FINAL REPORT
December 1999
ID: 499121504

Fecal Coliform TMDL for Okatoma Creek Pascagoula River Basin Mississippi

Prepared By

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

December 15, 1999

MDEQ
PO BOX 10385
Jackson MS 39289-0385
(601) 961-5171

CONTENTS

MONITORED SEGMENT IDENTIFICATION

Name:	Okatoma Creek
Waterbody ID:	MS080O2M
Location:	At Seminary: from confluence of Kelly Creek above Seminary to Sanford
Counties:	Covington, Simpson
USGS HUC Code	03170004
NRCS Watershed	080
Length:	11.6 miles impaired on 303(d) list
Use Impairment:	Contact Recreation
Cause Noted:	Pathogens (Fecal Coliform)
Priority Rank:	34
NPDES Permits:	MS0002089, MS0024911, MS0023761, MS0020699, MS0024872
Standards Variance:	N/A
Pollutant Standard:	Fecal coliform colony counts shall not exceed a geometric mean of 200 counts/100ml nor shall more than 10 percent of the samples examined during any month exceed a colony count of 400 counts/100ml.
Waste Load Allocation:	1.53E+12 counts/30 days (The TMDL requires all dischargers to meet water quality standards for disinfection.)
Load Allocation:	15.1E+12 counts/30 days
Margin of Safety:	Implicit: conservative modeling assumptions
Total Maximum Daily Load (TMDL):	16.7E+12 counts/30 days (Combination of point source loadings, direct input from cattle with access to streams and failing septic systems, and loadings from land surface runoff necessary to meet the fecal coliform standard.)

EVALUATED SEGMENT IDENTIFICATION

Name:	Okatoma Creek DA
Waterbody ID#:	MS080O1E
Location:	Drainage area from the headwaters by Magee to the confluence of Blakley Creek near Collins
Counties:	Covington, Simpson
USGS HUC Code	03170004
NRCS Watershed	080
Size:	140mi^2
Use Impairment:	Secondary Contact Recreation
Cause Noted:	Pathogens (Fecal Coliform)
Priority Rank:	Low
NPDES Permits:	MS0024911, MS0020699
Standards Variance:	N/A
Pollutant Standard:	*May through October* - geometric mean of 200 counts/100 ml, Not more than ten percent of samples exceed 400 counts/100ml. *November through April* - geometric mean of 2000 counts/100 ml, Not more than ten percent of samples exceed 4000 counts/100 ml.
Waste Load Allocation:	6.71E+11 counts/30 days (The TMDL requires all dischargers to meet water quality standards for disinfection.)
Load Allocation:	87.8E+11 counts/30 days
Margin of Safety:	Implicit: conservative modeling assumptions
Total Maximum Daily Load (TMDL):	94.5E+11 counts/30 days (Combination of point source loadings, direct input from cattle with access to streams and failing septic systems, and loadings from land surface runoff necessary to meet the fecal coliform standard.)

EVALUATED SEGMENT IDENTIFICATION

Name:	Okatoma Creek DA
Waterbody ID#:	MS080O2E
Location:	Drainage area from confluence of Blakley Creek near Collins to confluence with Bowie River at Lux
Counties:	Covington, Jones, Smith
USGS HUC Code	03170004
NRCS Watershed	080
Size:	114 mi^2
Use Impairment:	Secondary Contact Recreation
Cause Noted:	Pathogens (Fecal Coliform)
Priority Rank:	Low
NPDES Permits:	MS0002089, MS0024911, MS0023761, MS0020699, MS0024872
Standards Variance:	N/A
Pollutant Standard:	*May through October* - geometric mean of 200 counts/100 ml, Not more than ten percent of samples exceed 400 counts/100ml. *November through April* - geometric mean of 2000 counts/100 ml, Not more than ten percent of samples exceed 4000 counts/100 ml.
Waste Load Allocation:	8.62E+11 counts/30 days (The TMDL requires all dischargers to meet water quality standards for disinfection.)
Load Allocation:	63.5E+11 counts/30 days
Margin of Safety:	Implicit: conservative modeling assumptions
Total Maximum Daily Load (TMDL):	72.1E+11 counts/30 days (Combination of point source loadings, direct input from cattle with access to streams and failing septic systems, and loadings from land surface runoff necessary to meet the fecal coliform standard.)

EXECUTIVE SUMMARY

A segment of Okatoma Creek is included on the 303(d) list for not supporting its contact recreation designated use. Pathogens are the cause of impairment over this 11.6 mile reach from Seminary to Sanford. Additionally, MDEQ has identified drainage areas of the Okatoma Creek as being evaluated for the presence of fecal coliform bacteria. The purpose of this TMDL is to restore and maintain the quality of this waterbody through the establishment of allowable loads for fecal coliform.

For this study, the fecal coliform standard for contact recreation of 200 counts/100mL (monthly average) is the targeted endpoint to evaluate impairment and establish the TMDL for the reach from Seminary to Lux. The secondary contact recreation fecal coliform standard of 200 counts/100mL during summer months and 2,000 counts/100mL during winter months are the targeted endpoints for the remaining Okatoma reaches and tributaries. Because fecal coliform contributions to Okatoma Creek can be contributed by both point and nonpoint sources, the critical condition is represented by a multi-year period of wet and dry weather. Water quality monitoring data for the impaired segment of the Okatoma reveal a 30 percent violation rate over the most recent five year period (1/94 – 12/98).

The TMDL evaluation summarized in this report examines all potential sources of fecal coliform in the Okatoma Creek Watershed. This source assessment is used as the basis of developing the model and analyzing the TMDL allocation options. The point sources in the watershed include municipal waste treatment facilities and industrial and commercial dischargers. The nonpoint sources of fecal coliform include failing septic systems, wildlife, land application of hog and cattle manure, grazing animals, land application of poultry litter, cattle contributions directly deposited instream, and urban runoff.

The BASINS model platform and the NPSM model are used to predict the significance of fecal coliform sources and fecal coliform levels in the watershed. To obtain a spatial variation of the concentration of bacteria in Okatoma Creek, the watershed is divided into three subwatersheds. The weather data used for the model were collected at Meridian for the hydrologic period of January 1, 1985 through December 31, 1995.

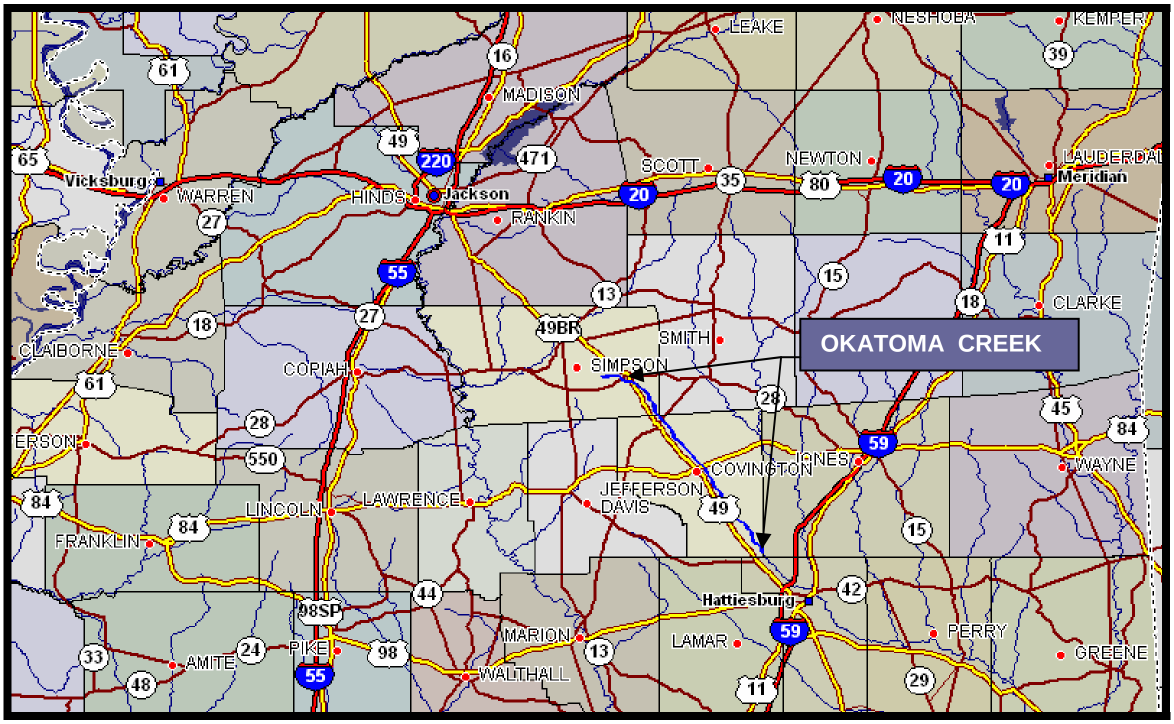
Total maximum daily loads (TMDL) are composed of the sum of individual waste load allocations (WLA) for point sources, load allocations (LA) for nonpoint sources, and a margin of safety (MOS). Reductions are allocated for two point sources, Magee POTW and Mount Olive POTW. Nonpoint surface loadings based on land use do not significantly impact the fecal coliform loadings in Okatoma Creek. These nonpoint sources include wildlife, land application of hog, cattle and chicken waste, cattle and hog grazing, and urban development. Model results indicate that the nonpoint sources of cattle in streams and failing septic systems are the primary contributors of fecal coliform bacteria to the creek. The scenarios chosen for these two sources to achieve adequate reduction in fecal loading is a 75 percent reduction in contributions from cattle in the stream and a 50 percent reduction from failing septic systems.

