonpoint source pollution from the land surface to the receiving stream.

Load allocation (LA): the portion of a receiving water's loading capacity attributed to or assigned to nonpoint sources (NPS) or background sources of a pollutant. The load allocation is the value assigned to the summation of all direct sources and land applied fecal coliform that enter a receiving waterbody. It also contains a portion of the contribution from septic tanks.

Loading: the total amount of pollutants entering a stream from one or multiple sources.

Nonpoint Source: pollution that is in runoff from the land. Rainfall, snowmelt, and other water that does not evaporate become surface runoff and either drains into surface waters or soaks into the soil and finds its way into groundwater. This surface water may contain pollutants that come from land use activities such as agriculture; construction; silviculture; surface mining; disposal of wastewater; hydrologic modifications; and urban development.

NPDES permit: an individual or general permit issued by the Mississippi Environmental Quality Permit Board pursuant to regulations adopted by the Mississippi Commission on Environmental Quality under Mississippi Code Annotated (as amended) §§ 49-17-17 and 49-17-29 for discharges into State waters.

Point Source: pollution loads discharged at a specific location from pipes, outfalls, and conveyance channels from either wastewater treatment plants or industrial waste treatment facilities. Point sources can also include pollutant loads contributed by tributaries to the main receiving stream.

Pollution: contamination, or other alteration of the physical, chemical, or biological properties, of any waters of the State, including change in temperature, taste, color, turbidity, or odor of the waters, or such discharge of any liquid, gaseous, solid, radioactive, or other substance, or leak into any waters of the State, unless in compliance with a valid permit issued by the Permit Board.

Publicly Owned Treatment Works (POTW): a waste treatment facility owned and/or operated by a public body or a privately owned treatment works which accepts discharges which would otherwise be subject to Federal Pretreatment Requirements.

Regression Coefficient: an expression of the functional relationship between two correlated variables that is often empirically determined from data, and is used to predict values of one variable when given values of the other variable.

Scientific Notation (Exponential Notation): mathematical method in which very large numbers or very small numbers are expressed in a more concise form. The notation is based on powers of ten. Numbers in scientific notation are expressed as the following: *4.16 x 10^(+b)* and *4.16 x 10^(-b) [same as 4.16E4 or4.16E-4]*. In this case, *b* is always a positive, real number. The *10^(+b)* tells us that the decimal point is *b* places to the right of where it is shown. The *10^(-b)* tells us that the decimal point is *b* places to the left of where it is shown.
For example: $2.7X10^{4}$ = 2.7E+4 =27000 and $2.7X10^{-4}$ = 2.7E-4=0.00027.

Sigma (Σ): shorthand way to express taking the sum of a series of numbers. For example, the sum or total of three amounts 24, 123, 16, (d_l, d_2, d_3) respectively could be shown as:

$$\sum_{i=1}^{3} d_i = d_1+d_2+d_3 = 24 + 123 + 16 = 163$$

Total Maximum Daily Load or TMDL: the calculated maximum permissible pollutant loading to a waterbody at which water quality standards can be maintained.

Waste: sewage, industrial wastes, oil field wastes, and all other liquid, gaseous, solid, radioactive, or other substances which may pollute or tend to pollute any waters of the State.

Wasteload allocation (WLA): the portion of a receiving water's loading capacity attributed to or assigned to point sources of a pollutant. It also contains a portion of the contribution from septic tanks.

Water Quality Standards: the criteria and requirements set forth in *State of Mississippi Water Quality Criteria for Intrastate, Interstate, and Coastal Waters*. Water quality standards are standards composed of designated present and future most beneficial uses (classification of waters), the numerical and narrative criteria applied to the specific water uses or classification, and the Mississippi antidegradation policy.

Water quality criteria: elements of State water quality standards, expressed as constituent concentrations, levels, or narrative statements, representing a quality of water that supports the present and future most beneficial uses.
Waters of the State: all waters within the jurisdiction of this State, including all streams, lakes, ponds, wetlands, impounding reservoirs, marshes, watercourses, waterways, wells, springs, irrigation systems, drainage systems, and all

other bodies or accumulations of water, surface and underground, natural or artificial, situated wholly or partly within or bordering upon the State, and such coastal waters as are within the jurisdiction of the State, except lakes, ponds, or other surface waters which are wholly landlocked and privately owned, and which are not regulated under the Federal Clean Water Act (33 U.S.C.1251 et seq.).

Watershed: the area of land draining into a stream at a given location.

ABBREVIATIONS

7Q10..........................Seven-Day Average Low Stream Flow with a Ten-Year Occurrence Period

BASINS .... Better Assessment Science Integrating Point and Nonpoint Sources

BMP ....Best Management Practice

CWA ....Clean Water Act

DMR .... Discharge Monitoring Report

EPA ....Environmental Protection Agency

GIS .... Geographic Information System

HUC ....Hydrologic Unit Code

LA ....Load Allocation

MARIS .... State of Mississippi Automated Information System

MDEQ .... Mississippi Department of Environmental Quality

MOS .... Margin of Safety

NRCS ....National Resource Conservation Service

NPDES .... National Pollution Discharge Elimination System

NPSM..Nonpoint Source Model

RF3.. Reach File 3

USGS .... United States Geological Survey

WLA ....Waste Load Allocation

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APPENDIX A

This appendix contains the fecal coliform monitoring data available for five on the monitoring stations on Hickahala Creek, James Wolf Creek, and Senatobia Creek. The flow measurements in Hickahala Creek were recorded from USGS gage 07277700. This flow gage is located east of Senatobia on a county road. This flow gage is located at the same location as monitoring station 07277700 on Hickahala Creek. Flow measurements at this station were used to estimate the flow for an additional monitoring station on Hickahala Creek, station 07277530. Flow from the gage on Hickahala Creek was also used to estimate the flow on James Wolf Creek at monitoring station 07277548 using a drainage area ratio. The flow measurements in Senatobia Creek were recorded from USGS gage 07277730. The flow data given for all of the monitoring stations on Senatobia Creek is based on the data collected at this gage. Monitoring station 07277730 is located at the same location as the flow gage. Flow was estimated for station 07277715 on Senatobia Creek using a ratio of the drainage area of the monitoring station to the drainage area of the gage.

Table A-1. Fecal Coliform Data reported in the Hickahala Creek, Station 07277700
June 1988 to November 1995

Date	Time	Flow (cfs)	Fecal Coliform (counts/100ml)
6/3/1988	6:00	28	180
6/3/1988	12:00	32	100
6/3/1988	18:00	32	73
6/4/1988		28	150
6/4/1988	6:00	28	190
6/4/1988	12:00	29	130
6/4/1988	18:00	31	260
6/5/1988		27	130
9/13/1988	6:00	28	100
9/13/1988	12:00	28	140
9/13/1988	18:00	29	58
9/14/1988		28	170
9/14/1988	6:00	28	120
9/14/1988	12:00	29	140
9/14/1988	18:00	28	27
9/15/1988		28	86
9/15/1988	6:00	28	160
10/25/1988	6:00	28	2000
10/26/1988	18:00	28	92
10/27/1988		28	150
10/27/1988	6:00	28	180
4/3/1989	18:00	71	290
4/4/1989		89	220
4/4/1989	6:00	279	3900
4/4/1989	12:00	408	13000
4/4/1989	18:00	238	29000
4/5/1989		159	18000
4/5/1989	6:00	112	10000
4/5/1989	12:00	97	6400
4/5/1989	18:00	82	2000

Table A-1 Continued

Date	Time	Flow (cfs)	Fecal Coliform (counts/100ml)
4/25/1990	18:00	50	860
4/26/1990		44	960
4/26/1990	6:00	43	840
4/26/1990	12:00	43	1200
4/26/1990	18:00	43	500
4/27/1990		43	920
4/27/1990	6:00	41	1100
4/27/1990	12:00	42	900
4/27/1990	18:00	43	1500
4/28/1990		5180	32000
4/28/1990	6:00	3080	24000
4/28/1990	12:00	1870	8000
4/28/1990	18:00	684	1300
4/29/1990		310	10000
4/29/1990	6:00	186	5800
4/29/1990	12:00	137	4000
4/29/1990	18:00	112	2900
4/30/1990		95	710
1/9/1991	12:00	100	390
1/9/1991	18:00	94	46
1/10/1991		90	46
1/10/1991	6:00	87	25
1/10/1991	12:00	1460	1000
1/10/1991	18:00	1490	3600
1/11/1991		483	3400
1/11/1991	6:00	228	1800
1/11/1991	12:00	239	1200
7/16/1991	12:30	41	58
7/16/1991	18:30	41	76
7/17/1991	0:30	40	140
7/17/1991	6:30	40	130
7/17/1991	12:30	41	64
7/17/1991	18:30	41	40
7/18/1991	0:30	40	110
7/18/1991	6:30	39	160
7/18/1991	12:30	40	69
10/22/1991	12:30	32	4
10/22/1991	18:30	34	30
10/23/1991	0:30	32	27
10/23/1991	6:30	32	39
10/23/1991	12:30	34	43
10/23/1991	18:30	34	36
10/24/1991	0:30	32	51
10/24/1991	6:30	32	49
10/24/1991	12:30	32	16
6/2/1992	18:30	40	24

