FINAL REPORT
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Fecal Coliform TMDL for the Back Bay of Biloxi and Biloxi Bay

Coastal Streams Basin

Harrison and Jackson Counties, Mississippi

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FOREWORD

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

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

Prefixes for fractions and multiples of SI units

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

Conversion Factors

To convert from	To	Multiply by	To Convert from	To	Multiply by
acres	sq. miles	0.0015625	days	seconds	86400
cubic feet	cu. meter	0.028316847	feet	meters	0.3048
cubic feet	gallons	7.4805195	gallons	cu. feet	0.133680555
cubic feet	liters	28.316847	hectares	acres	2.4710538
cfs	gal/min	448.83117	miles	meters	1609.344
cfs	MGD	0.6463168	mg/l	ppm	1
cubic meters	gallons	264.17205	μg/l * cfs	gm/day	2.45
cubic meters	liters	1000	μg/l * MGD	gm/day	3.79

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MONITORED SEGMENT IDENTIFICATION

Name:	Biloxi Bay
Waterbody ID:	MS118E03M
Location:	At Biloxi and Ocean Springs: From New Highway 90 Bridge to Arbitrary Line from SE Tip of Deer Island to Belle Fontaine Point
County:	Harrison and Jackson Counties, Mississippi
USGS HUC Code:	03170009
Use Impairment:	Shellfishing
Cause Noted:	Fecal Coliform, an indicator for the presence of pathogenic organisms
Priority Rank:	11
NPDES Permits:	There are 48 NPDES permits issued for facilities that potentially discharge fecal coliform in the watershed (Table 3.1).
Standards Variance:	None
Pollutant Standard:	Median fecal coliform MPN (most probable number) colony counts shall not exceed 14 per 100 ml, nor shall more than ten percent of the samples examined ordinarily exceed an MPN colony count of 43 per 100 ml in those portions or areas most probably exposed to fecal contamination during most unfavorable hydrographic and pollutional conditions.
Waste Load Allocation:	0.05E+14 MPN/15 days (The TMDL requires all dischargers to meet water quality standards for disinfection.)
Load Allocation:	1.80E+14 MPN/15 days
Margin of Safety:	Implicit modeling assumptions.
Total Maximum Daily Load (TMDL):	1.85E+14 MPN/15 days

MONITORED SEGMENT IDENTIFICATION

Name:	Back Bay of Biloxi
Waterbody ID:	MS118E02M2
Location:	From Popps Ferry Bridge to New Highway 90 Bridge
County:	Harrison and Jackson Counties, Mississippi
USGS HUC Code:	03170009
Length:	9 miles
Use Impairment:	Secondary Contact
Cause Noted:	Fecal Coliform, an indicator for the presence of pathogenic organisms
Priority Rank:	101
NPDES Permits:	There are 48 NPDES permits issued for facilities that potentially discharge fecal coliform in the watershed (Table 3.1).
Standards Variance:	None
Pollutant Standard:	May through October - Geometric mean of 200 per 100 ml, Less than 10 percent of the samples may exceed 400 per 100 ml. November through April - Geometric mean of 2000 per 100 ml, Less than 10 percent of the samples may exceed 4000 per 100 ml.
Waste Load Allocation:	0.05E+14 MPN/15 days (The TMDL requires all dischargers to meet water quality standards for disinfection.)
Load Allocation:	1.68E+14 MPN/15 days
Margin of Safety:	Implicit modeling assumptions.
Total Maximum Daily Load (TMDL):	1.73E+14 MPN/15 days

MONITORED SEGMENT IDENTIFICATION

Name:	Back Bay of Biloxi Coastline segment 3
Waterbody ID:	MS118C03M
Location:	From Popps Ferry (Cedar Point) to Highway 90 Bridge at Ocean Springs (Southern Coastline)
County:	Harrison County, Mississippi
USGS HUC Code:	03170009
Length:	10 miles
Use Impairment:	Secondary Contact
Cause Noted:	Fecal Coliform, an indicator for the presence of pathogenic organisms
Priority Rank:	102
NPDES Permits:	There are 48 NPDES permits issued for facilities that potentially discharge fecal coliform in the watershed (Table 3.1).
Standards Variance:	None
Pollutant Standard:	May through October - Geometric mean of 200 per 100 ml, Less than 10 percent of the samples may exceed 400 per 100 ml. November through April - Geometric mean of 2000 per 100 ml, Less than 10 percent of the samples may exceed 4000 per 100 ml.
Waste Load Allocation:	0.05E+14 MPN/15 days (The TMDL requires all dischargers to meet water quality standards for disinfection.)
Load Allocation:	1.68E+14 MPN/15 days
Margin of Safety:	Implicit modeling assumptions.
Total Maximum Daily Load (TMDL):	1.73E+14 MPN/15 days

MONITORED SEGMENT IDENTIFICATION

Name:	Back Bay of Biloxi Coastline segment 4
Waterbody ID:	MS118C04M
Location:	From Popps Ferry (Cedar Point) to Highway 90 Bridge at Ocean Springs (Northern Coastline)
County:	Harrison County, Mississippi
USGS HUC Code:	03170009
Length:	16 miles
Use Impairment:	Secondary Contact
Cause Noted:	Fecal Coliform, an indicator for the presence of pathogenic organisms
Priority Rank:	103
NPDES Permits:	There are 48 NPDES permits issued for facilities that potentially discharge fecal coliform in the watershed (Table 3.1).
Standards Variance:	None
Pollutant Standard:	May through October - Geometric mean of 200 per 100 ml, Less than 10 percent of the samples may exceed 400 per 100 ml. November through April - Geometric mean of 2000 per 100 ml, Less than 10 percent of the samples may exceed 4000 per 100 ml.
Waste Load Allocation:	0.05E+14 MPN/15 days (The TMDL requires all dischargers to meet water quality standards for disinfection.)
Load Allocation:	1.68E+14 MPN/15 days
Margin of Safety:	Implicit modeling assumptions.
Total Maximum Daily Load (TMDL):	1.73E+14 MPN/15 days

MONITORED SEGMENT IDENTIFICATION

Name:	Big Lake
Waterbody ID:	MS118E01M
Location:	Near Handsboro: From Mouth of Bernard Bayou - Industrial Seaway to Popps Ferry Bridge
County:	Harrison County, Mississippi
USGS HUC Code:	03170009
Length:	3 miles
Use Impairment:	Secondary Contact
Cause Noted:	Fecal Coliform, an indicator for the presence of pathogenic organisms
Priority Rank:	104
NPDES Permits:	There are 21 NPDES permits issued for facilities that potentially discharge fecal coliform in the watershed (Table 3.1).
Standards Variance:	None
Pollutant Standard:	May through October - Geometric mean of 200 per 100 ml, Less than 10 percent of the samples may exceed 400 per 100 ml. November through April - Geometric mean of 2000 per 100 ml, Less than 10 percent of the samples may exceed 4000 per 100 ml.
Waste Load Allocation:	0.03E+14 MPN/15 days (The TMDL requires all dischargers to meet water quality standards for disinfection.)
Load Allocation:	1.21E+14 MPN/15 days
Margin of Safety:	Implicit modeling assumptions.
Total Maximum Daily Load (TMDL):	1.24E+14 MPN/15 days

MONITORED SEGMENT IDENTIFICATION

Name:	Bernard Bayou segment 2
Waterbody ID:	MS118BBM2
Location:	Near Landon: From Headwaters West of Nugent to Highway 49
County:	Harrison County, Mississippi
USGS HUC Code:	03170009
Length:	9 miles
Use Impairment:	Secondary Contact
Cause Noted:	Fecal Coliform, an indicator for the presence of pathogenic organisms
Priority Rank:	42
NPDES Permits:	There are no NPDES permits issued for facilities that potentially discharge fecal coliform in the watershed.
Standards Variance:	None
Pollutant Standard:	May through October - Geometric mean of 200 per 100 ml, Less than 10 percent of the samples may exceed 400 per 100 ml. November through April - Geometric mean of 2000 per 100 ml, Less than 10 percent of the samples may exceed 4000 per 100 ml.
Waste Load Allocation:	There are no permitted facilities in the watershed. Therefore, there is no WLA contribution to the TMDL.
Load Allocation:	6.18E+12 MPN/15 days
Margin of Safety:	Implicit modeling assumptions.
Total Maximum Daily Load (TMDL):	6.18E+12 MPN/15 days

MONITORED SEGMENT IDENTIFICATION

Name:	Bernard Bayou segment 3
Waterbody ID:	MS118BBM3
Location:	Near Gulfport: From Highway 49 to Industrial Seaway at Entrance to Bernard Bayou Natural Channel
County:	Harrison County, Mississippi
USGS HUC Code:	03170009
Length:	4 miles
Use Impairment:	Secondary Contact
Cause Noted:	Fecal Coliform, an indicator for the presence of pathogenic organisms
Priority Rank:	21
NPDES Permits:	There are 5 NPDES permits issued for facilities that potentially discharge fecal coliform in the watershed (Table 3.1).
Standards Variance:	None
Pollutant Standard:	May through October - Geometric mean of 200 per 100 ml, Less than 10 percent of the samples may exceed 400 per 100 ml. November through April - Geometric mean of 2000 per 100 ml, Less than 10 percent of the samples may exceed 4000 per 100 ml.
Waste Load Allocation:	0.19E+13 MPN/15 days (The TMDL requires all dischargers to meet water quality standards for disinfection.)
Load Allocation:	2.75E+13 MPN/15 days
Margin of Safety:	Implicit modeling assumptions.
Total Maximum Daily Load (TMDL):	2.94E+13 MPN/15 days

MONITORED SEGMENT IDENTIFICATION

Name:	Bernard Bayou segment 4
Waterbody ID:	MS118BBM4
Location:	At Gulfport in Natural Channel: From Industrial Seaway to Mouth at Big Lake
County:	Harrison County, Mississippi
USGS HUC Code:	03170009
Length:	6 miles
Use Impairment:	Secondary Contact
Cause Noted:	Fecal Coliform, an indicator for the presence of pathogenic organisms
Priority Rank:	43
NPDES Permits:	There are 5 NPDES permits issued for facilities that potentially discharge fecal coliform in the watershed (Table 3.1).
Standards Variance:	None
Pollutant Standard:	May through October - Geometric mean of 200 per 100 ml, Less than 10 percent of the samples may exceed 400 per 100 ml. November through April - Geometric mean of 2000 per 100 ml, Less than 10 percent of the samples may exceed 4000 per 100 ml.
Waste Load Allocation:	0.19E+13 MPN/15 days (The TMDL requires all dischargers to meet water quality standards for disinfection.)
Load Allocation:	7.15E+13 MPN/15 days
Margin of Safety:	Implicit modeling assumptions.
Total Maximum Daily Load (TMDL):	7.34E+13 MPN/15 days

EVALUATED SEGMENT IDENTIFICATION

Name:	Heron Bayou
Waterbody ID:	MS118HBE
Location:	Near Ocean Springs: From Headwaters to Mouth at Davis Bayou
County:	Jackson County, Mississippi
USGS HUC Code:	03170009
Use Impairment:	Secondary Contact
Cause Noted:	Fecal Coliform, an indicator for the presence of pathogenic organisms
NPDES Permits:	There are no NPDES permits issued for facilities that potentially discharge fecal coliform in the watershed.
Standards Variance:	None
Pollutant Standard:	May through October - Geometric mean of 200 per 100 ml, Less than 10 percent of the samples may exceed 400 per 100 ml. November through April - Geometric mean of 2000 per 100 ml, Less than 10 percent of the samples may exceed 4000 per 100 ml.
Waste Load Allocation:	There are no permitted facilities in the watershed. Therefore, there is no WLA contribution to the TMDL.
Load Allocation:	3.16E+12 MPN/15 days
Margin of Safety:	Implicit modeling assumptions.
Total Maximum Daily Load (TMDL):	3.16E+12 MPN/15 days