1. 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 bacteria. Fecal coliform concentrations in natural waters are used as indicators of potential pathogen contamination. The purpose of the TMDL is to establish water quality based controls to reduce pollution from both point and nonpoint sources, and to restore and maintain the quality of water resources.

FIGURE 1.1 AREA MAP



As summarized in Table 1.1, the segment of Okatoma Creek starting at the confluence of Kelly Creek above Seminary and ending at Sanford is included on the 1998 Section 303(d) List of Waterbodies for not supporting its contact recreation designated use. Pathogens are the cause of impairment over this 11.6 mile monitored segment. This segment, shown in Figure 1.2 is one of the most popular for canoeing and kayaking in the state.

Also, MDEQ has identified the entire drainage area of the Okatoma Creek as being evaluated for the presence of fecal coliform bacteria. It is divided into two areas, MS080O1E and MS080O2E as reported in the Mississippi 1998 Section 303(d) List of Waterbodies. MS080O1E begins at the headwaters north of Magee and extends to the confluence of Blakley Creek near Collins.

MS080O2E begins at the confluence of Blakley Creek and ends at the confluence of Okatoma Creek with Bowie River. These areas are listed as evaluated because the data available in the watershed is insufficient to show a definite impairment caused by fecal coliform bacteria. Both evaluated sections are shown in Figure 1.3.

Table 1-1. 303d Listed Waterbodies Within the Okatoma Creek Watershed

Waterbody Name	*State Waterbody ID*	*Assessment type*	*Size*	*County*	*Use Impaired*	*Cause*
Okatoma Creek	MS080O2M	Monitored	12 mi NS	Covington	Contact Recreation	Pathogens
Location - At Seminary (HWY 590) from confluence of Kelly Creek above Seminary to Sanford.						
Okatoma Creek DA	MS080O1E	Evaluated	140 mi^2	Covington Simpson	Secondary Contact Recreation	Pathogens
Location - Drainage area from the headwaters by Magee to the confluence of Blakley Creek near Collins						
Okatoma Creek DA	MS080O2E	Evaluated	114 mi^2	Covington Jones Smith	Secondary Contact Recreation	Pathogens
Location - Drainage area from confluence of Blakley Creek near Collins to confluence with Bowie River at Lux						

Okatoma Creek lies within the Pascagoula River Basin Hydrologic Unit Code (HUC) 03170004, located in southeastern Mississippi (Figure 1.1). The river drains an area of approximately 254 square miles and lies within portions of Covington, Forrest and Simpson Counties. The watershed is divided into three subwatersheds: 3170004024 representing lower Okatoma Creek, 3170004025 representing Blakley Creek, and 3170004026 representing upper Okatoma Creek (Figure 1.3). The watershed is sparsely populated with small urban areas including Collins, Magee, Mount Olive, and Seminary. Most of the landuse is forest and pasture land.

Table 1.2 Landuse Distribution in Okatoma Watershed

Watershed ID	**3170004024**		**3170004025**		**3170004026**		**Watershed Totals**	
Landuse	*acre*	*percen.*	*acre*	*percen.*	*acre*	*percen.*	*acre*	*percen.*
Barren & Other	188	0.3%	0	0.0%	137	0.2%	**325**	**0.2%**
Cropland	1650	2.7%	461	4.2%	3207	3.6%	**5318**	**3.3%**
Forest	40163	64.8%	6814	62.3%	54551	60.7%	**101528**	**62.3%**
Pasture	18173	29.3%	3662	33.5%	29741	33.1%	**51576**	**31.7%**
Urban	1476	2.4%	0	0.0%	2131	2.4%	**3607**	**2.2%**
Water	341	0.5%	6	0.1%	149	0.2%	**496**	**0.3%**
Wetlands	33	0.1%	0	0.0%	16	0.0%	**49**	**0.0%**
Total	**62024**	100.0%	**10943**	100.0%	**89932**	100.0%	**162899**	**100.0%**

The Okatoma Creek Watershed lies within the Long-leaf Pine Hills physiographical region. The Long-leaf Pine Hills are characterized by rolling to moderately rugged hills underlain by the Vicksburg Group and the Catahoula, Hattiesburg, Pascagoula, and Citronelle Formations. The altitude of the land surface within the watershed ranges from just over 600 feet above sea level to approximately 210 feet at the downstream limits of Okatoma Creek. Land surface slopes range from nearly level (zero to three percent) to moderately sloped (three to five percent).

1.2 WATERBODY DESIGNATED USE

Designated beneficial uses and water quality standards are established by the State of Mississippi in the *Water Quality Criteria for Intrastate, Interstate and Coastal Waters* regulations. The designated use for Okatoma Creek from Seminary to Lux as specified by the regulations is Contact Recreation. The designated use for the remainder of Okatoma Creek as specified by the regulations is Secondary Contact Recreation.

1.3 APPLICABLE WATER QUALITY STANDARDS

The water quality standard applicable to the use of the waterbody and the pollutant of concern is listed in Table 1.3 as defined by the *State of Mississippi Water Quality Criteria for Intrastate, Interstate, and Coastal Waters* regulations.

Table 1.3 State of Mississippi Water Quality Criteria for Intrastate, Interstate, and Coastal Waters

Parameter	***Beneficial use***	***Water Quality Criteria***
Fecal Coliform	Contact Recreation	Fecal coliform shall not exceed a geometric mean of 200 counts/ 100 ml, nor shall more than ten percent of the samples examined during any month exceed 400 counts/100 ml.
	Secondary Contact Recreation	May through October - Fecal coliform shall not exceed a geometric mean of 200 counts/100 ml, nor shall more than ten percent of the samples examined during any month exceed 400 counts/100 ml. November through April - fecal coliform shall not exceed a geometric mean of 2000 counts/100 ml, nor shall more than ten percent of the samples examined during any month exceed 4000 counts/100 ml.

