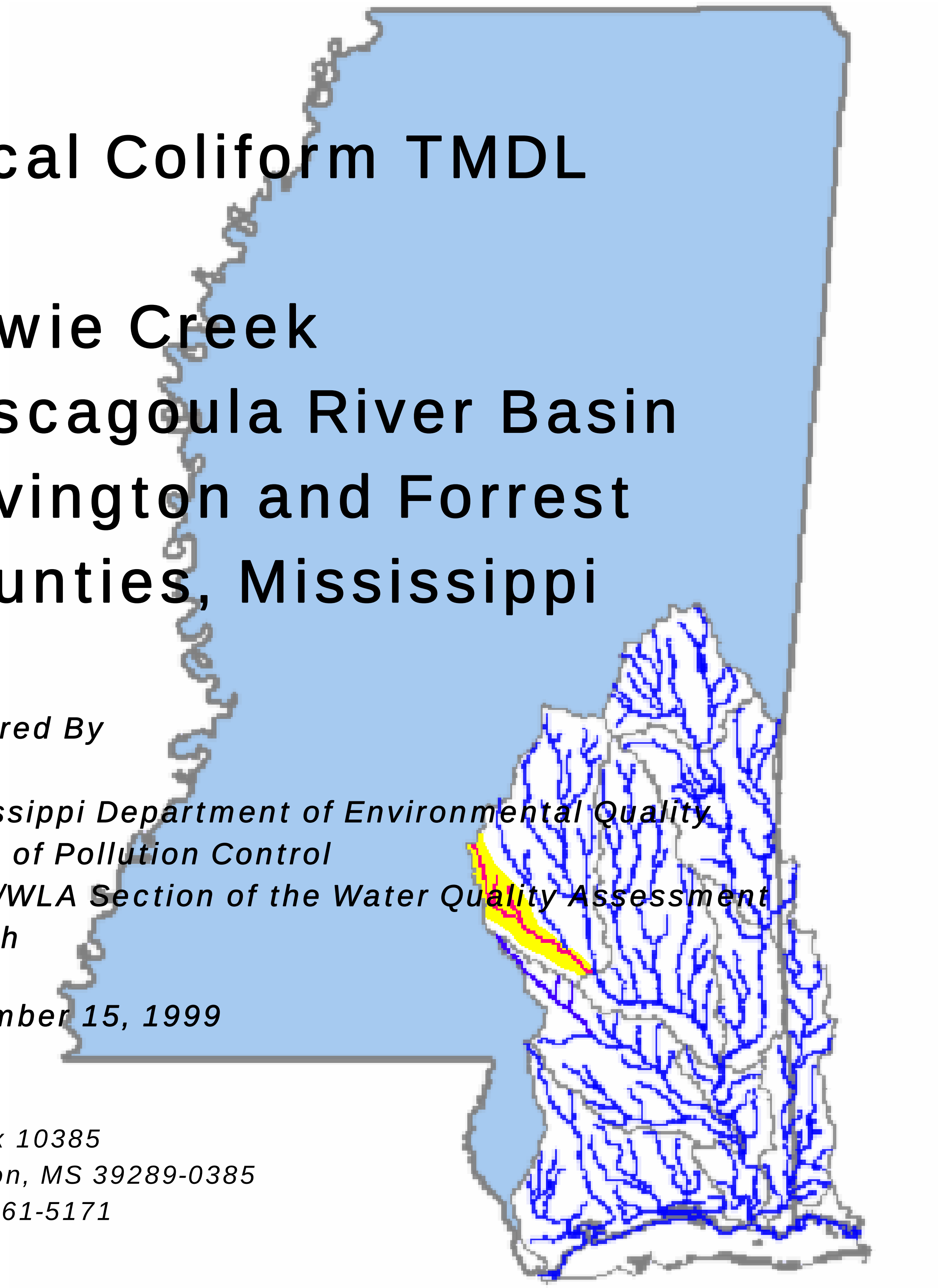
FINAL REPORT
December 1999
ID: 499121502

Fecal Coliform TMDL for Bowie Creek Pascagoula River Basin Covington and Forrest Counties, Mississippi



Prepared By

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

December 15, 1999

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CONTENTS

MONITORED SEGMENT IDENTIFICATION

Name:	Bowie Creek
Waterbody ID:	MS084M
Location:	Near Hattiesburg, from Hwy 589 to the Confluence with Okatoma Creek
County:	Covington and Forrest Counties, Mississippi
USGS HUC Code:	03170004
NRCS Watershed:	120
Length:	Nine miles
Use Impairment:	Contact Recreation
Cause Noted:	Fecal Coliform, an Indicator of the Presence of Pathogenic Bacteria
Priority Rank:	82
NPDES Permits:	There are 12 NPDES Permits issued for facilities that discharge fecal coliform in the watershed (Table 3.1.1).
Pollutant Standard:	Fecal coliform colony counts shall not exceed a geometric mean of 200 per 100 ml nor shall more than 10% of the samples examined during any month exceed a colony count of 400 per 100 ml.
Waste Load Allocation:	2.03E+12 (counts/30 days) All dischargers must meet water quality standards for disinfection.
Load Allocation:	2.08E+13 (counts/30 days)
Margin of Safety:	Implicit in conservative modeling assumptions.
Total Maximum Daily Load (TMDL):	2.28E+13 (counts/30 days) The TMDL is a combination of point and nonpoint sources due to NPDES Permitted dischargers, cattle with access to streams, failing septic tanks, and fecal coliform applied to the land available for surface runoff.

EVALUATED DRAINAGE AREA IDENTIFICATION

Name:	Bowie Creek Drainage Area
Waterbody ID:	MS081BE
Location:	Drainage Area Near Terrell
County:	Simpson, Jefferson Davis, and Covington Counties, Mississippi
USGS HUC Code:	03170004
NRCS Watershed:	090
Area:	Approximately 29,900 Acres
Use Impairment:	Secondary Contact Recreation
Cause Noted:	Fecal Coliform, an Indicator of the Presence of Pathogenic Bacteria
Priority Rank:	Low
NPDES Permits:	There are 12 NPDES Permits issued for facilities that discharge fecal coliform in the watershed (Table 3.1.1).
Pollutant Standard:	May through October - Fecal coliform colony counts shall not exceed a geometric mean of 200 per 100 ml, Less than 10% of the samples may exceed 400 per 100 ml. November through April - Fecal coliform colony counts shall not exceed a geometric mean of 2,000 per 100 ml, Less than 10% of the samples may exceed 4,000 per 100 ml.
Waste Load Allocation:	1.70E+11 (counts/30 day) All dischargers must meet water quality standards for disinfection.
Load Allocation:	2.73E+12 (counts /30 day)
Margin of Safety:	Implicit in conservative modeling assumptions.
Total Maximum Daily Load (TMDL):	2.90E+12 (counts/30 day) The TMDL is a combination of point and nonpoint sources of fecal coliform bacteria due to NPDES Permitted dischargers, cattle with access to streams, failing septic tanks, and fecal coliform applied to the land available for surface runoff.

EVALUATED DRAINAGE AREA IDENTIFICATION

Name:	Bowie Creek Drainage Area
Waterbody ID:	MS084E
Location:	Drainage Area Near Lux
County:	Covington, Jefferson Davis, and Lamar Counties, Mississippi
USGS HUC Code:	03170004
NRCS Watershed:	120
Area:	Approximately 98,300 Acres
Use Impairment:	Secondary Contact Recreation
Cause Noted:	Fecal Coliform, an Indicator of the Presence of Pathogenic Bacteria
Priority Rank:	Low
NPDES Permits:	There are 12 NPDES Permits issued for facilities that discharge fecal coliform in the watershed (Table 3.1.1).
Pollutant Standard:	May through October - Fecal coliform colony counts shall not exceed a geometric mean of 200 per 100 ml, Less than 10% of the samples may exceed 400 per 100 ml. November through April - Fecal coliform colony counts shall not exceed a geometric mean of 2,000 per 100 ml, Less than 10% of the samples may exceed 4,000 per 100 ml.
Waste Load Allocation:	5.67E+11 (counts/30 day) All dischargers must meet water quality standards for disinfection.
Load Allocation:	9.29E+12 (counts/30 day)
Margin of Safety:	Implicit in conservative modeling assumptions.
Total Maximum Daily Load (TMDL):	9.86E+12 (counts/30 day) The TMDL is a combination of point and nonpoint sources of fecal coliform bacteria due to NPDES Permitted dischargers, cattle with access to streams, failing septic tanks, and fecal coliform applied to the land available for surface runoff.