Table A-1 Continued

Date	Time	Flow (cfs)	Fecal Coliform (counts/100ml)
6/3/1992	0:30	39	3000
6/3/1992	6:30	116	32000
6/3/1992	12:30	2390	2100
6/3/1992	18:30	597	14000
6/4/1992	0:30	174	20000
6/4/1992	18:30	81	14000
3/30/1993	15:30	59	200
3/30/1993	21:00	144	5200
3/31/1993	3:00	246	8000
3/31/1993	9:30	751	15000
3/31/1993	15:30	388	33000
3/31/1993	21:00	210	18000
4/1/1993	3:00	138	7800
4/1/1993	9:30	108	5500
4/1/1993	15:30	92	5100
1/26/1994	21:30	585	52000
1/27/1994	0:30	1340	36000
1/27/1994	6:30	2450	60000
1/27/1994	12:30	7480	6400
1/27/1994	18:30	6570	3900
1/28/1994	0:30	6680	3400
1/28/1994	6:30	3320	4500
1/28/1994	12:30	1370	2000
1/28/1994	18:30	664	2200
8/31/1994	10:30	322	960
2/15/1995	6:30	61	72
2/15/1995	12:30	63	45
2/15/1995	18:30	65	63
2/16/1995	0:30	64	60
2/16/1995	6:30	2020	6700
2/16/1995	12:30	1590	9700
2/16/1995	18:30	582	3700
2/17/1995	0:30	314	4400
2/17/1995	6:30	224	4900
8/15/1995	10:30	45	140
10/31/1995	6:30	40	440
10/31/1995	12:30	40	520
10/31/1995	18:30	41	660
11/1/1995	0:30	39	640
11/1/1995	12:30	38	8700
11/1/1995	18:30	44	2000
11/2/1995	0:30	41	1100
11/2/1995	6:30	47	3700

Table A-2. Fecal Coliform Data reported in Hickahala Creek, Station 07277530
June 1988 to February 1995

Date	Time	Flow (cfs)	Fecal Coliform (counts/100ml)
6/3/1988	6:30	18	130
6/3/1988	12:40	18	240
6/3/1988	18:30	18	42
6/4/1988	0:45	18	140
6/4/1988	6:40	18	100
6/4/1988	12:40	18	50
6/4/1988	18:30	18	62
6/5/1988	0:30	18	210
6/5/1988	6:30	18	160
9/13/1988	6:00	15	120
9/13/1988	12:00	15	65
9/13/1988	18:00	15	50
9/14/1988		15	240
9/14/1988	6:30	15	96
9/14/1988	12:00	15	24
9/14/1988	18:00	15	45
9/15/1988		15	92
9/15/1988	6:00	15	160
10/25/1988	6:00	16	1300
10/25/1988	12:00	16	760
10/25/1988	18:00	14	1600
10/26/1988		14	5
10/26/1988	6:00	14	160
10/26/1988	12:00	16	120
10/26/1988	18:00	14	31
10/27/1988		16	92
10/27/1988	6:00	16	88
4/3/1989	18:30	40	100
4/4/1989	0:30	40	140
4/4/1989	6:30	560	24000
4/4/1989	12:30	165	4900
4/4/1989	18:25	110	11000
4/5/1989	0:30	72	11000
4/5/1989	6:30	55	3100
4/5/1989	12:30	49	1200
4/5/1989	18:30	41	510
4/25/1990	18:20	27	140
4/26/1990	0:20	27	350
4/26/1990	6:20	25	280
4/26/1990	12:20	25	64
4/26/1990	18:20	24	88
4/27/1990	0:20	24	220
4/27/1990	6:00	23	96
4/27/1990	12:20	25	120
4/27/1990	18:20	28	3500

Table A-2 Continued

Date	Time	Flow (cfs)	Fecal Coliform (counts/100ml)
4/28/1990	0:20	2650	12000
4/28/1990	6:20	690	15000
4/28/1990	12:20	385	4600
4/28/1990	18:20	172	5700
4/29/1990	0:20	96	5200
4/29/1990	6:20	66	3700
4/29/1990	12:20	57	2000
4/29/1990	18:20	46	2100
4/30/1990	0:20	40	610
1/9/1991	12:30	56	33
1/9/1991	18:30	54	20
1/10/1991	0:30	54	15
1/10/1991	6:30	50	12
1/10/1991	12:30	1070	6800
1/10/1991	18:30	295	1000
1/11/1991	0:30	157	2800
1/11/1991	6:30	113	860
1/11/1991	12:30	123	1200
7/16/1991	12:30	27	31
7/16/1991	18:30	27	65
7/17/1991	0:30	27	58
7/17/1991	6:30	27	77
7/17/1991	12:30	27	270
7/17/1991	18:30	27	77
7/18/1991	0:30	27	100
7/18/1991	6:30	27	100
7/18/1991	12:30	27	120
10/22/1991	12:30	19	4
10/22/1991	18:30	19	4
10/23/1991	0:30	19	13
10/23/1991	6:30	19	540
10/23/1991	12:30	19	12
10/23/1991	18:30	19	17
10/24/1991	0:30	19	25
10/24/1991	6:30	19	33
10/24/1991	12:30	19	3
6/2/1992	18:30	21	38
6/3/1992	0:30	22	120
6/3/1992	6:30	400	11000
6/3/1992	13:15	405	400
6/3/1992	18:30	82	21000
6/4/1992	0:30	395	9600
6/4/1992	6:30	89	1100
6/4/1992	18:30	34	8600
3/30/1993	15:30	27	300
3/30/1993	21:30	125	31000
3/31/1993	3:30	248	9800

Table A-2 Continued

Date	Time	Flow (cfs)	Fecal Coliform (counts/100ml)
3/31/1993	9:30	255	72000
3/31/1993	15:30	108	13000
3/31/1993	21:30	76	7000
4/1/1993	3:30	58	6700
4/1/1993	9:30	50	3500
4/1/1993	15:30	46	2800
1/26/1994	19:00	270	12000
1/27/1994	1:00	310	12000
1/27/1994	7:00	2050	9600
1/27/1994	13:00	4100	4200
1/27/1994	19:00	920	2600
1/28/1994	1:00	1550	4500
1/28/1994	7:00	490	5400
1/28/1994	13:00	260	2400
1/28/1994	19:00	200	2300
2/15/1995	6:30	26	96
2/15/1995	12:30	32	110
2/15/1995	18:30	28	58
2/16/1995	0:30	28	40
2/16/1995	6:30	1070	7300
2/16/1995	12:30	136	1500
2/16/1995	18:30	132	11000
2/17/1995	0:30	78	5000
2/17/1995	6:30	58	4000

Table A-3. Fecal Coliform Data reported in James Wolf Creek, Station 07277548
June 1988 to November 1995

Date	Time	Flow (cfs)	Fecal Coliform (counts/100ml)
6/3/1988	6:00	4.7	260
6/3/1988	12:00	4.4	320
6/3/1988	18:00	4.2	760
6/4/1988	6:00	4.4	940
6/4/1988	12:00	4.4	560
6/4/1988	18:00	4.2	300
6/5/1988		4.2	1200
6/5/1988	6:00	4.2	600
9/13/1988	6:35	6.2	410
9/13/1988	12:30	6.2	88
9/13/1988	18:20	5.9	320
9/14/1988	0:30	6.2	310
9/14/1988	6:30	5.9	240
9/14/1988	12:25	6.2	150
9/14/1988	18:20	5.8	200
9/15/1988	0:25	5.8	130
9/15/1988	6:25	5.8	500
10/25/1988	7:15	4.2	35
10/25/1988	12:30	4.7	40
10/25/1988	18:30	4.7	60
10/26/1988	0:30	4.7	50
10/26/1988	6:35	4.7	54
10/26/1988	12:30	4.6	36
10/26/1988	18:25	4.6	20
10/27/1988	0:30	4.6	35
10/27/1988	6:30	4.6	16
4/3/1989	18:00	18	120
4/4/1989		18	320
4/4/1989	6:00	67	4300
4/4/1989	12:00	76	64000
4/4/1989	18:00	67	16000
4/5/1989		37	9600
4/5/1989	6:00	27	5200
4/5/1989	12:00	25	3100
4/5/1989	18:00	22	1100
4/25/1990	18:00	14	230
4/26/1990		14	130
4/26/1990	6:00	14	210

Table A-3 Continued

Date	Time	Flow (cfs)	Fecal Coliform (counts/100ml)
4/26/1990	12:00	20	56
4/26/1990	18:00	15	190
4/27/1990	6:00	14	280
4/27/1990	12:00	14	120
4/27/1990	18:00	14	160
4/28/1990		2150	39000
4/28/1990	6:00	500	33000
4/28/1990	12:00	200	23000
4/28/1990	18:00	97	7300
4/29/1990		63	8600
4/29/1990	6:00	34	4800
4/29/1990	12:00	31	2700
4/29/1990	18:00	27	1200
4/30/1990		24	1300
1/9/1991	12:00	15	260
1/9/1991	18:00	15	15
1/10/1991		14	42
1/10/1991	6:00	14	20
1/10/1991	12:00	580	1100
1/10/1991	18:00	208	620
1/11/1991		105	4800
1/11/1991	6:00	58	1200
1/11/1991	12:00	64	1400
7/16/1991	13:00	11	110
7/16/1991	19:00	11	76
7/17/1991	1:00	11	200
7/17/1991	7:00	11	440
7/17/1991	13:00	11	36
7/17/1991	19:00	11	110
7/18/1991	1:00	11	140
7/18/1991	7:00	11	110
7/18/1991	13:00	11	130
10/22/1991	13:00	9	4
10/22/1991	19:00	9	12
10/23/1991	1:00	9	61
10/23/1991	7:00	9	190