EVALUATED SEGMENT IDENTIFICATION

Name:	Old Fort Bayou
Waterbody ID:	MS118M1
Location:	At Ocean Springs: From Headwaters to Washington Street Bridge
County:	Jackson County, Mississippi
USGS HUC Code:	03170009
Use Impairment:	Secondary Contact
Cause Noted:	Fecal Coliform, an indicator for the presence of pathogenic organisms
NPDES Permits:	There are no NPDES permits issued for facilities that potentially discharge fecal coliform in the watershed.
Standards Variance:	None
Pollutant Standard:	May through October - Geometric mean of 200 per 100 ml, Less than 10 percent of the samples may exceed 400 per 100 ml. November through April - Geometric mean of 2000 per 100 ml, Less than 10 percent of the samples may exceed 4000 per 100 ml.
Waste Load Allocation:	There are no permitted facilities in the watershed. Therefore, there is no WLA contribution to the TMDL.
Load Allocation:	1.98E+12 MPN/15 days
Margin of Safety:	Implicit modeling assumptions.
Total Maximum Daily Load (TMDL):	1.98E+12 MPN/15 days

EVALUATED SEGMENT IDENTIFICATION

Name:	Tidewater Bayou
Waterbody ID:	MS118TBM
Location:	At Ocean Springs: From Headwaters to Mouth at Biloxi Bay
County:	Jackson County, Mississippi
USGS HUC Code:	03170009
Use Impairment:	Secondary Contact
Cause Noted:	Fecal Coliform, an indicator for the presence of pathogenic organisms
NPDES Permits:	There are no NPDES permits issued for facilities that potentially discharge fecal coliform in the watershed.
Standards Variance:	None
Pollutant Standard:	May through October - Geometric mean of 200 per 100 ml, Less than 10 percent of the samples may exceed 400 per 100 ml. November through April - Geometric mean of 2000 per 100 ml, Less than 10 percent of the samples may exceed 4000 per 100 ml.
Waste Load Allocation:	There are no permitted facilities in the watershed. Therefore, there is no WLA contribution to the TMDL.
Load Allocation:	5.29E+12 MPN/15 days
Margin of Safety:	Implicit modeling assumptions.
Total Maximum Daily Load (TMDL):	5.29E+12 MPN/15 days

EXECUTIVE SUMMARY

Several waterbodies and waterbody segments in the Biloxi Bay Watershed are on the Mississippi 1998 Section 303(d) List of Waterbodies as impaired due to fecal coliform bacteria. Table ES.1 on page xx presents the waterbodies and waterbody segments that are included in this TMDL.

For Secondary Contact, the applicable state standard specifies that for the months of May through October, when water contact activities may be expected to occur, fecal coliform shall not exceed a geometric mean of 200 per 100 ml nor shall more than 10 percent of the samples examined during any month exceed 400 per 100 ml. For the months of November through April, when incidental contact is not likely, fecal coliform shall not exceed 2000 per 100 ml as a geometric mean nor exceed a maximum of 4000 per ml in any one sample. MDEQ requires a minimum of 5 samples collected over a 30 day period to determine a geometric mean.

For Shellfishing the applicable standard specifies that the median fecal coliform MPN (most probable number) colony counts shall not exceed 14 per 100 ml, nor shall more than ten percent of the samples examined ordinarily exceed an MPN colony count of 43 per 100 ml in those portions or areas most probably exposed to fecal contamination during most unfavorable hydrographic and pollutional conditions.

The listing of these waterbody segments was influenced by both water quality monitoring data and shellfish classifications. For the waterbodies impaired for the use of Secondary Contact, water quality monitoring data from various sources were used for assessment. However, the Biloxi Bay (MS118E03M) was listed as impaired for shellfish harvesting due to the prohibited and restricted classification of the shellfish beds in the Bay by the Mississippi Department of Marine Resources (MDMR). Current monitoring data indicates an improvement in the water quality of the Biloxi Bay Watershed.

The TMDLs for these watebodies were developed through one monitoring and modeling project. The modeling for this project was conducted under contract by the Civil Engineering Department at Mississippi State University.

The Biloxi Bay Watershed is located along the Mississippi Gulf Coast in Jackson and Harrison Counties. The metropolitan areas of Biloxi, Gulfport, Ocean Springs, and D'Iberville are included. The Back Bay of Biloxi provides convenient navigation and transportation services to the economic activities of the area. Besides navigation, the Back Bay of Biloxi provides recreational opportunities, as well as stimulates industrial development within the region. This industrialization, in turn, tends to promote population growth and economic development within the adjoining communities and Jackson and Harrison Counties.

According to the study made in 1970 (Gulf Regional Planning Commission, 1972), the 1970 population of the counties in and adjacent to Jackson, Harrison, and Hancock Counties was 240,000. The study also projected that by year 2015, the population of the counties in the region was expected to exceed 700,000. The 1990 census showed a combined population of 580,000. Since 1950, convenient water transportation, unlimited water supplies, natural gas, availability of refining products as raw materials, and extensive timber resources have provided the base for rapid industrial growth in this area. Growth has also been stimulated by resort facilities and casinos, by the presence of abundant fresh and saltwater fisheries, and by the establishment or expansion of military installations.

Figure ES.1 Live Oak on Mississippi Coast

Unfortunately, population growth and industrial development have been accompanied by an increased demand for water and wastewater disposal facilities. Over the past 25 years, pollution source studies (Gaines et al., 1987) revealed that in spite of the enormous improvements in physical wastewater treatment facilities, the rapid growth of residential, commercial, and industrial developments was still overwhelming the treatment systems.

Overall these comprehensive water quality surveys showed that the Biloxi Bay and Back Bay were receiving large volumes of pollution from a variety of point and nonpoint sources, and that the overall estuarine system was experiencing considerable environmental stress. It is also anticipated that the volume of wastewater generated by industry and surrounding municipalities, especially in Biloxi and Gulfport, will continue to increase in direct proportion to regional development. This is due to the fact that virtually every municipality and industry located along the Bay use the natural water system for wastewater effluent disposal.

The BASINS Nonpoint Source Model (NPSM) and the Water Quality Analysis Simulation Program-5 (WASP5) were selected as the models for performing the TMDL allocations for this study. The weather data used for this model were collected at several locations in the study area. The representative hydrologic period used for this TMDL was a wet year, 1995, and a dry year, 1986, as determined by an analysis of mean annual rainfall distributions at several stations including Biloxi, Gulfport Naval Center, Merril, Ocean Springs, Saucier Experimental Forest Station, Vancleave, and Wiggins Ranger Station. Bacteria data collected by MDEQ at ambient water quality stations within the Biloxi Bay Watershed indicate the possibility of a violation of the water quality standards for Secondary Contact for fecal coliform bacteria in these waterbodies.

Fecal coliform loadings from nonpoint sources in the watershed were calculated based upon wildlife populations; livestock populations; information on livestock and manure management practices for the Biloxi Bay Watershed; and urban development. The estimated fecal coliform production and accumulation rates due to nonpoint sources that result in runoff from the watershed were incorporated into the model. Also represented in the model were the nonpoint sources that would be directly deposited in a stream, such as failing septic systems and animals that have direct access to the tributaries of the Back Bay of Biloxi and Biloxi Bay. A 50 percent failure rate of septic tanks in the drainage area was assumed for input into the model. There are 48 NPDES permitted discharges included as point sources in the model.

Under existing, or baseline, conditions, output from the model indicates violations of the Secondary Contact fecal coliform standard in Bernard Bayou segment 2 (MS118BBM2) and violations of the Shellfishing fecal coliform standard in the Biloxi Bay (MS118E03M). The use of Shellfish Harvesting requires the most stringent water quality standards. An instream fecal coliform target of a median of 14 MPN counts per 100 ml must be maintained. Reductions utilized to meet this target will be sufficient to meet all other standards. After applying a TMDL reduction scenario, there were no violations of the standard according to the model.

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.

Because over 97 percent of the allocated load is due to nonpoint sources, those loads were the focus for reduction. Also, the permitted dischargers in the watershed are currently required to disinfect and to discharge at levels equivalent to the contact recreation water quality standard. The reductions could be achieved through many different scenarios, which might include addressing urban nonpoint source issues in the small watersheds around the Bay. The Biloxi Bay is classified as restricted and prohibited for shellfish harvesting and one of the goals of this TMDL is to improve water quality to allow for upward re-classification of the waters to once again allow shellfish harvesting where appropriate. Additional stakeholder input should be sought to develop an appropriate plan for this watershed.

Table ES.1 Waterbodies included in the Back Bay of Biloxi Fecal Coliform TMDL

Waterbody Name	Waterbody ID	Use Impairment	Cause of Impairment
Biloxi Bay	MS118E03M	Shellfishing	Pathogens
Back Bay of Biloxi	MS118E02M2	Secondary Contact	Pathogens
Back Bay of Biloxi Coastline segment 3	MS118C03M	Secondary Contact	Pathogens
Back Bay of Biloxi Coastline segment 4	MS118C04M	Secondary Contact	Pathogens
Big Lake	MS118E01M	Secondary Contact	Pathogens
Bernard Bayou segment 2	MS118BBM2	Secondary Contact	Pathogens
Bernard Bayou segment 3	MS118BBM3	Secondary Contact	Pathogens
Bernard Bayou segment 4	MS118BBM4	Secondary Contact	Pathogens
Heron Bayou	MS118HBE	Secondary Contact	Pathogens
Old Fort Bayou	MS118M1	Secondary Contact	Pathogens
Tidewater Bayou	MS118TBM	Secondary Contact	Pathogens

1.0 INTRODUCTION

1.1 Background

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

The Mississippi Department of Environmental Quality (MDEQ) has identified several segments within the Biloxi Bay Watershed as being impaired by fecal coliform bacteria as reported in the Mississippi 1998 Section 303(d) List of Waterbodies. The listing of these waterbody segments was influenced by both water quality monitoring data and shellfish classifications. For the waterbodies impaired for the use of Secondary Contact, water quality monitoring data from various sources were used for assessment. However, the Biloxi Bay (MS118E03M) was automatically listed as impaired for shellfish harvesting due to the prohibited and restricted classification of the shellfish beds in the Bay by MDMR.

The listed segments are in the Coastal Streams Basin Hydrologic Unit Code (HUC) 03170009 in southern Mississippi. The drainage area of the listed segments is approximately 400,000 acres; and lies within portions of Harrison, Jackson, and Stone Counties. Figure 1.1 is an area map of this drainage area. The land use distribution is provided in Table 1.1. This distribution of landuse can be seen in Figure 3.1. Forest and wetland areas represent the largest percentage of landuses within the watershed. Urban areas represent a small percentage of the Biloxi Bay Watershed. However, the urban areas are primarily concentrated around the Back Bay of Biloxi and Biloxi Bay. The watershed includes the metropolitan areas of Biloxi, Gulfport, Ocean Springs, and D'Iberville. Keesler Air Force Base is also located on the south side of the Back Bay of Biloxi.

Biloxi is the oldest city in the Gulf Coast Region and is located in Harrison County. Its major industries include canning, boat building and repair, seafood processing, tourism, and casinos. Principal shipments through the ports are seafood, pulpwood, and petroleum products.

Gulfport is also located in Harrison County. Its major industries include fishing, glass making, seafood processing, chemicals, pharmaceuticals, steel products, iron and machine works, and aluminum extrusions. Waterborne commerce includes fertilizers, chemicals, seafood, and pulpwood products.

Ocean Springs, located in Jackson County on the east side of Biloxi Bay, is primarily a satellite community of Biloxi and Pascagoula. Local industries include tourism, soft drink bottling, seafood packaging, and the manufacture of ladies handbags, pottery, and boats.