EVALUATED DRAINAGE AREA IDENTIFICATION

Name:	Bowie River Drainage Area
Waterbody ID:	MS085E
Location:	Drainage Area Near Hattiesburg
County:	Lamar and Forrest Counties, Mississippi
USGS HUC Code:	03170004
NRCS Watershed:	130
Area:	Approximately 42,900 Acres
Use Impairment:	Contact Recreation and Secondary Contact Recreation
Cause Noted:	Fecal Coliform, an Indicator of the Presence of Pathogenic Bacteria
Priority Rank:	Low
NPDES Permits:	There are 12 NPDES Permits issued for facilities that discharge fecal coliform in the watershed (Table 3.1.1).
Pollutant Standard:	Fecal coliform colony counts shall not exceed a geometric mean of 200 per 100 ml nor shall more than 10% of the samples examined during any month exceed a colony count of 400 per 100 ml.
Waste Load Allocation:	7.13E+11 (counts/30 day) All dischargers must meet water quality standards for disinfection.
Load Allocation:	1.83E+12 (counts/30 day)
Margin of Safety:	Implicit in conservative modeling assumptions.
Total Maximum Daily Load (TMDL):	2.54E+12 (counts/30 day) The TMDL is a combination of point and nonpoint sources of fecal coliform bacteria due to NPDES Permitted dischargers, cattle with access to streams, failing septic tanks, and fecal coliform applied to the land available for surface runoff.

EVALUATED DRAINAGE AREA IDENTIFICATION

Name:	Dry Creek Drainage Area
Waterbody ID:	MS082E
Location:	Drainage Area Near Terrell
County:	Covington County, Mississippi
USGS HUC Code:	03170004
NRCS Watershed:	100
Area:	Approximately 13,600 Acres
Use Impairment:	Secondary Contact Recreation
Cause Noted:	Fecal Coliform, an Indicator of the Presence of Pathogenic Bacteria
Priority Rank:	Low
NPDES Permits:	There are 12 NPDES Permits issued for facilities that discharge fecal coliform in the watershed (Table 3.1.1).
Pollutant Standard:	May through October - Fecal coliform colony counts shall not exceed a geometric mean of 200 per 100 ml, Less than 10% of the samples may exceed 400 per 100 ml. November through April - Fecal coliform colony counts shall not exceed a geometric mean of 2,000 per 100 ml, Less than 10% of the samples may exceed 4,000 per 100 ml.
Waste Load Allocation:	7.77E+10 (counts/30 day) All dischargers must meet water quality standards for disinfection.
Load Allocation:	1.46E+12 (counts/30 day)
Margin of Safety:	Implicit in conservative modeling assumptions.
Total Maximum Daily Load (TMDL):	1.54E+12 (counts/30 day) The TMDL is a combination of point and nonpoint sources of fecal coliform bacteria due to NPDES Permitted dischargers, cattle with access to streams, failing septic tanks, and fecal coliform applied to the land available for surface runoff.

EVALUATED DRAINAGE AREA IDENTIFICATION

Name:	Skiffer Creek Drainage Area
Waterbody ID:	MS081SE
Location:	Drainage Area Near Clem
County:	Simpson Jefferson Davis, and Covington Counties, Mississippi
USGS HUC Code:	03170004
NRCS Watershed:	090
Area:	Approximately 4,500 Acres
Use Impairment:	Secondary Contact Recreation
Cause Noted:	Fecal Coliform, an Indicator of the Presence of Pathogenic Bacteria
Priority Rank:	Low
NPDES Permits:	There are 12 NPDES Permits issued for facilities that discharge fecal coliform in the watershed (Table 3.1.1).
Pollutant Standard:	May through October - Fecal coliform colony counts shall not exceed a geometric mean of 200 per 100 ml, Less than 10% of the samples may exceed 400 per 100 ml. November through April - Fecal coliform colony counts shall not exceed a geometric mean of 2,000 per 100 ml, Less than 10% of the samples may exceed 4,000 per 100 ml.
Waste Load Allocation:	2.56E+10 (counts/30 days) All dischargers must meet water quality standards for disinfection.
Load Allocation:	4.10E+11 (counts/30 days)
Margin of Safety:	Implicit in conservative modeling assumptions.
Total Maximum Daily Load (TMDL):	4.36E+11 (counts/30 days) The TMDL is a combination of point and nonpoint sources of fecal coliform bacteria due to NPDES Permitted dischargers, cattle with access to streams, failing septic tanks, and fecal coliform applied to the land available for surface runoff.

EVALUATED DRAINAGE AREA IDENTIFICATION

Name:	West Bowie Creek Drainage Area
Waterbody ID:	MS083E
Location:	Drainage Area Near Deen
County:	Jefferson Davis County, Mississippi
USGS HUC Code:	03170004
NRCS Watershed:	110
Area:	Approximately 38,600 Acres
Use Impairment:	Secondary Contact Recreation
Cause Noted:	Fecal Coliform, an Indicator of the Presence of Pathogenic Bacteria
Priority Rank:	82
NPDES Permits:	There are 12 NPDES Permits issued for facilities that discharge fecal coliform in the watershed (Table 3.1.1).
Pollutant Standard:	May through October - Fecal coliform colony counts shall not exceed a geometric mean of 200 per 100 ml, Less than 10% of the samples may exceed 400 per 100 ml. November through April - Fecal coliform colony counts shall not exceed a geometric mean of 2,000 per 100 ml, Less than 10% of the samples may exceed 4,000 per 100 ml.
Waste Load Allocation:	2.20E+11 (counts/30 days) All dischargers must meet water quality standards for disinfection.
Load Allocation:	3.64E+12 (counts/30 days)
Margin of Safety:	Implicit in conservative modeling assumptions.
Total Maximum Daily Load (TMDL):	3.86E+12 (counts/30 days) The TMDL is a combination of point and nonpoint sources of fecal coliform bacteria due to NPDES Permitted dischargers, cattle with access to streams, failing septic tanks, and fecal coliform applied to the land available for surface runoff.

EXECUTIVE SUMMARY

A segment of Bowie Creek has been placed on the Mississippi 1998 Section 303(d) List of Waterbodies as an impaired waterbody, due to fecal coliform bacteria. Six drainage areas of Bowie Creek, Bowie River, and tributaries of Bowie Creek have also been placed on the list as evaluated areas, due to fecal coliform bacteria. The applicable state standard for the monitored segment specifies that the maximum allowable level of fecal coliform shall not exceed a geometric mean of 200 per 100 ml, nor shall more than 10% of the samples examined during any month exceed a colony count of 400 per 100 ml. This standard also applies to the drainage areas during the months of May through October. For the months of November through April, the state standard for the drainage areas specifies that the maximum allowable level of fecal coliform stall not exceed a geometric mean of 2000 per 100 ml, nor shall more than 10% of the samples examined during any month exceed a colony count of 4000 per 100 ml. A review of the available monitoring data for the watershed indicates that there is a violation of the standard for the impaired waterbody.

Bowie Creek is a major waterbody in the Pascagoula Basin. It flows approximately 40 miles in a south-eastern direction from its headwaters in the southeast corner of Simpson County to its confluence with the Okatoma Creek in Forrest County. Bowie River is formed at the confluence of Bowie Creek and Okatoma Creek. Bowie River flows 10 miles, in a south-eastern direction, until it joins the Leaf River. This TMDL, however, has been developed for the monitored segment and six drainage areas of Bowie Creek found on the 1998 303(d) list. The nine mile long, impaired section of the creek, which begins in Covington County near Hattiesburg and ends at the confluence of Okatoma Creek in Forrest County. The BASINS Nonpoint Source Model (NPSM) was selected as the modeling framework for performing the TMDL allocations for this study. Daily flow values from the USGS gage on Bowie Creek near Hattiesburg were used to calibrate the hydrologic flow for the watershed. The weather data used for this model were collected at Leaksville, MS. The representative hydrologic period used for this TMDL is January 1, 1985 through December 31, 1995.

Fecal coliform loadings from nonpoint sources in the watershed were calculated based upon wildlife populations; numbers of cattle, hogs, and chickens; information on livestock and manure management practices for the Pascagoula Basin; and urban development. The estimated fecal coliform production and accumulation rates due to nonpoint sources for the watershed were incorporated into the model. Also represented in the model were the nonpoint sources such as failing septic systems and cattle which have direct access to Bowie Creek or a tributary of Bowie Creek. There are 12 NPDES permitted dischargers located in the watershed which are included as point sources in the model. Under existing conditions, output from the model indicates violation of the fecal coliform standard in the stream. After applying a load reduction scenario, there were no violations of the standard according to the model.

The scenario used to reduce the fecal coliform load involves a cooperative effort between all fecal coliform contributors in the Bowie Creek Watershed. First, all NPDES facilities will be required to treat their discharge so that the fecal coliform concentrations do not exceed water quality standards. Careful monitoring of all permitted facilities in the Bowie Creek should be continued to ensure that compliance with permit limits is consistently attained. Second is the removal of 75% of cattle's direct access to tributaries. This could be accomplished by fencing streams in cattle pastures. Education on best management practices is a vital part of achieving this goal. Finally, a 50%

reduction in the fecal coliform contribution from failing septic tanks is required. The model assumed there is a 40% failure rate of septic tanks in the Bowie Creek drainage area. A reduction could be accomplished by education on best management practices for septic tank owners. Additionally, users of individual onsite wastewater treatment plants could be educated on the importance of disinfection of the effluent from their treatment plant.