Figure 1.2

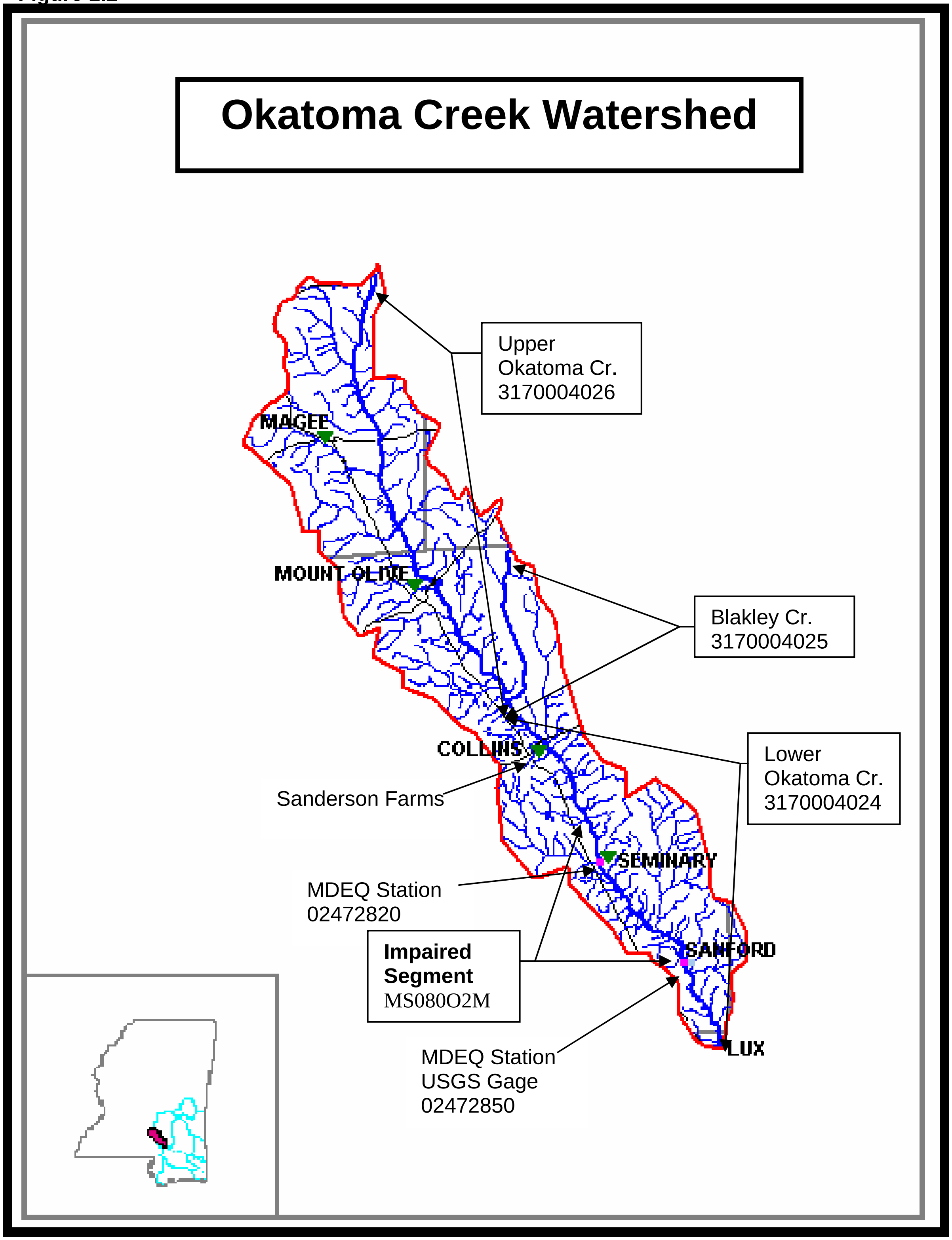
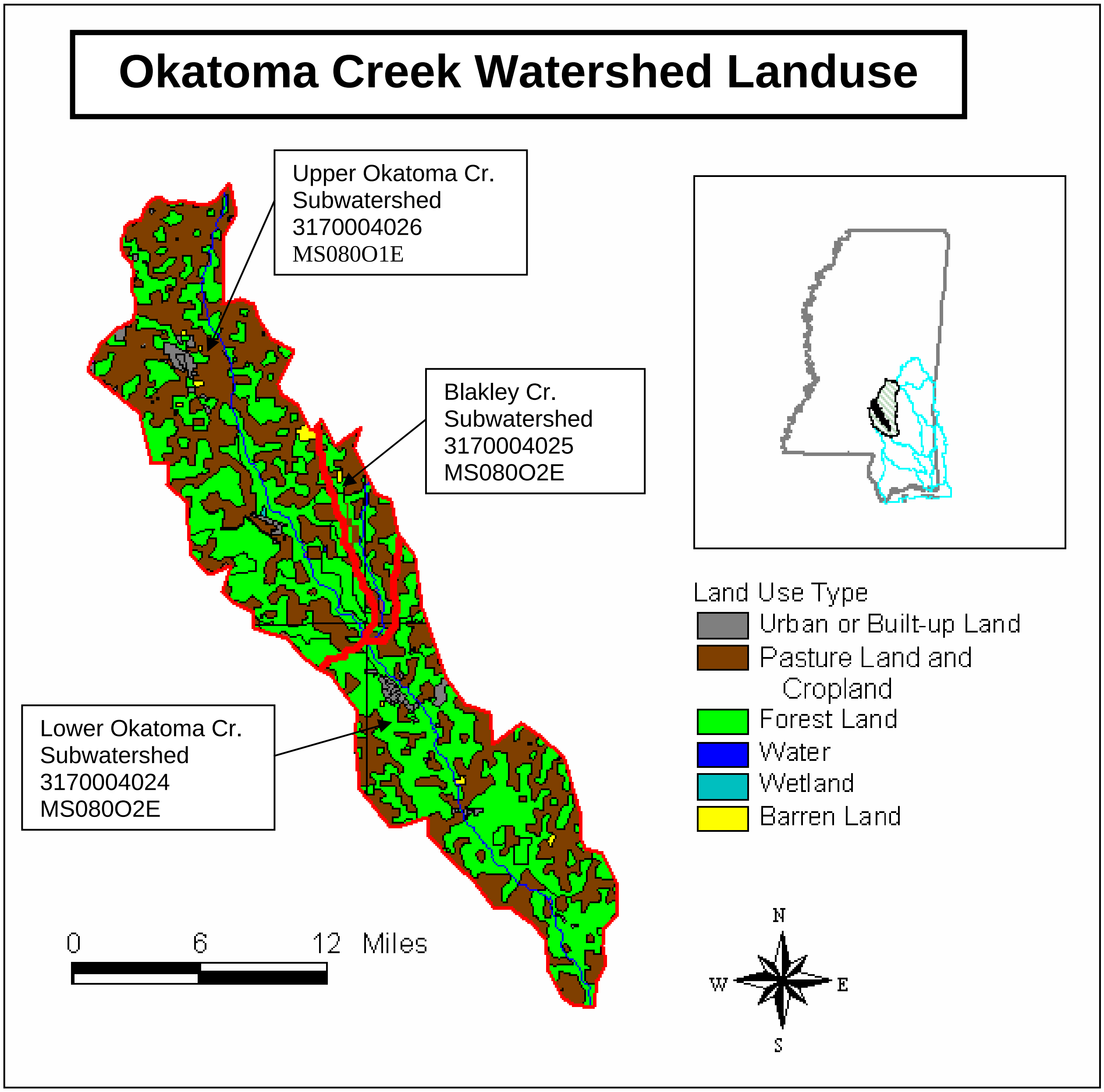

Okatoma Creek Watershed
Upper
Okatoma Cr.
3170004026
MAGEE
MOUNT OLIVE
Blakley Cr.
3170004025
COLLINS
Lower
Okatoma Cr.
3170004024
Sanderson Farms
SEMINARY
MDEQ Station
02472820
Impaired
Segment
MS080O2M
SANFORD
LUX
MDEQ Station
USGS Gage
02472850

Figure 1.3 Okatoma Creek Watershed Landuse



2. 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 reductions specified in the TMDL. The endpoints allow for a comparison between observed instream conditions and conditions that are expected to restore designated uses. For this TMDL, the fecal coliform 30-day geometric mean standard for contact recreation is the targeted endpoint to evaluate impairment and establish the TMDL for the reach from Seminary to Lux, and the fecal coliform 30-day geometric mean standard for secondary contact recreation is the targeted endpoint for the remaining Okatoma reaches and tributaries.

Because fecal coliform contributions may be attributed to both nonpoint and point sources, the critical condition used for the modeling and evaluation of stream response is 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. However, 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 is selected as representing critical conditions associated with all potential sources of fecal coliform bacteria within the watershed.

2.2 DISCUSSION OF INSTREAM WATER QUALITY

According to the State's 1998 Section 305(b) Water Quality Assessment Report, Okatoma Creek is not supporting the use of contact recreation. This conclusion is based on instantaneous data collected at station 02472820 from 1992 to 1997. Data collected at this station and at station 02472850 is summarized and analyzed in the following sections.

2.2.1 Inventory of Water Quality Monitoring Data

There are two MDEQ stations on the Okatoma where water quality data has been collected—one is located at Seminary and the other is at Sanford.

Table 2.1 MDEQ Station Data Inventory

STATION	*LOCATION*	*FREQUENCY*	*STATUS*	*DATE*
02472820	Seminary	approx. bimonthly (6/yr)	inactive	8/80-9/97*
02472850	Sanford	monthly	active	12/96-Present

* no samples taken in 1987, only one in 1989

Fecal coliform samples collected from station 02472820 were analyzed using the Membrane Filter Method from 8/80 through 9/88, and the Most Probable Number Method from 11/88 through 9/97. Samples collected from station 02472850 were analyzed using the Membrane Filter Method.

2.2.2 Analysis of Instream Water Quality Monitoring Data

Water quality monitoring data are analyzed to evaluate conditions and trends within the Okatoma Creek Watershed, as well as to identify violations of state water quality standards. Statistical summaries of the parameters of concern for Okatoma Creek and related water quality parameters at selected stations are presented in Table 2.2. The statistical summaries are based on available STORET data from the year 1980 to the most recently available data.