Figure 1.1 Area Map for the Biloxi Bay Watershed

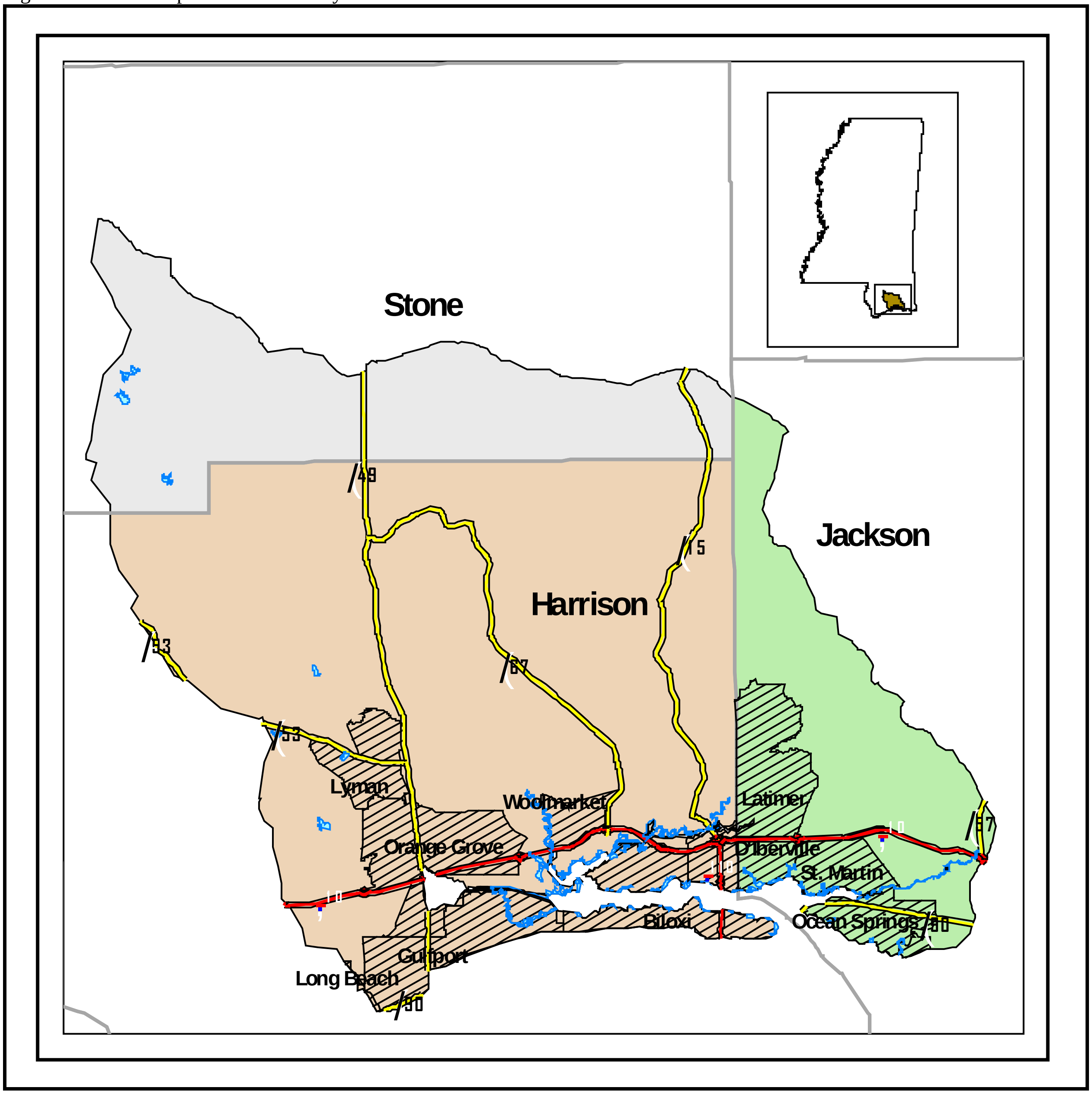
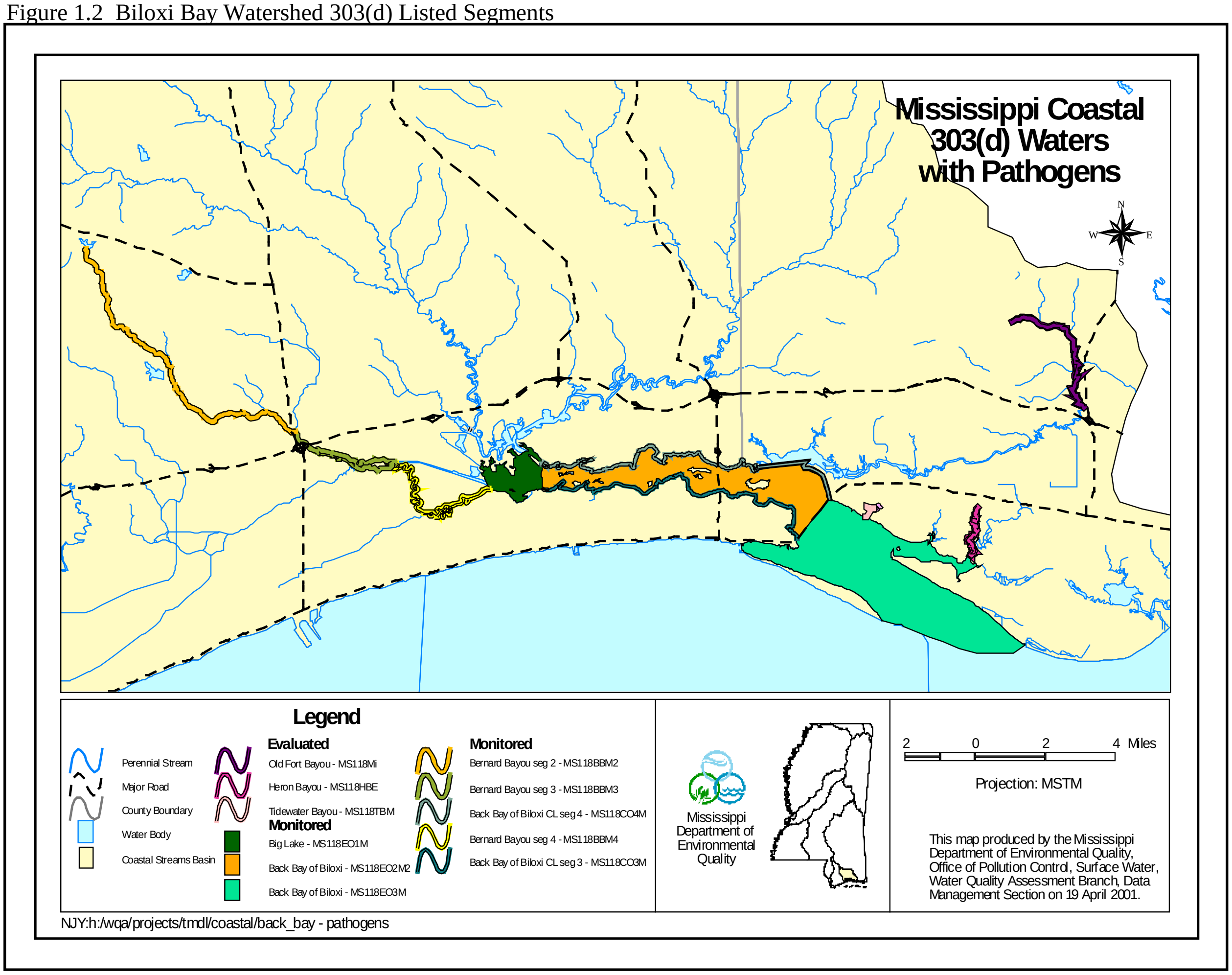


Table 1.1 Landuse Distribution in Acres for the Biloxi Bay Watershed

	Urban	Forest	Cropland	Pasture	Barren	Water	Wetland	Total
Area (acres)	22,651	245,051	4,009	37,750	583	4,552	88,525	403,121
% Area	5.6%	60.8%	1.0%	9.4%	0.1%	1.1%	22.0%	100%

Figure 1.2 shows the waterbody segments within the Biloxi Bay Watershed that are on the Mississippi 1998 Section 303(d) List of Waterbodies as impaired due to fecal coliform bacteria. Eight monitored segments and three evaluated segments are included in this watershed.

Figure 1.2 Biloxi Bay Watershed 303(d) Listed Segments



1.2 Applicable Waterbody Segment Use

The water use classification for the listed segments within the Biloxi Bay Watershed, as established by the State of Mississippi in the *Water Quality Criteria for Intrastate, Interstate and Coastal Waters* regulation, are Fish and Wildlife Support and Shellfish Harvesting. The designated beneficial uses for these segments are Secondary Contact and Shellfishing.

The waters of the Biloxi Bay are classified as restricted and prohibited for shellfish harvesting. These classifications are determined by MDMR and are fully explained in the National Shellfish Sanitation Program (NSSP) Ordinance which is available on the Interstate Shellfish Sanitation Conference (ISSC) website, http://www.issc.org. The goal is to improve water quality and allow for upward classification where appropriate.

1.3 Applicable Waterbody Segment Standard

The water quality standard applicable to the use of the waterbody and the pollutant of concern is defined in the *State of Mississippi Water Quality Criteria for Intrastate, Interstate, and Coastal Waters*. The standards are shown in Table 1.2. These water quality standards will be used as the targeted endpoints to evaluate impairments and to establish this TMDL.

Table 1.2 Water Quality Standards

Water Use	Purpose	Water Quality Standards
Fish and Wildlife	Waters in this classification are intended for fishing and for propagation of fish, aquatic life, and wildlife. Waters that meet Fish and Wildlife Criteria shall also be suitable for secondary contact Secondary contact is defined as incidental contact with the water, including wading and occasional swimming.	For the months of May through October, when water contact activities may be expected to occur, fecal coliform shall not exceed a geometric mean of 200 per 100 ml nor shall more than 10 percent (10%) of the samples examined during any month exceed 400 per 100 ml. For the months of November through April, when incidental contact is not likely, fecal coliform shall not exceed geometric mean of 2000 per 100 ml, nor shall more than ten percent (10%) of the samples examined during any month exceed 4000 per 100 ml.
Shellfish Harvesting	Waters for this use are for propagation and harvesting shellfish for sale or use as a food product.	The median fecal coliform most probable number (MPN) of the water shall not exceed 14 per 100 ml, and not more than ten percent (10%) of the samples shall ordinarily exceed an MPN of 43 per 100 ml in those portions or areas most probably exposed to fecal contamination during most unfavorable hydrographic and pollutional conditions.

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.

While there are various designated uses in the Biloxi Bay Watershed, the use with the most stringent water quality standards is Shellfishing, which requires an instream fecal coliform target of a median of 14 MPN counts per 100 ml. Reductions utilized to meet this target will be sufficient to meet all other standards.

Because fecal coliform may be attributed to both sources that are runoff dependent and sources that are constantly discharging to the stream, the critical condition must account for both high and low flow conditions. Critical conditions for waters impaired by nonpoint sources that are runoff-related generally occur during periods of wet-weather and high surface runoff. But, critical conditions for nonpoint and point sources that continually discharge generally occur during low-flow, low-dilution conditions. The watershed modeling was done using a wet year and a dry year that were determined to be representative through the evaluation of precipitation records for the period of record of several stations in the area. The wet year (1995) has been determined to be the most critical for the water quality in the Bay.

2.2 Discussion of Instream Water Quality

There are several ambient stations on the listed segments operated by MDEQ where fecal coliform monitoring data were collected. Data from these stations are used to determine the status of the segments. In addition, MDEQ recently received new data collected by MDMR. The new data, including data collected through 1999, indicate that the Back Bay of Biloxi is now fully supporting the designated use of Secondary Contact.

The Biloxi Bay remains prohibited and restricted for shellfishing. However, with future improvements in water quality within Biloxi Bay, there is the potential for upward re-classification where appropriate.

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. The 1998 Section 305(b) Water Quality Assessment Report was based on data collected from 1991 through 1996. According to the report, the waterbody segments included in this report are not supporting their designated uses of Secondary Contact and Shellfishing. This conclusion was based on data collected through the MDEQ ambient monitoring network, the 1994–1995 Back Bay of Biloxi Model Study data (MDEQ), and MDMR Shellfish Sanitation Program classifications. The historic data collected by MDEQ available for these waterbodies is included in Appendix B.