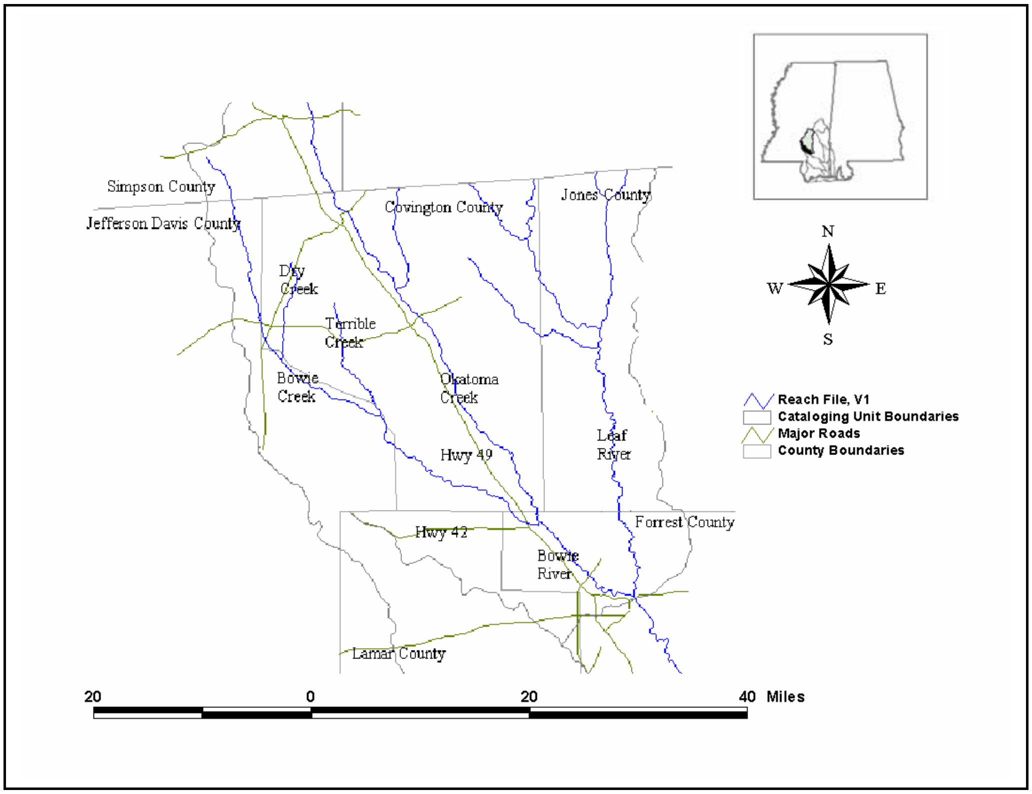
The model accounted for seasonal variations in hydrology, climatic conditions, and watershed activities. The use of the continuous simulation model allowed for consideration of the seasonal aspects of rainfall and temperature patterns within the watershed. Calculation of the fecal coliform accumulation parameters and source contributions on a monthly basis accounted for seasonal variations in watershed activities such as livestock grazing and land application of manure.

1.0 INTRODUCTION

1.1 Background

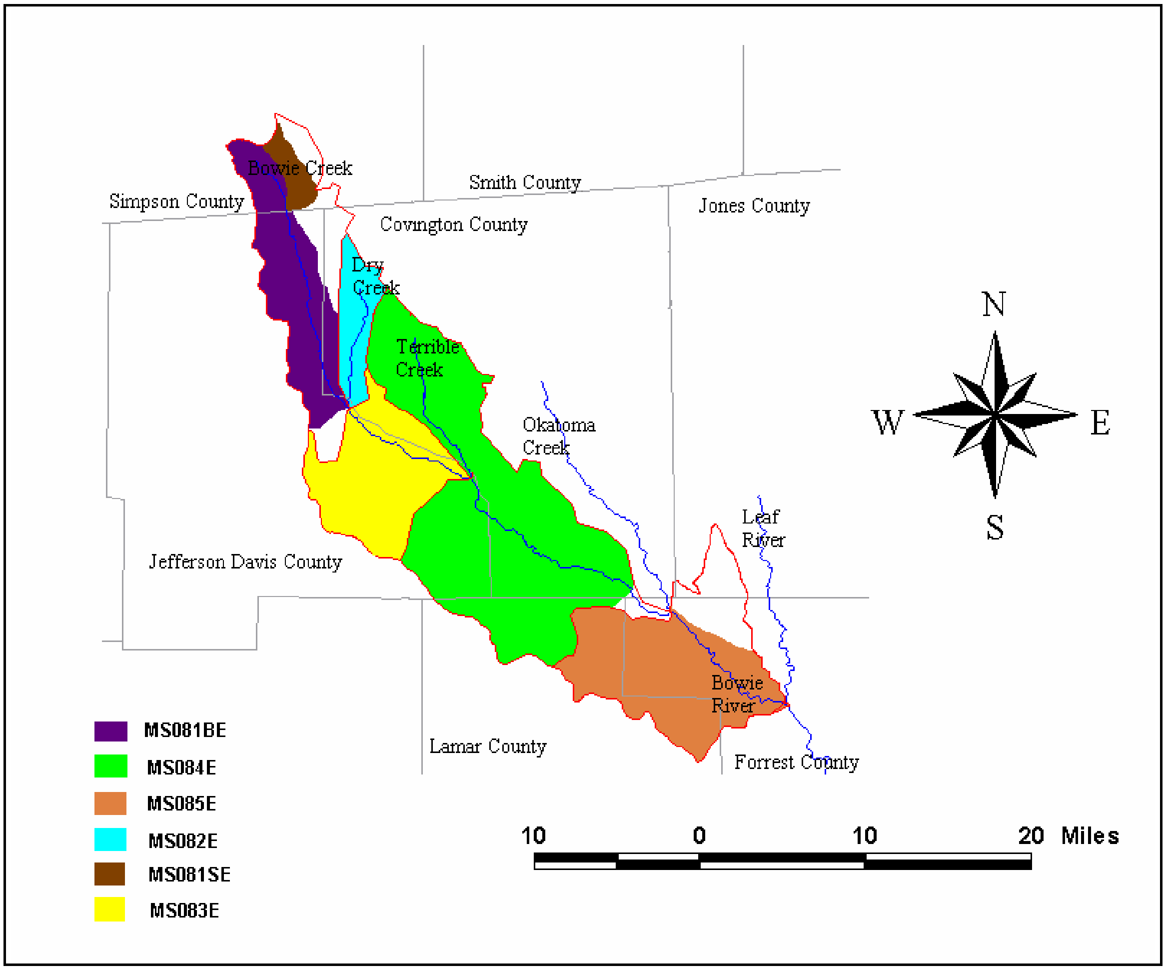
The identification of waterbodies not meeting their designated use and the development of total maximum daily loads (TMDL) for those waterbodies are required by Section 303(d) of the Clean Water Act and the Environmental Protection Agency's (EPA) Water Quality Planning and Management Regulations (40 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 bacteria in the waterbody. The TMDL process can be used to establish water quality based controls to reduce pollution from both point and nonpoint sources, and restore and maintain the quality of water resources.

The Mississippi Department of Environmental Quality (MDEQ) has identified a segment of Bowie Creek as being impaired by fecal coliform bacteria for a length of nine miles as reported in the Mississippi 1998 Section 303(d) List of Waterbodies. The impaired segment begins near



Hattiesburg, at the Highway 589 bridge, and ends at the confluence with Okatoma Creek. This section is shown in Figure 1.1.

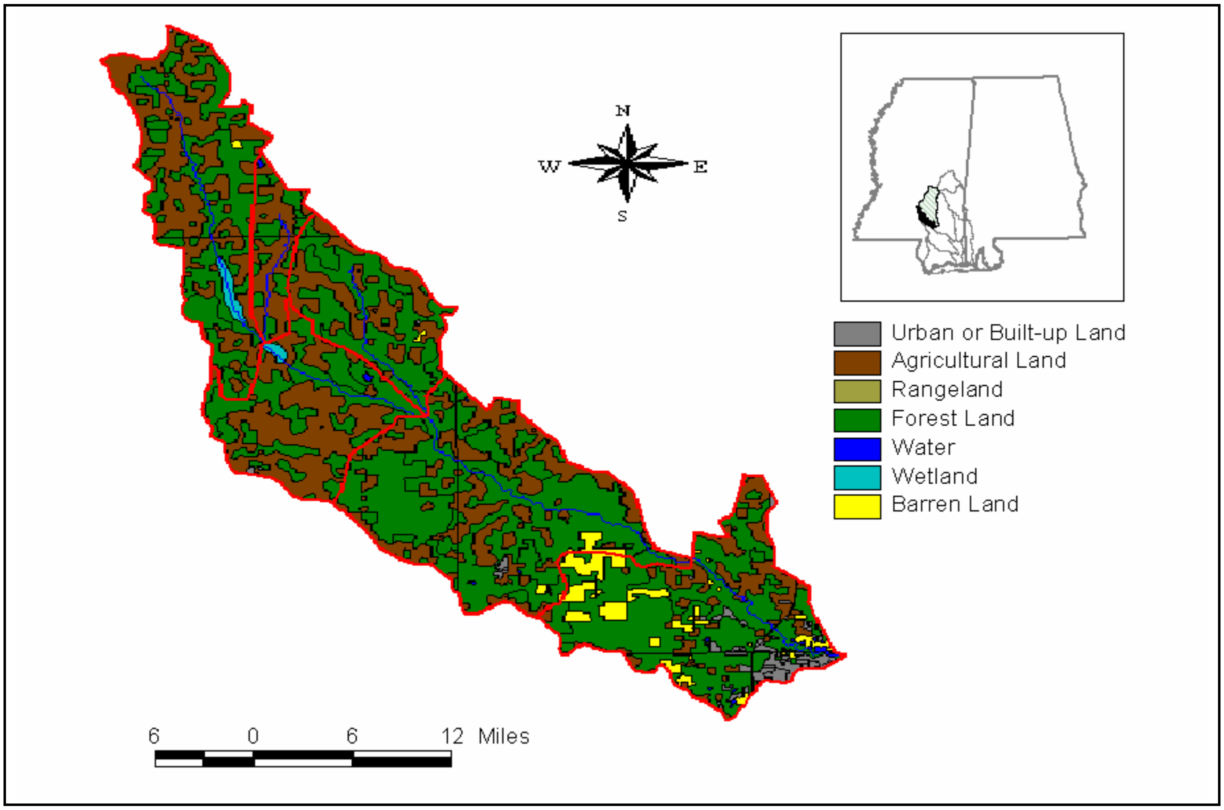
MDEQ has also identified six drainage areas of Bowie Creek as being evaluated for the presence of fecal coliform bacteria. These drainage areas have a combined area of approximately 227,800 acres. They are shown in Figure 1.2 below. These drainage areas are listed as evaluated because the data



available for these areas are insufficient to show a definite impairment caused by fecal coliform bacteria.

