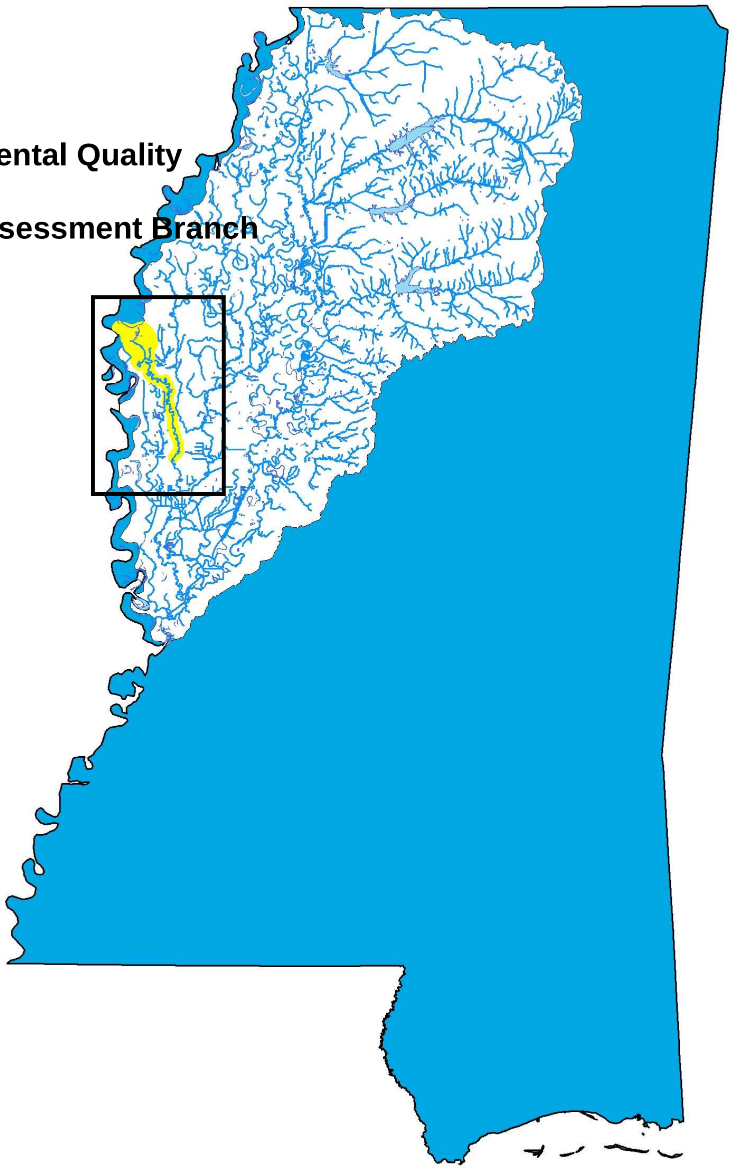
FINAL REPORT
June 2003
ID: 903063006

Phase 1
Fecal Coliform TMDL
for Deer Creek

Yazoo River Basin

Bolivar and Washington Counties, Mississippi



Prepared By

Mississippi Department of Environmental Quality
Office of Pollution Control
TMDL/WLA Section/Water Quality Assessment Branch

MDEQ
PO Box 10385
Jackson, MS 39289-0385
(601) 961-5171
www.deq.state.ms.us

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

CONTENTS

FIGURES

TABLES

PHOTOS

TMDL INFORMATION PAGE

Table i. Listing Information

Name	ID	County	HUC	Cause	Mon/Eval
Deer Creek seg 6	MS403M6	Washington	08030209	Pathogens	Monitored
Near Hollandale: From Arcola to Percy					
Deer Creek – DA	MS402E	Bolivar	08030209	Pathogens	Evaluated
Drainage area near Winterville					

Tale 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.

Table iii. NPDES Facilities

NPDES ID	Facility Name	Receiving Water
MS0040339	J. Whitten Delta Research	Deer Creek
MS0047791	National Warm Water Aquaculture Center	Deer Creek

Table iv. Total Maximum Daily Load

Season	WLA (counts/30 days)	LA (counts/30 days)	MOS (counts/30 days)	TMDL (counts/30 days)
Summer (May – October)	1.42E+11	4.97E+12	5.68E+11	5.68E+12
Winter (November – April)	1.42E+12	4.97E+13	5.68E+12	5.68E+13

EXECUTIVE SUMMARY

One segment of Deer Creek has been placed on the Mississippi 1998 Section 303(d) List of Waterbodies as a monitored waterbody segment, due to fecal coliform bacteria. In addition, a drainage area of Deer Creek has been listed as an evaluated drainage area due to the potential presence of fecal coliform bacteria. Deer Creek flows in a southern direction from Lake Bolivar near Scott, Mississippi to the Yazoo River, Photo 1. The 303(d) listed segment flows from Arcola to Percy, Mississippi in Washington County. The drainage area is near Winterville, in the northern part of the watershed. The drainage of Deer Creek has been altered at Rolling Fork, where much of the flow in Deer Creek has been diverted into Rolling Fork Creek. This TMDL, however, has been developed for both the listed section of the Deer Creek and the drainage area of Deer Creek that are located upstream of the flow diversion. A mass-balance approach was used to develop the Phase1 TMDL for these segments.

Photo 1. Deer Creek near Hollandale

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 Deer Creek Watershed. There are two NPDES Permitted dischargers included in the waste load allocation (WLA). Nonpoint sources considered include wildlife and urban development. Also considered were the nonpoint sources such as failing septic systems and other direct inputs to tributaries of Deer Creek. The location of the Deer Creek watershed is shown in Figure 1 below.