As stated earlier, MDEQ now has access to MDMR's most recent 10-year data set which includes data collected through 1999. This data set was used as part of the most recent MDEQ water quality assessment (State of Mississippi's 2001 Section 305(b) Coastal Basin electronic update). According to this assessment, based on data collected from 1994 through 1999, the Back Bay of Biloxi is now fully supporting the designated use of Secondary Contact.

3.0 SOURCE ASSESSMENT

The TMDL evaluation summarized in this report examined all known potential fecal coliform sources in the Biloxi Bay 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, Modeling Procedure: Linking the Sources to the Endpoint.

3.1 Assessment of Point Sources

Figure 3.1 Industry on Mississippi Coast

Typically, point sources of fecal coliform bacteria have their greatest potential impact on water quality during periods of low flow. There are 48 facilities permitted to discharge fecal coliform included in the Biloxi Bay Watershed (see Table 3.1). These 48 facilities serve a variety of activities including residential subdivisions, schools, industries, and municipalities. Marinas and shipyards located in the study area were considered to be discharging to the municipalities.

All identified NPDES permitted point sources in Table 3.1 are included in the Back Bay of Biloxi and Biloxi Bay model. As a conservative approach, facilities were modeled at 200 counts/100 ml for the entire year. The seafood processors, which do not have fecal coliform limits in their permits, were modeled at 58 counts/100 ml. This discharge number represents the average fecal discharge from seafood processors measured during the 1994-95 Back Bay of Biloxi Study.

Samples were collected at the point sources during the September 1994 calibration study and again in the April – May 1995 verification study. Flow and fecal coliform values from the September 1994 study were used as input into the model for calibration. For subsequent application runs of the model the maximum permitted limits were used for each facility. This is a conservative practice and is included in the margin of safety for this TMDL.

Table 3.1 Inventory of Identified NPDES Permitted Facilities

Facility Name	NPDES Permit	Receiving Waterbody	Flow (MGD)	Permit Limit (MPN/100 ml)
Reichhold Inc.	MS0001520	Big Lake	0.025	200
Harrison County/West Biloxi POTW	MS0030333	Back Bay of Biloxi	9.000	200
D'Iberville POTW	MS0042340	Back Bay of Biloxi	1.156	200
Harrison County/East Biloxi POTW	MS0023159	Keegan Bayou to Back Bay	10.000	200
Fast Lane #735	MS0047201	Back Bay of Biloxi	0.002	200
Gollott Brothers Seafood	MS0047597	Back Bay of Biloxi	0.039	58
Coast to Coast Seafood	MS0047520	Back Bay of Biloxi	0.005	58
R. Fournier & Sons Seafood Inc.	MS0001562	Back Bay of Biloxi	0.010	58
C. F. Gollott & Sons Seafood Co.	MS0002861	Back Bay of Biloxi	0.083	58
Seymour & Sons Seafood Inc.	MS0036315	Back Bay of Biloxi	0.034	58
R. A. Fayard Seafood Company Inc.	MS0001589	Back Bay of Biloxi	0.099	58
R. A. Lesso Seafood	MS0037656	Back Bay of Biloxi	0.042	58
Golden Gulf Coast Packing Co.	MS0040142	Back Bay of Biloxi	0.198	58
Gulf Pride Enterprises Inc.	MS0039276	Back Bay of Biloxi	0.006	58
M & M Shrimp Company Inc.	MS0044466	Back Bay of Biloxi	0.200	58
J & W Seafood	MS0045012	Back Bay of Biloxi	0.040	58
David Gollot Seafood	MS0045799	Back Bay of Biloxi	0.019	58
G & R Seafood L.L.C.	MS0046493	Back Bay of Biloxi	0.060	58
David Gollot Seafood Inc.	MS0052400	Back Bay of Biloxi	0.019	58
Weems Brothers Seafood	MS0001759	Back Bay of Biloxi	0.013	58
AC Foods Inc.	MS0044431	Back Bay of Biloxi	0.015	200
Custom Pack	MS0045004	Back Bay of Biloxi	0.060	58
Seven Oaks Gulf Hills Resort	MS0031143	Old Fort Bayou	0.030	200
KOA Kampground	MS0041629	Old Fort Bayou	0.008	200
Ocean Springs Seafood Company	MS0037001	Biloxi Bay	0.360	58
1st Am Printing and Direct Mail	MS0041700	Old Fort Bayou	0.009	200
St. Martin High School	MS0038008	Bayou Talla	0.015	200
Schmidt Apartments	MS0047554	St. Martin Bayou	0.002	200
Gulfcoast 7th Day Adventist Church	MS0050504	Parker Creek	0.001	200
Parker's Landing RV Park Alt	MS0052159	Tchoutacabouffa River	0.012	200
Pine Haven Mobile Home Park	MS0036854	Parker Creek	0.020	200
Mazalea RV Park	MS0039594	Tchoutacabouffa River	0.017	200
Country Living Mobile Home Park	MS0042218	Howard Creek	0.023	200
North Woolmarket Village Estates	MS0049298	Howard Creek	0.064	200
Gutierrez RV Park	MS0050938	Howard Creek	0.023	200
Destination RV Park	MS0039250	Tuxachanie Creek	0.003	200
West Jackson Artificial Wetlands	MS0045446	Costapia Bayou	5.000	200
Oaklawn Mobile Home Park	MS0050717	Tchoutacabouffa River	0.001	200
Clark Oil Company #11 - Exxon	MS0046418	Fritz Creek	0.002	200
Jig's Fish Camp	MS0052230	Biloxi River	0.001	200
Harrison County/Eagle Point POTW	MS0034436	Biloxi River	0.182	200
Apple Valley Trailer Park	MS0040169	Biloxi River	0.013	200
Woolmarket Elementary School	MS0030899	Biloxi River	0.015	200
Harrison County WWM District/Gulfport South	MS0023345	Bernard Bayou	10.500	200
Bernard Bayou Industrial Park	MS0027537	Bernard Bayou	0.600	200
Harrison County/Gulport POTW – North #2	MS0051756	Bernard Bayou (Gulfport Lake)	5.500	200
Homestead Trailer Village	MS0051373	Flat Branch	0.029	200
Walters Trailer Park	MS0046086	Bernard Bayou	0.002	200

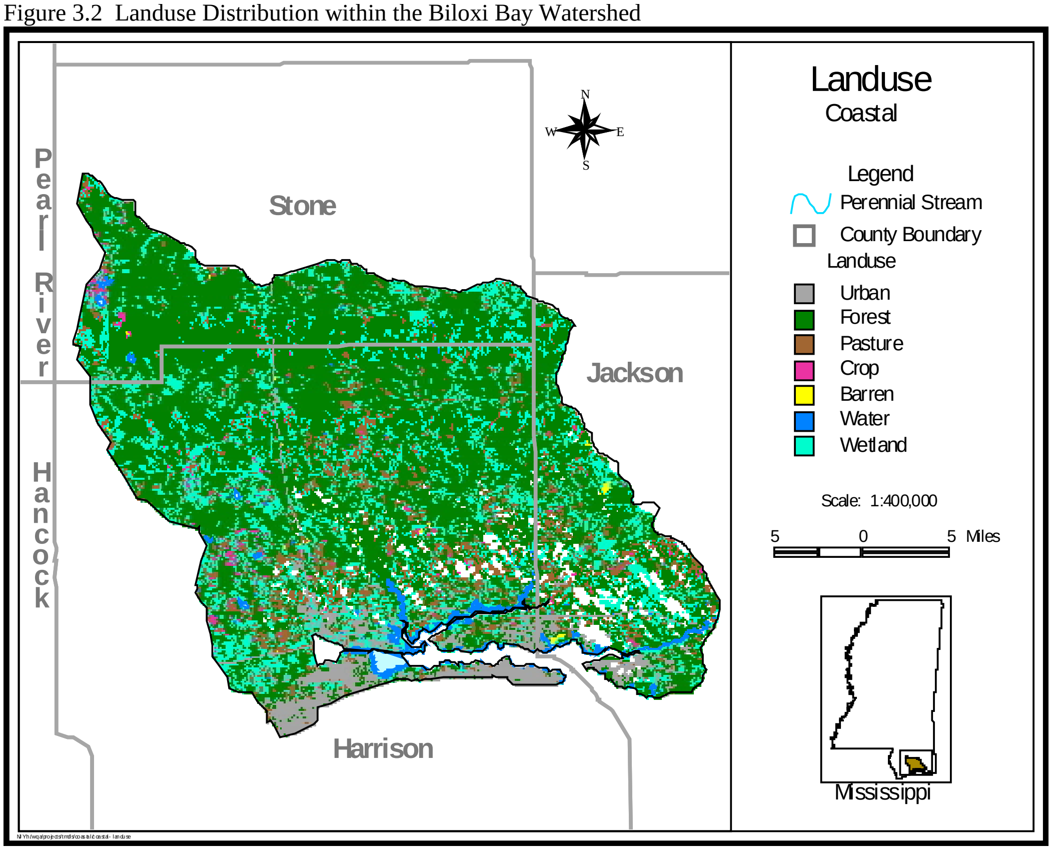
3.2 Assessment of Nonpoint Sources

There are many potential nonpoint sources of fecal coliform bacteria for the Biloxi Bay Watershed, including:

- Failing septic systems
- Wildlife
- Land application of animal manure
- Grazing animals
- Other direct inputs
- Urban development

The 400,000 acre drainage area of the Biloxi Bay contains many different landuse types, including urban, forest, cropland, pasture, barren, and wetlands. The modeled landuse information for the entire watershed is based on the State of Mississippi's Automated Resource Information System (MARIS), 1997. This data set is based on Landsat Thematic Mapper digital images taken between 1992 and 1993. The MARIS data are classified on a modified Anderson level one and two system with additional level two wetland classifications. For modeling purposes the landuse categories were grouped into the landuses of urban, forest, cropland, and pasture. Figure 3.1 shows the landuse distribution for the Biloxi Bay Watershed.

Figure 3.2 Landuse Distribution within the Biloxi Bay Watershed



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, and agriculture census data. 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 of wildlife density in the Biloxi Bay Watershed. The Mississippi State Department of Health and the Mississippi Gulf Regional Planning Commission were 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 animal manure. The Natural Resources Conservation Service also gave MDEQ information on manure treatment practices and land application of manure.

Table 3.2 Agricultural Animals Estimated within the Biloxi Bay Watershed

Beef Cows	Dairy Cows	Total Cattle	Swine
2871	212	5270	70

3.2.1 Wildlife

Wildlife present in the Biloxi Bay Watershed contribute to fecal coliform bacteria on the land surface and are a direct input to the waterbody. In the Back Bay of Biloxi and Biloxi Bay 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, such as ducks and geese, contributing to the area. An upper limit of 30 deer per square mile was used as the estimate. The wildlife population was modeled as a constant variable throughout the year.

Figure 3.3 White Tail Deer beside the Little Biloxi River

3.2.2 Land Application of Animal Manure

In the Biloxi Bay Watershed processed manure from confined animal feeding operations is collected in lagoons and routinely applied to pastureland during April through October. This manure is a potential contributor of bacteria to receiving waterbodies due to runoff produced during a rain event. For this model, it was assumed that all of the hog manure produced was applied evenly to the available pastureland. Application rates of hog manure to pastureland from confined operations varied monthly.

The dairy farms that are currently operating in the Biloxi Bay 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. The manure collected during confinement is applied to the available pastureland in the watershed. Application rates of dairy cow manure to pastureland vary monthly.

3.2.3 Grazing Beef and Dairy Cattle

Grazing cattle deposit manure on pastureland where it is available for wash-off and delivery to receiving waterbodies. The manure produced by grazing cattle was modeled as a fecal coliform load to available pastureland in the watershed.

3.2.4 Land Application of Poultry Litter

There are no commercial chicken houses in the Biloxi Bay Watershed. Therefore, a loading contribution from this source is not included.