Drainage Area ID	Drainage Area Name	Area (Acres)	Use Listed
MS081BE	Bowie Creek	29,900	Secondary Contact Recreation
MS084E	Bowie Creek	98,300	Secondary Contact Recreation
MS085E	Bowie River	42,900	Contact Recreation Secondary Contact Rec.
MS082E	Dry Creek	13,600	Secondary Contact Recreation
MS081SE	Skiffer Creek	4,500	Secondary Contact Recreation
MS083E	West Bowie Creek	38,600	Secondary Contact Recreation

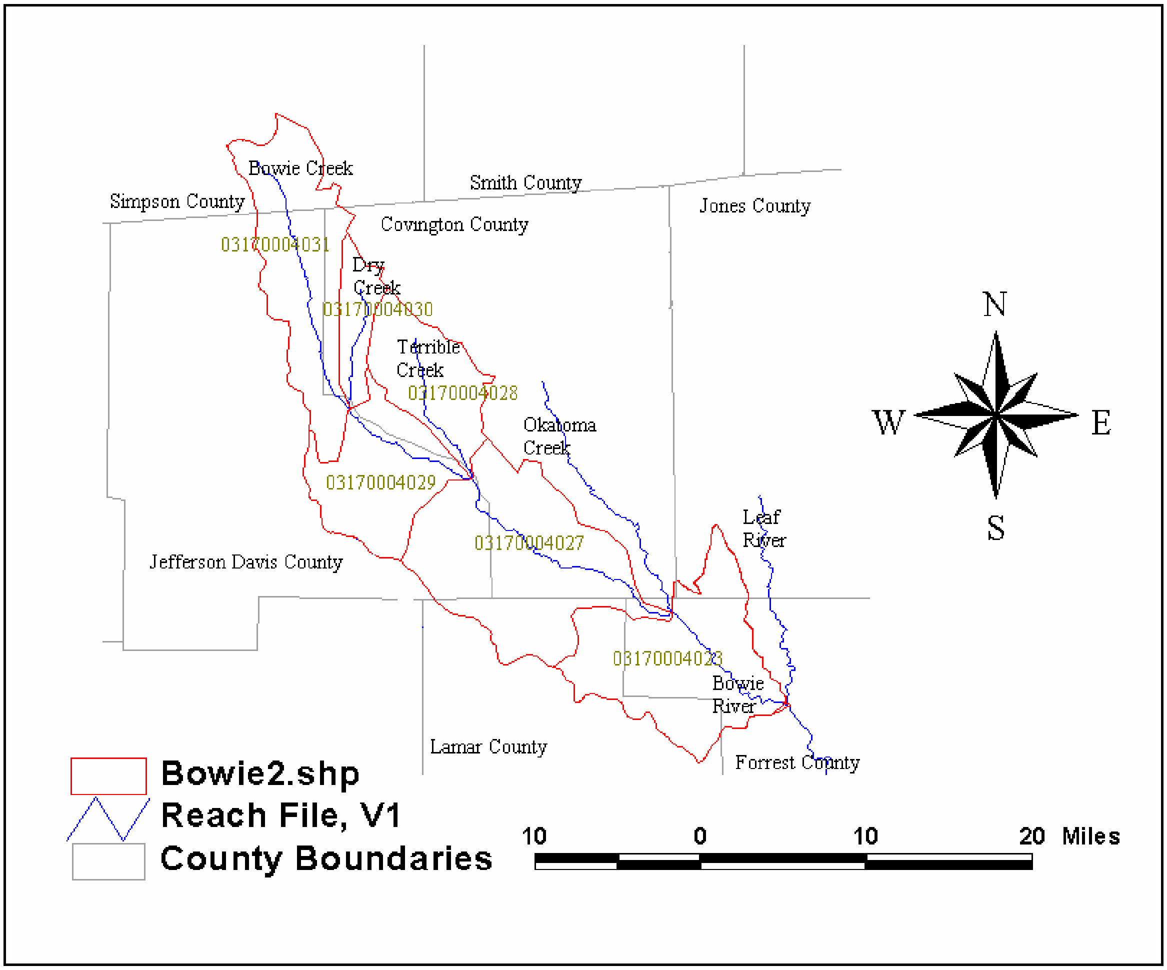
The impaired segment and evaluated drainage areas of Bowie Creek lie within the Pascagoula River Basin Hydrologic Unit Code (HUC) 03170004 in southeastern Mississippi. The drainage area included in the model for the monitored segment is approximately 249,437 acres; and lies within portions of Simpson, Jefferson Davis, Lamar, Covington, Jones, and Forrest Counties. It begins at the headwaters in Simpson County, and continues downstream for approximately 50 miles, to include the entire impaired section and the confluence with Okatoma Creek. The modeled section ends at the confluence with the Leaf River. The watershed is sparsely populated with several urban areas including the cities of Hattiesburg, Bassfield, and Sumrall. Forest is the dominant the landuse within this watershed. The landuse distribution within the watershed of the impaired section is given below in Figure 1.3.



In order to analyze the sources of fecal coliform bacteria in the Bowie Creek watershed, the entire area was divided into six separate subwatersheds. The monitored section is contained entirely within the watershed, 03170004027. The evaluated drainage areas, however, are scattered throughout the modeled subwatersheds. Due to the location of the monitored segment and evaluated drainage areas, the load and waste load allocations required in this TMDL are based on water quality in the most downstream watershed, 03170004023.

Bowie Creek was generally divided into a new reach at the confluence of each major tributary. The watershed delineations were based primarily on an analysis of the Reach File 3 (RF3) stream network in the basin as well as topographic analysis of the watershed. Figure 1.4 shows a map of the drainage area of Bowie Creek and its division into subwatersheds. The map also shows an 11-digit identification number for each of the subwatersheds.

1.2 Applicable Waterbody Segment Use



Designated beneficial uses and water quality standards are established by the *State of Mississippi Water Quality Criteria for Intrastate, Interstate, and Coastal Waters* regulations. The designated uses for Bowie Creek as defined by the regulations are Contact Recreation (from Highway 589 to the confluence with Okatoma Creek), and Fish and Wildlife. The monitored segment of Bowie Creek has the designated use of Contact Recreation. All the drainage areas are designated for use as Secondary Contact Recreation, with the exception of MS085E. Drainage area MS085E is designated for use as Contact Recreation as well as Secondary Contact Recreation. Secondary Contact Recreation is defined as incidental contact with water, including wading and occasional swimming.

1.3 Applicable Waterbody Segment Standard

The water quality standard applicable to the use of the monitored waterbody and the pollutant of concern is defined in the *State of Mississippi Water Quality Criteria for Intrastate, Interstate, and Coastal Waters* regulations. The standard states that the fecal coliform colony counts shall not exceed a geometric mean of 200 per 100 ml, nor shall more than 10% of the samples examined during any month exceed a colony count of 400 per 100 ml. This water quality standard will be used as targeted endpoints to evaluate impairments and establish this TMDL for the monitored segment and the drainage areas, because it is the most stringent standard.

For segments and drainage areas designated for use as Secondary Contact Recreation, the standard states that from May through October 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. From November through April the fecal coliform colony counts shall not exceed a geometric mean of 2000 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.

2.0 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 a 30-day geometric mean of 200 colony counts per 100 ml.

Because fecal coliform may be attributed to both nonpoint and point sources, the critical condition used for the modeling and evaluation of stream response was represented 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 1985-1995 period represents both low-flow conditions as well as wet-weather conditions and encompasses a range of wet and dry seasons. Therefore, the 11-year period was selected as representing critical conditions associated with all potential sources of fecal coliform bacteria within the watershed.