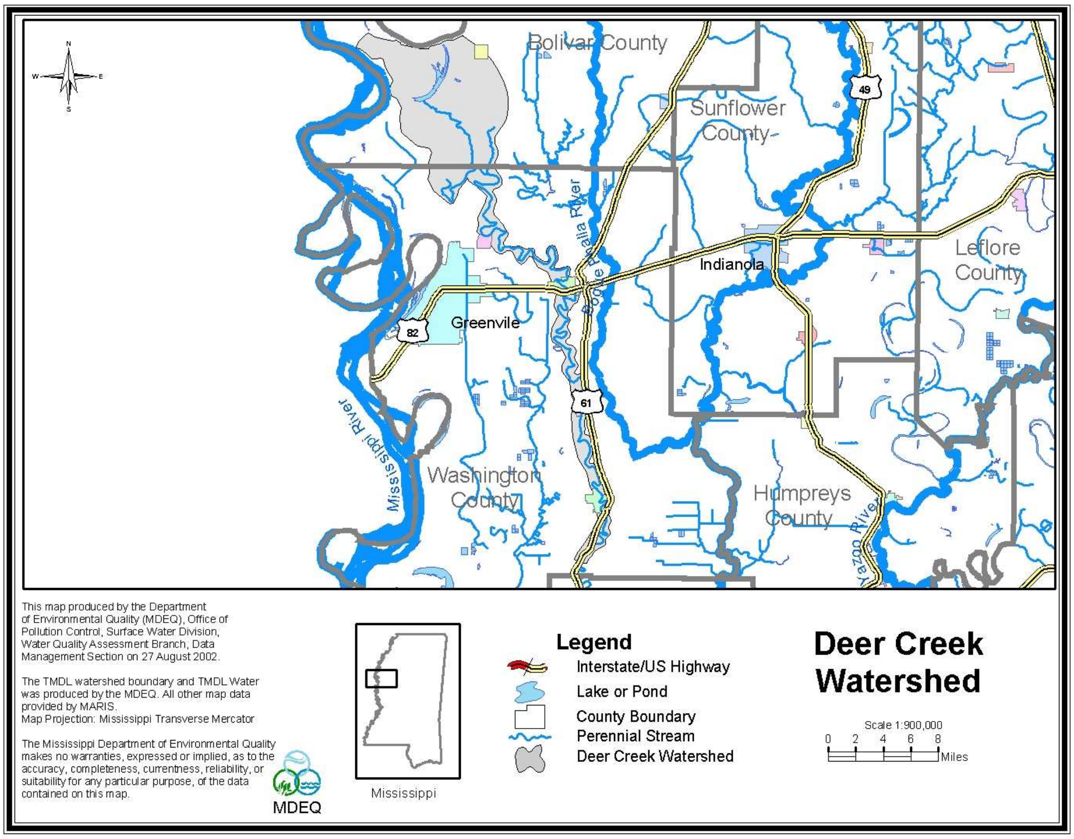


Figure 1. Location of Deer Creek Watershed

Water quality data available for Deer Creek indicate violation of the fecal coliform standard in the waterbody. A mass balance approach was selected for calculating this TMDL due to the lack of continuous flow monitoring data within Deer Creek as well the limited amount of water quality data. MDEQ estimated the annual average flow to calculate this TMDL; therefore, the seasonal differences are incorporated in average the flow value. An explicit margin of safety (MOS) of 10% for the summer and winter was used to accommodate uncertainty in the mass balance method. Phase 1 TMDLs for fecal coliform bacteria are 8.61E+12 counts per 30 days in the summer and 3.59E+14 counts per 30 days in the winter. Additional flow monitoring and fecal coliform bacteria sampling are currently underway. These additional data may be used in the development of a Phase 2 TMDL.

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. The Mississippi Department of Environmental Quality (MDEQ) has placed Deer Creek on the Mississippi 1998 Section 303(d) List of Waterbodies. The 303(d) listed sections are shown in Figure 2.

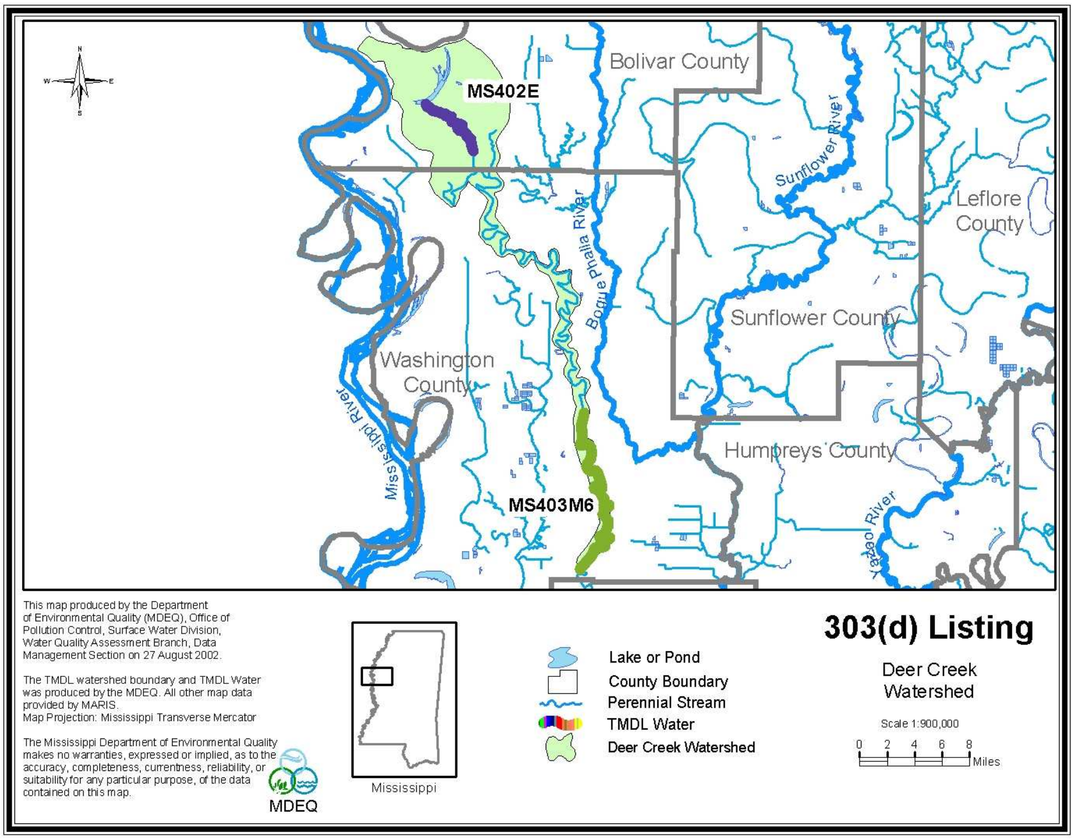


Figure 2. 303(d) Listed Sections of Deer Creek

The Deer Creek Watershed is in the Yazoo River Basin Hydrologic Unit Code (HUC) 08030209 in northwest Mississippi. It is approximately 70,000 acres; and lies within portions of Bolivar, Washington, Sharkey, Issaquena, and Warren Counties. The watershed is rural, and cropland is the dominant landuse within the watershed.

1.2 Applicable Waterbody Segment Use

The water use classification for the listed segment of the Deer 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 Deer Creek are Secondary Contact and Aquatic Life Support.

1.3 Applicable Waterbody Segment Standard

The water quality standard applicable to the use of the water body and the pollutant of concern is defined in the *State of Mississippi Water Quality Criteria for Intrastate, Interstate, and Coastal Waters* (2002). The standard states that for the summer months the fecal coliform colony counts shall not exceed a geometric mean of 200 per 100 ml, based on a minimum of 5 samples taken over a 30-day period with no less than 12 hours between individual samples, nor shall the samples examined during a 30-day period exceed 400 per 100 ml more than 10 percent of the time. For the winter months, the maximum allowable level of fecal coliform shall not exceed a geometric mean of 2000 colonies per 100 ml, based on a minimum of 5 samples taken over a 30-day period with no less than 12 hours between individual samples, nor shall the samples examined during a 30-day period exceed 4000 per 100 ml more than 10 percent of the time. The water quality standard will be used to assess the data to determine impairment in the water body. The water quality standard will be used as the targeted endpoint to establish this TMDL.

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. Recently, MDEQ established a revision to the fecal coliform standard that allows for a statistical review of any fecal coliform data set. There are two tests that the data set must pass to show non-impairment.

The first test states that for the summer the fecal coliform colony count shall not exceed a geometric mean of 200 per 100 ml based on a minimum of 5 samples taken over a 30-day period with no less than 12 hours between individual samples and for the winter the fecal coliform colony counts shall not exceed a geometric mean of 2000 per 100 ml based on a minimum of 5 samples taken over a 30-day period with no less than 12 hours between individual samples. The second test states that for the summer the samples examined during a 30-day period shall not exceed a count of 400 per 100 ml more than 10 percent of the time and for the winter the samples examined during a 30-day period shall not exceed a count of 4000 per 100 ml more than 10 percent of the time.

2.1.1 Discussion of the Geometric Mean Test

The level of fecal coliform found in a natural water body varies greatly depending on several independent factors such as temperature, flow, or distance from the source. This variability is accentuated by the standard test used to measure fecal coliform levels in the water. The membrane filtration or MF method uses a direct count of bacteria colonies on a nutrient medium to estimate the fecal level. The fecal coliform colony count per 100 ml is determined using an equation that incorporates the dilution and volume of the sample filtered.