Table A-3 Continued

Date	Time	Flow (cfs)	Fecal Coliform (counts/100ml)
10/23/1991	13:00	9	30
10/23/1991	19:00	9	20
10/24/1991	1:00	9	20
10/24/1991	7:00	9	20
10/24/1991	13:00	9	16
6/2/1992	19:00	7.7	81
6/3/1992	1:00	8.2	330
6/3/1992	7:00	740	21000
6/3/1992	14:00	125	3700
6/3/1992	19:00	22	12000
6/4/1992	1:00	75	12000
6/4/1992	7:00	16	12000
6/4/1992	19:00	10	11000
3/30/1993	16:00	7.2	900
3/30/1993	21:30	7.2	2000
3/31/1993	3:30	214	5900
3/31/1993	10:00	198	21000
3/31/1993	16:00	66	6600
3/31/1993	21:30	36	7400
4/1/1993	10:00	26	3400
1/27/1994	6:30	550	13000
1/27/1994	12:30	3900	5000
1/27/1994	18:30	640	5300
1/28/1994	0:30	720	5800
1/28/1994	6:30	275	2200
1/28/1994	12:30	138	6400
1/28/1994	18:30	86	6800
2/15/1995	7:00	10	92
2/15/1995	13:00	12	100
2/15/1995	19:00	11	90
2/16/1995	1:00	12	70
2/16/1995	7:00	430	6000
2/16/1995	13:00	122	17000
2/16/1995	19:00	47	1200
2/17/1995	1:00	28	1300
2/17/1995	7:00	20	3300

Table A-3 Continued

Date	Time	Flow (cfs)	Fecal Coliform (counts/100ml)
10/31/1995	7:00	8.3	140
10/31/1995	13:00	8.6	100
10/31/1995	19:00	8.3	170
11/1/1995	13:00	8.1	220
11/1/1995	19:00	9.1	460
11/2/1995	1:00	8.9	300
11/2/1995	3:30	9.3	580

Table A-4. Fecal Coliform Data reported in Senatobia Creek, Station 07277730
June 1988 to November 1995

Date	Time	Flow (cfs)	Fecal Coliform (counts/100ml)
6/3/1988	6:15	9	420
6/3/1988	12:15	9	300
6/3/1988	18:30	9	900
6/4/1988	0:30	9	260
6/4/1988	6:25	8.8	300
6/4/1988	18:30	8.8	140
6/5/1988	0:30	8.8	260
6/5/1988	6:35	8.7	520
9/13/1988	6:20	8.1	240
9/13/1988	12:20	8.1	180
9/13/1988	18:20	8	250
9/14/1988	0:20	8	400
9/14/1988	6:20	8	260
9/14/1988	12:20	8	190
9/14/1988	18:20	8	220
9/15/1988	0:20	8	300
9/15/1988	6:20	8	260
10/25/1988	6:25	8.5	860
10/25/1988	12:15	8.5	880
10/25/1988	18:15	8.5	290
10/26/1988	0:15	8.2	300
10/26/1988	6:15	8.2	150
10/26/1988	12:20	8.2	100
10/26/1988	18:15	8.5	110
10/27/1988	0:15	8	120
10/27/1988	6:15	8	100
4/3/1989	18:30	36	190
4/4/1989	0:30	35	280
4/4/1989	6:30	46	720
4/4/1989	12:30	96	18000
4/4/1989	18:30	112	13000
4/5/1989	0:30	66	5900
4/5/1989	6:30	50	4300
4/5/1989	12:30	46	2100
4/5/1989	18:30	42	1200
4/25/1990	18:25	18	240
4/26/1990	0:15	16	360
4/26/1990	6:15	16	370
4/26/1990	12:15	16	490
4/26/1990	18:15	16	180
4/27/1990	0:30	15	940

Table A-4 Continued

Date	Time	Flow (cfs)	Fecal Coliform (counts/100ml)
4/27/1990	6:15	15	420
4/27/1990	12:15	16	1000
4/27/1990	18:15	18	900
4/28/1990	0:15	3030	24000
4/28/1990	6:15	1030	26000
4/28/1990	12:15	720	4200
4/28/1990	18:15	307	5500
4/29/1990	0:15	139	8200
4/29/1990	6:15	73	3200
4/29/1990	12:15	53	3500
4/29/1990	18:15	43	1500
4/30/1990	0:15	33	2200
1/9/1991	12:30	47	96
1/9/1991	18:30	43	15
1/10/1991	0:30	38	5
1/10/1991	6:30	37	20
1/10/1991	12:30	1610	3900
1/10/1991	18:30	766	2900
1/11/1991	0:30	317	3000
1/11/1991	6:30	185	2400
1/11/1991	12:30	182	2400
7/16/1991	13:00	11	840
7/16/1991	19:00	12	1600
7/17/1991	1:00	12	760
7/17/1991	7:00	12	1100
7/17/1991	13:00	12	1200
7/17/1991	19:00	12	1100
7/18/1991	1:00	12	500
7/18/1991	7:00	12	1100
7/18/1991	13:00	12	1200
10/22/1991	13:00	10	24
10/22/1991	19:00	10	110
10/23/1991	1:00	10	37
10/23/1991	7:00	10	88
10/23/1991	13:00	11	120
10/23/1991	19:00	11	120
10/24/1991	1:00	12	41
10/24/1991	7:00	11	77
10/24/1991	13:00	11	15
6/2/1992	19:00	9.4	3300
6/3/1992	1:00	9.4	290
6/3/1992	7:00	95	11000
6/3/1992	13:00	1410	520
6/3/1992	19:00	313	19000
6/4/1992	1:00	90	13000

Table A-4 Continued

Date	Time	Flow (cfs)	Fecal Coliform (counts/100ml)
6/4/1992	19:00	31	5600
3/30/1993	16:00	25	220
3/30/1993	21:30	38	480
3/31/1993	3:30	434	7400
3/31/1993	10:00	785	13000
3/31/1993	16:00	258	14000
3/31/1993	21:30	144	7500
4/1/1993	3:30	89	4800
4/1/1993	10:00	63	2700
4/1/1993	16:00	89	2100
1/26/1994	22:00	456	46000
1/27/1994	1:00	999	13000
1/27/1994	7:00	1230	12000
1/27/1994	13:00	5680	9200
1/27/1994	19:00	2030	3600
1/28/1994	1:00	2920	4500
1/28/1994	7:00	1130	2100
1/28/1994	13:00	599	1600
1/28/1994	19:00	365	2100
8/31/1994	11:15	266	33000
2/15/1995	7:00	17	80
2/15/1995	13:00	17	100
2/15/1995	19:00	17	52
2/16/1995	1:00	17	52
2/16/1995	7:00	1550	2300
2/16/1995	13:00	693	8000
2/16/1995	19:00	256	2000
2/17/1995	1:00	183	4000
2/17/1995	7:00	136	3300
8/15/1995	11:20	14	240
10/31/1995	7:00	13	780
10/31/1995	13:00	12	320
10/31/1995	19:00	13	240
11/1/1995	1:00	13	320
11/1/1995	13:00	12	380
11/1/1995	19:00	18	920
11/2/1995	1:00	16	1900
11/2/1995	7:00	16	2300

Table A-5. Fecal Coliform Data reported in Senatobia Creek, Station 07277715
June 1988 to November 1995

Date	Time	Flow (cfs)	Fecal Coliform (counts/100ml)
6/3/1988	12:30	2.2	69
6/3/1988	18:20	2.1	50
6/4/1988	0:25	2.1	50
6/4/1988	6:20	2.1	65
6/4/1988	12:25	2.4	19
6/4/1988	18:25	1.9	35
6/5/1988	0:20	1.9	69
6/5/1988	6:20	1.9	65
9/13/1988	6:00	2.5	81
9/13/1988	12:00	2.5	100
9/13/1988	18:00	2.5	88
9/14/1988		2.5	110
9/14/1988	6:00	2.5	160
9/14/1988	12:00	2.5	67
9/14/1988	18:00	2.3	67
9/15/1988		2.3	130
9/15/1988	6:00	2.3	160
10/25/1988	6:30	2.1	220
10/25/1988	12:00	2.1	800
10/25/1988	18:00	2.1	120
10/26/1988		2.1	170
10/26/1988	6:00	2.1	120
10/26/1988	12:00	2.2	96
10/26/1988	18:00	2.2	84
10/27/1988		2.2	580
10/27/1988	6:00	2.2	120
4/3/1989	18:20	9.4	420
4/4/1989	0:30	9.4	420
4/4/1989	6:20	40	20000
4/4/1989	12:20	38	10000
4/4/1989	18:20	32	12000
4/5/1989	0:20	14	9300
4/5/1989	6:25	12	4300
4/5/1989	12:20	12	1000
4/5/1989	18:20	8.5	780
4/25/1990	18:36	6	100
4/26/1990	0:35	6.1	280
4/26/1990	6:35	6.1	440
4/26/1990	12:35	6.4	200
4/26/1990	18:30	6.4	100
4/27/1990	0:35	6.1	420
4/27/1990	6:35	6	240