2.2 Discussion of Instream Water Quality

Water quality data available for Bowie Creek show that the stream is occasionally impaired by high levels of fecal coliform bacteria. There is an ambient station operated by MDEQ which collected fecal coliform monitoring data during the 11-year modeling period. At station 02472500, MDEQ collected bimonthly fecal coliform samples and flow measurements between January 1994 and September 1996. This station is located on Bowie Creek north of Hattiesburg, MS. The data indicate that high instream fecal coliform concentrations occurred during both periods of high-flow and dry, low-flow conditions.

2.2.1 Inventory of Available Water Quality Monitoring Data

The State's 1998 Section 305(b) Water Quality Assessment Report was reviewed to assess water quality conditions and data available for the watershed. According to the report, Bowie Creek is partially supporting the use of contact recreation due to the presence of fecal coliform bacteria. These conclusions were based on instantaneous data collected at station 02472500. Data collected at this station are listed below in Table 2.2.1

Table 2.2.1 Fecal Coliform Data reported in Bowie Creek, Station 20472500

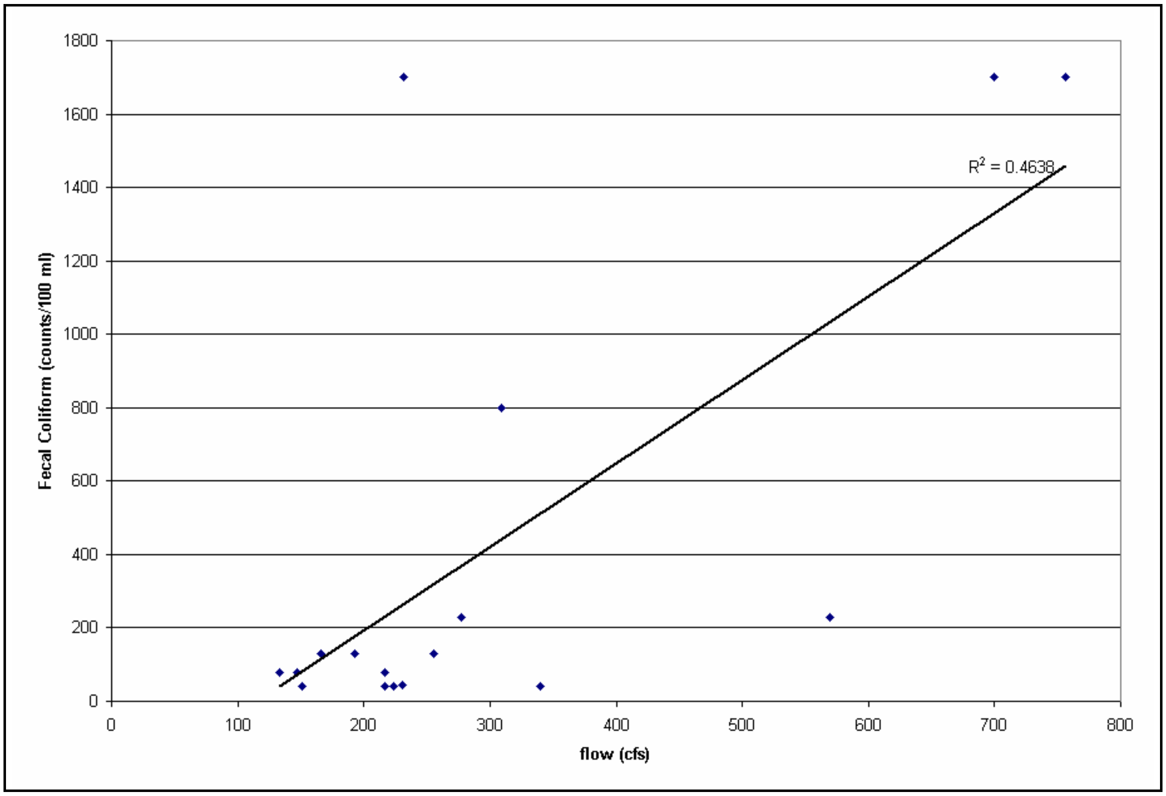
Date	Flow (cfs)	Fecal Coliform (counts/100 ml)
01/09/94	309	800
01/12/94	340	40
03/06/94	569	230
05/05/94	756	1,700
06/20/94	231	44
08/23/94	193	130
11/07/94	232	1,700
03/6/95	700	1,700
04/17/95	217	80
05/06/95	217	40
07/10/95	166	130
09/11/95	133	80
11/08/95	255	130
01/09/96	224	40
03/04/96	277	230
07/09/96	151	40
09/10/96	147	80

2.2.2 Analysis of Instream Water Quality Monitoring Data

Statistical summaries of the water quality data reported above are presented in Table 2.2.2. The number of instantaneous exceedances listed in the table is the number of times that the instantaneous fecal coliform concentration exceeded the standard of 200 counts per 100 ml. The percent instantaneous exceedance was calculated for each station by dividing the number of exceedances by the total number of samples. The correlation between instantaneous flow and instream fecal coliform concentrations was also evaluated. In Figure 2.1, the instantaneous fecal coliform concentrations generally increased when the flow increased. The regression coefficient (R^2) and the linear regression line are shown on the graph. The regression coefficient value is high enough to show a reasonably good correlation between stream flow and instantaneous fecal coliform concentration.

Table 2.2.2 Statistical Summaries

Station Number	Number of Samples	Minimum Value (counts/100ml)	Maximum Value (counts/100ml)	Average Value (counts/100ml)	Number of Exceedances	Percent Instantaneous Exceedance
02472500	17	40	1700	423	7	35%



Fecal Coliform (counts/100 ml)
flow (cfs)
$R^2 = 0.4638$
0
200
400
600
800
1000
1200
1400
1600
1800
0
100
200
300
400
500
600
700
800

3.0 SOURCE ASSESSMENT

The TMDL evaluation summarized in this report examined all known potential fecal coliform sources in the Bowie Creek watershed. The source assessment was used as the basis of development for the model and ultimate analysis of the TMDL allocation options. 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. The representation of the following sources in the model is discussed in Section 4.0.

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 12 wastewater treatment plants in the Bowie Creek watershed serve a variety of activities including residential subdivisions, schools, recreational areas, and other businesses. The majority of the 12 wastewater treatment plants serve residential subdivisions.

A point source assessment was completed for each subwatershed in the Bowie Creek drainage area, given in Figure 1.3. Table 3.1.1 lists all of the fecal coliform dischargers according to subwatershed, along with the NPDES Permit number and the receiving waterbody.

Once the permitted dischargers were located, the effluent from each source was characterized based on all available monitoring data including permit limits, discharge monitoring reports, and information on treatment types. Discharge monitoring reports (DMR) were the best data source for characterizing effluent because they report measurements of flow and fecal coliform present in effluent samples. Of the facilities for which they were available, the DMRs for the past five years, 1993 through 1998, were analyzed. When data were available, the fecal coliform concentrations used in the model were calculated by taking an average of fecal coliform concentrations reported in the discharge monitoring reports. If the discharge monitoring data were inadequate, permit limits were used to represent fecal coliform concentrations in the model. If evidence of insufficient treatment existed, best professional judgement was used to estimate a fecal coliform loading rate in the model. The permit limits of each facility included in the model are given in Table 3.1.1.

Table 3.1.1 Inventory of Point Source Dischargers

Facility Name	Subwatershed	NPDES	Fecal Coliform (counts/100ml)	Receiving Waterbody
Trace Subdivision Number 4	03170004023	MS0055140	200	Tributary of Cross Creek
Serene Hills Subdivision	03170004023	MS0050172	200	Mineral Creek
The Trace Subdivision First Addition	03170004023	MS0051080	200	Mixons Creek
Great Southern National Bank	03170004023	MS0053660	200	Mixons Creek
Westover West Subdivision	03170004023	MS0031801	200	Mixons Creek
Pecan Grove Trailer Park	03170004023	MS0047473	200	Tributary to Mixons Creek
Creekwood Subdivision	03170004023	MS0039004	200	Big Creek
Lakewood Estates Subdivision	03170004023	MS0038792	200	Big Creek
Hattiesburg North Lagoon	03170004023	MS0020826	200	Bowie Creek
North Haven Subdivision	03170004023	MS0022314	200	Mineral Creek
Al Cascio Custom Cutting and Wrap	03170004027	MS0037176	200	Bowie Creek
Deen's Riverside Restaurant	03170004029	MS0043788	200	Bowie Creek

3.2 Assessment of Nonpoint Sources

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

- Failing septic systems
- Wildlife
- Land application of hog and cattle manure
- Grazing animals
- Land application of poultry litter
- Cattle contributions directly deposited instream
- Urban development

The 249,437 acre drainage area included in the model contains many different landuse types, including urban, forest, cropland, pasture, barren, and wetlands. The landuse information is based on data collected by the State of Mississippi's Automated Information System (MARIS), 1997. This data set is based on Landsat Thematic Mapper digital images taken between 1992 and 1993. This classification is based on a modified Anderson level one and two system with additional level two wetland classifications. The contributions of each of these land types to the fecal coliform loading of Bowie Creek was considered on a subwatershed basis. Table 3.2.1 shows the landuse distribution within each subwatershed in number of acres.