To account for this variability the dual test standard was established. The geometric mean test is used to dampen the impact of the large numbers when there are smaller numbers in the data set. The geometric mean is calculated by multiplying all of the data values together and taking the root of that number based on the number of samples in the data set.

$$G = \sqrt[n]{s1 * s2 * s3 * s4 * s5 * sn}$$

The standard requires a minimum of 5 samples be used to determine the geometric mean. MDEQ routinely gathers 6 samples within a 30-day period in case there is a problem with one of the samples. It is conceivable that there would be more samples available in an intensive survey, but typically each data set will contain 6 samples therefore, n would equal 6. For the data set to indicate no impairment, the result must be less than or equal to 200.

2.1.2 Discussion of the 10% Test

The other test looks at the data set as representing the 30 days for 100% of the time. The data points are sorted from the lowest to the highest and each value then represents a point on the curve from 0% to 100% or from day 1 to day 30. The lowest value becomes the 1st data point and the highest data point becomes the nth data point. The standard requires that 90% of the time, the counts of fecal coliform in the stream be less than or equal to 400 counts per 100 ml in summer and 4000 counts per 100 ml in winter.

By calculating a concentration of fecal coliform for every percentile point based on the data set, it is possible to determine a curve that represents the percentile ranking of the data set. Once the 90th percentile of the data set has been determined, it may be compared to the standard of 400 counts per 100 ml. If the 90th percentile of the data is greater than 400 then the stream will be considered impaired. This can be used not only to assess actual water quality data, but also computer generated model results. Actual water quality data will typically have 5 or 6 values in the data set, and computer generated model results would have 30 values.

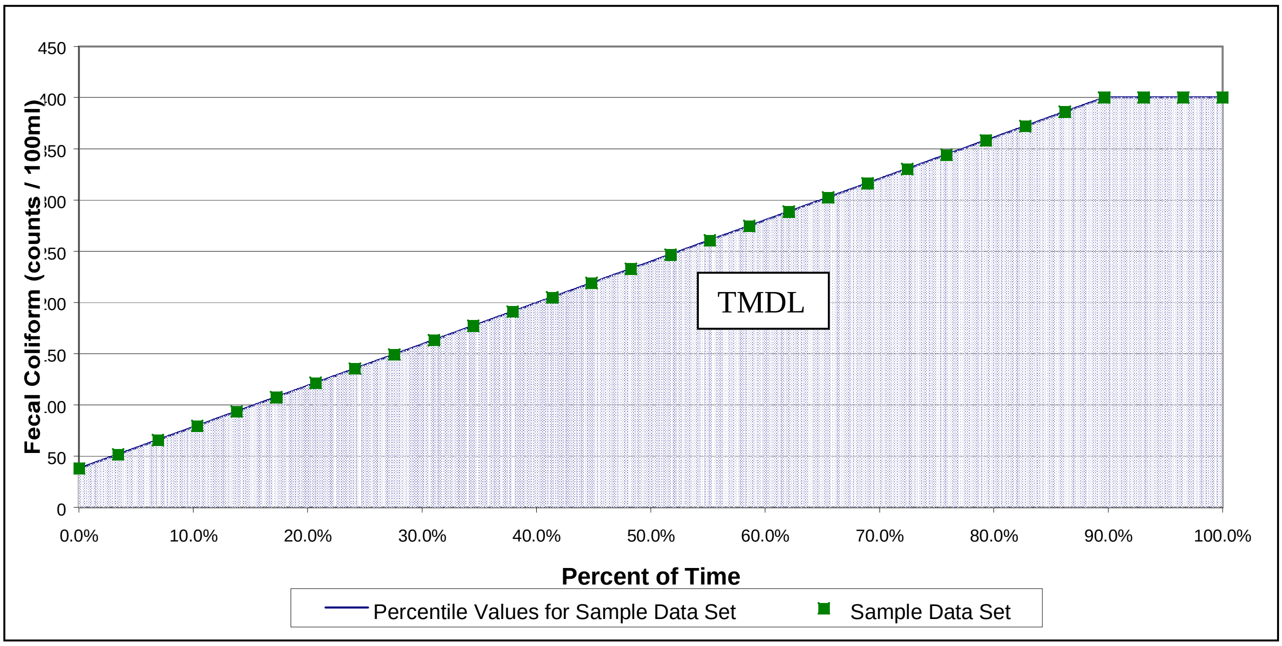
2.1.3 Discussion of Combining the Tests

MDEQ determined a curve that meets both portions of the standard and is indicative of possible water quality conditions. The integral of this curve represents the TMDL. That is, the maximum amount of fecal coliform in the water body either based on actual data sets or on computer generated values. By multiplying the integral of the 30-sample data set curve by the flow in the stream, the TMDL can be calculated. A sample 30 point data set, representative of the contact recreation season, is shown below in Table 1 and Figure 3.

Table 1. 30 point data set

Fecal Coliform (counts/100ml)	Percentile Ranking
37.82	0.0%
51.75	3.4%
65.68	6.9%
79.61	10.3%
93.54	13.8%
107.47	17.2%
121.4	20.7%
135.33	24.1%
149.26	27.6%
163.19	31.0%
177.12	34.5%
191.05	37.9%
204.98	41.4%
218.91	44.8%
232.84	48.3%
246.77	51.7%
260.7	55.2%
274.63	58.6%
288.56	62.1%
302.49	65.5%
316.42	69.0%
330.35	72.4%
344.28	75.9%
358.21	79.3%
372.14	82.8%
386.07	86.2%
400	89.7%
400	93.1%
400	96.6%
400	100.0%

Figure 3. 30-Point Data Set



2.1.4 Discussion of the Targeted Endpoint

While the endpoint of a TMDL calculation is similar to a standard for a pollutant, the endpoint is not the standard. The endpoint selected for this TMDL is 200 counts per 100 ml for any given sample. If all of the data points are less than or equal to 200 then the water body will automatically pass both tests and not be considered impaired. Meeting the geometric mean test and applying the 10% test to the data sets apply both parts of the standard when applied to an actual data set or when considering a computer generated data set. It is therefore appropriate to select 200 as the targeted endpoint for the TMDL.

2.1.5 Discussion of the Critical Condition for Fecal Coliform

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 periods of low-flow, low-dilution conditions. Therefore a careful examination of the data or the computer generated fecal estimates is needed to determine the critical 30-day period to be used for the TMDL.

2.2 Discussion of Instream Water Quality and Quantity

There are several locations at which water quality and quantity data are available for Deer Creek. MDEQ collected data at monitoring station 07288770, which is located near Hollandale, in 1988 through 1990. Data for fecal coliform bacteria concentration, as well as several other parameters were collected on a monthly basis at this station.

MDEQ no longer collects monthly fecal monitoring data at any of these stations on a monthly basis. In order to collect fecal coliform data, MDEQ now samples six times within a 30-day period. These data can then be used to calculate the geometric mean for the waterbody. Two locations on Deer

Creek were recently included in this type of monitoring. These data were used to confirm impairment in this waterbody for fecal coliform. Additional fecal coliform bacteria sampling has been recently conducted as part of an ongoing restoration effort in Deer Creek. The restoration effort includes several state and federal agencies; US Geological Survey, U.S. Army Corps of Engineers, U.S. Fish and Wildlife Service, Yazoo-Mississippi-Delta Joint Water Management District, and MDEQ. The restoration efforts may include repairing failing septic systems, cleaning up illegal trash dumps, improving landscapes to minimize nonpoint source pollution, and possibly augmenting flow to reestablish the natural flow patterns in the lower part of the watershed. The recent sampling efforts were intended to characterize baseline conditions in the watershed prior to beginning restoration efforts. The sampling effort included six sites along Deer Creek; below Lake Bolivar, Leland, Rolling Fork, Hollandale, Cary, and Valley Park.