3.2.5 Urban Development

Figure 3.4 Mississippi Coastline at Biloxi, Mississippi

Approximately 22,560 acres of the Biloxi Bay Watershed are classified as urban. Even though this area represents only 5.6 percent of the total watershed area, it is a significant source of the fecal coliform loadings to the Bay. The urban areas are primarily concentrated around the Biloxi Bay and Back Bay of Biloxi, including the metropolitan areas of Biloxi, Gulfport, Ocean Springs, and D'Iberville (Figure1.1). Fecal coliform contributions from urban and residential areas may include the activities of domestic pets, wildlife, septic systems, illicit connections, and landfills. Because the Bay supports both recreational and commercial boating, waste from those boats is a likely source in the Bay.

3.2.6 Direct Inputs

Failing septic systems, illicit dischargers, and animals with access to the stream are nonpoint sources that have the potential to directly deposit in the stream with no time or mechanism for die off of the organisms. Therefore, these sources account for a large percentage of the actual load in the stream.

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

Another consideration is the use of individual onsite wastewater treatment plants. These treatment systems are in wide use in Mississippi. They can adequately treat wastewater when properly maintained. However, these systems may not receive the maintenance needed for proper, long-term operation. These systems require disinfection to properly operate. When this expense is ignored, the water is discharged with higher pathogenic concentrations than intended.

Animals often have direct access to flowing and intermittent streams. These small streams are tributaries of larger streams. Fecal coliform bacteria deposited in the streams are modeled as a direct input of bacteria to the waterbody. In order to estimate the amount of bacteria introduced into streams from animals, it was assumed that two percent of the manure load produced by cattle represents the available load. This two percent represents manure loading by all animals in the watershed.

4.0 MODELING PROCEDURE: LINKING THE SOURCES TO THE ENDPOINT

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

4.1 Modeling Framework Selection

The Back Bay of Biloxi and Biloxi Bay Fecal Coliform TMDL Modeling Project utilizes two computer simulation models. The BASINS NPSM model, described below, was used to model the watershed hydrology of the entire Biloxi Bay Watershed. It was also used to model the water quality of the freshwater rivers and streams in the watershed. The watershed model (NPSM) was linked with the Water Quality Analysis Simulation Program –5 (WASP5) to simulate hydrodynamics, salinity, and water quality in the Back Bay of Biloxi, Biloxi Bay, and tidally influenced portions of the freshwater systems.

4.2 Model Setup

The BASINS model platform and the NPSM model were used to model the watershed hydrology and load washoff of the entire Biloxi Bay Watershed. NPSM has the capability to run a single watershed or a system of multiple watersheds that have been delineated through the BASINS environment. 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. 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.

The NPSM model simulates nonpoint source runoff from selected watersheds, as well as the transport and flow of the pollutants through stream reaches. The freshwater portion of the Biloxi Bay Watershed (the portion that is not tidally influenced) was modeled within the watershed modeling system (NPSM). This portion was divided into subwatersheds in order to isolate the major stream reaches and to allow for the relative contribution of nonpoint sources to be addressed within each subwatershed.

A calibrated NPSM model was used to simulate the flow and fecal coliform loadings from each subwatershed in the freshwater study area. The output from the NPSM model was used to provide boundary condition input into the Bay model.

The NPSM watershed model was linked with the Water Quality Analysis Simulation Program – 5 (WASP5) to simulate hydrodynamics, salinity, and water quality in the Back Bay of Biloxi and tidally influenced portions of the freshwater systems. This model can be applied in one, two, or three dimensions and is designed for linkage with the hydrodynamic model DYNHYD5. The hydrodynamics program, DYNHYD5, simulates the movement of water, while the water quality program, WASP5, simulates the movement and interaction of pollutants within the water. This model is capable of interpreting and predicting water quality responses to natural phenomena and man-made pollution.

4.3 Selection of Representative Modeling Period

The modeling was done using a wet year (1995) and a dry year (1986) that were determined to be representative through the evaluation of precipitation records of several stations in the area between the years of 1965 and 1998. Because large time spans are used, a margin of safety is implicitly applied. Seasonality and critical conditions are also accounted for during the time frame of the simulation.

The critical condition for fecal coliform impairment from nonpoint source contributors occurs after a heavy rainfall that is preceded by several days of dry weather. The dry weather allows a build up of fecal coliform bacteria, which is then washed off the ground by a heavy rainfall. By using the year-long modeling 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.

4.4 Source Representation

Both point and nonpoint sources were represented in the model. A spreadsheet was developed for quantifying point and nonpoint sources of bacteria for the Back Bay of Biloxi and Biloxi Bay model. This spreadsheet estimates 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 included in the spreadsheet.

The discharge from point sources was added as a direct input into the appropriate segment of the waterbody. There are 48 NPDES permitted facilities in the watershed which discharge fecal coliform bacteria. 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 the waterbodies in the Biloxi Bay Watershed. Other sources are represented as an application rate to the land in the Biloxi Bay Watershed, which enter the waterbody as a distributed source. 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 to be equal. Urban and barren areas were also considered to produce equal loads. The fecal coliform accumulation rate for pastureland is the sum of accumulation rates due to litter application, wildlife, processed manure, and grazing animals. For cropland, the accumulation rate is only due to wildlife. Accumulation rates for pastureland are calculated on a monthly basis to account for seasonal variations in manure and litter application. The fecal coliform bacteria applied to land are subject to a die-off rate and an absorption rate before entering the stream.

4.4.1 Wildlife

Based on information provided by the Mississippi Department of Wildlife and Fisheries at Mississippi State University the deer population throughout the Biloxi Bay Watershed was estimated to be 20 to 30 animals per square mile. For the model, the upper limit of 30 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 per acre loading rate applied to the landuses is 2.34E+07 counts/acre/day.

4.4.2 Land Application of Animal Manure

The spreadsheet estimated the fecal coliform loadings contributed by hog and cattle from each subwatershed. Fecal coliform production rates of 1.08E+10 count per day per hog and 5.40E+09 counts per day per cow were used to quantify the fecal coliform loadings (ASAE, 1998 and Metcalf and Eddy, 1991). Manure application rates to pastureland vary on a monthly basis.

4.4.3 Grazing Beef and Dairy Cattle

The manure produced by grazing beef and dairy cattle is assumed to be evenly spread on pastureland throughout the year. The number of grazing cattle is computed by subtracting the number of confined cattle from the total number of cattle in each subwatershed. The cattle population was determined from the 1997 Census of Agriculture Data. 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).

4.4.4 Land Application of Poultry Litter

There are no commercial chicken houses in the Biloxi Bay Watershed. Therefore, a loading contribution from this source is not included.

4.4.5 Urban Development

The urban and barren areas in the Biloxi Bay Watershed were combined and classified as high density, low density, or transportation. Fecal coliform buildup rates for each classification were determined from the following literature rates of 1.54E+07 counts per acre per day for high density areas, 1.03E+07 counts per acre per day for low density areas, and 2.00E+05 counts per acre per day for transportation areas (Horner, 1992).

4.4.6 Direct Inputs

Figure 4.1 Houseboats in MS Coastal Streams Basin

The number of failing septic systems used in the model was derived from the watershed area normalized county populations. The percentage of the population on septic systems was determined from 1990 United States Census Data and information from the Gulf Regional Planning Commission. A failure rate of 50 percent was estimated based on the coastal environmental conditions of a high ground water table and saturated geologic material. 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 individual onsite wastewater treatment systems and illicit dischargers in the area. 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 70 gallons per person per day, and a septic system effluent fecal coliform concentration of 10^4 counts per 100 ml. The septic system contribution in the model is based on the assumption that all fecal coliform bacteria discharged from failing septic systems directly reaches the stream. Additionally, these failing septic system discharges were assumed to be constant throughout the whole simulation.

The direct contribution of fecal coliform from animals to a stream is also represented as a direct source to the stream in the model. The fecal coliform loading is estimated by using a representative number of cattle and a bacteria production rate of 5.40E+09 counts per animal per day (Metcalf and Eddy, 1991).

4.5 Model Calibration Process

Water quality calibration began after completion of the hydrologic calibration. Whereas, flow modeling deals with a single constituent, water quantity, and a single primary source, precipitation, water quality must consider numerous constituents, various forms or species, and multiple sources. Fecal coliform contributions from all sources are estimated or measured, hydrologic transport processes are superimposed, and then water quality modeling is performed to allow adjustments in parameters and sources as part of the calibration process.

Water quality calibration is an iterative process; the model predictions are the integrated results of all the assumptions used in developing the model input and in representing the modeled process. Difference in model predictions and the observations require the model user to re-evaluate these assumptions, in terms of both the estimated model input and model parameters, and consider the accuracy and uncertainty in the observations.

To develop a representative linkage between the sources and the instream water quality response in all the reaches in the Biloxi Bay Watershed, model parameters were adjusted until reasonable nonpoint and point source loading rates were found. Parameters related to fecal coliform surface loading as well as background concentrations in the reaches were adjusted by comparing the modeled in-stream concentrations to available observed data. This process was limited by the absence of continuous data for high flow and storm flow conditions. Calibration information is provided in Appendix C.

4.6 Existing Loading

Appendix A includes graphs of the model results showing the instream fecal coliform concentrations of the impaired waterbodies included in this TMDL. The graphs show a 30-day geometric mean of the data. The straight line at 200 counts per 100 ml indicates the water quality standard for the streams that need to meet the Secondary Contact standard. (The 2000 counts per 100 ml water quality standard is not shown on the graph since there are no fecal coliform concentrations approaching this limit.) As shown by the graphs, Bernard Bayou segment 2, MS118BBM2, is the only waterbody segment that shows impairment of the Secondary Contact standards under existing conditions according to the model.

Appendix A also includes graphs of the model results for Biloxi Bay. The graphs show a running median of the fecal coliform concentration data. The straight line at 14 counts per 100 ml indicates the water quality standard for Shellfishing. As shown by the graph, the model results indicate occasional violations of the Shellfishing standard within Biloxi Bay

5.0 ALLOCATION

The allocation for this TMDL involves a wasteload allocation (WLA) for point sources, a load allocation (LA) for nonpoint sources, and an implicit margin of safety (MOS) which will result in the reduction necessary for attainment of water quality standards. The reduction can be achieved in many ways. While this TMDL does not specify the specific scenario which may be applied, it does describe the potential sources in detail.

5.1 Wasteload Allocations

The contribution of load from point sources was included in the model. The modeled contribution of each discharger was based on the facility's discharge monitoring data and other records of past performance.

No reduction in the current wasteload allocation was necessary to establish this TMDL. Future facility permits will require end-of-pipe criteria equivalent to the water quality standard of 200 fecal coliform colony counts per 100 ml. It is important that facilities potentially discharging bacteria disinfect their effluent as well as monitor their effluent for compliance.

5.2 Load Allocations

The load allocation for this TMDL involves the two different types of nonpoint sources described earlier: those modeled as direct sources to the stream and those modeled as diffuse runoff to the stream. While some nonpoint sources, such as animals in the stream and failing septic tanks were modeled as direct inputs to the stream, other nonpoint source contributions were applied to land area on a counts per day per acre basis and available for transport to the stream in runoff from a rain event. Contributions from direct sources are input into the model in a manner similar to point source input, with a flow and fecal coliform concentration in counts per hour. The fecal coliform bacteria deposited on the land, either through land application or grazing, are subject to a die-off rate and an absorption rate before entering the stream. Therefore, the sources that runoff into the stream are not as predominant of a source as the direct sources. The load allocation is the load resultant from all of the aforementioned sources, direct sources and distributed, which result in meeting the appropriate water quality standard for each waterbody's designated use.

As stated earlier, according to the model under existing conditions only Bernard Bayou segment 2 and Biloxi Bay show impairment. A 60 percent reduction in septic tank failures within the drainage area of Bernard Bayou segment 2 was necessary in order for this segment to meet the water quality standards for Secondary Contact.

The load allocation necessary for Biloxi Bay to meet the water quality standards for Shellfishing involves a reduction in the urban nonpoint source runoff from the watersheds surrounding the Back Bay of Biloxi and Biloxi Bay. A 35 percent reduction in the concentration of urban runoff was necessary from each of these small watersheds.