Table 2.2 MDEQ Station Data Analysis

Station	*Param. Code*	*Parameter*	*Samples*	*Min*	*Max*	*Mean*	*Median*	*Standard Deviation*
02472820	31613	Fecal Coliform, membr Filter,m-fc Agar,44.5c,24hr	51	5	60,000	2073	167	8479
02472820	31615	Fecal Coliform, mpn,ec Med,44.5c (Tube 31614)	43	40	8,000	941	220	1618
02472850	31616	Fecal Coliform, membr Filter,m-fc Broth,44.5 C	23	29	3,600	521	110	925

The two monitoring stations, 02472820 and 02472850, are within the impaired segment of Okatoma Creek (Figure 1.2). Station 02472820 is a long term monitoring station while sampling at station 02472850 started in 1996. Comparisons of the in-stream water quality data with regulatory standards are presented in Table 2.3. This analysis is based on available data from the most recent five year period (1994-1998).

Table 2.3 Analysis of Violations

	400/100ml SAMPLE			
STATION	*NUMBER OF SAMPLES*	*NUMBER OF VIOLATIONS*	*PERCENT EXCEEDANCE*	*PERIOD OF RECORD*
2472820	17	6	35%	1/94-9/97
2472850	23	6	26%	12/96-12/98

The samples are compared to the instantaneous maximum standard of 400 counts/100mL because sampling was conducted either monthly or bimonthly (Table 2.1). Figures 2.1 and 2.2 contain graphical analyses of the instream water quality data.

Regarding the graphs, peaks of fecal coliform above 400 counts/100mL occur during periods of both high flow and low-flow conditions. This reinforces the need for the model to consider fecal contributions from point as well as non-point sources. The vertical grid lines in Figures 2.1 and 2.2 represent seasonal boundary dates (May 1 and October 31).

Figure 2.1 Data from MDEQ Station 02472820

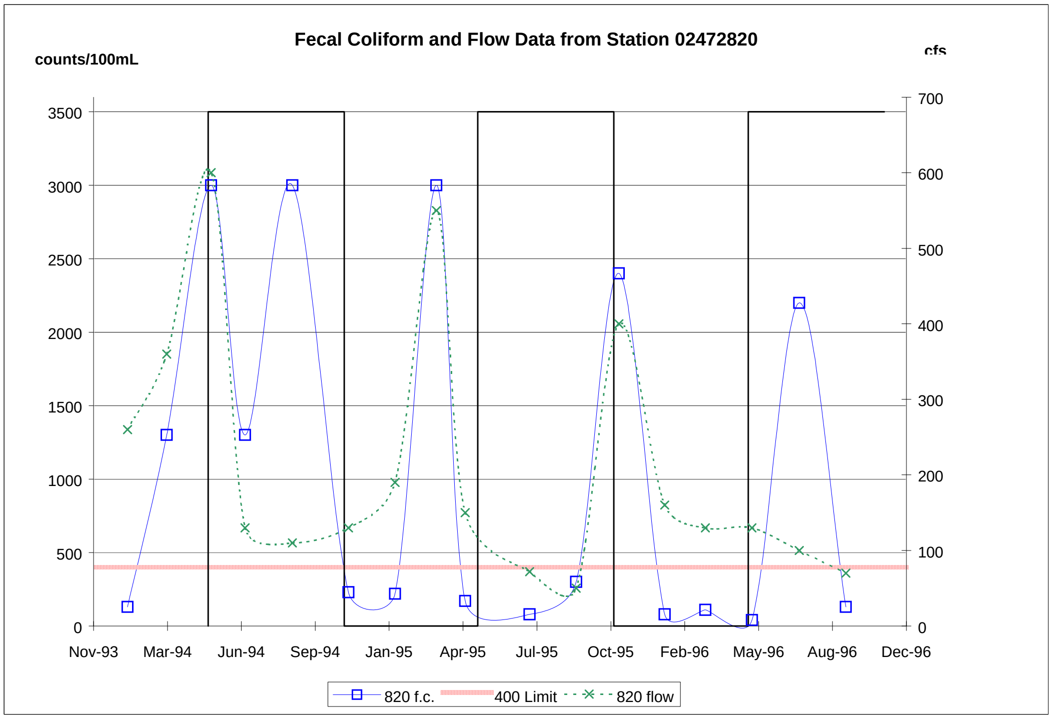
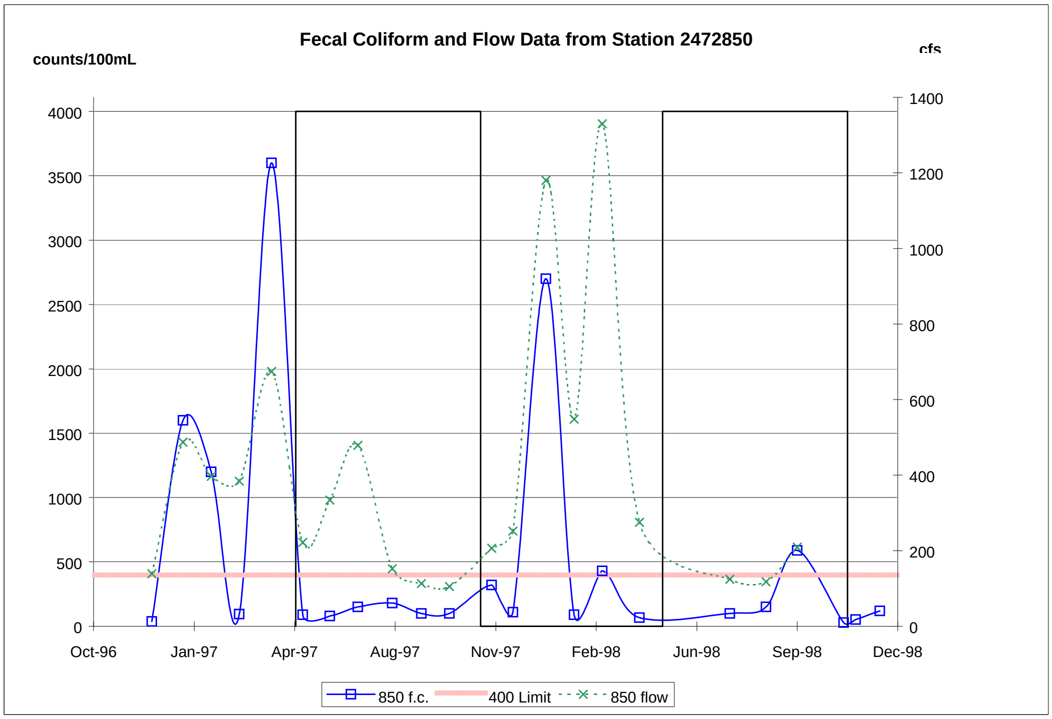


Figure 2.2 Data from MDEQ Station 02472850



3. SOURCE ASSESSMENT

The TMDL evaluation summarized in this report examines all known potential sources of fecal coliform in the Okatoma Creek Watershed. The source assessment is used as the basis of development of the model and ultimate analysis of the TMDL allocation options. In evaluation of the sources, loads are characterized by the best available information, literature values, and local management activities. This section documents the available information and interpretation for the analysis. The source assessment chapter is organized into point and nonpoint sections. The representation of the following sources in the model is discussed in Section 4.0, Modeling Procedure: Linking the Sources to the Endpoint.