Measurements of flow and stage were also available for several locations on Deer Creek. Stage data has been collected at Corps of Engineers station 387, located 1 mile south of Hollandale from 1961 through 1993. During this time period, daily stage readings were recorded at 8 AM. There are however, several years missing from the stage record. A single measurement of flow was collected at this station by the Corps of Engineers in 1989. The location of flow monitoring station 387 corresponds with the location of water quality monitoring station 07288770. Several flow measurements were made by the USGS at this location including one measurement in 1961 and one measurement in 1986. Stage data can usually be converted to flow data using flow-rating curves. However, the few flow measurements available for the station were not sufficient for developing an accurate rating curve. A flow monitoring station has recently been installed on Deer Creek near Leland, MS. This station, number 0728875070, provides real-time flow data as well as water quality data for several parameters. This station, however, has not been in existence long enough to calculate annual average or critical flow conditions on Deer Creek.

2.2.1 Inventory of Available Water Quality Monitoring Data

Fecal Coliform data collected at station 07288770 from January 1988 through November 1990 are included in Table 2. Data collected from the geometric mean study from 2001 are also shown in Table 3 and Table 4. Station 39 is located in the upper part of the watershed. Station 23 is located further downstream, at the lower end of the monitored segment. A map showing the location of these segments is shown in Figure 4.

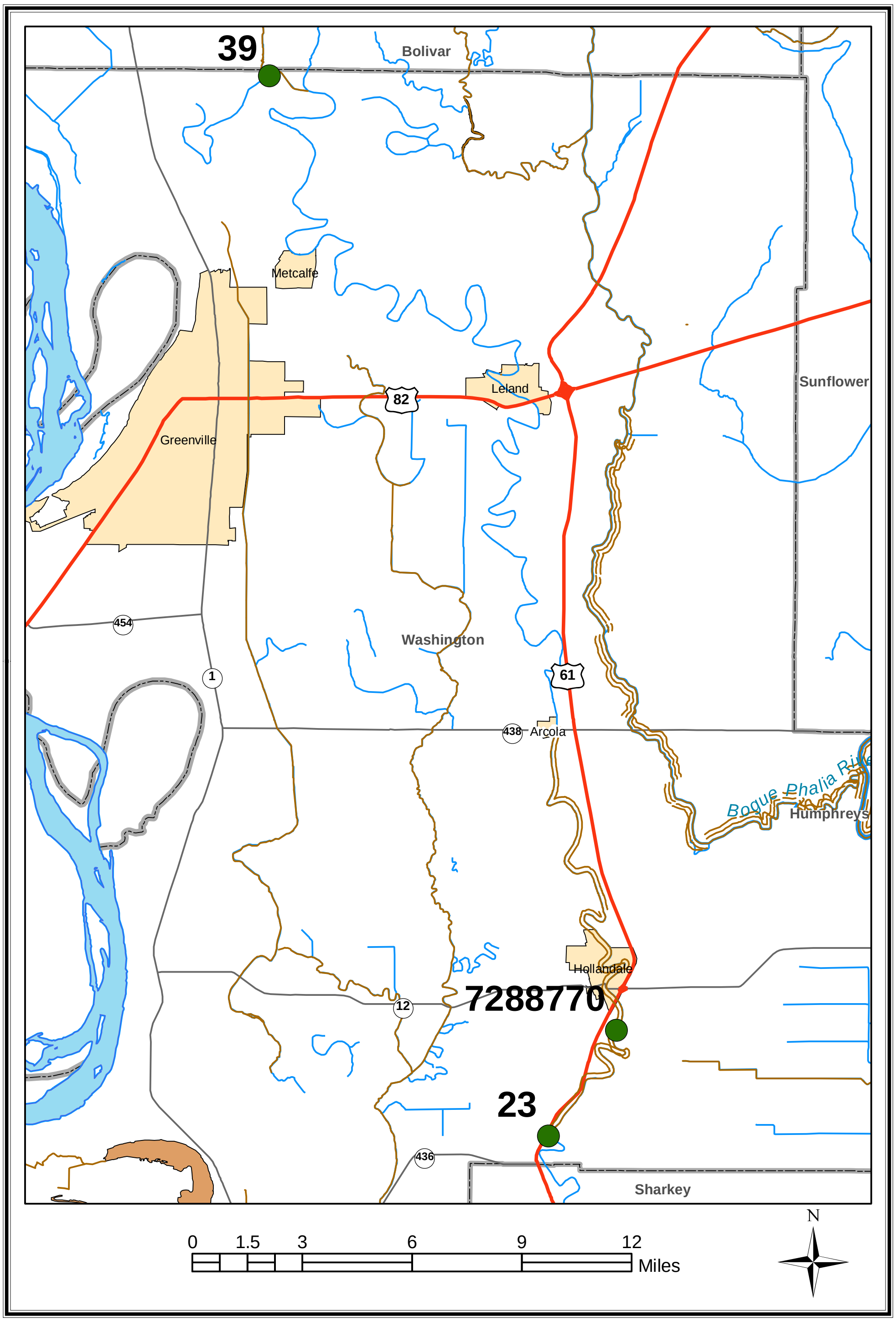


Figure 4. Monitoring Station Locations

Table 2. Fecal Coliform Data, Station 07288770, Reported in Deer Creek

Date	Fecal Coliform (counts/100ml)
5-Jan-88	300
8-Mar-88	4300
2-May-88	2400
5-Jul-88	1600
6-Sep-88	2400
7-Nov-88	90
5-Sep-89	2400
7-Nov-89	2400
8-Jan-90	920
5-Mar-90	920
1-May-90	2400
9-Jul-90	170
4-Sep-90	790
7-Nov-90	940

Table 3. Fecal Coliform Data reported in the Deer Creek, Station 39 near Lamont

Date	Tape Down Measurement	Fecal Coliform (counts/100ml)	Geometric Mean
9/28/2001 14:34	15.96	340	374
10/4/2001 11:46	16.02	390	
10/10/2001 12:02	15.99	240	
10/16/2001 12:12	7.02	1100	
10/19/2001 11:41	10.33	500	
10/25/2001 12:01	13.40	156	
11/16/2001 12:01	15.52	24	437
11/21/2001 10:38	12.46	340	
11/28/2001 11:37	7.22	6000	
12/3/2001 12:00	3.79	1300	
12/6/2001 10:32	4.89	254	
12/12/2001 12:10	6.94	430	

Table 4. Fecal Coliform Data reported in the Deer Creek, Station 23 near Percy

Date	Tape Down Measurement	Fecal Coliform (counts/100ml)	Geometric Mean
9/28/2001 11:23	16.06	1200	508
10/4/2001 10:26	16.30	240	
10/10/2001 9:12	16.40	3300	
10/15/2001 10:05	13.70	224	
10/18/2001 9:30	10.10	580	
10/24/2001 9:43	11.25	140	
11/15/2001 10:06	15.09	103	225
11/21/2001 9:44	15.60	18	
11/28/2001 10:07	15.46	450	
12/6/2001 9:55	5.29	266	
12/3/2001 9:59	5.35	2000	
12/12/2001 10:01	5.85	295	

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% of the time 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 at least 5 times at a site during a 30-day period must be assessed for both parts of the standard. Tables 5 and 6 show the statistical summary of the recent monitoring data collected in 2001, which is part of an ongoing project. The data are provisional data and verify impairment indicated by previous assessments. The geometric mean of each data set was compared to the geometric mean portion of the standard for each season. In order to compare the data to the instantaneous portion of the standard, the percent 90^{th} percentile of each data set was calculated. If the 90^{th} percentile value is less than the instantaneous standard, the standard is not violated.