Table A-5 Continued

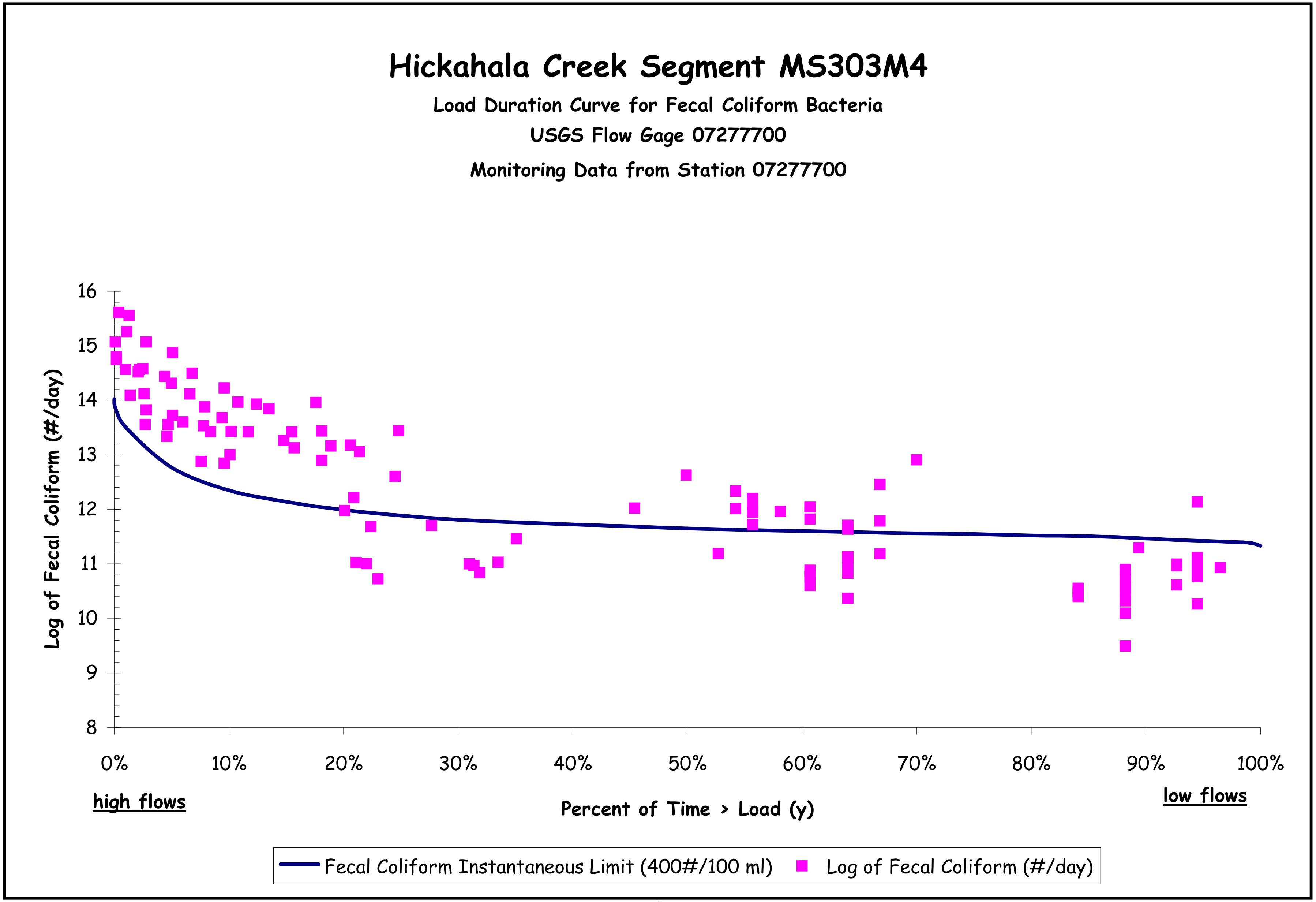
Date	Time	Flow (cfs)	Fecal Coliform (counts/100ml)
4/27/1990	12:35	6.1	120
4/27/1990	18:35	6.6	10000
4/28/1990	0:25	1340	19000
4/28/1990	6:25	203	15000
4/28/1990	12:25	155	8900
4/28/1990	18:25	57	1600
4/29/1990	0:25	23	4600
4/29/1990	6:30	12	1700
4/29/1990	12:25	11	1800
4/29/1990	18:25	9.2	440
4/30/1990	0:25	9	600
1/9/1991	12:30	9.6	120
1/9/1991	18:30	9.5	10
1/10/1991	0:30	9.2	5
1/10/1991	6:30	8.8	12
1/10/1991	12:30	485	1300
1/10/1991	18:30	88	600
1/11/1991	0:30	50	2400
1/11/1991	6:30	36	1300
1/11/1991	12:30	42	2200
7/16/1991	12:00	4	180
7/16/1991	18:00	4	140
7/17/1991		4	110
7/17/1991	6:00	4	76
7/17/1991	12:00	4	84
7/17/1991	18:00	4	660
7/18/1991		4	77
7/18/1991	6:00	4	140
7/18/1991	12:00	4	220
10/22/1991	12:00	3	4
10/22/1991	18:00	3	23
10/23/1991		3	20
10/23/1991	6:00	3	260
10/23/1991	12:00	3	43
10/23/1991	18:00	3	520
10/24/1991		3	40
10/24/1991	6:00	3	49
10/24/1991	12:00	3	13
6/2/1992	18:00	3.8	69
6/3/1992		3.9	700
6/3/1992	6:00	103	4900
6/3/1992	12:00	101	660
6/3/1992	18:00	16	11000
6/4/1992		11	5500
6/4/1992	18:00	6.2	1000

Table A-5 Continued

Date	Time	Flow (cfs)	Fecal Coliform (counts/100ml)
3/30/1993	15:00	6.9	230
3/30/1993	21:00	7.3	16000
3/31/1993	3:00	310	1200
3/31/1993	9:00	215	11000
3/31/1993	15:00	50	3900
3/31/1993	21:00	29	3100
4/1/1993	3:00	21	5000
4/1/1993	9:00	10	560
4/1/1993	15:00	15	640
1/26/1994	21:00	54	22000
1/27/1994		620	80000
1/27/1994	6:00	340	12000
1/27/1994	12:00	3020	14000
1/27/1994	18:00	350	4900
1/28/1994		610	4700
1/28/1994	6:00	220	2800
1/28/1994	12:00	125	2100
1/28/1994	18:00	78	1300
2/15/1995	6:00	4.8	88
2/15/1995	12:00	4.9	75
2/15/1995	18:00	4.9	32
2/16/1995		4.6	48
2/16/1995	6:00	437	12000
2/16/1995	12:00	102	8300
2/16/1995	18:00	38	5000
2/17/1995		32	5000
2/17/1995	6:00	14	640
10/31/1995	6:00	3.6	280
10/31/1995	12:00	3.6	160
10/31/1995	18:00	3.6	1500
11/1/1995		3.6	180
11/1/1995	12:00	3.7	160
11/1/1995	18:00	4.8	370
11/2/1995		4.8	140
11/2/1995	6:00	5.8	3100