Table 5.1 Reduction in Septic Tank Failures

Waterbody Name	Existing Load (MPN/15 days)	Allocated Load (MPN/15 days)	Percent Reduction
Bernard Bayou segment 2	2.06E+12	0.82E+12	60%

Figure 5.1 Urban Watersheds Surrounding the Back Bay of Biloxi and Biloxi Bay

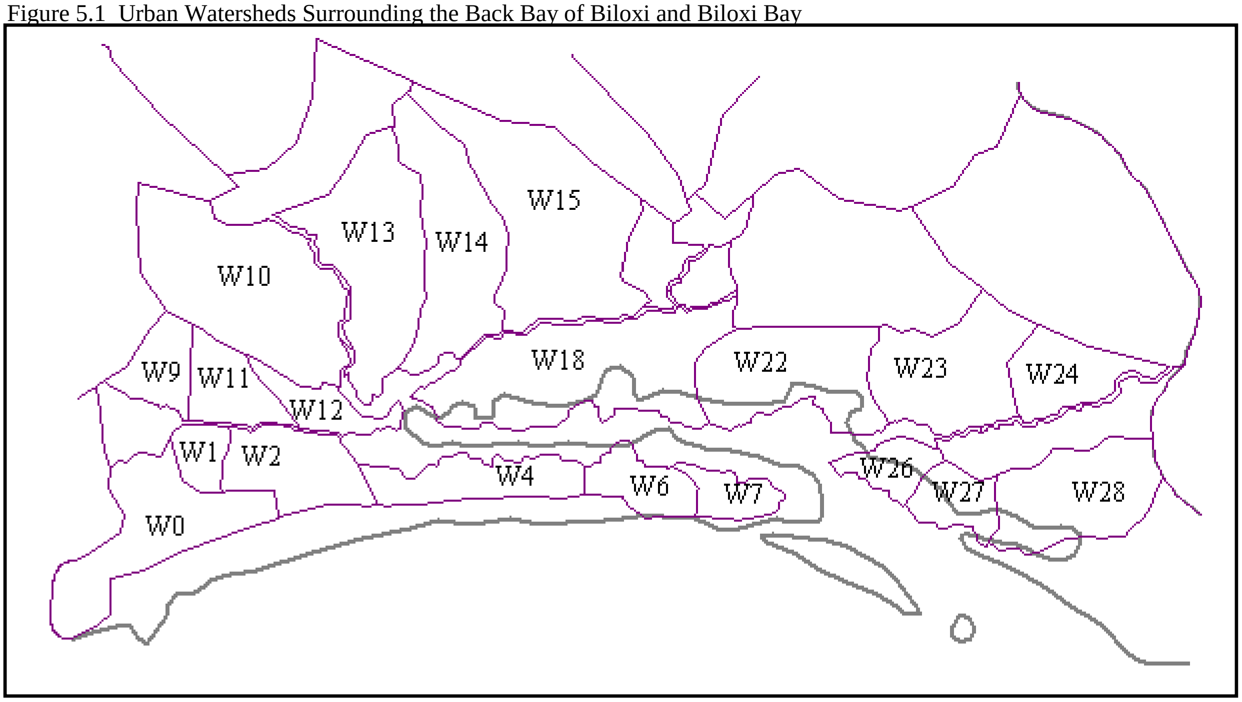


Table 5.2 Reduction in Urban Runoff

Watershed	Existing Load (MPN/15 days)	Allocated Load (MPN/15 days)	Percent Reduction
W0	5.30E+13	3.44E+13	35%
W1	7.37E+12	4.79E+12	35%
W2	1.47E+13	9.57E+12	35%
W4	1.38E+13	8.94E+12	35%
W6	7.75E+12	5.04E+12	35%
W7	6.19E+12	4.02E+12	35%
W9	7.61E+12	4.94E+12	35%
W10	3.26E+13	2.12E+13	35%
W11	1.02E+13	6.64E+12	35%
W12	3.77E+12	2.45E+12	35%
W13	1.16E+13	7.51E+12	35%
W14	9.26E+12	6.02E+12	35%
W15	7.54E+12	4.90E+12	35%
W18	1.53E+13	9.95E+12	35%
W22	1.87E+13	1.21E+13	35%
W23	6.70E+12	4.35E+12	35%
W24	1.37E+12	8.89E+11	35%
W26	8.14E+12	5.29E+12	35%
W27	5.65E+12	3.67E+12	35%
W28	4.86E+12	3.16E+12	35%

5.3 Incorporation of a Margin of Safety (MOS)

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. For this study, the MOS is incorporated into the modeling process by utilizing a conservative fecal coliform decay rate, conservative loading and environmental conditions, and running a dynamic simulation to calculate fecal coliform values in the Back Bay of Biloxi and Biloxi Bay every two hours.

In addition, ensuring compliance with the standard throughout all of the critical periods represented during the modeling period is a conservative practice. Another component of the implicit 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 die-off during transport.

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5.4 Calculation of the TMDL

This TMDL is calculated based on the following equation:

TMDL = WLA + LA + MOS

WLA = NPDES Permitted Facilities
LA = Surface Runoff + Direct Sources (Surface Runoff, Failing Septic Tanks, etc.)
MOS = Implicit

The TMDL was calculated based on the 15-day critical period for the Biloxi Bay Watershed according to the model. Each of the loading rates has been converted to the 15-day equivalent. The wasteload allocation incorporates the fecal coliform contributions from identified NPDES Permitted facilities. The load allocation includes the fecal coliform contributions from nonpoint sources. The margin of safety for this TMDL is derived from the conservative loading assumptions used in setting up the model and is implicit. Table 5.1 gives the TMDL for each of the listed segments.

Table 5.3 Calculation of the TMDL (MPN/15 days)

Waterbody	Waterbody ID	WLA	LA	MOS	TMDL
Biloxi Bay	MS118E03M	0.05E+14	1.80E+14	implicit	1.85E+14
Back Bay of Biloxi	MS118E02M2	0.05E+14	1.68E+14	implicit	1.73E+14
Back Bay of Biloxi Coastline segment 3	MS118C03M	0.05E+14	1.68E+14	implicit	1.73E+14
Back Bay of Biloxi Coastline segment 4	MS118C04M	0.05E+14	1.68E+14	implicit	1.73E+14
Big Lake	MS118E01M	0.03E+14	1.21E+14	implicit	1.24E+14
Bernard Bayou segment 2	MS118BBM2	---	6.18E+12	implicit	6.18E+12
Bernard Bayou segment 3	MS118BBM3	0.19E+13	2.75E+13	implicit	2.94E+13
Bernard Bayou segment 4	MS118BBM4	0.19E+13	7.15E+13	implicit	7.34E+13
Heron Bayou	MS118HBE	---	3.16E+12	implicit	3.16E+12
Old Fort Bayou	MS118M1	---	1.98E+12	implicit	1.98E+12
Tidewater Bayou	MS118TBM	---	5.29E+12	implicit	5.29E+12

*Reduction Scenario: 60% reduction in failing septic tanks within the Bernard Bayou segment 2 drainage area
35% reduction in the runoff from the watersheds surrounding the Back Bay of Biloxi and Biloxi Bay

5.5 Seasonality

For many waterbodies and streams in the state, fecal coliform limits vary according to the seasons. Most of the impaired waterbodies addressed in this TMDL are designated for the use of Secondary Contact. For this use, the pollutant standard is seasonal. The Biloxi Bay is designated for the use of Shellfishing. For this use, the pollutant standard is not seasonal.

The model was run for a representative wet and dry year to save on computer run time. It took into account all of the seasons within the calendar year. This 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 CONCLUSION

The fecal coliform scenario used in this TMDL included requiring all NPDES permitted dischargers to maintain current permit limits. In addition, for the Back Bay of Biloxi and all its upstream segments to meet the water quality standards for Secondary Contact, a 60 percent reduction in septic tank failures within the drainage area of Bernard Bayou segment 2 was necessary. For Biloxi Bay to meet the water quality standards for Shellfishing, a 35 percent reduction in the urban nonpoint source runoff from the watersheds surrounding the Back Bay of Biloxi and Biloxi Bay was necessary.

6.1 Future Monitoring and Activities

MDEQ has adopted the Basin Approach to Water Quality Management, a plan that divides Mississippi's major drainage basins into five groups. During each yearlong cycle, MDEQ resources for water quality monitoring will be focused on one of the basin groups. During the next monitoring phase in the Coastal Streams Basin, additional monitoring is needed to identify any change in water quality within the Back Bay of Biloxi and Biloxi Bay Watershed.

MDEQ guidance for future Section 319 project funding will encourage NPS restoration projects that attempt to address TMDL related issues within Section 303(d)/TMDL watersheds in Mississippi. An additional potential funding source for future activities in this watershed is the Coastal Impact Assistance Program (CIAP). CIAP is a program recently formed to provide funds for projects which deal with environmental resources on the Mississippi Coast.

The Gulf of Mexico Program Office (GMPO) is facilitating efforts to evaluate options for future wastewater treatment needs in Hancock County (URS, 2001). Recommendations include consolidating the wastewater treatment in the county under one authority, Southern Regional Wastewater Management District (SRWWMD), and building collection and transport systems for rural parts of the county. The consolidated facility might utilize innovative approaches to treatment and disposal including land application. Similar efforts could be undertaken by Harrison and Jackson Counties.

Additional monitoring is needed within the Back Bay of Biloxi and Biloxi Bay Watershed to quantify the bacteria loadings entering the bay. This data could be used to validate the loadings predicted by the modeling used for this TMDL. Bacterial source tracking (BST) involves identifying the sources of the bacteria present in surface water through various monitoring and analytical techniques including biochemical profiling and DNA. This technique could be used to determine the sources of the bacteria entering the Back Bay of Biloxi and Biloxi Bay.

Numerous other management practices could be implemented to reduce bacteria loadings within the Back Bay of Biloxi and Biloxi Bay Watershed. These include improving stormwater treatment practices, repairing sanitary sewers, and getting pet owners to clean up after their pets either through implementation of an aggressive pet waste education program or city ordinances. Also, the counties could establish ordinances for inspection, maintenance, and repair of septic systems and individual onsite wastewater treatment systems in the area.

6.2 Public Participation

This TMDL will be published for a 30-day public notice. During this time, the public will be notified by publication in the statewide newspaper and a newspaper in the area of the watershed. The public will be given an opportunity to review the TMDL and submit comments. In addition, a public meeting was held on September 27, 2001 at 6:30 p.m. in Biloxi, MS. This was an open meeting, public forum style, to discuss plans for this TMDL.

All comments received during the public notice period become a part of the record of this TMDL. All comments will be considered in the completion of this TMDL for submission to EPA Region IV for final approval.

DEFINITIONS

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

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

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

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

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

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

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

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

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

Effluent: treated wastewater flowing out of the treatment facilities.

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

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

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

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

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

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

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

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

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

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

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

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

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

Sigma (Σ): shorthand way to express taking the sum of a series of numbers. For example, the sum or total of three amounts 24, 123, 16, ($\mathbf{d}_1$, $\mathbf{d}_2$, $\mathbf{d}_3$) respectively could be shown as:

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

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

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

Wasteload allocation (WLA): the portion of a receiving water's loading capacity attributed to or assigned to point sources of a pollutant.

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

CIAP ....Coastal Impact Assistance Program

CWA ....Clean Water Act

DMR .... Discharge Monitoring Report

DYNHYD5 ....Hydrodynamic Model - 5

EPA ....Environmental Protection Agency

GIS .... Geographic Information System

HUC ....Hydrologic Unit Code

LA ....Load Allocation

MARIS.. State of Mississippi Automated Information System

MDEQ.. Mississippi Department of Environmental Quality

MOS.. Margin of Safety

NRCS ....National Resource Conservation Service

NPDES.. National Pollution Discharge Elimination System

NPSM...Nonpoint Source Model

RF3.. Reach File 3

USGS .... United States Geological Survey

WASP5 .... Water Quality Analysis Simulation Program - 5

WLA ....Waste Load Allocation

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APPENDIX A

Appendix A includes graphs of the model results showing the instream fecal coliform concentrations of the impaired waterbodies included in this TMDL. A reduction in septic tank failures within the drainage area of Bernard Bayou segment 2 was necessary in order to meet the water quality standard for Secondary Contact. This reduction in the Bernard Bayou segment 2 drainage area is the only reduction necessary in order for the Back Bay of Biloxi and all its upstream segments to comply with the Secondary Contact standard. However, further reductions were necessary for Biloxi Bay to comply with the water quality standard for Shellfishing.