Table 3.2.1 Landuse Distribution in Number of Acres

Subwatershed	Forest	Croplands	Pasture	Urban	Barren	Wetlands	Total
03170004031	25,224	2,453	16,111	0	146	38	**43,972**
03170004030	7,656	1,119	4,798	0	34	6	**13,613**
03170004029	23,473	1,476	13,573	24	92	0	**38,636**
03170004028	19,644	952	8,264	0	6	13	**28,879**
03170004027	48,965	2,825	16,892	482	234	40	**69,437**
03170004023	34,749	2,205	9,819	3,246	1,125	3,756	**54,900**
All Watersheds	**159,710**	**11,030**	**69,457**	**3,752**	**1,636**	**3,853**	**249,437**

The nonpoint fecal coliform contribution from each landuse was estimated using the latest information available. The MARIS landuse data for Mississippi was utilized by the BASINS model to extract landuse sizes, populations, agriculture census data, and other information. MDEQ contacted several agencies to refine the assumptions made in determining the fecal coliform loading. The Mississippi Department of Wildlife, Fisheries, and Parks provided information on wildlife density in the Bowie Creek Watershed. The Mississippi State Department of Health was contacted regarding the failure rate of septic tank systems in this portion of the state. Mississippi State University researchers provided information on manure application practices and loading rates for hog farms and cattle operations. The Natural Resources Conservation Service also gave MDEQ information on manure treatment practices and land application of manure.

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 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 do not typically receive the maintenance needed for proper, long-term operation. These systems require some disinfection to properly operate. When this expense is ignored, the water does not receive adequate disinfection prior to release.

3.2.2 Wildlife

Wildlife present in the Bowie Creek watershed contribute to fecal coliform bacteria on the land surface. In the Bowie Creek model, all wildlife was accounted for by considering contributions from deer. Estimates of deer population were designed to account for the deer combined with all of the other wildlife contributing to the area. It was assumed that the wildlife population remained constant throughout the year, and that wildlife were present on all land classified as pastureland, cropland, and forest. It was also assumed that the wildlife and the manure produced by the wildlife were evenly distributed throughout these land types.

3.2.3 Land Application of Hog and Cattle Manure

In the Pascagoula Basin of Mississippi, processed manure from confined hog and dairy cattle operations is collected in lagoons and routinely applied to pastureland during the months of April through October. This manure is a potential contributor of bacteria to receiving waterbodies due to runoff produced during a rain event. Hog farms in the Pascagoula Basin operate by either keeping the animals confined by or allowing hogs to graze in a small pasture or pen. For this model, it was assumed that all of the hog manure produced by either farming method was applied evenly to the available pastureland.

The dairy farms that are currently operating in the Bowie Creek watershed only confine the animals for a limited time during the day. The model assumed a confinement time of four hours per day, during which time the cattle are milked and fed. During all other times, dairy cattle are allowed to graze on pasturelands. The manure collected during confinement is applied to the available pastureland in the watershed. Like the hog farms, manure produced by confined dairy cattle is applied to pastureland during the months of April through October.

3.2.4 Grazing Beef and Dairy Cattle

Grazing cattle deposit manure on pastureland where it is available for wash-off and delivery to receiving waterbodies. Beef cattle have access to pastureland for grazing all of the time. However, dairy cattle can spend four hours per day confined in milking barns, and the remainder of their time grazing on pastureland. Manure produced by grazing beef and dairy cows is directly deposited onto pastureland.

3.2.5 Land Application of Poultry Litter

There is a considerable number of chickens produced in Simpson, Jefferson Davis, Lamar, Covington, Jones, and Forrest Counties each year. In these counties, poultry farming operations use houses in which chickens are confined all of the time. The litter produced by the chickens is collected and is routinely applied as a fertilizer to pastureland in the watershed in the months of April to October.
Predominately, two kinds of chickens are raised on farms in the Pascagoula Basin, broilers and layers. For the broiler chickens, the amount of growth time from when the chicken is born to when it is sold off the farm is approximately 48 days or 1.6 months. Layer chickens remain on farms for

10 months or longer. More than 93% of the chickens raised in this area are broilers. For the model, a weighted average of growth time was determined to account for both types of chickens. An average growth time of 52 days, or one-seventh of a year, was used. To determine the number of chickens on farms on any given day, the yearly population of chickens sold was divided by seven.

3.2.6 Cattle Contributions Directly Deposited Instream

Cattle often have direct access to flowing and intermittent streams which run through pastureland. These small streams are tributaries of larger streams. Fecal coliform bacteria deposited in these streams by grazing cattle are modeled as a direct input of bacteria to the stream. Due to the general topography in the Bowie Creek watershed, it was assumed that all land slopes in the watershed are such that cattle are able to access the intermittent streams in all pastures. In order to determine the amount of bacteria introduced into streams from cattle, it was assumed that all grazing cattle spent three percent of their time standing in the streams. Thus, the model assumes that three percent of the manure produced by grazing beef and dairy cows is deposited directly in the stream.

3.2.7 Urban Development

Even though only a small percentage of the watershed is classified as urban, the contribution of the urban areas to fecal coliform loading in Bowie Creek was considered. Pollution sources from urban areas come from storm water runoff, runoff from construction sites, and runoff contribution from improper disposal of materials such as household toxic materials and litter.

4.0 MODELING PROCEDURE: LINKING THE SOURCES TO THE ENDPOINT

Establishing the relationship between the instream water quality target and the source loadings is a critical component of TMDL development. It allows for the evaluation of management options that will achieve the desired source load reductions. The link can be established though a range of techniques, from qualitative assumptions based on sound scientific principles to sophisticated modeling techniques. 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 Modeling Framework Selection

The BASINS model platform and the NPSM model were used to predict the significance of fecal coliform sources to fecal coliform levels in the Bowie Creek watershed. BASINS is a multipurpose environmental analysis system for use in performing watershed and water quality-based studies. A geographic information system (GIS) provides the integrating framework for BASINS and allows for the display and analysis of a wide variety of landscape information such as landuses, monitoring stations, point source discharges, and stream descriptions. The NPSM model simulates nonpoint source runoff from selected watersheds, as well as the transport and flow of the pollutants through stream reaches. A key reason for using BASINS as the modeling framework is its ability to integrate both point and nonpoint sources in the simulation, as well as its ability to assess instream water quality response.

4.2 Model Setup

The Bowie Creek TMDL model includes the impaired section of the creek as well as all the watersheds which are upstream of the impaired segment. Thus, all upstream contributors of bacteria are accounted for in the model. To obtain a spatial variation of the concentration of bacteria along Bowie Creek, the watershed was divided into six subwatersheds in an effort to isolate the major stream reaches of Bowie Creek. This allowed the relative contribution of point and nonpoint sources to be addressed within each subwatershed.

Okatoma Creek, a major tributary of Bowie Creek, was modeled separately and then added to the Bowie Creek model in reach 03170004023. This input allows the model to assess Okatoma Creek's contribution to the hydrology and fecal coliform loading in the lower reaches of Bowie Creek. The Okatoma Creek input was added to the model with both the existing loading conditions and also after the load reduction scenario was applied. The fecal coliform load reduction scenario for Okatoma Creek included a 50% reduction in failing septic tanks, a 65% reduction in cow's access to streams, and required all NPDES permitted facilities to meet water quality standards for disinfection.

4.3 Source Representation

Both point and nonpoint sources were represented in this model. Due to die-off rates and overland transportation assumptions, the fecal coliform loadings from point and nonpoint sources must be addressed separately. There are 12 NPDES permitted facilities in the watershed which discharge fecal coliform bacteria. The discharge was added as a direct input into the appropriate reach of the waterbody. Fecal coliform loading rates for point sources are input to the model as flow in cubic feet per second and fecal coliform contribution in counts per hour. The nonpoint sources are represented in the model with two different methods. The first of these methods is a direct fecal coliform loading to Bowie Creek. Other sources are represented as an application rate to the land in the Bowie Creek watershed. For these sources, fecal coliform accumulation rates in counts per acre per day were calculated for each subwatershed on a monthly basis and input to the model for each landuse. Fecal coliform contributions from forests and wetlands were considered at the same time, and all forest and wetland contributions were combined for model input. Urban and barren areas were combined and input into the model in the same manner.

Appendix A contains the Fecal Coliform Spreadsheet developed for quantifying point and nonpoint sources of bacteria for the Bowie Creek model. This spreadsheet calculates the model inputs for fecal coliform loading due to point and nonpoint sources using assumptions about land management, septic systems, farming practices, and permitted point source contributions. Each of the potential bacteria sources are covered in the fecal coliform spreadsheet. The spreadsheet also contains a reference page which lists the literature references used to generate the fecal coliform loading rates.

4.3.1 Failing Septic Systems

The number of failing septic systems used in the model was derived from the watershed area normalized population of Simpson, Jefferson Davis, Lamar, Covington, Jones, and Forrest Counties. The percentage of the population on septic systems, which was determined from 1990 United States Census Data, is given in Table 4.3.1. Based on the best available information, a failure rate of 40% was assumed. This information was used to calculate the estimated number of failing septic tanks per watershed. The number of failing septic tanks also incorporates an estimate for the failing onsite wastewater treatment systems in the area.