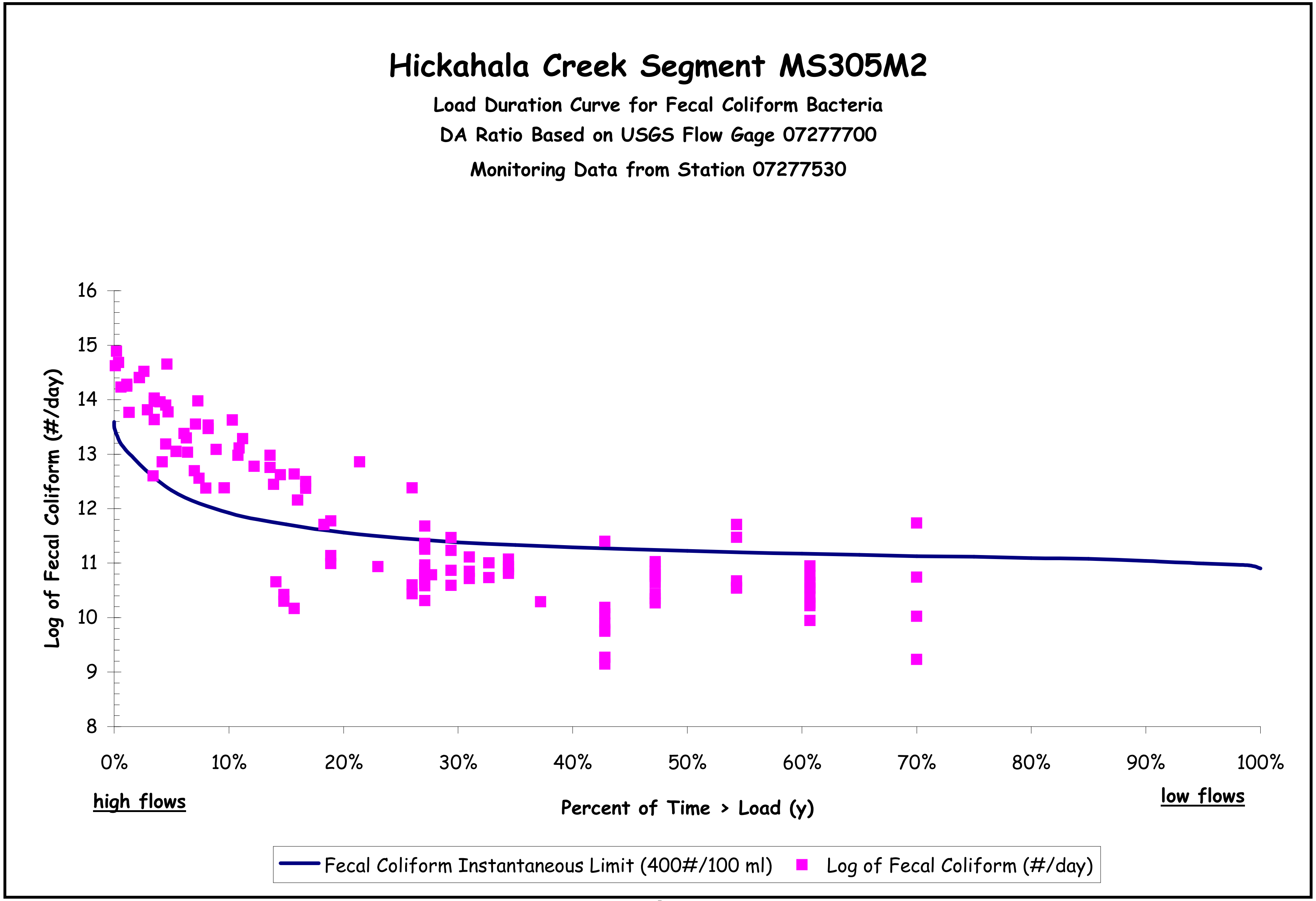
APPENDIX B

This appendix contains the load duration curves for the five segments included in this TMDL. The load duration curves for all segments are shown on semi-log plots. In order to show the curves and data more clearly, the y-axis of the plots begins at 1.0E+8 fecal coliform (counts/day). Graph B-1 shows the load duration curve for segment MS303M4. The flow data used to develop this load duration curve are from USGS station 07277700, and the water quality data are from station 07277700. Both the flow and water quality monitoring sites are located at the same location. Graph B-2 shows the load duration curve for segment MS305M2. The flow data used to develop this load duration curve were taken from USGS station 07277700, and applied to water quality monitoring station 07277530 using a drainage area ratio. Graph B-3 shows the load duration curve for segment MS305M1. The flow data used to develop this load duration curve were taken from USGS station 07277700, and applied to water quality monitoring station 07277548 using a drainage area ratio. Graph B-4 shows the load duration curve for segment MS304M2. The flow data used to develop this load duration curve are from USGS station 07277730, and the water quality data are from station 0727730. Both the flow and water quality monitoring sites are located at the same location. Graph B-5 shows the load duration curve for segment MS304M1. Data from flow monitoring station 07277730 were applied to this segment using a drainage are ratio. The water quality data used to develop this curve were collected at monitoring station 07277715.

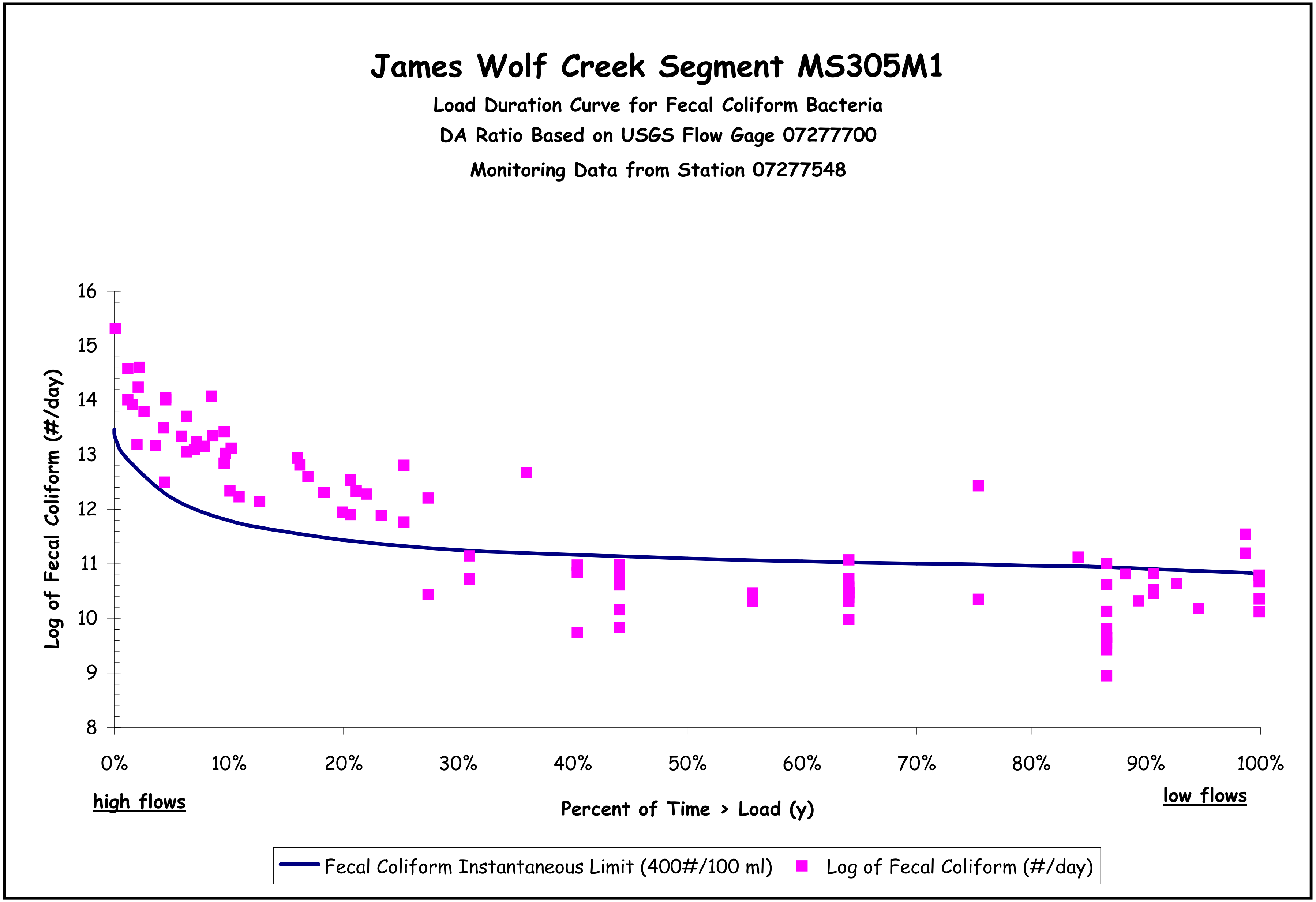


Hickahala Creek Segment MS303M4
Load Duration Curve for Fecal Coliform Bacteria
USGS Flow Gage 07277700
Monitoring Data from Station 07277700
Log of Fecal Coliform (#/day)
16
15
14
13
12
11
10
9
8
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
high flows
Percent of Time > Load (y)
low flows
Fecal Coliform Instantaneous Limit (400#/100 ml)
Log of Fecal Coliform (#/day)

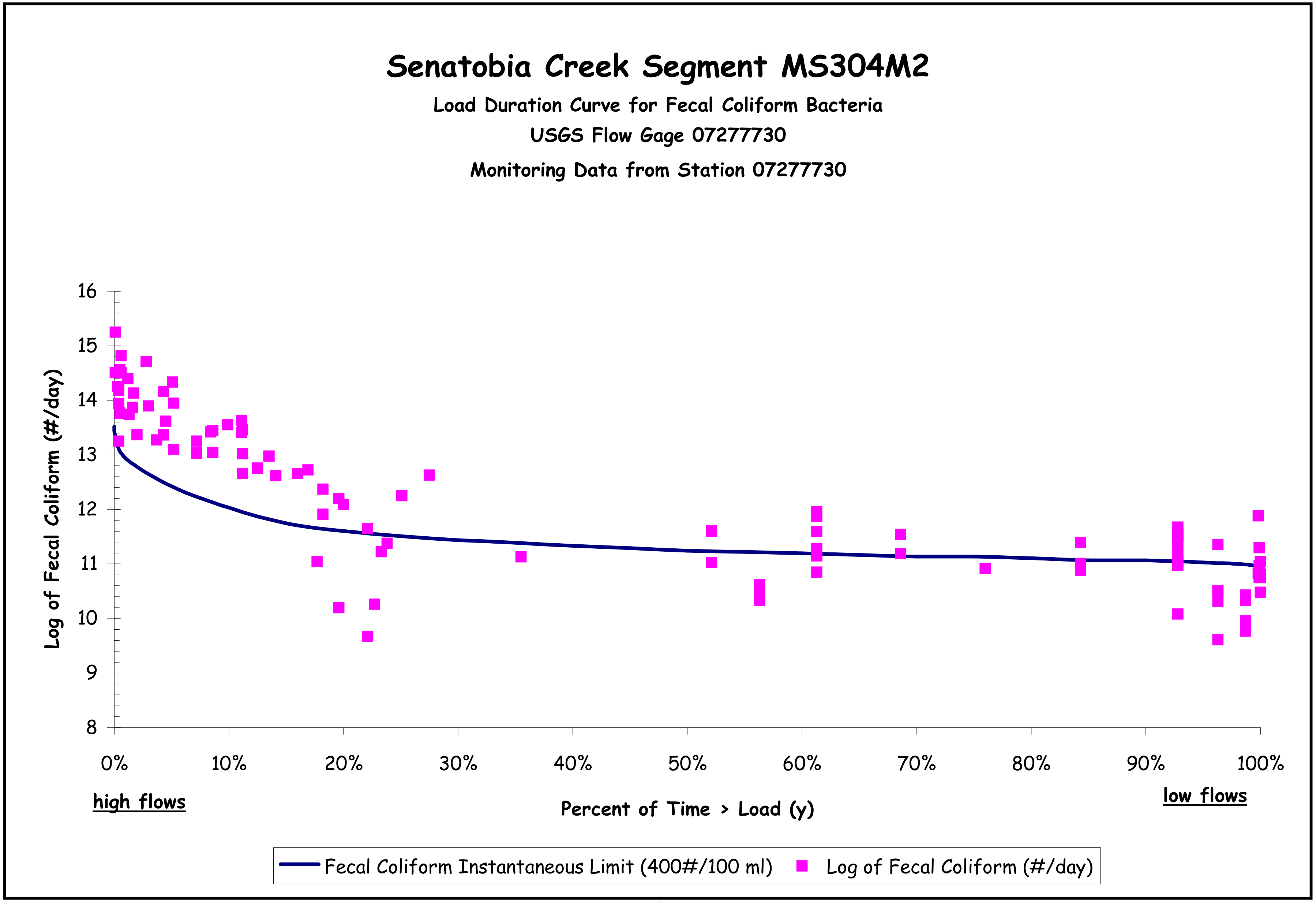
Graph B-1


Hickahala Creek Segment MS305M2
Load Duration Curve for Fecal Coliform Bacteria
DA Ratio Based on USGS Flow Gage 07277700
Monitoring Data from Station 07277530
Log of Fecal Coliform (#/day)
16
15
14
13
12
11
10
9
8
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
high flows
Percent of Time > Load (y)
low flows
Fecal Coliform Instantaneous Limit (400#/100 ml)
Log of Fecal Coliform (#/day)