The graphs for Biloxi Bay show a 15-day running median of the data. The straight line at 14 MPN per 100 ml indicates the water quality standard for Shellfishing.

All other graphs show a 30-day geometric mean of the data. The straight line at 200 counts per 100 ml indicates the water quality standard of Secondary Contact for the streams. (The 2000 counts per 100 ml water quality standard is not shown on the graph since there are no fecal coliform concentrations approaching this limit.) All graphs are shown on the same scale for comparison purposes.

As shown by the graphs, Biloxi Bay (MS118E03M) is showing impairment of the Shellfishing standard and Bernard Bayou segment 2, MS118BBM2, is showing impairment of the Secondary Contact standard under existing conditions according to the model.

Graphs A-1 and A-2 show the fecal coliform levels for Biloxi Bay. The load allocation necessary for Biloxi Bay to meet the water quality standards for Shellfishing involves a reduction in the urban nonpoint source runoff from the watersheds surrounding the Back Bay of Biloxi and Biloxi Bay. A 35 percent reduction in the concentration of urban runoff was necessary from each of these small watersheds.

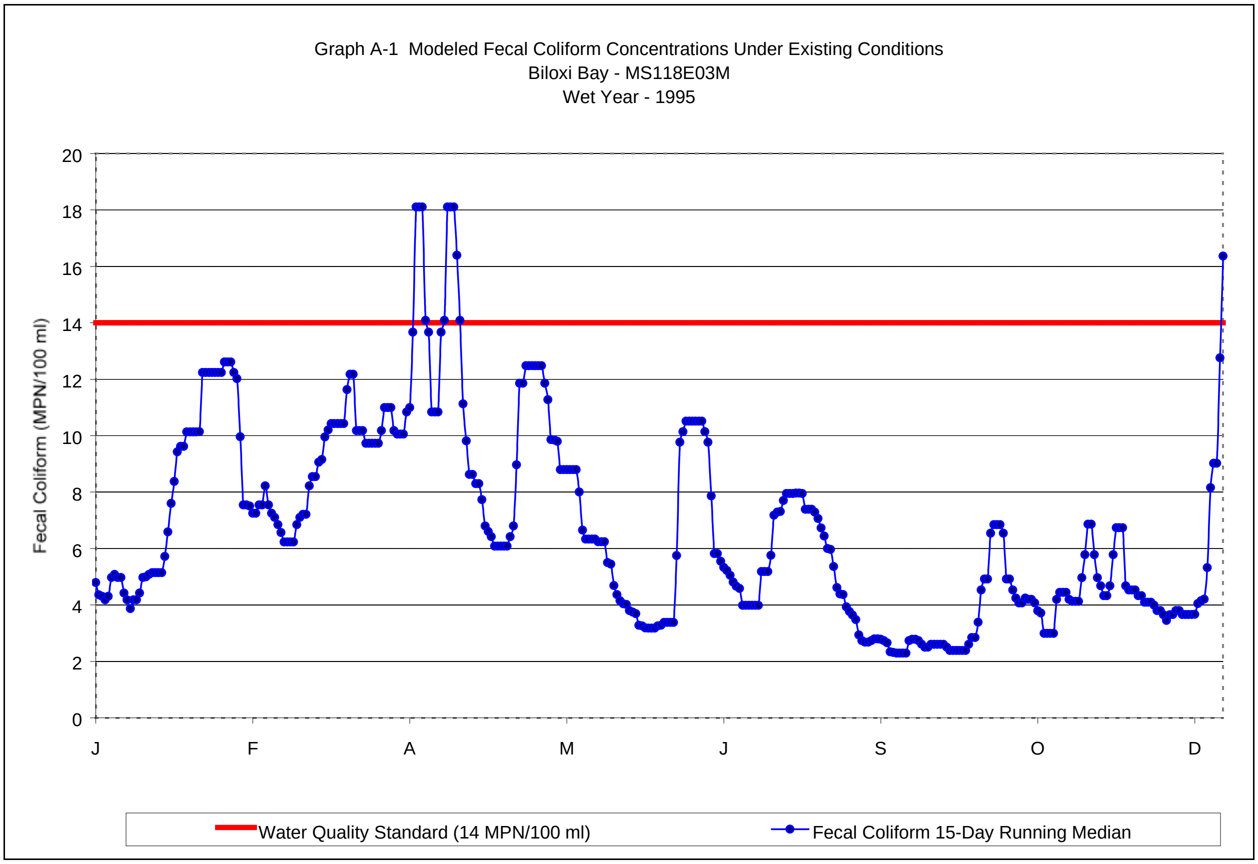
Graphs A-3 through A-20 show the fecal coliform levels for all other tidally influenced waterbodies within the Biloxi Bay Watershed. These waterbodies all have the designated use of Secondary Contact. Both wet year and dry year results are shown for existing conditions. As shown by the graphs, these segments did not show impairment of the Secondary Contact standard according to the model. However, reductions were necessary in order for Biloxi Bay to meet the more stringent water quality standard for Shellfishing.

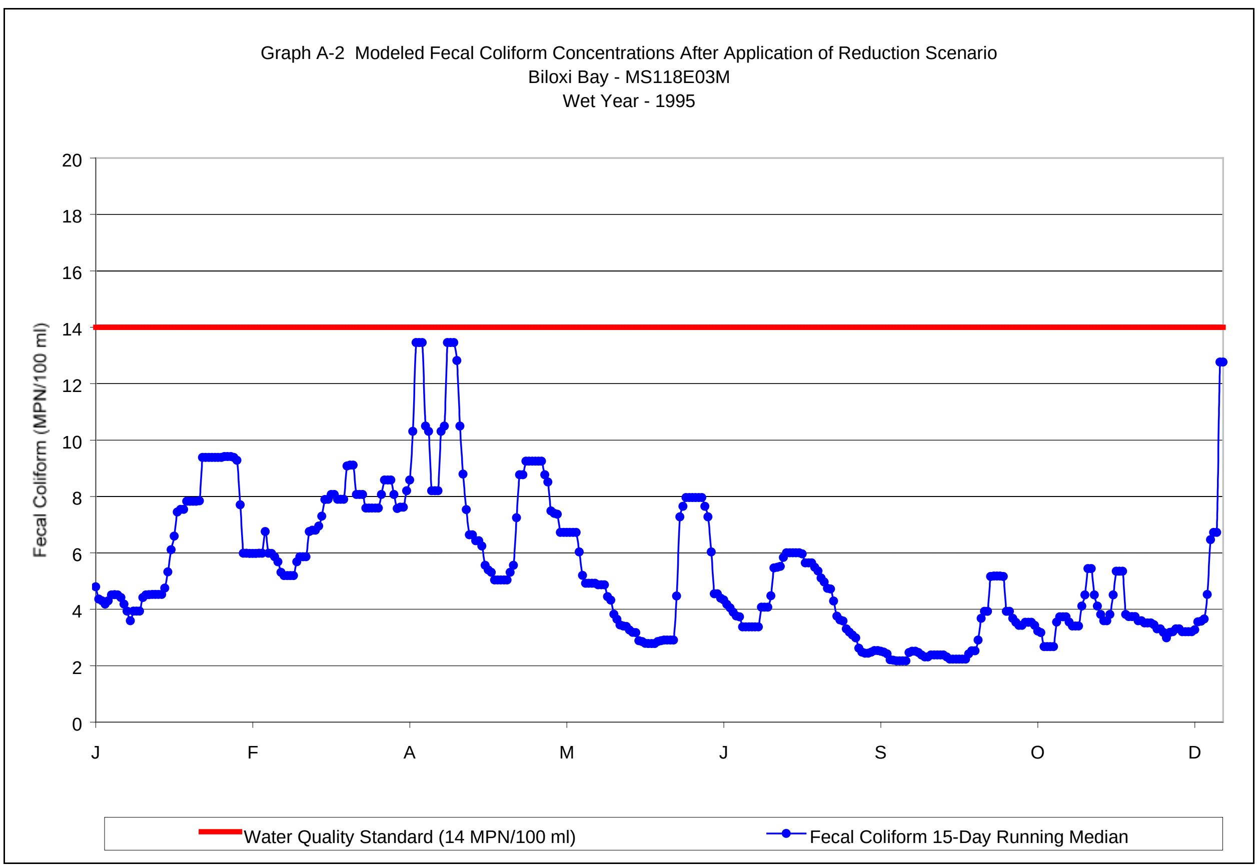
Graphs A-21 through A-25 show the fecal coliform levels for the freshwater segments that are not tidally influenced, the most upstream segment of Bernard Bayou and Old Fort Bayou. These were modeled using the watershed model, NPSM. Both dry year and wet year results are shown.

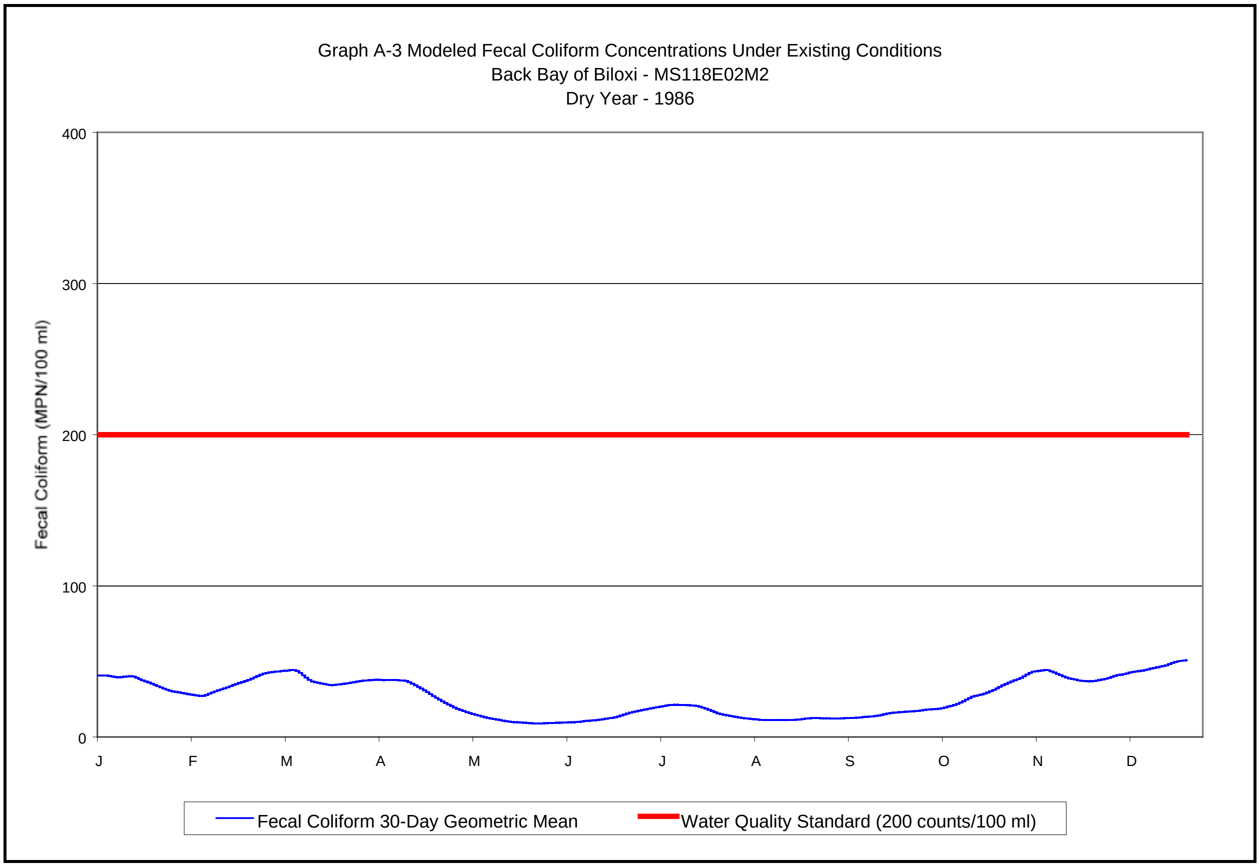
Under existing conditions Old Fort Bayou showed no impairment based on the Secondary Contact standard (Graphs A-21 and A-22) Therefore, no reduction was necessary to meet this standard. Bernard Bayou segment 2, MS118BBM2, did show impairment of the Secondary Contact standard (Graphs A-23 and A-24). A 60 percent reduction in failing septic tanks within the drainage area of this segment was the reduction scenario used to meet the water quality standard for Secondary Contact (Graph A-25).