3.1 ASSESSMENT OF POINT SOURCES

The point sources in the Okatoma Creek Watershed include municipal waste facilities and industrial and commercial dischargers. Municipal and Industrial facilities located in the watershed which have potential for appreciable discharge of fecal coliforms are listed in Table 3.1. The table lists permitted flow and fecal coliform concentrations as compiled from the Permit Compliance System (PCS) database:

Table 3.1 Permitted Facilities

Name	*NPDES ID*	*Discharge Stream*	*Q*	*Q*	*F.C.-Av.*	*F.C.-Av.*
			MGD	*cfs*	*counts/ 100mL*	*counts/day*
Sanderson Farms	MS0002089	Okatoma Creek	1.84	2.85	200/2000	1.39E+10 /1.39E+11
Magee POTW	MS0024911	Goodwater Creek	0.45	0.70	no limit	no limit
Collins POTW	MS0023761	Okatoma Creek	0.40	0.62	200	3.02E+09
Mount Olive POTW	MS0020699	Town Creek	0.15	0.23	200/20500	1.13E+09 /1.16E+11
Seminary POTW	MS0024872	Okatoma Creek	0.12	0.19	200	9.07E+08

The Collins Publicly Owned Treatment Works (POTW) and Seminary POTW both have fecal concentration average limits of 200 counts/100mL year-round. The Mount Olive POTW and Sanderson Farms processing facility have limits that vary seasonally. The Mount Olive POTW has a 200 counts/100mL average limit in the summer months (May-Oct.), and a 20,500 counts/100mL limit in the winter months (Nov.-April). Sanderson Farms has a 200 counts/100mL average limit in the summer months and a 2,000 counts/100mL average limit in the winter months. All 200 counts/100mL and 2,000 counts/100mL average limits imply 400 counts/100mL and 4,000 counts/100mL instantaneous limits respectively. Mount Olive's winter instantaneous limit is 41,000 counts/100mL. The Magee POTW has no permitted limitation on the fecal coliform concentration of its effluent. This was granted by MDEQ in 1993 after an Instream Bacteria Monitoring Study was performed by the city in 1992.

The following table contains statistics of fecal coliform levels from the effluent of the five facilities:

Table 3.2 DMR Data from Permitted Facilities

Name	**Sanderson Farms**		**Magee POTW**	**Collins POTW**	**Mt. Olive POTW**		**Seminary POTW**
Date Range of Samples	1/93 - 10/98		3/86 - 8/92	3/93 - 6/98	9/97 - 10/98		3/93 - 3/99
Season	summer	winter	all year	all year	summer	winter	all year
Total no. of Months sampled	34	35	2	21	8	6	24
Minimum	2	2	16000	20	5	1	6
Maximum	19	412	24450	95	60000	92000	24000
Median	2	2	20225	20	1245	825	20
Mean	3	19	20225	29	12397	20277	1496
S.D.	4	69	5975	20	22040	36834	4963
No. of Months in Violation	0	0	2	0	4	2	4
% Violations	0%	0%	100%	0%	50%	33%	17%

Sanderson Farms and Collins POTW report consistently low fecal coliform counts. Mount Olive POTW reports consistently high levels with a 50 percent violation rate and a median of 1245 counts/100mL in summer months. Seminary's median level of 20 counts/100mL and 17 percent violation rate suggest its levels are normally low, but its mean of 1496 counts/100mL indicates high peaks when violations do occur.

Industrial and commercial facilities with no potential for appreciable fecal coliform discharge in the watershed include:

Table 3.3 Permitted Facilities Not Considered in TMDL

Amerada Hess	MS0045381	Exxon	MS0044628	Southeast Wood Fiber	MS0054224
Hazclean Env.	MS0053864	Chevron	MS0039934	T&M Terminal Co.	MS0047627
Rutland Lumber	MS0044288	Covington Hardwood	MS0028312	Louis Dreyfus Energy	MS0021245

3.2 ASSESSMENT OF NONPOINT SOURCES

The nonpoint sources of fecal coliform pollution include every fecal contributor that does not have a localized point of release into a stream. In the Okatoma watershed these sources are:

- Failing septic systems
- Wildlife
- Land application of hog and cattle manure
- Grazing animals

- Land application of poultry litter
- Cattle contributions directly deposited instream
- Urban runoff

The contributions from each of these sources are estimated using the latest information available. MDEQ has contacted several agencies to refine the data assumptions made in determining the fecal loading. One of these is the Mississippi Department of Wildlife, Fisheries, and Parks, who provided an estimate of the concentration of deer in this section of Mississippi. 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 valuable information on manure application practices and loading rates for hog farms and cattle operations. The National Resources Conservation Service (NRCS) also gave MDEQ information on manure treatment practices and loading rates for the manure.

The location and amplitude of these loads are related to the different land uses in the watershed. The source of land use cover data utilized in this TMDL is the State of Mississippi's Automated Resource Information System (MARIS), 1996. This data set is based on Landsat Thematic Mapper digital images taken in 1997. This classification is based on a modified Anderson level one and two system. The MARIS land use categories are condensed into the categories in Table 3.4. Each subwatershed consists mainly of forest land (60 percent) and pasture land (30 percent). The next highest percentage is cropland at about 3 percent.

Table 3.4 Landuse Distribution in Subwatersheds

Watershed ID	**3170004024**		**3170004025**		**3170004026**		**Watershed Totals**	
Landuse	*acre*	*percen.*	*acre*	*percen.*	*acre*	*percen.*	*acre*	*percen.*
Barren & Other	188	0.3%	0	0.0%	137	0.2%	**325**	**0.2%**
Cropland	1650	2.7%	461	4.2%	3207	3.6%	**5318**	**3.3%**
Forest	40163	64.8%	6814	62.3%	54551	60.7%	**101528**	**62.3%**
Pasture	18173	29.3%	3662	33.5%	29741	33.1%	**51576**	**31.7%**
Urban	1476	2.4%	0	0.0%	2131	2.4%	**3607**	**2.2%**
Water	341	0.5%	6	0.1%	149	0.2%	**496**	**0.3%**
Wetlands	33	0.1%	0	0.0%	16	0.0%	**49**	**0.0%**
Total	**62024**	100.0%	**10943**	100.0%	**89932**	100.0%	**162899**	**100.0%**

3.2.1 Failing Septic Systems

Septic systems provide the potential to deliver fecal coliform bacteria loads to surface waters due to malfunctions, failures, and direct pipe discharges. Properly operating septic systems treat the wastewater and dispose of the water through a series of underground field lines. The water is applied through these field 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. The septic water reaches the surface and is then available for wash-off into the stream. Another related potential fecal source is the occurrence of direct bypasses to streams. In efforts to keep wastewater from seeping up in a drain field, pipes are sometimes laid from the septic tanks or the field lines to the nearest creek.

Another consideration is the use of individual onsite wastewater treatment plants, which are widely used in Mississippi. They can adequately treat wastewater if properly maintained. However, the systems do not typically receive the attention needed for proper long-term operation. They require some sort of disinfection to properly operate. This step is often ignored by homeowners, and the water does not receive adequate disinfection prior to release.

The number of failing septic systems is derived from the watershed area normalized count of septic systems in each county (1997 estimates based on 1990 U.S. Census). Of these, it is estimated that 40 percent are currently failing. This number also incorporates estimates for direct bypasses and estimates for failing onsite wastewater treatment systems in the watershed.

Table 3.4 Septic Systems in Subwatersheds

Watershed	*1997 Est. Population*	*Population on Septic Systems*	*No. of Septic Systems*	*Estimated No. of Failing Septic Systems*
3170004024	4121	3008	1074	430
3170004025	639	472	169	67
3170004026	5815	4115	1470	588

3.2.2 Wildlife

Wildlife present in the Okatoma Creek Watershed contribute fecal coliform bacteria onto the land surface where it is available for wash-off during a rain event. In the Okatoma Creek model, all wildlife is accounted for by considering contributions from deer. The deer population is estimated to be 30 to 45 animals per square mile for this area. The upper limit of 45 deer per square mile has been chosen to account for the deer and all of the other wildlife present in the area. It is assumed that the wildlife population remains constant throughout the year, and that wildlife are present on all land classified as forest land, pastureland, cropland, and wetlands. It is also assumed that the wildlife are evenly distributed throughout the aforementioned landuse types.

3.2.3 Land Application of Hog and Cattle Manure

In the Pascagoula Basin processed manure from confined hog and dairy cattle operations is collected in lagoons and applied to pastureland during certain months of the year. 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 or allowing them to graze in small pastures or pens. For this model, it is assumed that all of the hog manure produced by either farming method is applied evenly to the available pastureland. Application rates of hog manure to pastureland from confined operations vary monthly according to management practices currently used in the area.

As can be seen from Table 3.5, the cattle operations are almost exclusively beef cattle. There are very few dairy farms operating in the watershed. In those farms, the cows are only confined for a limited period each day, during which time they are being milked and fed. This is estimated to be four hours per day for each cow. The percentage of manure collected during confinement is applied to the available pastureland in the watershed. Like the hog farms, application rates of dairy cow manure to pastureland vary monthly according to management practices currently used in this area.

Data sources for confined feeding operations include the Census of Agriculture and the Mississippi Agricultural Statistics Service (MASS) which is one of 45 state offices of the U.S. Department of Agriculture's National Agricultural Statistics Service (NASS). 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 percent of the county within the subwatershed boundaries. This estimate is made with the assumption that the livestock are uniformly distributed throughout the county.