Table 5. Summer Statistical Summaries of Water Quality Data

Station Number	Number of Samples	Geometric Mean	Standard Violation (200 counts/100 ml)	90th Percentile	Standard Violation (90th Percentile Greater than 400 counts/100 ml)
39	6	374	Yes	800	Yes
23	6	508	Yes	3650	Yes

Table 6. Winter Statistical Summaries of Water Quality Data

Station Number	Number of Samples	Geometric Mean	Standard Violation (2000 counts/100 ml)	90th Percentile	Standard Violation (90th Percentile Greater than 4000 counts/100 ml)
39	6	437	No	2250	No
23	6	225	No	1225	No

The critical conditions for Deer Creek were evaluated by developing plots of the observed fecal coliform data and the amount of precipitation. Figures 5 through 8 are plots of the data collected at stations 39 and 23 and precipitation data from the nearest available weather station, which is located at Cleveland, MS. These graphs were used to attempt to correlate rain events and water quality observations. The graphs show that some violations of the fecal coliform standards are clearly associated with a large rain event (10/1/01 at station 23, 11/28/01 at station 39). However, fecal coliform counts are also elevated during dry periods (12/3/01 at station 23, 10/16/01 at station 39). In addition, there are some samples collected immediately following large rain events that do not violate the instantaneous portion of the standard (11/28/01 at station 23, 10/10/01 at station 39). Therefore, no direct correlation between fecal coliform concentration and rain events could be determined from the plots. Based on this analysis, elevated fecal coliform concentrations can occur during both wet and dry periods. This implies that both point and nonpoint sources contribute to fecal coliform loading in Deer Creek, and no specific statements about the critical condition can be made. A much more detailed data set of fecal coliform samples and weather conditions would be required in order to make a determination of critical conditions.