Table 4.3.1 Percent of Population on Septic Systems, by County

County	Simpson	Jefferson Davis	Lamar	Jones	Covington	Forest
Percent On Septic Systems	64%	80%	53%	53%	73%	24%

Discharges from failing septic systems were quantified based on several factors including the estimated population served by the septic systems, an average daily discharge of 100 gallons per person per day, and a septic system effluent fecal coliform concentration of 10^4 counts per 100 ml. The model inputs for flow and fecal coliform concentration from failing septic tanks are shown in Appendix A.

4.3.2 Wildlife

Based on information provided by the Mississippi Department of Wildlife, Fisheries, and Parks, the deer population throughout the Bowie Creek watershed was estimated to be 30 to 45 animals per square mile. For the model, the upper limit of 45 deer per square mile was used to account for the deer and all other wildlife contributing to fecal coliform accumulation in the area. The wildlife contribution in counts per acre per day is calculated by multiplying a loading rate by the number of animals. The loading rate used in the model was estimated to be 5.00E+08 counts per day per animal. The loading rates for each subwatershed are available in Appendix A.

4.3.3 Land Application of Hog and Cattle Manure

The fecal coliform spreadsheet was used to estimate the amount of waste and the concentration of fecal coliform bacteria contained in hog and dairy cattle manure produced by confined animal feeding operations. The livestock count per county is based upon the 1997 Census of Agriculture data. The county livestock count is used to estimate the number of livestock on a subwatershed scale. This is calculated by multiplying the county livestock figures with the area of the county within the subwatershed boundaries. This estimate is made with the assumption that the livestock are uniformly distributed throughout the county. A fecal coliform production rate in counts per day per animal was multiplied by the number of confined animals to quantify the amount of bacteria produced. The manure produced by these operations is collected in lagoons and applied evenly to all pastureland. Manure application rates to pastureland vary on a monthly basis. This monthly variation is incorporated into the model by using monthly loading rates. The fecal coliform loading rates for land application of hog and liquid dairy manure are shown in Appendix A.

4.3.4 Grazing Beef and Dairy Cattle

The model assumes that the manure produced by grazing beef and dairy cattle is evenly spread on pastureland throughout the year. The fecal coliform content of manure produced by grazing cattle is estimated by multiplying the number of grazing cattle by a fecal coliform production of 5.40E+09 counts per day per animal (Metcalf and Eddy, 1991). The resulting fecal coliform loads are in the units of counts per acre per day. The fecal coliform loading rates due to grazing cattle are shown in the spreadsheet in Appendix A.

4.3.5 Land Application of Poultry Litter

The fecal coliform spreadsheet estimates the concentration of bacteria which accumulates in the dry litter where poultry waste is collected. This is done by multiplying the daily number of chickens on farms by a fecal coliform production rate in counts per day per animal given in Metcalf & Eddy, 1991. The model assumed a watershed area normalized chicken population. The chicken population was determined from the 1997 Census of Agriculture Data for the number of chickens sold from each county per year. Litter application to pastureland varies monthly, and is modeled with a monthly loading rate. The fecal coliform loading rates from poultry litter application are shown in Appendix A.

4.3.6 Cattle Contributions Deposited Directly Instream

The contribution of fecal coliform from cattle to a stream is represented as a direct input into the stream by the model. In order to estimate the point source loading produced by grazing beef and dairy cattle with access to streams, it is assumed that three percent of the number of grazing cattle in each subwatershed are standing in a stream at any given time. When cattle are standing in a stream, their fecal coliform production is estimated as flow in cubic feet per second and a concentration in counts per hour. As shown in Appendix A, the fecal coliform concentration is calculated using the number of cows in the stream and a bacteria production rate of 5.40E+09 counts per animal per day (Metcalf and Eddy, 1991).

4.3.7 Urban Development

The MARIS landuse data divide urban land into several categories. For the Bowie Creek watershed, the urban land is divided into three different categories, high density, low density, and transportation. For the model, fecal coliform buildup rates for each category were determined by using literature values from Horner, 1992. The literature value accounts for all of the potential fecal coliform sources in each urban category. The literature values for each urban landuse category are given in Table 4.3.3. Table 4.3.4 shows the urban landuse distribution within each subwatershed. In the model, fecal coliform loading rates on urban land are input as counts per acre per day. These loading rates for each watershed are shown in Appendix A.

Table 4.3.3 Urban Loading Rates, by Landuse

High Density Area	Low Density Area	Transportation Area
1.54E+07	1.03E+07	2.00E+05

Table 4.3.4 Urban Landuse Distribution

Subwatershed	High Density Area (acres)	Low Density Area (acres)	Transportation Area (acres)	Total
03170004031	23	66	57	**146**
03170004030	5	15	13	**34**
03170004029	18	52	45	**115**
03170004028	1	3	2	**6**
03170004027	115	322	279	**716**
03170004023	699	1,967	1,705	**4,371**
All Watersheds	**862**	**2,425**	**2,101**	**5,388**

4.4 Stream Characteristics

The stream characteristics given below describe the entire modeled section of Bowie Creek. This section begins at the headwaters and ends 10 miles downstream of the monitored reach, at the confluence of Bowie River and Leaf River. The channel geometry and lengths for Bowie Creek are based on data available within the BASINS modeling system. The 7Q10 flow is was determined from USGS data. The characteristics of the modeled section of Bowie Creek are as follows.

·	Length	41 miles
·	Average Depth	1.49 ft
·	Average Width	78.76 ft
·	Mean Flow	453.03 cubic ft per second
·	Mean Velocity	1.47 ft per second
·	7Q10 Flow	100.51 cubic ft per second
·	Slope	0.00049 ft per ft

4.5 Selection of Representative Modeling Period

The model was run for 12 years, from January 1, 1984 through December 31, 1995. The first year of data were used to stabilize the model. Results from the model were evaluated for the time period from January 1, 1985, until December 31, 1995. Because the 11-year time span is used, a margin of safety is implicitly applied. Seasonality and critical conditions are accounted for during the extended time frame of the simulation.

The critical condition for fecal coliform impairment from nonpoint source contributors occurs after a heavy rainfall which 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 11-year time period, many such occurrences are captured in the model results. Critical conditions for point sources, which occur during low flow and low dilution conditions, are simulated as well.

4.6 Model Calibration Process

The hydrological model had a continuous USGS gage available on Bowie Creek near Hattiesburg for comparison with the modeled flow in reach 03170007027 of Bowie Creek. A set of input values for hydrologic parameters established for the Pascagoula Basin as a means of calibration and validation of the hydrology. Samples of these results are included in Appendix B, Graph B-1a and Graph B-1b. Modeled output and actual gage data are shown on the same graph for selected years. There is a good correlation between the two data sets.

Several assumptions were made to determine the fecal coliform loading rates from the nonpoint source contributors. Many of these assumptions were incorporated into the fecal coliform spreadsheet. An extensive effort was made by MDEQ to contact researchers and agricultural experts to give as much validity as possible to the assumptions made within the BASINS model.

4.7 Existing Loadings

Appendix B includes two graphs of the model results showing the instream fecal coliform concentrations for the monitored segment of Bowie Creek, 03170007027. Graph B-2 shows the fecal coliform levels in the stream during the 11-year modeling period. The graph shows a 30-day geometric mean of the data. There have been 25 standards violations in 11 years according to the model. The straight line at 200 counts per 100 ml indicates the water quality standard for the stream. Graph B-3 shows the 30-day geometric mean of the fecal coliform levels after the reduction scenario has been modeled. The scale matches the previous graph for comparison purposes. The graph indicates that there are no violations of the water quality standard after the reduction scenario was applied.

5.0 ALLOCATION

This TMDL involves a wasteload allocation for point sources and a load allocation for nonpoint sources necessary for attainment of water quality standards in segment MS084M and drainage areas MS081BE, MS084E, MS085E, MS082E, MS081SE, and MS083E. Point and nonpoint source fecal coliform contributions enter the stream in the appropriate reach. The fecal coliform sources used in the model have two different transportation methods. NPDES Permitted dischargers, cows in the stream, and failing septic tanks were modeled as direct inputs to the stream. The other nonpoint source contributions were applied to land area on a counts per day per acre basis. The fecal coliform bacteria applied to land are subject to a die-off rate and an absorption rate before entering the stream.

5.1 Wasteload Allocations

Point sources within the watershed discharging at their current level are subject to some reduction from their current fecal coliform contribution. The contribution of point sources was considered on a subwatershed basis for the model. Within each subwatershed, the modeled contribution of each discharger was based on the facility’s discharge monitoring data and other records of past performance. In several cases, the fecal coliform contribution from a facility is much greater than the permitted limit of 200 counts per100 ml. As part of this TMDL, all facilities will be required to meet water quality standards at end of pipe. All wastewater treatment facilities should take steps to comply with their current NPDES Permits. Table 5.1.1 lists contributions from NPDES dischargers, on a subwatershed basis, along with their existing load, allocated load, and percent reduction. Several of the subwatersheds do not contain any NPDES permitted discharges, and are not included in the table.