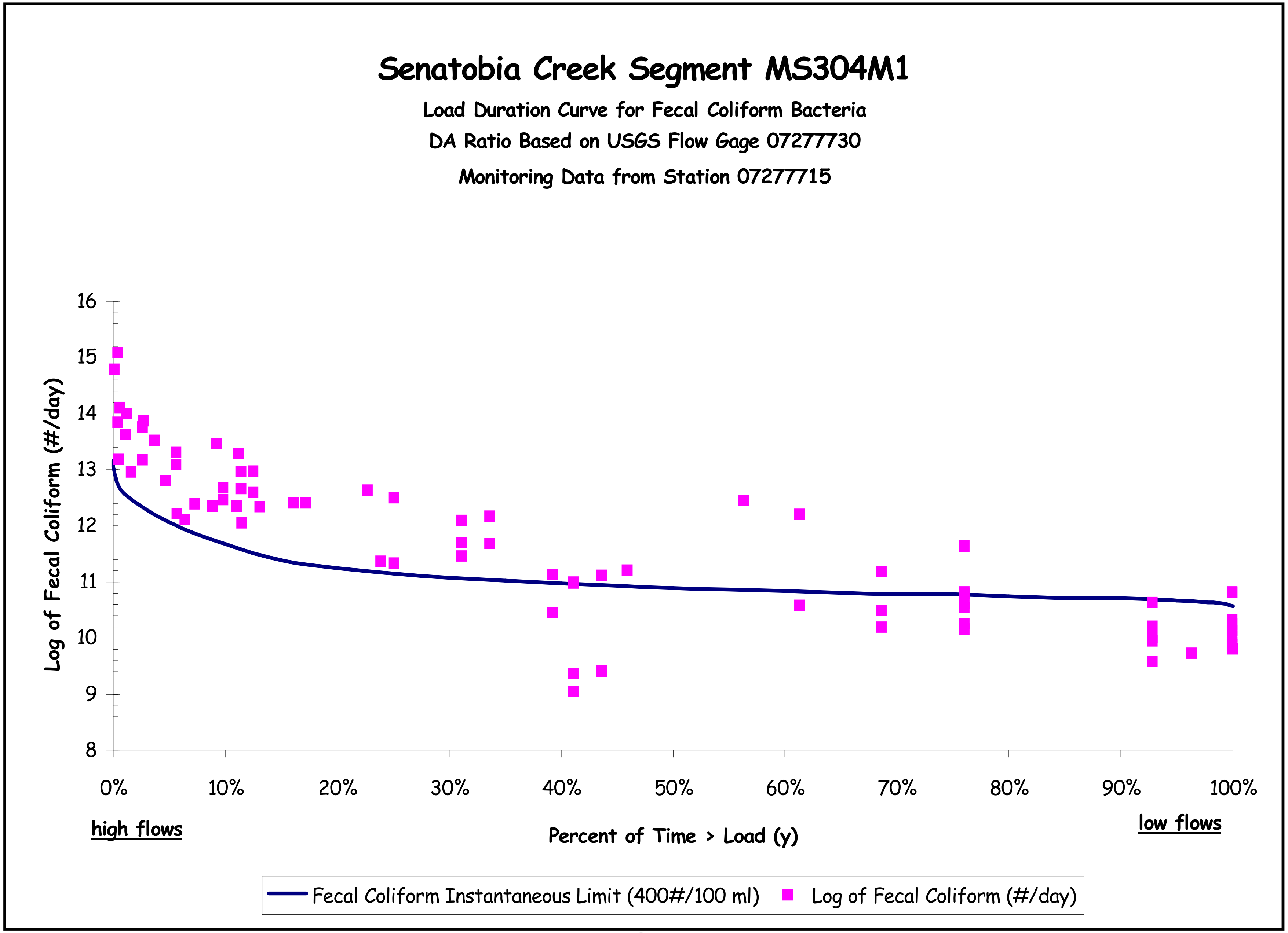
Graph B-2


James Wolf Creek Segment MS305M1
Load Duration Curve for Fecal Coliform Bacteria
DA Ratio Based on USGS Flow Gage 07277700
Monitoring Data from Station 07277548
Log of Fecal Coliform (#/day)
16
15
14
13
12
11
10
9
8
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
high flows
Percent of Time > Load (y)
low flows
Fecal Coliform Instantaneous Limit (400#/100 ml)
Log of Fecal Coliform (#/day)

Graph B-3


Senatobia Creek Segment MS304M2
Load Duration Curve for Fecal Coliform Bacteria
USGS Flow Gage 07277730
Monitoring Data from Station 07277730
Log of Fecal Coliform (#/day)
16
15
14
13
12
11
10
9
8
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
high flows
low flows
Percent of Time > Load (y)
Fecal Coliform Instantaneous Limit (400#/100 ml)
Log of Fecal Coliform (#/day)

Graph B-4

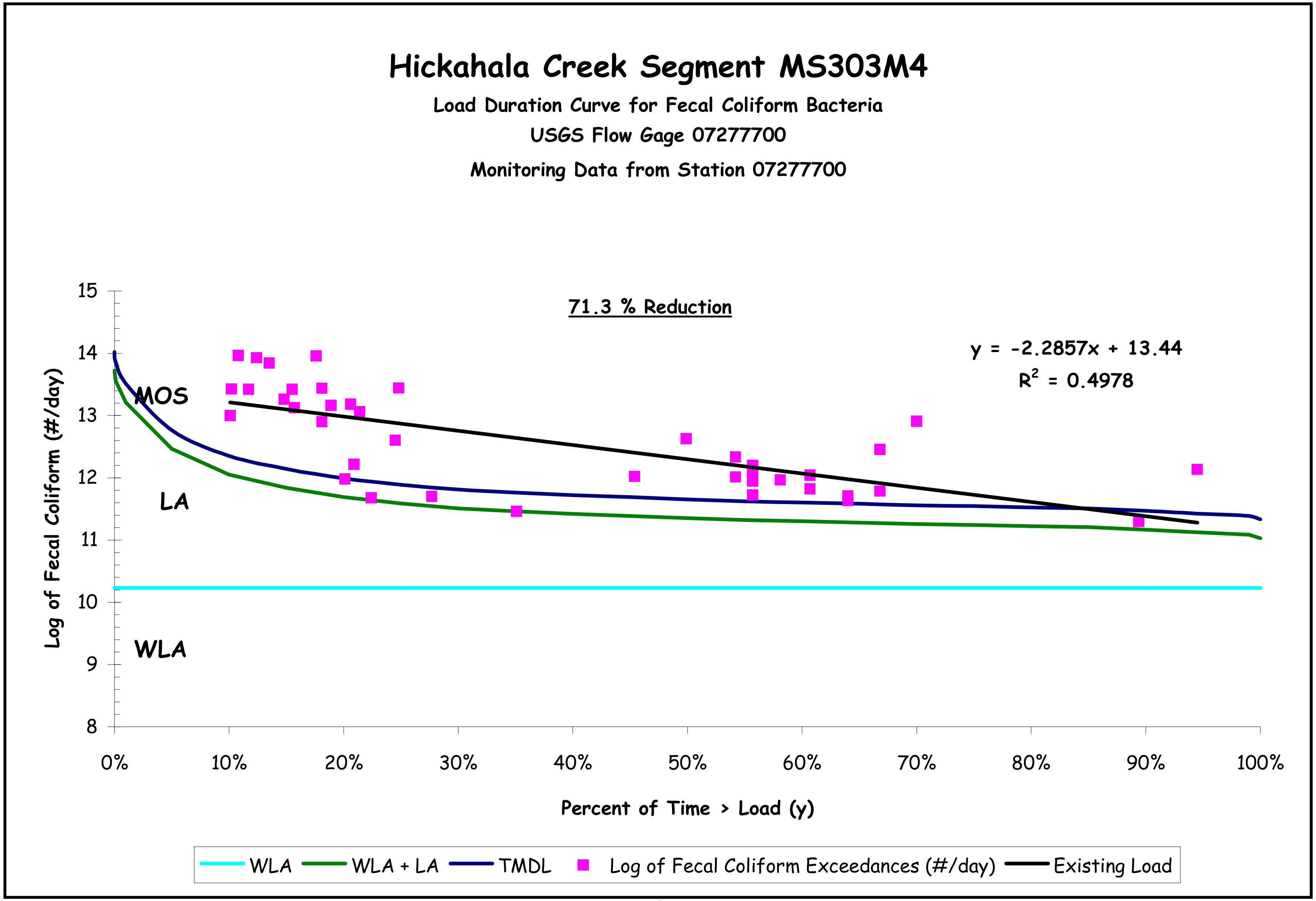

Senatobia Creek Segment MS304M1
Load Duration Curve for Fecal Coliform Bacteria
DA Ratio Based on USGS Flow Gage 07277730
Monitoring Data from Station 07277715
Log of Fecal Coliform (#/day)
16
15
14
13
12
11
10
9
8
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
high flows
Percent of Time > Load (y)
low flows
Fecal Coliform Instantaneous Limit (400#/100 ml)
Log of Fecal Coliform (#/day)