Table 3.5 Agricultural Animals in Subwatersheds

WATERSHED	*BEEF COWS*	*DAIRY COWS*	*HOGS*	*CHICKENS SOLD*
3170004024	4,870	40	70	2,485,800
3170004025	770	10	20	774,300
3170004026	5,800	110	1,150	7,484,500
TOTAL	**11,440**	**160**	**1,240**	**10,744,600**

3.2.4 Grazing Animals

Cattle, including beef and dairy, spend time grazing on pastureland, depositing manure containing fecal coliform bacteria onto the land surface. During a rain event, a portion of this fecal matter is available for wash-off and delivery to receiving waterbodies. A proportion of hogs in the Okatoma watershed also spend time on pastureland depositing manure onto the land surface.

In this region of the state, there is no monthly variation in beef and dairy cattle access to the pastures. Therefore, it is assumed that their loading rates are equal throughout the year. Beef cattle spend all of their time in pasture, while dairy cattle are confined for a limited period each day. They are being milked and fed during this time, which is estimated to be four hours per day for each cow. The percentage of manure deposited during their grazing time is applied to the available pastureland in the watershed.

3.2.5 Land Application of Poultry Litter

Like hog and cattle manure, poultry litter in this region of the state is applied only to pastureland and not to cropland. It is also a potential contributor of pathogens to streams in the watershed when a rain event washes a portion of it to a receiving waterbody. It is assumed that all of the poultry litter from chicken houses is applied evenly to the available pastureland. While there are some alternative uses of poultry litter, such as utilization as cattle feed, almost all of the litter in the state is used as fertilizer.

Predominantly 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 ten months or longer. Approximately 96 percent of the chickens raised in the watershed are broilers. For the model, a weighted average of growth time is determined to account for both types of chickens. An average growth time of 52 days, or 1/7 of a year, is used. To determine the number of chickens on farms on any given day, the yearly population of chickens sold is divided by seven.

3.2.6 Cattle Contributions Deposited Directly Instream

Cattle often have direct access to small streams which run through pastureland. 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 Okatoma Creek Watershed, it is assumed that all bank slopes in the watershed are such that cattle are able to access the streams in the pastures. In order to determine the amount of bacteria introduced into streams from cattle, it is assumed that all grazing cattle spend five 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

Municipalities in the watershed include the cites of Magee and Mount Olive located in the Upper Okatoma, and Collins and Seminary located in the Lower Okatoma watershed (Figure 1.2). Pathogen contributions from urban areas may come from storm water runoff through stormwater sewers (e.g. residential, commercial, industrial, road transportation), illicit discharges of sanitary wastes, and runoff contribution from improper disposal of waste materials. Failures of sewer and septic systems and subsequent migration with stormwater runoff is also a potentially significant source. Urban land use is represented in Table 3.4 under the “Urban” and “Barren” categories.

4. 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 are used to predict the significance of fecal coliform sources and fecal coliform levels in the Okatoma 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 land uses, monitoring stations, point source discharges, and stream descriptions. The NPSM model simulates nonpoint source runoff from the selected watershed, 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 source simulation, as well as its ability to assess instream water quality response.

4.2 MODEL SETUP

To obtain a spatial variation of the concentration of bacteria in Okatoma Creek, the watershed is divided into three subwatersheds in an effort to isolate the major stream reaches. This allows analysis to address the relative contribution of sources within each subwatershed to the different segments of the creek. The delineation of the watersheds is based primarily on an analysis of the reach file three (RF3) stream network in the basin as well as the topographic analysis of the watershed. The three subwatersheds are as follows: 3170004024 representing lower Okatoma Creek, 3170004025 representing Blakley Creek, and 3170004026 representing upper Okatoma Creek (Figure 1.3).

4.3 SOURCE REPRESENTATION

Both point and nonpoint sources are represented in the model. Due to die-off rates and overland transportation assumptions, the fecal coliform loadings from point and nonpoint sources must be addressed separately. A fecal coliform spreadsheet has been developed for quantifying point and nonpoint sources of bacteria for the Okatoma 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 is covered in the fecal coliform spreadsheet.

For fecal coliform and flow, very little monthly effluent concentration data exist for the point sources for the modeling period of 1985 to 1995 (Table 3.2). Therefore, flow and fecal coliform loading rates are derived from the monthly average permit limits, with seasonal variations taken into account. The Magee POTW fecal coliform loading rate is derived from the average of its monthly readings.

Table 4.1 Model Loadings for Point Sources

Name	*NPDES ID*	*Season*	*Q*	*F.C.-Av.*	*F.C.-Av.*
			cfs	*counts/ 100mL*	*counts/ day*
Sanderson Farms	MS0002089	summer	2.85	200	1.39E+10
		winter		2000	1.39E+11
Magee POTW	MS0024911	all	0.70	20225	3.44E+11
Collins POTW	MS0023761	all	0.62	200	3.02E+09
Mount Olive POTW	MS0020699	summer	0.23	200	1.13E+09
		winter		20500	1.16E+11
Seminary POTW	MS0024872	all	0.19	200	9.07E+08

The nonpoint sources discussed in Section 3.2 are represented in the model to account for their contributions of fecal coliform either directly to Okatoma Creek or as applied to the land in the Okatoma Creek Watershed. Due to die off rates and transportation assumptions, the two types of nonpoint fecal loadings must be addressed separately. Fecal coliform accumulation rates (counts/acre/day) are calculated for each land use based on all sources contributing fecal coliform to the surface of the land. For example, the fecal coliform accumulation rate for pastureland is the sum of accumulation rates due to litter application, wildlife, processed manure, and grazing animals. Accumulation rates for pastureland are calculated on a monthly basis to account for seasonal variations in manure and litter application.

4.3.1 Failing Septic Systems

Septic system discharges are quantified based on the following information: The number of septic systems in each subwatershed, the estimated population served by the septic systems, an assumed failure rate of 40 percent, an average daily discharge of 100 gallons/person/day, and a septic effluent fecal coliform concentration of 10^4 cfu/100mL. These loads are represented in the model as direct discharges containing the total load from each subwatershed delivered to each corresponding reach (counts/day).

4.3.2 Wildlife

Deer are distributed throughout the watershed with a density of 45 deer/mi^2, as discussed in Section 3.2.2. The fecal coliform loading from the deer is evenly distributed in the model to the forest land, pastureland, cropland, and wetlands. The per animal loading rate used in the model is 5.00E+08 counts/day/deer. The per acre loading rate applied to the landuses is calculated to be 3.52E+07 counts/acre/day.

4.3.3 Land Application of Hog and Cattle Manure

The manure produced by hog and dairy cattle operations is collected in lagoons and applied to pastureland in the Okatoma Creek Watershed, as discussed in Section 3.2.3. It is applied only during the months of April through October, and the rates of application typically vary during those months. This monthly variation is incorporated into the model.

The fecal loading rates of 1.08E+10 counts/day/hog (ASAE) and 5.40E+09 counts/day/cow (Metcalf & Eddy, 1991) are utilized in the model. The per acre loading rates for cow and hog manure on pasture land are shown in Appendix A.

4.3.4 Grazing Animals

The Okatoma Creek Watershed contains beef and dairy cattle and hogs that contribute fecal coliform directly to the land surface during grazing, as discussed in Section 3.2.4. Because there is no monthly variation in animal access to pasture in this region of the state, the fecal loading rate to pasture land does not vary throughout the year. The per animal fecal loading rates of 1.08E+10 counts/day/hog (ASAE) and 5.40E+09 counts/day/cow (Metcalf & Eddy, 1991) are utilized in this TMDL. The per acre loading rates for grazing animals on pasture land are shown in Appendix A.

4.3.5 Land Application of Poultry Litter

Poultry litter is applied to pastureland in the Okatoma Creek Watershed, as discussed in Section 3.2.5. It is applied only during the months of April through October. The fecal loading rate of 6.75E+07 counts/day/chicken (ASAE) is utilized in the model. The counts/acre/day loading rates for poultry litter on pasture land are shown in Appendix A.

4.3.6 Cattle Contributions Deposited Directly Instream

Cattle that have access to streams represent direct contributors of fecal coliform bacteria to the Okatoma and its tributaries. The model assumes a cattle-in-stream rate of three percent as discussed in Section 3.2.6. The fecal loading rate of 5.40E+09 counts/day/cow (Metcalf & Eddy, 1991) is utilized in the model. Loads from cattle in streams are represented in the model as direct discharges containing the total load from each subwatershed delivered to its corresponding reach (counts/day).