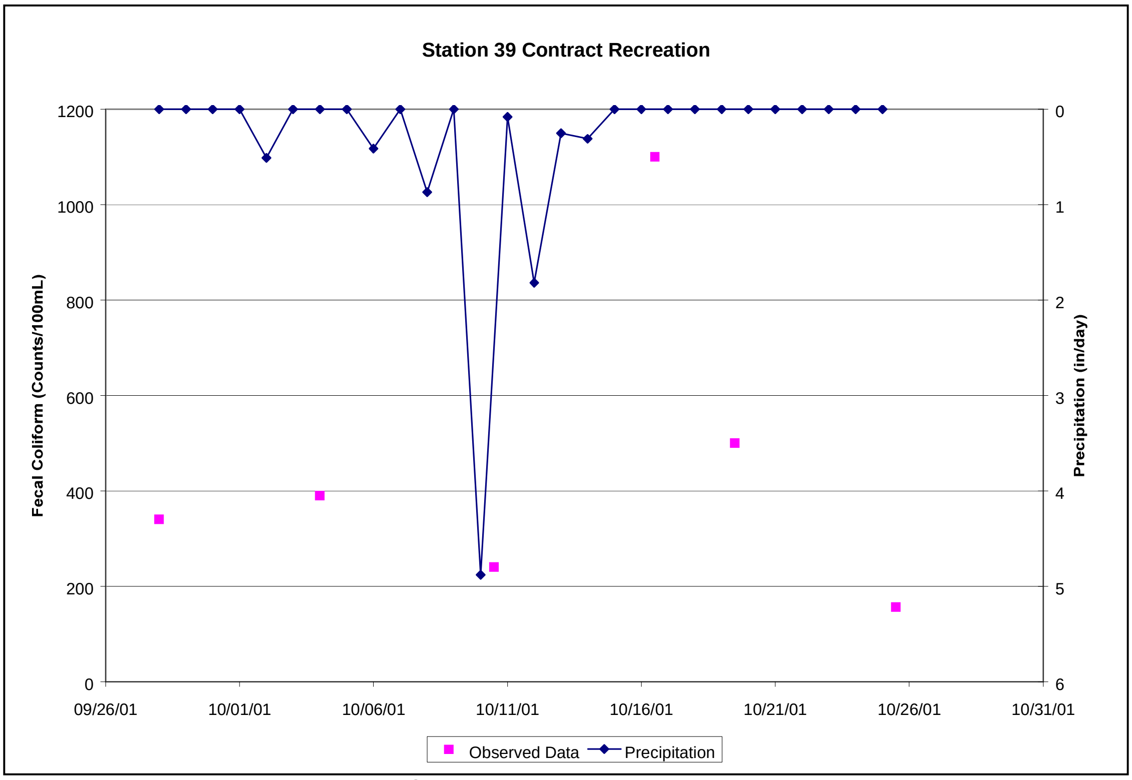


Figure 5. Fecal Coliform and Precipitation Data Station 39, Summer

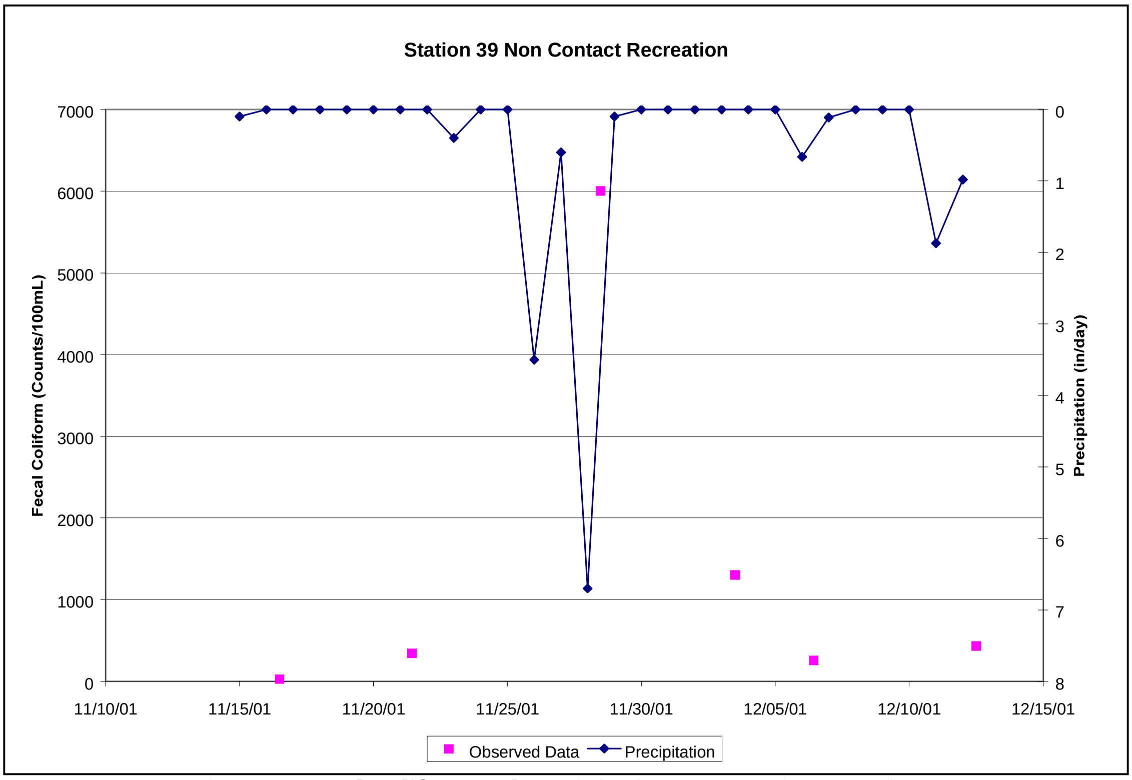


Figure 6. Fecal Coliform and Precipitation Data Station 39, Winter

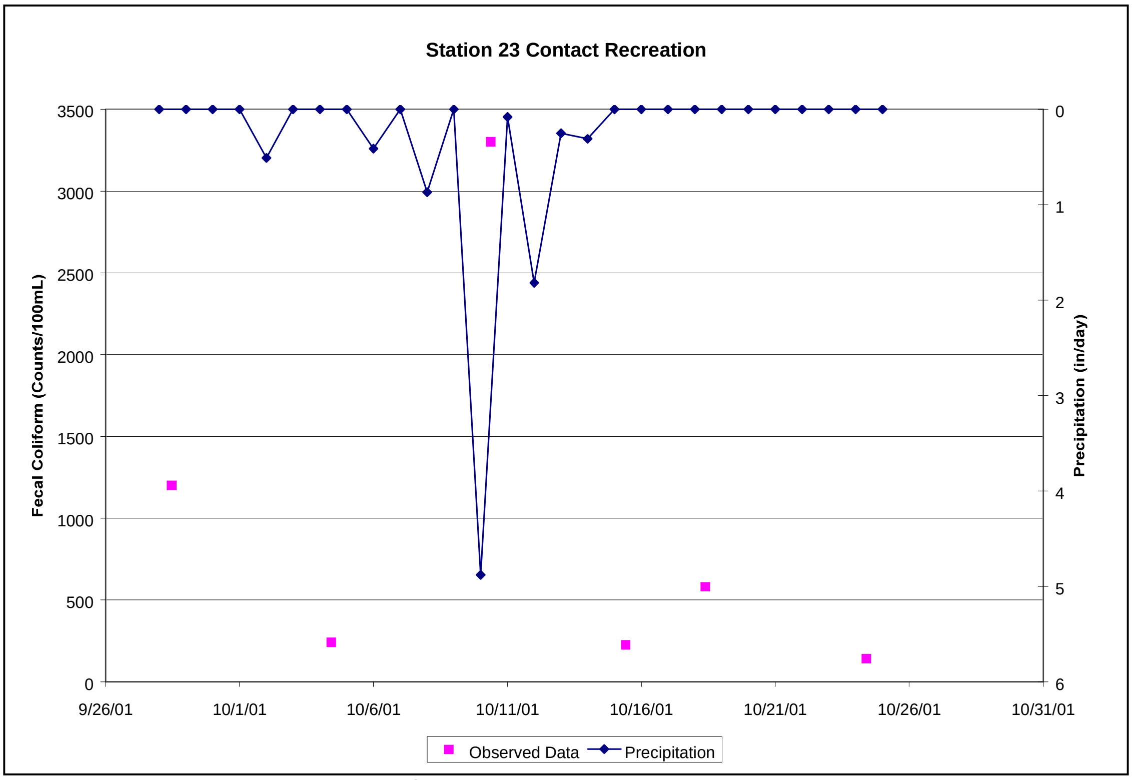


Figure 7. Fecal Coliform and Precipitation Data Station 23, Summer

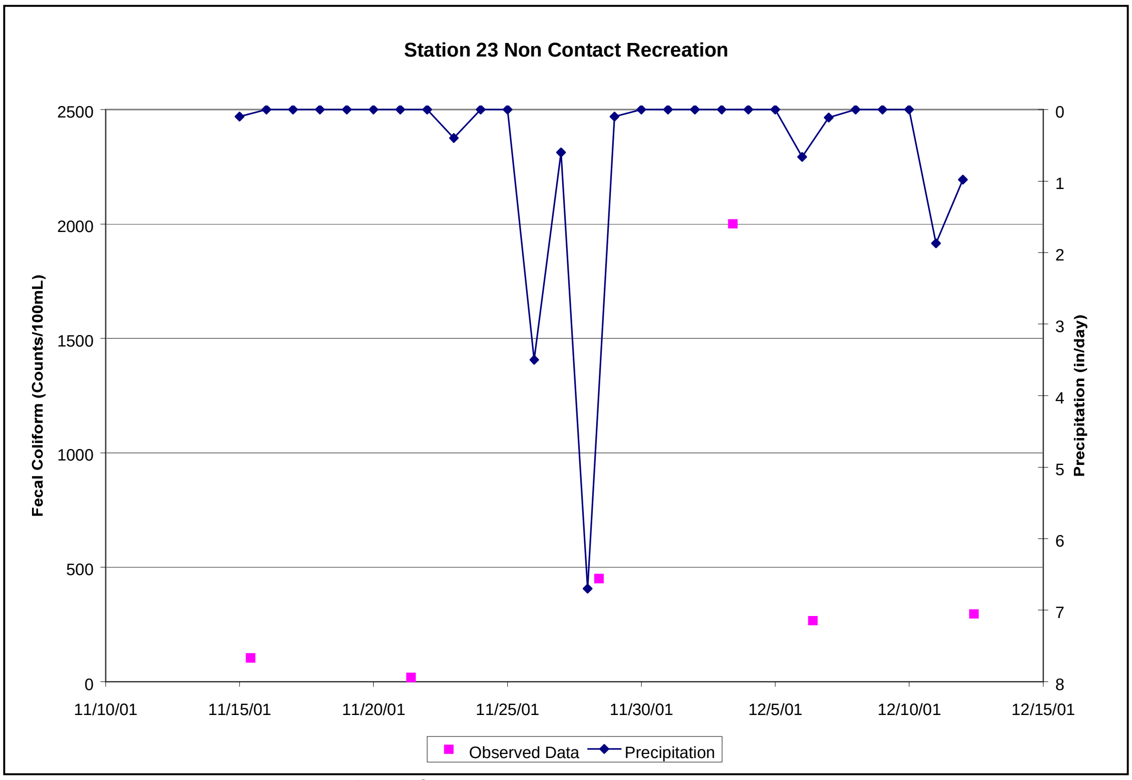


Figure 8. Fecal Coliform and Precipitation Data Station 23, Winter

SOURCE ASSESSMENT

The TMDL evaluation summarized in this report examined all known potential fecal coliform sources in the Deer Creek Watershed. The source assessment is provided as an indication of what 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. There are currently two NPDES Permitted point sources in the Deer Creek Watershed, Table 7. A third NPDES permit for the Hollandale POTW was removed from the Deer Creek watershed in 1999. A new lagoon for the Town of Hollandale was constructed to discharge into Black Bayou. The closed Hollandale facility had a history of compliance problems that included violations in their permitted limit of fecal coliform bacteria. It is important to note that the fecal coliform bacteria samples collected at station 07288770 (given in Table 2) were collected during the time that the original facility was operating.

Once the permitted dischargers were 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 for the J Whitten Delta Research Center or the National Warm Water Aquaculture Center.

Table 7. Inventory of Point Source Dischargers

NPDES ID	Facility Name	Design Flow (MGD)	Fecal Coliform Bacteria Limits (#/100 ml)
MS0040339	J. Whitten Delta Research	0.05	200 (May – October) 2,000 (November – April)
MS0047791	National Warm Water Aquaculture Center	0.576	200 (May – October) 2,000 (November – April)

3.2 Assessment of Nonpoint Sources

Nonpoint sources of pollutants in Deer Creek have been observed for quite some time. A report published in 1972 by the Mississippi Game and Fish Commission (Parker and Robinson, 1972) noted that pollution sources of concern were homes located on the creek banks and storm sewer drainage from the City of Leland. These nonpoint sources are still of concern today.

The 70,000-acre drainage area of Deer Creek contains many different landuse types, including urban, cropland, pasture, and wetlands. Cropland, the dominant landuse, is often found near the edge of Deer Creek, photo 2. The landuse distribution for each subwatershed is provided in Table 8 and Figure 9. The 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. The landuse categories were grouped into the landuses of urban, forest, cropland, pasture, barren, and wetlands.