Graph B-5

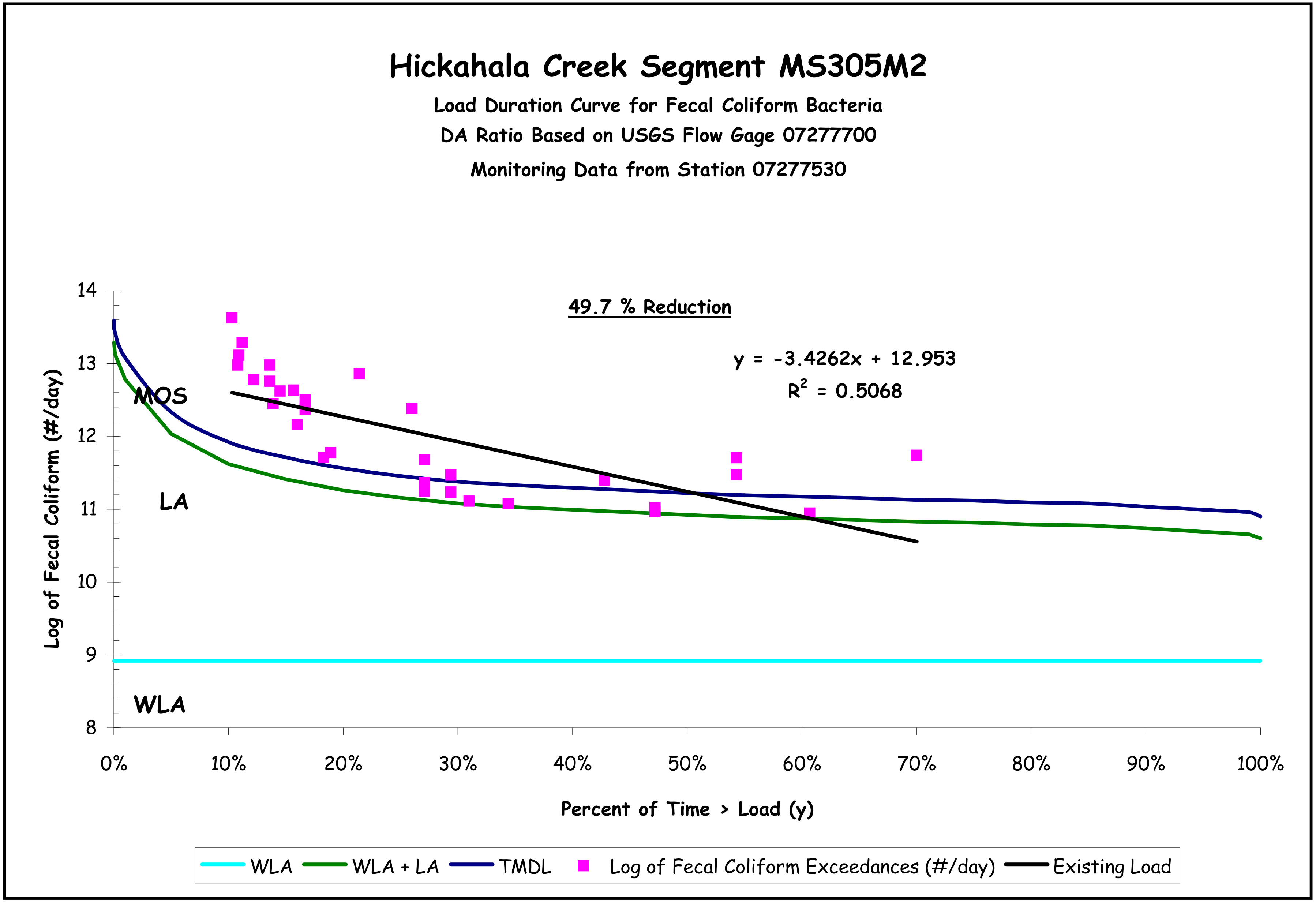
APPENDIX C

This appendix contains the load duration curves used to calculate the percent reductions included in this TMDL. Each graph contains a regression line that represents the existing fecal coliform bacteria load at the monitoring station. As stated in the report, the regression lines were developed by applying a best-fit linear regression line to the data points that exceed the water quality standard. The equation displayed on each graph defines the linear regression line. The R-squared (R^2) values, which indicate how closely the regression line corresponds to the actual data, are also shown. R-squared values closer to 1 indicate a better fit of the data. The percent reductions are based on the average difference between the regression line and the curve representing the target load (WLA + LA). The target load curve represents the TMDL target of 200 counts per 100 ml. Finally, the MOS is represented graphically as the difference between the target load curve and the curve representing the 400 counts per 100 ml standard.

In order to show the curves and data more clearly, the y-axis of the plots begins at 1.0E+8 fecal coliform (counts/day) on all of the graphs. Because of this, the line representing the WLA is not visible on the load duration curve in graph C-5. Graph C-1 shows the load duration curve for Hickahala Creek segment MS303M4. Graph C-2 shows the load duration curve for Hickahala Creek segment MS305M2. Graph C-3 shows the load duration curve for James Wolf Creek segment MS305M1. Graph C-4 shows the load duration curve for Senatobia Creek segment MS304M2. Graph C-5 shows the load duration curve for Senatobia Creek segment MS304M1.

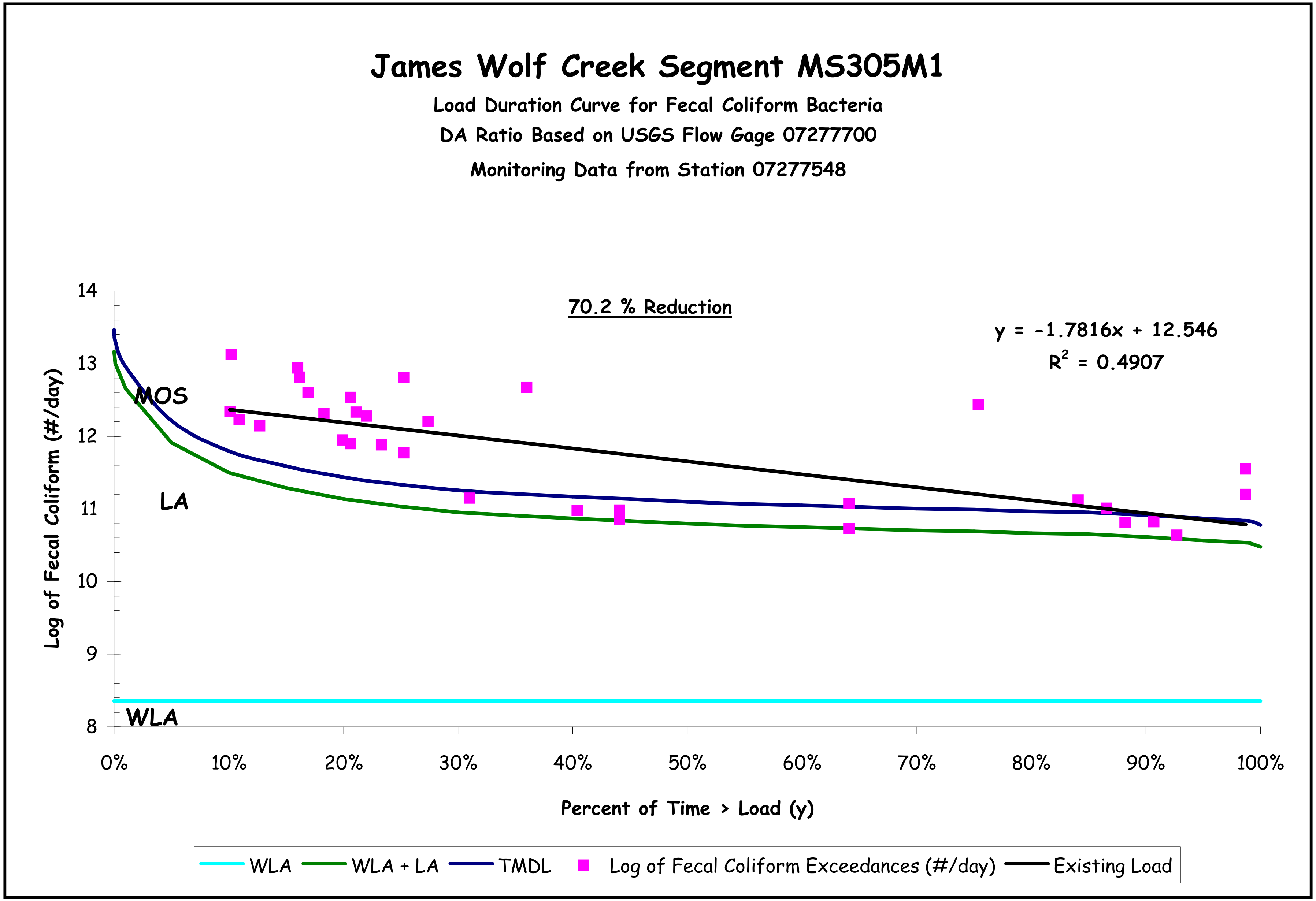

Hickahala Creek Segment MS303M4
Load Duration Curve for Fecal Coliform Bacteria
USGS Flow Gage 07277700
Monitoring Data from Station 07277700
71.3 % Reduction
y = -2.2857x + 13.44
R^2 = 0.4978
MOS
LA
WLA
Log of Fecal Coliform (#/day)
Percent of Time > Load (y)
15
14
13
12
11
10
9
8
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
WLA
WLA + LA
TMDL
Log of Fecal Coliform Exceedances (#/day)
Existing Load