4.3.7 Urban Development

Urban land use is represented in Table 3.4 under the "Urban" and "Barren" categories. Due to a lack of fecal loading data for the urban land in the watershed, literature values are used. A single, weighted urban loading value of 7.18E+6 counts/acre/day is quantified for each subwatershed based on individual built-up landuses present and their corresponding loading rates (Table 4.6). These urban landuses are assumed to be 50 percent impervious and 50 percent pervious.

Table 4.6 Sub-Categories of Urban and Barren Landuses

Modeled Land Use Category	***Original Land Use Category***	**3170004024**	**3170004025**	**3170004026**
URBAN	HIGH DENSITY	266	0	363
URBAN	LOW DENSITY	749	0	1021
URBAN	TRANSPORTATION	649	0	885
	total:	**1664**	**0**	**2268**

4.4 STREAM CHARACTERISTICS

The stream characteristics given below describe the entire modeled section of Okatoma Creek. This section begins at the headwaters and ends at the confluence of Bowie Creek. The channel geometry and lengths for Okatoma Creek are based on data available within the BASINS modeling system. The mean flow and 7Q10 flow data are based on historical stream flow data from U.S. Geological Survey's National Water Information System (NWIS) Station 02472850. The characteristics of the modeled section of the creek are as follows.

- Length 51 miles
- Average Depth 1.1 ft
- Average Width 60 ft
- Mean Flow 378 cfs
- Mean Velocity 1.24 f/s
- 7Q10 Flow 90 cfs
- Slope 0.00075

4.5 SELECTION OF REPRESENTATIVE MODELING PERIOD

The modeling period is from 1/1/85 to 12/31/95. The model actually begins running at 1/1/84, but that first year of output data is disregarded to allow for model stabilization. Results from the model are analyzed only for the 11-year time period of 1/1/85 to12/31/95. Because this 11-year time spread is used, a margin of safety is implicitly applied. Also, seasonality is accounted for during the extended time frame.

The critical condition for fecal coliform impairment from nonpoint source contributors is 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 the rainfall. By using the 11-

year time period, many of these washloads are represented in the model. Critical conditions for point sources, which occur during low-flow and low dilution conditions, are simulated as well.

4.6 MODEL CALIBRATION PROCESS

Hydraulic calibration has been achieved by comparing predicted flow to historical flow data from USGS Station 02472850. Some of the factors included in this calibration are groundwater inflow, groundwater storage, evapotranspiration, infiltration capacity of the soil, and length of overland flow. A sample of the results of the calibration is included in Appendix B. Modeled output and actual gage data are shown on the same graph for one of the model years.

Insufficient monitoring data are available for calibration of the water quality model. However, an extensive effort has been 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 a graph of the model results showing the existing fecal coliform 30-day geometric mean concentration in the stream over the 1985 – 1995 modeling period. The model calculates 28 violations of the 200 counts/100mL standard in the 11 year period, or a 37 percent exceedance rate of the standard.

5. ALLOCATION

Total maximum daily loads (TMDL) are composed of the sum of individual waste load allocations (WLA) for point sources, load allocations (LA) for nonpoint sources, and a margin of safety (MOS). This definition is expressed by the equation:

$$TMDL = 3WLA + 3LA + MOS$$

The TMDL is the total amount of a pollutant that can be assimilated by the receiving water while still achieving water quality standards. For most pollutants, TMDLs are expressed on a mass loading basis (e.g., pounds/day). For bacteria, however, TMDLs are expressed in terms of organism counts (counts/day).

Point source contributions, including permitted facilities and a portion of failing septic systems, enter the stream directly in the appropriate reaches. The nonpoint fecal coliform sources in the model have two different transportation methods. Cattle in the stream and the remaining portion of failing septic systems are modeled as direct inputs to the stream. The other nonpoint source contributions are applied to land area on a counts per day per acre basis. The fecal coliform bacteria applied to land is subject to a die-off rate and an absorption rate before it enters the stream.

The TMDL calculated in this report represents the maximum fecal coliform load that can be assimilated by the waterbody segment during the critical 30-day period that will maintain water quality standards. The calculation of this TMDL is based on the critical hydrologic flow condition that occurred during the modeled time span. The TMDL calculation includes the sum of the loads from all identified point and nonpoint sources applied or discharged within the modeled watershed.

An individual TMDL calculation was prepared for the impaired waterbody segment and each monitored evaluated drainage area included in this report. The numerical values for the wasteload allocation (point sources) and load allocation (nonpoint sources) for each waterbody segment or drainage area can be found on the waterbody segment identification pages at the beginning of this report.

5.1 WASTELOAD ALLOCATIONS

Two point sources in the watershed significantly impact the fecal coliform loadings in the stream. As discussed in Section 3.1 the Magee POTW currently has no fecal coliform limits. The resulting fecal concentration of its effluent significantly impacts the fecal coliform load in the stream during low-flow conditions. The recommended allocation for this point source is a 200 counts/100mL summer concentration limit which gives a 3.41E+08 counts/day fecal loading at its peak discharge of 0.45 MGD. The recommended winter allocation is a 2,000 counts/100mL concentration limit which gives a 3.41E+09 counts/day fecal loading at its peak discharge of 0.45 MGD.

Also as discussed in Section 3.1, the Mount Olive POTW has a higher fecal coliform limit during winter months (Nov. - April). This higher limit of 20,500 counts/100mL substantially influences the fecal loading in the creek during periods of low-flow in the winter months of the 11-year modeling period. The recommended allocation for this point source is a 2,000 counts/100mL winter concentration limit which gives a 4.72E+07 counts/day fecal loading for Mount Olive at its peak discharge of 0.45 MGD. The allocations to the Collins POTW, Seminary POTW, and Sanderson Farms Facility are equivalent to their current permit limits.

Table 5.1 Permitted Facility Loading Allocations

				EXISTING LOAD		*ALLOC. LOAD*		
Name	***NPDES ID***	***Season***	***Q***	***F.C.-Av.***	***F.C.-Av.***	***F.C.-Av.***	***F.C.-Av.***	*%*
			cfs	*counts/ 100mL*	*counts/ day*	*counts/ 100mL*	*counts/ day*	*RED.*
Sanderson Farms	MS0002089	summer	2.85	200	1.39E+10	200	1.39E+10	0%
		winter	2.85	2000	1.39E+11	2000	1.39E+11	0%
Magee POTW	MS0024911	summer	0.70	20225	3.44E+11	200	3.40E+09	99%
		winter	0.70	20225	3.44E+11	2000	3.40E+10	90%
Collins POTW	MS0023761	all	0.62	200	3.02E+09	200	3.02E+09	0%
Mount Olive POTW	MS0020699	summer	0.23	200	1.13E+09	200	1.13E+09	0%
		winter	0.23	20500	1.16E+11	2000	1.13E+10	90%
Seminary POTW	MS0024872	all	0.19	200	9.07E+08	200	9.07E+08	0%

The total WLA reported on the waterbody segment identification pages account for loadings from the above listed permitted facilities as well as a portion of the loadings from failing septic systems.

5.2 LOAD ALLOCATIONS

Discussion of load allocations to nonpoint sources is divided into categories of surface loadings from land uses and direct discharges from cows in the stream and septic systems.

Sensitivity analyses reveal that surface loadings based on land use do not significantly impact the fecal coliform loadings in Okatoma Creek. These nonpoint sources include wildlife, land application of hog, cattle and chicken waste, cattle and hog grazing, and urban runoff. The percent reduction in fecal loading for these sources is zero. The data in Table 5.2 represent the fecal coliform loading that is applied to the land surface in the watershed. These loadings are not directly added to the total loading of Okatoma Creek, but are subject to die-off and absorption before they enter the stream. The allocated loads listed in the table do not imply a limitation of future fecal coliform loadings to these landuses. Background conditions are incorporated in the model as loadings from wildlife.

Table 5.2 Nonpoint Surface Loading Allocations

Source	Existing Loads	Allocated Loads	Reduction
	counts/day	counts/day	%
Urban	2.82E+10	2.82E+10	0%
Forest	3.57E+12	3.57E+12	0%
Cropland	1.87E+11	1.87E+11	0%
Pasture	1.36E+14	1.36E+14	0%
Total	**1.39E+14**	**1.39E+14**	0%

The nonpoint sources modeled as direct discharges are cattle in streams and failing septic systems. Sensitivity analyses of the model reveal these to be significant sources of fecal coliform bacteria to Okatoma Creek.