Photo 2. Cropland Located Near Deer Creek

Table 8. Landuse Distribution for Each Subwatershed (acres)

Subwatershed	Urban	Forest	Cropland	Pasture	Barren	Wetland	Aquaculture	Water	Total
080302090DC	1,541	0	59,181	3,257	0	5,201	9	1,059	70,249
Total	2%	0%	84%	5%	0%	7%	0%	2%	100%

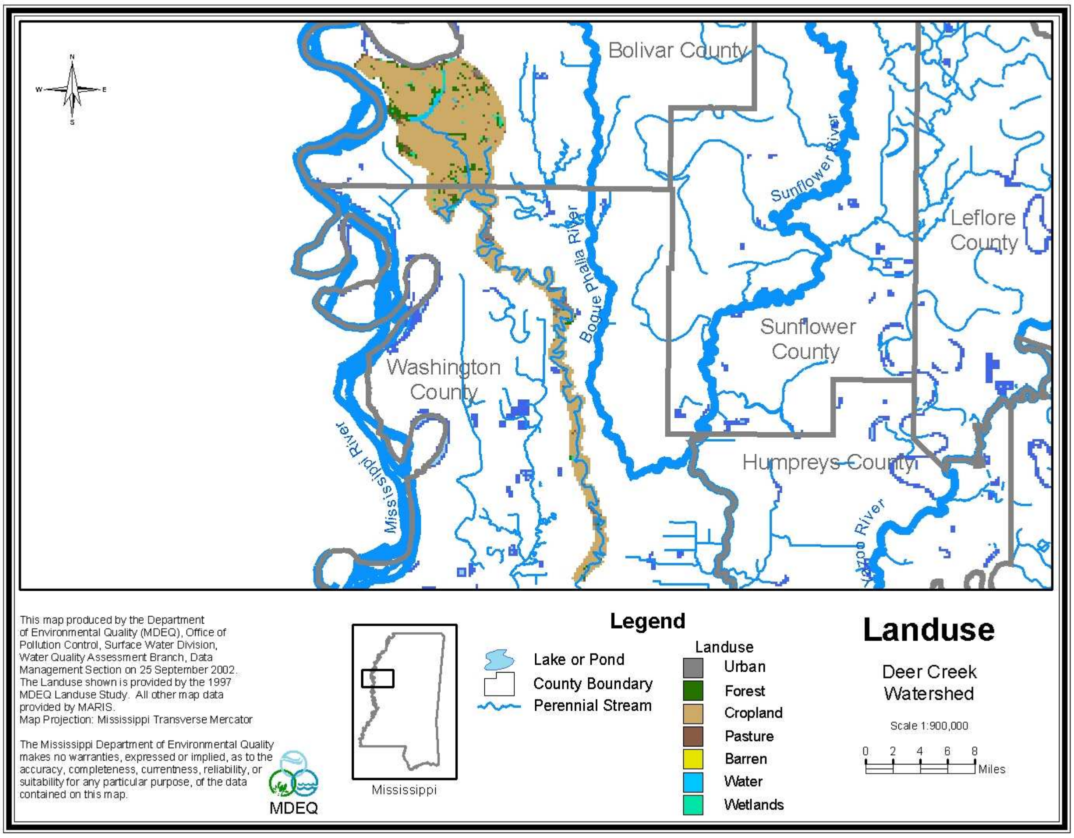


Figure 9. Landuse Distribution Map for the Deer Creek Watershed

A potential source of information regarding nonpoint source pollutants in the Deer Creek watershed is interpretation of aerial photographs. Low-level infrared aerial photographs of the watershed were taken in February 2002, and are available for interpretation. Interpretation of these photographs could yield significant information about the watershed such as the locations of locations of failing septic tanks, detailed landuse inventories, and riparian zone conditions. Because funding is not available at the present time, this activity has not yet occurred. Watershed-specific data could also be obtained from surveys of septic tanks and onsite wastewater treatment plants and inspections of sewer lines in the 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 Deer Creek Watershed. 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 Deer Creek Watershed may contribute 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 Deer 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, and leaking sewer collection lines.

3.2.4 Urban Development

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

MASS BALANCE PROCEDURE

Establishing the relationship between the instream water quality target and the source loading is a critical component of TMDL development. It allows for the evaluation of management options that will achieve the desired source load reductions. Ideally, the linkage will be supported by monitoring data that allow the TMDL developer to associate certain waterbody responses to flow and loading conditions. In this section, the selection of the modeling tools, setup, and model application are discussed.

4.1 Calculation Framework Selection

A mass balance approach was used to calculate this TMDL. This method of analysis was selected because the man-made modifications, such as weir structures near Leland and flow diversions, could not be accurately represented with the BASINS model. Also, the absence of water quality data available for model calibration made Deer Creek a poor choice for the development of a complex model.

4.2 Calculation of Flow

Because there is not a continuous record of flow available for Deer Creek, the annual average flow was estimated based on data from a nearby waterbody in the Mississippi River Alluvial Plain. The waterbody located closest to the Deer Creek Watershed that has a long-term continuous record of flow is Bogue Phalia Creek. The Bogue Phalia Creek Watershed occupies an area of approximately 309,760 acres (484 square miles) and lies in parts of Washington, Bolivar, and Sunflower Counties. Bogue Phalia flows in a southern direction from its headwaters to its confluence with the Big Sunflower River near Darlove. The location of Bogue Phalia and its confluence with the Big Sunflower River can be seen in Figure 1. USGS gage 07288650 is located on Bogue Phalia near Leland, MS. Though there are differences in the hydrological characteristics of these two waterbodies due to variations in watershed size, geology, and man-made modifications to the landscape, flow coefficients (amount of flow per drainage area size) were extrapolated from Bogue Phalia to Deer Creek. Due to lack of flow data for the Deer Creek watershed, the accuracy of this method could not be determined. The flow data currently being collected on the recently installed gage near Leland, MS may be used to evaluate the seasonal variation of flow in Deer Creek once sufficient data are available. Evaluation of the seasonal variation of flow may be included in a Phase 2 TMDL.

Flow data for the USGS monitoring station on Bogue Phalia near Leland, which were available for 1986 through 2000, were used to develop a flow duration curve. The flow in Bogue Phalia at Leland that is equaled or exceeded 50% of the time (the median flow) was used to calculate the flow coefficient. For Bogue Phalia Creek, the median flow is 143 cfs. The contributing drainage area of Bogue Phalia, 484 square miles, was used to determine the median flow coefficient as shown below.

Median Flow Coefficient (cfs/square mile) = 143 cfs/484 square miles = **0.295 cfs/square mile**

Then the median flow for Deer Creek was estimated by multiplying by the contributing drainage area size of Deer Creek, 110 square miles.

Median Flow in Deer Creek = 0.295 cfs/square mile * 110 square miles = **32.5 cfs**

4.3 Calculation of Load

The mass balance approach utilizes the conservation of mass principle. Loads can be calculated by multiplying the fecal coliform concentration in the water body for a 30-day period by the flow. The principle of the conservation of mass allows for the addition and subtraction of those loads to determine the appropriate numbers necessary for the TMDL. The loads can be calculated using the following relationship:

Load (counts/30days) = [**Concentration for 30 days** (30 days*counts/ 100 ml)] * [**Flow** (cfs)] * (Conversion Factor)

where (Conversion Factor) = [(28316.8 ml/1 ft^3)*(1 (100 ml)/100 (1 ml))*(60 s/1 min)* (60 min/1 hour)*(24 hour/1 day)*(30 days/1 (30 days)/30 days]
= 2.45 E+07 ((100 ml * s)/(ft^3 *30 days*30days))

For the calculation of this TMDL, the concentration for 30 days used was the area under a curve that meets both portions of the standard with an assumed 30-sample data set. This value is 7129 (30days*counts/100 ml) in the summer months and 71031 (30days*counts/100 ml) in the winter months.