Graph C-1

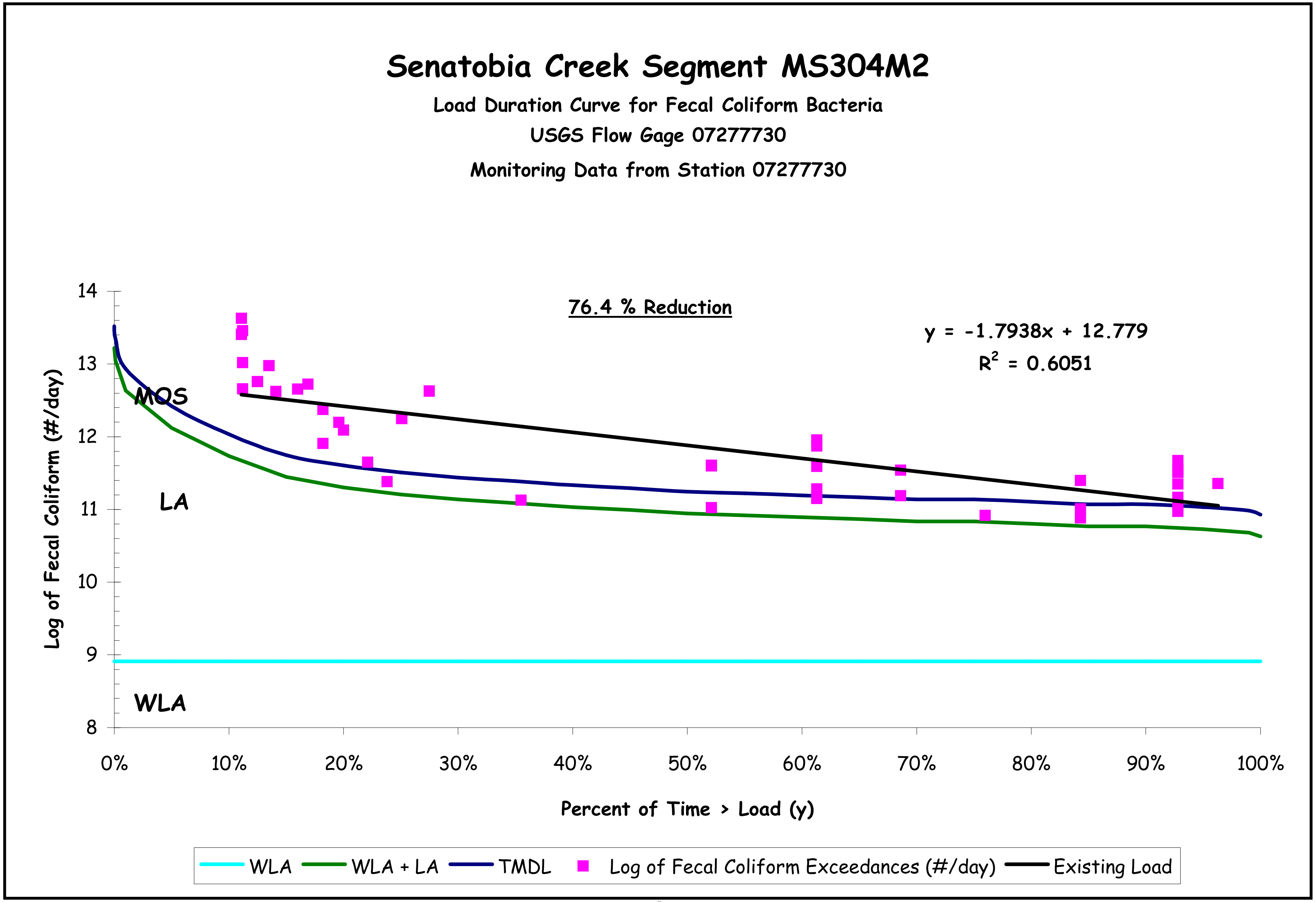


Hickahala Creek Segment MS305M2
Load Duration Curve for Fecal Coliform Bacteria
DA Ratio Based on USGS Flow Gage 07277700
Monitoring Data from Station 07277530
49.7 % Reduction
y = -3.4262x + 12.953
R2 = 0.5068
MOS
LA
WLA
Log of Fecal Coliform (#/day)
14
13
12
11
10
9
8
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Time > Load (y)
WLA
WLA + LA
TMDL
Log of Fecal Coliform Exceedances (#/day)
Existing Load

Graph C-2

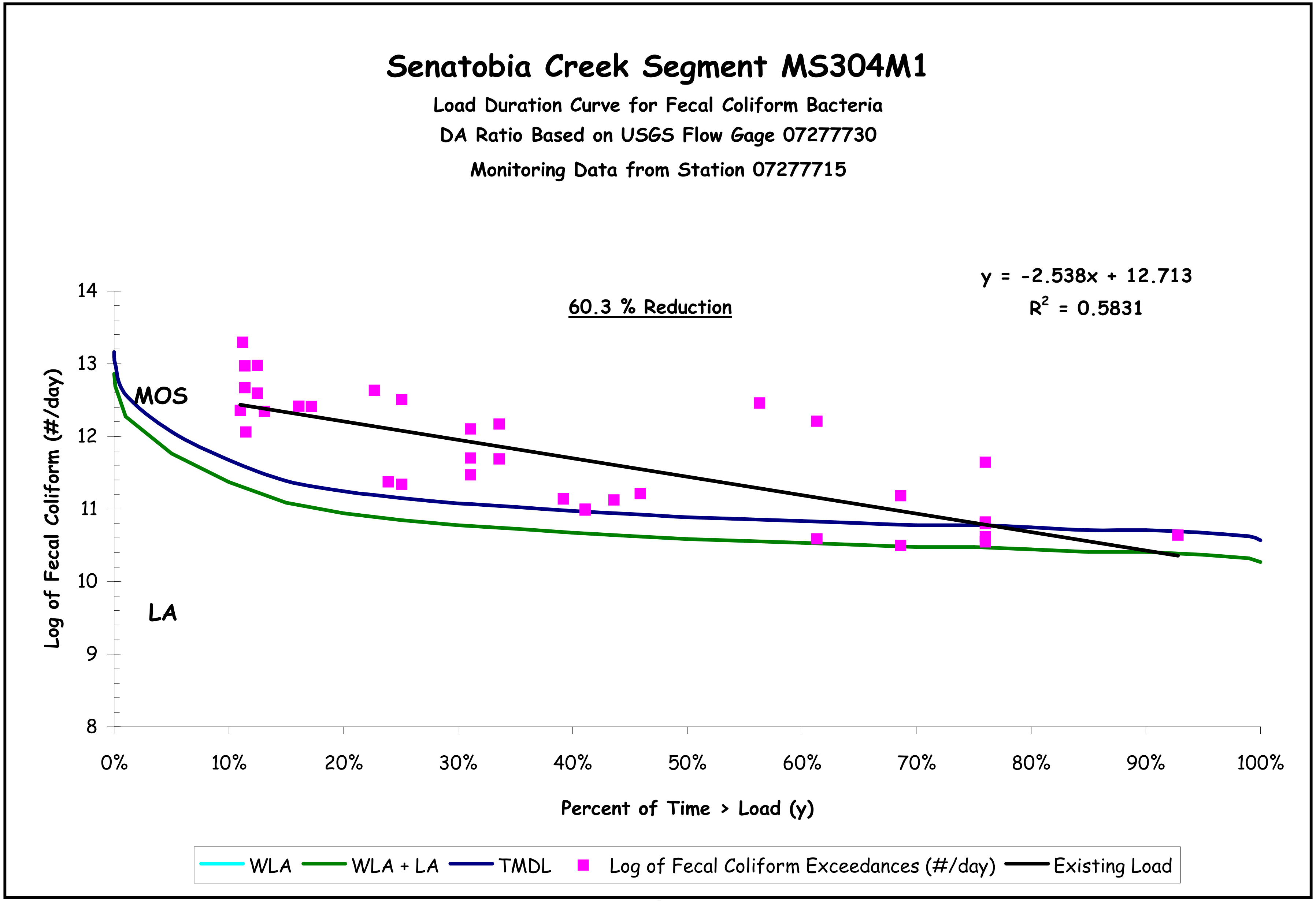

James Wolf Creek Segment MS305M1
Load Duration Curve for Fecal Coliform Bacteria
DA Ratio Based on USGS Flow Gage 07277700
Monitoring Data from Station 07277548
70.2 % Reduction
y = -1.7816x + 12.546
R2 = 0.4907
MOS
LA
WLA
Log of Fecal Coliform (#/day)
14
13
12
11
10
9
8
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Time > Load (y)
WLA
WLA + LA
TMDL
Log of Fecal Coliform Exceedances (#/day)
Existing Load

Graph C-3



Senatobia Creek Segment MS304M2
Load Duration Curve for Fecal Coliform Bacteria
USGS Flow Gage 07277730
Monitoring Data from Station 07277730
76.4 % Reduction
y = -1.7938x + 12.779
R2 = 0.6051
MOS
LA
WLA
Log of Fecal Coliform (#/day)
14
13
12
11
10
9
8
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Time > Load (y)
WLA
WLA + LA
TMDL
Log of Fecal Coliform Exceedances (#/day)
Existing Load

Graph C-4


Senatobia Creek Segment MS304M1
Load Duration Curve for Fecal Coliform Bacteria
DA Ratio Based on USGS Flow Gage 07277730
Monitoring Data from Station 07277715
y = -2.538x + 12.713
R2 = 0.5831
60.3 % Reduction
MOS
LA
Log of Fecal Coliform (#/day)
14
13
12
11
10
9
8
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Time > Load (y)
WLA
WLA + LA
TMDL
Log of Fecal Coliform Exceedances (#/day)
Existing Load

Graph C-5