Table 5.1.1 NPDES Permitted Sources

Subwatershed	Existing Flow (cfs)	Existing Load (counts/hr)	Allocated Flow (cfs)	Allocated Load (counts/hr)	Percent Reduction
03170004029	0.001	1.89E+05	0.001	1.89E+05	**0%**
03170004027	0.043	1.76E+07	0.043	8.82E+06	**50%**
03170004023	4.092	5.97E+09	4.092	8.32E+08	**86%**
Total	**4.136**	**5.99E+09**	**4.136**	**8.41E+08**	**86%**

5.2 Load Allocations

Nonpoint sources which contribute to fecal coliform accumulation within the Bowie Creek watershed are subject to reduction from their current level of contribution. This TMDL involves reductions of two different types of nonpoint sources: cattle access to streams and septic tanks. Contributions from both of these sources are input directly into the modeled waterbodies with a flow and fecal coliform concentration in counts per hour. Table 5.2.1 lists the nonpoint source contributions due to cattle access to streams, on a subwatershed basis, along with their existing load, allocated load, and percent reduction. Table 5.2.2 gives the same parameters for contributions due to septic tank failure. The septic tank failures in reality are both point and nonpoint source contributions and have been calculated as equal contributors to the WLA and the LA component of the TMDL calculation.

Table 5.2.1 Fecal Coliform loading rates for cattle access to streams

Subwatershed	Existing Flow (cfs)	Existing Load (counts/hr)	Allocated Flow (cfs)	Allocated Load (counts/hr)	Percent Reduction
03170004031	7.46E-04	1.97E+10	1.87E-04	4.92E+09	**75%**
03170004030	2.77E-04	7.31E+09	6.93E-05	1.83E+09	**75%**
03170004029	6.90E-04	1.82E+10	1.72E-04	4.54E+09	**75%**
03170004028	5.85E-04	1.54E+10	1.46E-04	3.85E+09	**75%**
03170004027	1.17E-03	3.09E+10	2.93E-04	7.71E+09	**75%**
03170004023	4.04E-04	1.07E+10	1.01E-04	2.66E+09	**75%**
Total	**2.87E-03**	**1.02E+11**	**9.68E-04**	**2.55E+10**	**75%**

Table 5.2.2 Fecal Coliform loading Rates for failing septic tanks

Subwatershed	Existing Flow (cfs)	Existing Load (counts/hr)	Allocated Flow (cfs)	Allocated Load (counts/hr)	Percent Reduction
03170004031	1.37E-01	1.39E+09	6.84E-02	6.96E+08	**50%**
03170004030	4.24E-02	4.31E+08	2.12E-02	2.16E+08	**50%**
03170004029	1.20E-01	1.22E+09	6.01E-02	6.12E+08	**50%**
03170004028	8.99E-02	9.15E+08	4.49E-02	4.57E+08	**50%**
03170004027	2.16E-01	2.20E+09	1.08E-01	1.10E+09	**50%**
03170004023	1.71E-01	1.74E+09	8.55E-02	8.69E+08	**50%**
Total	**7.76E-01**	**7.91E+09**	**3.88E-01**	**3.95E+09**	**50%**

Nonpoint fecal coliform loadings due to cattle grazing; land application of manure produced by confined dairy cattle, hogs, and poultry; wildlife; and urban development are also included in the load allocation. Currently, no reduction is required for these contributors in order for Bowie Creek to achieve water quality standards. Table 5.2.3 shows the number of fecal coliform bacteria applied to land, available for land surface runoff, in counts per day. The application rates in this table are given for each landuse type on a subwatershed basis.

The loading rates are constant throughout the year for forest, cropland, and urban land. The loading rates for pastureland vary for each month. However, in the table, the given rate is based on an average of the monthly application rates. Monthly accumulation rates for pastureland are shown in the fecal coliform spreadsheet in Appendix A.

Table 5.2.3 Number of Bacteria Applied to Land, Available for Surface Runoff, in Counts per Day

Subwatershed	Urban and Barren	Forest and Wetland	Cropland	Pastureland	Total
03170004031	1.05E+09	8.89E+11	8.63E+10	2.62E+13	**2.72E+13**
03170004030	2.44E+08	2.70E+11	3.94E+10	7.72E+12	**8.02E+12**
03170004029	8.26E+08	8.26E+11	5.20E+10	1.87E+13	**1.95E+13**
03170004028	4.31E+07	6.92E+11	3.35E+10	1.62E+13	**1.69E+13**
03170004027	5.14E+09	1.72E+12	9.94E+10	3.22E+13	**3.40E+13**
03170004023	3.14E+10	1.36E+12	7.76E+10	1.28E+13	**1.42E+13**
Total	**3.87E+10**	**5.76E+12**	**3.88E+11**	**1.14E+14**	**1.20E+14**

The scenario chosen for the load allocation in the Bowie Creek watershed is a 75% reduction in contributions from cows in the stream, and a 50% reduction from failing septic tanks. The scenario also requires all permitted dischargers to meet water quality standards for disinfection. This scenario could be achieved by supporting BMP projects that promote fencing around streams in pastures, and by supporting education projects that encourage homeowners to properly maintain their septic tanks by routinely pumping them out, repairing broken field lines, and disinfecting the effluent from individual onsite wastewater treatment plants.

5.3 Incorporation of a Margin of Safety

The two types of MOS development are to implicitly incorporate the MOS using conservative model assumptions or to explicitly specify a portion of the total TMDL as the MOS. The MOS selected for this model is implicit. The primary component of the MOS is provided by running the model for 11 years with no violations of the water quality standard. Ensuring compliance with the standard throughout all of the critical condition periods represented during the 11 years is a conservative practice. Another component of the MOS is the conservative assumption that in the model all of the fecal coliform bacteria discharged from failing septic tanks reaches the stream, while it is likely that only a portion of the bacteria will reach the stream due to filtration and die off during transport.

5.4 Seasonality

For many streams in the state, fecal coliform limits vary according to the seasons. The monitored segment of Bowie Creek, however, is designated for the use of contact recreation. For this use, the pollutant standard is constant throughout the year.

Because the model was established for an 11-year time span, it took into account all of the seasons within the calendar years from 1985 to 1995. The extended time period allowed the simulation of many different atmospheric conditions such as rainy and dry periods and high and low temperatures. It also allowed seasonal critical conditions to be simulated.

6.0 IMPLEMENTATION

6.1 Follow-Up Monitoring

MDEQ has adopted the Basin Approach to Water Quality Management, a plan which divides Mississippi's major drainage basins into five groups. During each year-long cycle, MDEQ resources for water quality monitoring will be focused on one of the basin groups. During the next monitoring phase in the Pascagoula Basin, Bowie Creek may receive follow-up monitoring to identify the improvement in water quality from the implementation of the strategies in this TMDL.

6.2 Reasonable Assurance

The fecal coliform reduction scenario used in this TMDL includes requiring all NPDES permitted dischargers of fecal coliform to meet water standards for disinfection, along with reducing 75% of the cattle access to streams and 50% of the failing septic tanks in the watershed. Reasonable assurance for the implementation of the TMDL has been considered for both point and nonpoint source contributors. The TMDL will not impact existing or future NPDES permits as long as the effluent is disinfected to meet water quality standards for fecal coliform bacteria. Permits for constructing wastewater treatment plants without the proper disinfection equipment are not recommended for approval by this TMDL. Also, this TMDL should not effect the growth of animal operations or the continued installation of septic tanks in the Bowie Creek watershed as long as they are both properly maintained. Education projects which 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.

6.3 Public Participation

This TMDL will be published for a 30-day public notice in August, 1999. During this time, the public will be notified by publication in the statewide newspaper and a newspaper in Forrest County. The public will be given an opportunity to review the TMDL and submit comments on the TMDL. 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 hearing.

If a public hearing is deemed appropriate, the public will be given a 30-day notice of the hearing at a location near the watershed. That public hearing would be an official hearing of the Mississippi Commission on Environmental Quality, and would be transcribed.

All comments received during the public notice period and at any public hearings become a part of the record of this TMDL. All comments will be considered in the ultimate approval of this TMDL by the Commission on Environmental Quality and for submission of this TMDL to EPA Region Four 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 30th 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 a unknown cause of impairment.

[illegible]

[illegible]

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 becomes surface runoff and either drains into surface waters or soaks into the soil and finds its way into ground water. 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.

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

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.
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.

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, Version 3

USGS .... United States Geological Survey

WLA .... Waste Load Allocation

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APPENDIX A

The following documents comprise the spreadsheet used to estimate all of the fecal coliform loadings used in the model. The spreadsheet consists of several sheets, each dealing with a different aspect of the estimation. The final sheet brings all of the inputs into one format for model input.

APPENDIX B

This appendix contains printouts of the various model run results. Graphs B-1a and B-1b show the modeled flow, in cfs, through reach 03170004027 compared to the USGS gage readings from Bowie Creek near Hattiesburg, gage 02472500. The graphs show data from selected years of the modeled period, 01/01/1986-12/31/1986 and 01/01/1990-12/31/1990. The second set of graphs show the 30-day geometric mean for fecal coliform concentrations in counts per 100 ml in the impaired section of Bowie Creek, reach 03170004027. Both graphs represent an 11-year time period, from 01/01/1985, to 12/31/1995. The graphs contain a reference line at 200 counts per 100 ml. Graph B-2 represents the existing fecal coliform loading in Bowie Creek. There are 25 violations of the fecal coliform standard on this graph. Graph B-3 represents the conditions in Bowie Creek after the reduction scenario has been applied. Graphs B-2 and B-3 are shown with the same scale for comparison purposes.