ALLOCATION

The allocation for this Phase 1 TMDL could include a wasteload allocation (WLA) for point sources, a load allocation (LA) for nonpoint sources, and a margin of safety (MOS). This Phase 1 TMDL is comprised of the WLA, LA and MOS.

5.1 Wasteload Allocations

Within this watershed, the contribution of each discharger was based on the facility's discharge monitoring data and other records of past performance. The wasteload allocations are given on a seasonal basis in Table 9 for summer conditions and Table 10 for winter conditions. The tables list the point source contributions, along with their existing load, allocated load, and percent reduction. The loads are expressed in the units of counts per 30 days. The percent reduction needed for both facilities is zero because the effluent for these facilities currently meets water quality standards at the end of pipe. The removal of the Hollandale POTW in 1999 represents a significant reduction in the waterbody that has already occurred.

Table 9. Wasteload Allocations, Summer

Facility	Existing Flow (cfs)	Existing Load (counts/30 days)	Allocated Flow (cfs)	Allocated Load (counts/30 days)	Percent Reduction
J. Whitten Delta Research	0.077	1.13E+10	0.077	1.13E+10	0%
National Warm Water Aquaculture Center	0.891	1.31E+11	0.891	1.31E+11	0%
Total		**1.42E+11**		**1.42E+11**	

Table 10. Wasteload Allocations, Winter

Facility	Existing Flow (cfs)	Existing Load (counts/30 days)	Allocated Flow (cfs)	Allocated Load (counts/30 days)	Percent Reduction
J. Whitten Delta Research	0.077	1.13E+11	0.077	1.13E+11	0%
National Warm Water Aquaculture Center	0.891	1.31E+12	0.891	1.31E+12	0%
Total		**1.42E+12**		**1.42E+12**	

5.2 Load Allocations

The LA for Deer Creek was calculated using the water quality criteria and the estimated median flow. In calculating the LA component, the water quality criterion was reduced by a 10 percent MOS. For this Phase 1 TMDL, the LA is based on a seasonal fecal coliform concentration for 30 days determined by the maximum area under a curve that meets both portions of the standards for a 30 sample data set and the estimated median flow of the water body. The estimated median flow of 32.5 cfs was not varied seasonally. The WLA is then subtracted from this load to calculate the LA. The resulting LA is estimated to be 4.97E+12 counts for 30 days for the summer months and 4.97E+13 counts for 30 days for the winter months. The calculations are shown below. Currently, no percent reduction can be calculated due to a lack of adequate data to characterize the existing conditions. However, MDEQ recommends a reduction in the existing sources be achieved through the elimination of failing septic tanks and direct pipes that potentially pollute the waterbody.

LA_{SUMMER} = 0.9*(7129 (30 days*counts/100 ml) * 32.5 (cfs) * 2.45E+07 ((100 ml * s)/(ft^3 *30 days*30 days))) – 1.42E+11(counts/30 days)

LA_{SUMMER} = 4.97E+12 counts for 30 days

LA_{WINTER} = 0.9*(71301 (30 days*counts/100 ml) * 32.5 (cfs) * 2.45E+07 ((100 ml * s)/(ft^3 *30 days))) – 1.42E+12

LA_{WINTER} = 4.97.xxE+13 counts for 30 days

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 study, reducing the TMDL by 10 percent explicitly specifies the MOS.

MOS_{SUMMER} = 0.1*(7129 (30 days*counts/100 ml) * 32.5 (cfs) * 2.45E+07 ((100 ml * s)/(ft^3 *30 days*30 days)))

MOS_{SUMMER} = 5.68E+11 counts for 30 days

MOS_{WINTER} = 0.1*(71301 (30 days*counts/100 ml) * 32.5 (cfs) * 2.45E+07 ((100 ml * s)/(ft^3 *30 days)))

MOS_{WINTER} = 5.68E+12 counts for 30 days

5.4 Calculation of the TMDL

This TMDL is calculated based on the following equation where WLA is the wasteload allocation (the load from the point sources), the LA is the load allocation (the load from nonpoint sources), and MOS is the margin of safety:

TMDL = WLA + LA + MOS

Where:
WLA = NPDES Permitted Facilities
LA = Surface Runoff + Other Direct Inputs
MOS = Explicit

The TMDLs calculated based on a fecal coliform concentration for 30 days determined by the maximum area under the curve that meets both portions of the standard for a 6 sample data set. Table 11 gives the Phase 1 TMDL for Deer Creek.

$TMDL_{SUMMER}$ = 7129 (30 days*counts/100 ml) * 32.5 (cfs) * 2.45E+07 ((100 ml * s)/(ft^3 *30 days*30 days))

$\mathbf{TMDL_{SUMMER}}$ = 5.68E+12 counts for 30 days

$TMDL_{WINTER}$ = 71301 (30 days*counts/100 ml) * 32.5 (cfs) * 2.45E+07 ((100 ml * s)/(ft^3*30 days))

$\mathbf{TMDL_{WINTER}}$ = 5.68E+13 counts for 30 days

Table 11. Calculation of the Phase 1 TMDLs

Season	WLA (counts/30 days)	LA (counts/30 days)	MOS (counts/30 days)	TMDL (counts/30 days)
Summer (May – October)	1.42E+11	4.97E+12	5.68E+11	5.68E+12
Winter (November – April)	1.42E+12	4.97E+13	5.68E+12	5.68E+13

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 TMDL has been calculated on a seasonal basis in order to account for the seasonal standard.

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. The point sources are required to discharge effluent treated and disinfected that will be below the 200 colony counts per 100 ml 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 in the Deer Creek Watershed 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 Deer 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.

Other future data collection activities could include interpretation of the aerial photographs available for the Deer Creek watershed. Also, the watershed restoration effort currently underway in the Deer Creek watershed will also provide additional water quality data. This effort may also include implementation of restoration efforts that would reduce nonpoint pollutant sources in Deer Creek.

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 *n*th 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, ($\mathbf{d}_1$, $\mathbf{d}_2$, $\mathbf{d}_3$) 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

REFERENCES

Metcalf and Eddy. 1991. *Wastewater Engineering: Treatment, Disposal, Reuse*. 3rd Edition. McGraw-Hill, Inc., New York.

MDEQ. 1994. *Wastewater Regulations for National Pollutant Discharge Elimination System (NPDES) Permits, Underground Injection Control (UIC) Permits, State Permits, Water Quality Based Effluent Limitations and Water Quality Certification.* Office of Pollution Control.

MDEQ. 2002. *State of Mississippi Water Quality Criteria for Intrastate, Interstate, and Coastal Waters*. Office of Pollution Control.

MDEQ. 1998. *Mississippi List of Waterbodies, Pursuant to Section 303(d) of the Clean Water Act*. Office of Pollution Control.

MDEQ. 1998. *Mississippi 1998 Water Quality Assessment, Pursuant to Section 305(b) of the Clean Water Act*. Office of Pollution Control.

Mississippi Department of Wildlife, Fisheries, and Parks. 1972. Parker, Walter, and David Robinson. Completion Report. 1971-1972. Pollution Studies on Big Sunflower River, Little Sunflower River, and Deer Creek. Mississippi Department of Wildlife, Fisheries, and Parks. Jackson, MS.

Natural Resources Conservation Service. *Mississippi Delta Comprehensive, Multipurpose, Water Resource Plan*. October 21, 1998.

USEPA. 1998. *Better Assessment Science Integrating Point and Nonpoint Sources, BASINS, Version 2.0 User's Manual*. U.S. Environmental Protection Agency, Office of Water, Washington, D.C.