Table 5.3 Cattle in Streams Loading Allocations

		Existing Load	Allocated Load	Percent Reduced
Subwatershed	Flow	Fecal Coliform	Fecal Coliform	
	(cfs)	(counts/day)	(counts/day)	
3170004024	0.0004	7.95E+11	1.99E+11	75%
3170004025	0.0001	1.26E+11	3.16E+10	75%
3170004026	0.0005	9.55E+11	2.39E+11	75%
Total	0.0010	**1.88E+12**	**4.69E+11**	75%

Table 5.4 Septic Systems

		Existing Load	Allocated Load	Percent Reduced
Subwatershed	Flow	Fecal Coliform	Fecal Coliform	
	(cfs)	(counts/day)	(counts/day)	
3170004024	0.063	4.37E+10	2.18E+10	50%
3170004025	0.011	7.75E+09	3.87E+09	50%
3170004026	0.091	6.36E+10	3.18E+10	50%
Total	0.165	**1.15E+11**	**5.75E+10**	50%

The scenario chosen for these two sources to achieve adequate reduction in fecal loading is a 75 percent reduction in contributions from cows in the stream and a 50 percent reduction from failing septic systems. This scenario can be achieved for the cattle in streams loading by supporting BMP projects that promote fencing around streams in pastures. The 50 percent reduction of fecal coliform loadings from failing septic systems can be attained by extending sewerage systems, and by supporting education projects that encourage homeowners or properly maintain their septic tanks by routinely pumping them out and repairing broken field lines. Stopping direct bypasses and requiring owners of individual onsite treatment plants to disinfect would also contribute to the reduction.

The impact of the wasteload and load allocations on the instream fecal coliform bacteria concentration of the impaired segment of Okatoma Creek can be seen in the time-series plot presented in Appendix B.

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 requiring no violations of the water quality standard over the entire 11-year modeling period. 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 all of the fecal coliform bacteria discharged from failing septic tanks reach 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

Seasonal variation is explicitly included in the modeling approach for this TMDL. Fecal coliform accumulation rates for animal manure application are determined on a monthly basis for pasture land. Also, seasonality in the permit limits of certain point sources is represented in the model. Lastly, the use of continuous simulation modeling considers the seasonal aspects of rainfall patterns and temperature. Seasonality is considered in the reduction allocations for point sources which discharge into stream segments with seasonal fecal coliform standards.

6. 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 are focused on one of the basin groups. During the next monitoring phase in the Pascagoula Basin, Okatoma Creek may receive follow-up monitoring to identify the improvement in water quality from the implementation of the strategies in this TMDL. Additionally, flow and fecal coliform samples will continue to be taken monthly at MDEQ Station 02472850.

6.2 REASONABLE ASSURANCE

Table 6.1 lists the facilities for which a restriction in permitted limits is allocated and the expiration dates of current permits. The TMDL will not restrict future NPDES permits which disinfect to meet water quality standards for fecal coliform bacteria.

Table 6.1 NPDES Permit Expiration Dates

Name	NPDES ID	Permit Exp. Date
Magee POTW	MS0024911	09/08/2002
Mount Olive POTW	MS0020699	11/12/2002

All reductions in nonpoint fecal loadings addressed in the TMDL are contingent upon the voluntary actions of the landowners and homeowners in the watershed. MDEQ is working within the Basin Approach to Water Quality Management to educate the public on the importance of nonpoint source pollution management. In order to encourage their participation, educational projects funded under Section 319 of the Clean Water Act can be utilized to teach best management practices.

6.3 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. 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 to be held 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 IV for final approval.

DEFINITIONS

Ambient stations: 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 amount of contaminant load that can be discharged to a specific stream or river without violating the provisions of the *State of Mississippi Water Quality Criteria for Intrastate, Interstate, and Coastal Waters and Water Quality* regulations. Assimilative capacity is used to define the ability of a waterbody to naturally absorb and use waste matter and organic materials without impairing water quality or harming aquatic life.

Background: the condition of waters in the absence of 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 waterbody or on historical least impaired data.

Best management practices: methods, measures, or practices that are determined to be reasonable and cost-effective means for a land owner to meet certain, generally nonpoint source, pollution control needs. BMPs include structural and nonstructural controls and operation and maintenance procedures.

Calibration: testing and tuning of a model to a set of field data. Also includes minimization of deviations between measured field conditions and output of a model by selecting appropriate model coefficients.

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

Discharge monitoring report: report of effluent characteristics submitted by a facility that has been granted an NPDES Permit.

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: municipal sewage or industrial or commercial liquid waste (untreated, partially treated, or completely treated).

Fecal coliform bacteria: a group of bacteria that normally reside within the intestines of mammals, including humans. Fecal coliform bacteria are used as indicators of the presence of pathogens 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.

Impairment: the condition in which the applicable state water quality standards are not met for a waterbody and the designated use is impaired.

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 cattle 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.

Margin Of Safety (MOS): a required component of the TMDL that accounts for the uncertainty about the relationship between the pollutant load and the quality of the receiving waterbody.

Nonpoint source pollution: pollution that is 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 groundwater. This surface water may contain pollutants that come from land use activities such as agriculture, construction, silviculture, surface mining, disposal of watewater, hydrologic modifications, and urban development.

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

Point source pollution: 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) : municipal wastewater treatment plant owned and operated by a public governmental entity such as a town or city.

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:

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

STORET: EPA national water quality database for STORage and RETrieval (STORET). The database includes physical, chemical, and biological data measured in waterbodies throughout the United States.

Storm runoff: rainfall that does not evaporate or infiltrate the ground because of impervious land surfaces or a soil infiltration rate lower than rainfall intensity, but instead flows into adjacent land or waterbodies or is routed into a drain or sewer system.

Total Maximum Daily Load (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.

Water quality criteria: water quality criteria comprise numeric and narrative criteria. Numeric criteria are scientifically derived ambient concentrations developed by EPA or states for various pollutants of concern to protect human health and aquatic life. Narrative criteria are statements that describe the desired water quality goal.

Water quality standards: a law or regulation that consists of the beneficial designated use or uses of a waterbody, the numeric and narrative water quality criteria that are necessary to protect the use or uses of that particular waterbody and an antidegradation statement.

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: a part of the land area enclosed by a topographic divide from which direct surface runoff from precipitation normally drains by gravity into a receiving water. Also referred to as drainage basin, river basin, or hydrologic unit.

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
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
PCS	Permit Compliance System
RF3	Reach File Three
USGS	United States Geological Survey
WLA	Waste Load Allocation

REFERENCES

ASAE, 1998. ASAE (American Society of Agricultural Engineers) Standards, 45th Edition, Standards Engineering Practices Data.

Horner, 1992. Water Quality Criteria/Pollutant Loading Estimation/Treatment Effectiveness Estimation. In R.W. Beck and Associates. Covington Master Drainage Plan. King County Surface Water Management Division, Seattle, WA.

Horsley & Whitten, Inc. 1996. Identification and Evaluation of Nutrient Bacterial Loadings to Maquoit Bay, Brunswick, and Freeport, Maine. Casco Bay Estuary Project.

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

MDEQ. 1995. *State of Mississippi Water Quality Criteria for Intrastate, Interstate, and Coastal Waters*.Office of Pollution Control.

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

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.

APPENDIX A: FECAL COLIFORM LOADINGS TO PASTURE LAND

Table A-1 reports the fecal coliform loading rates (counts/acre/day) applied to pastureland in each subwatershed for each month.

APPENDIX B: GRAPHICAL REPRESENTATION OF MODEL OUTPUT

This appendix contains printouts of various model run results. Graph B-1 shows the results of the hydraulic calibration by comparing the modeled flow at the end of reach 3170004024 with the actual flow measured at USGS Gage #02472850. Graph B-2 displays the modeled existing instream fecal coliform concentration during the modeling period. Graph B-3 shows the instream fecal concentration after allocations are applied.

The TMDL calculated in this report represents the maximum fecal coliform load that can be assimilated by the waterbody segment during the critical 30-day period that will maintain water quality standards. The calculation of this TMDL is based on the critical hydrologic flow condition that occurred during the modeled time span. Graph B-3, which shows the 30-day geometric mean of instream fecal coliform concentrations representing the allocated loading scenario, was used to identify the critical condition. The TMDL calculation includes the sum of the loads from all identified point and nonpoint sources applied or discharged within the modeled watershed.

An individual TMDL calculation was prepared for the impaired waterbody segment and each monitored evaluated drainage area included in this report. The numerical values for the wasteload allocation (point sources) and load allocation (nonpoint sources) for each waterbody segment or drainage area can be found on the waterbody segment identification pages at the beginning of this report.