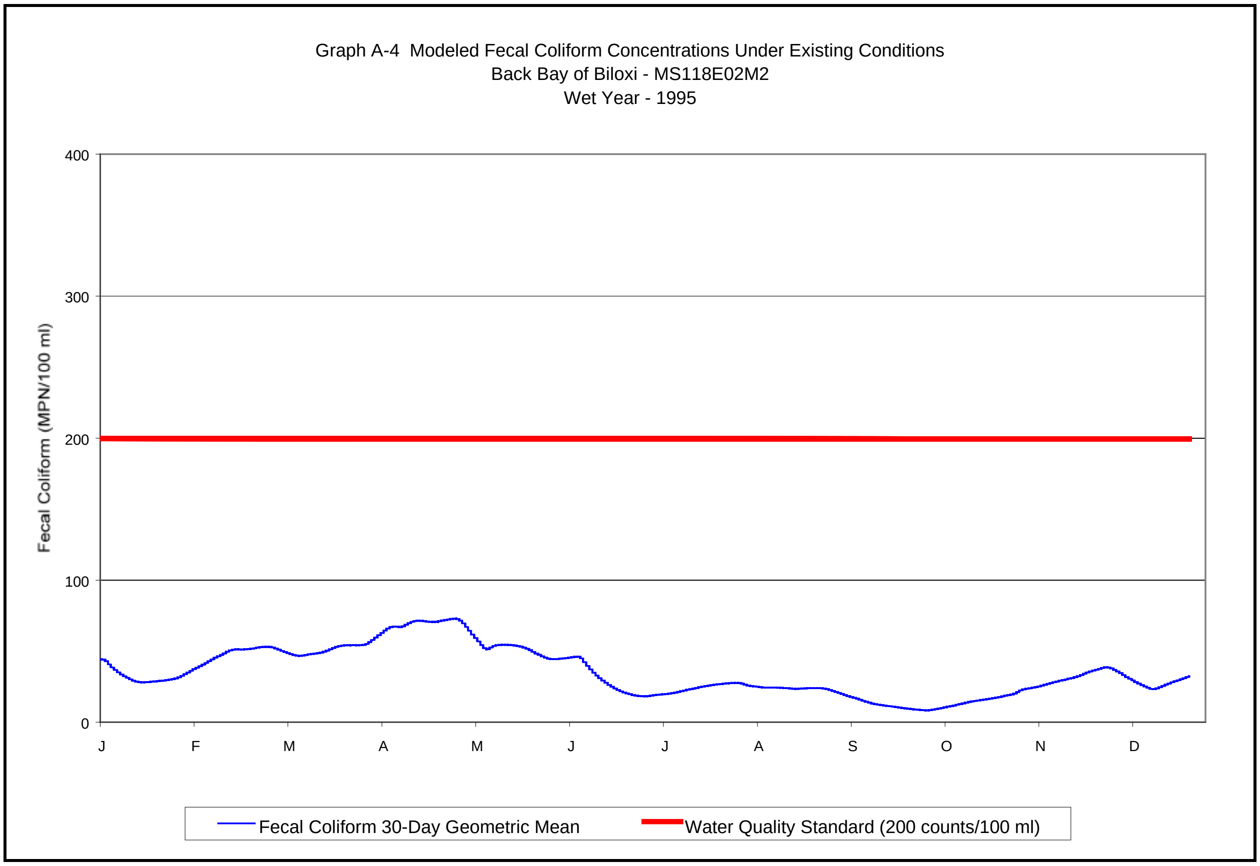
The TMDL calculated in this report represents the maximum fecal coliform load that can be assimilated by the waterbody segment during the critical 15-day period that will maintain water quality standards within Biloxi Bay. The calculation of this TMDL is based on the critical hydrologic flow condition 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.

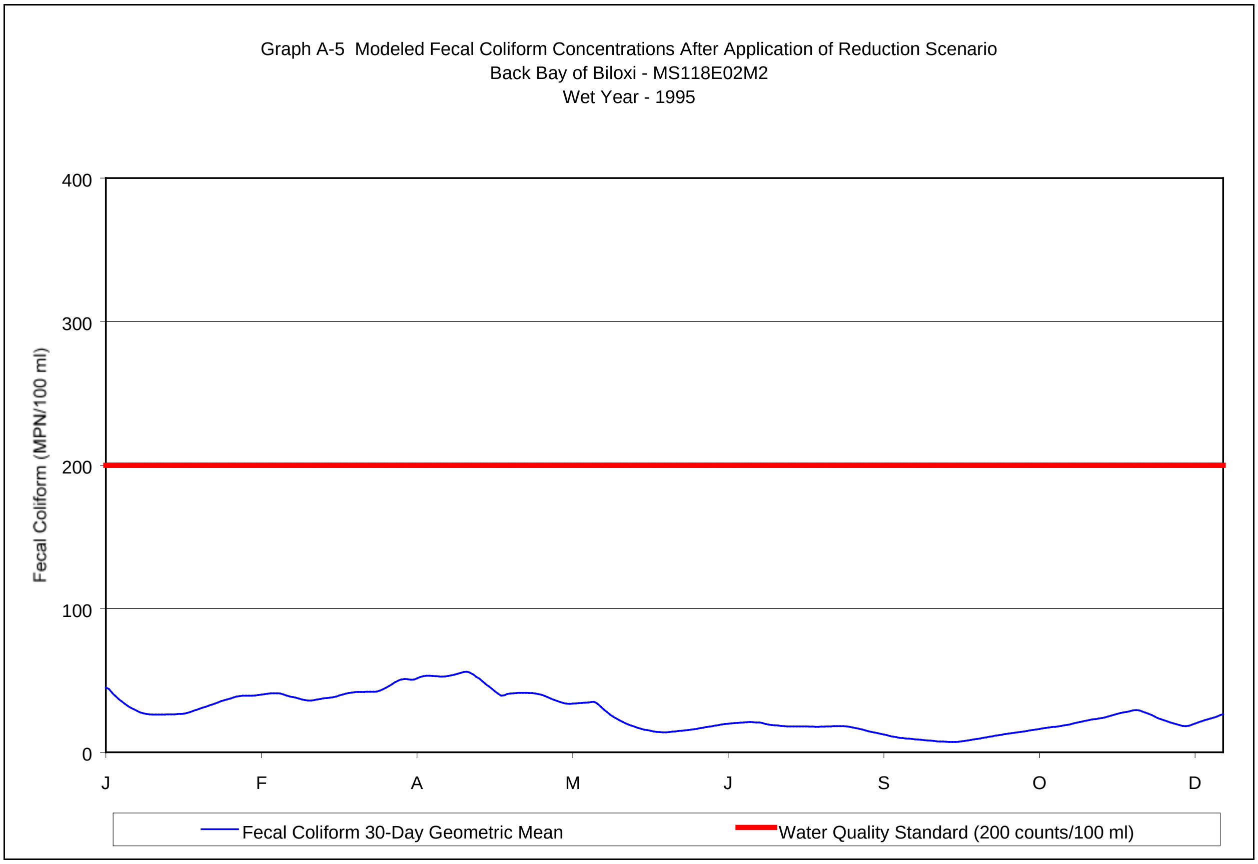
An individual TMDL calculation was prepared for each listed waterbody segment included in this report. The numerical values for the wasteload allocation (point sources) and load allocation (nonpoint sources) for each waterbody segment can be found on the waterbody segment identification pages at the beginning of this report and in Table 5.1.

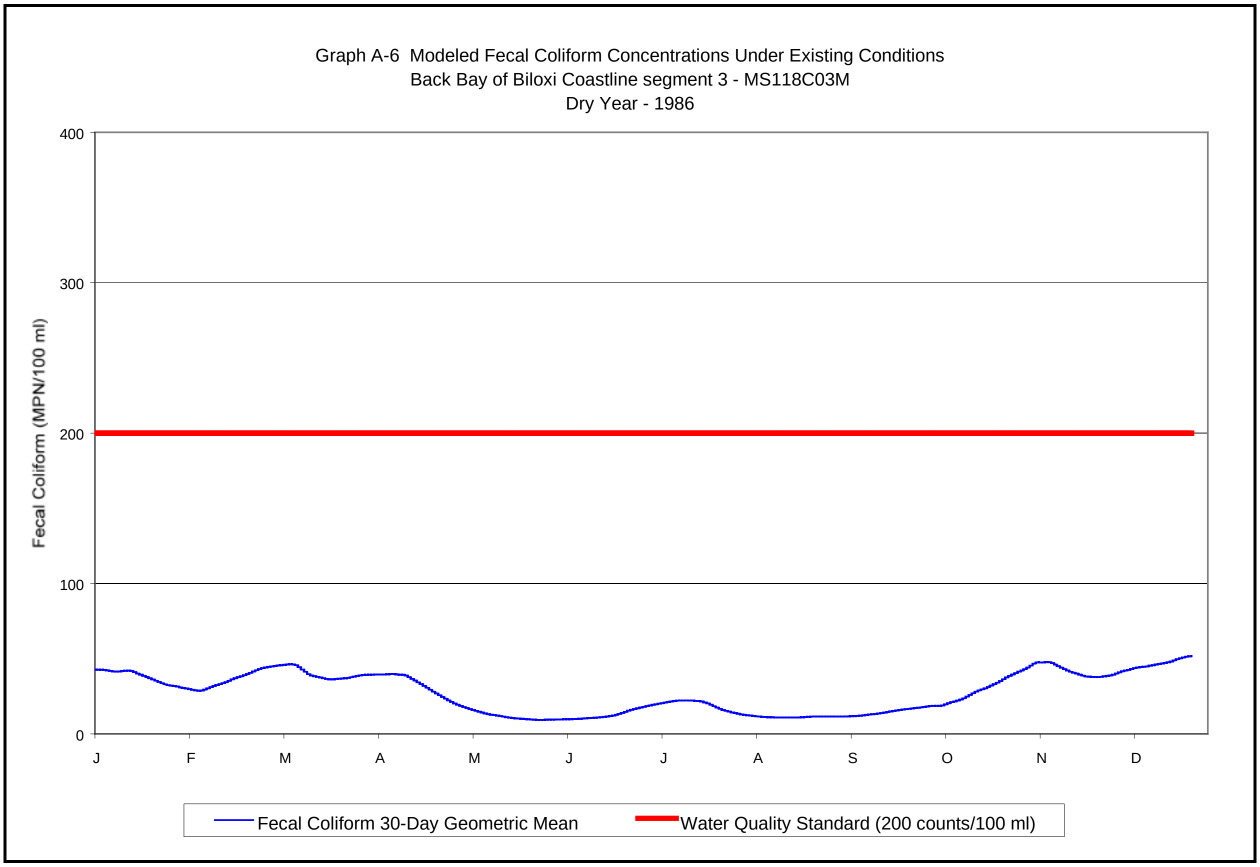

Graph A-1 Modeled Fecal Coliform Concentrations Under Existing Conditions
Biloxi Bay - MS118E03M
Wet Year - 1995
Fecal Coliform (MPN/100 ml)
20
18
16
14
12
10
8
6
4
2
0
J
F
A
M
J
S
O
D
Water Quality Standard (14 MPN/100 ml)
Fecal Coliform 15-Day Running Median

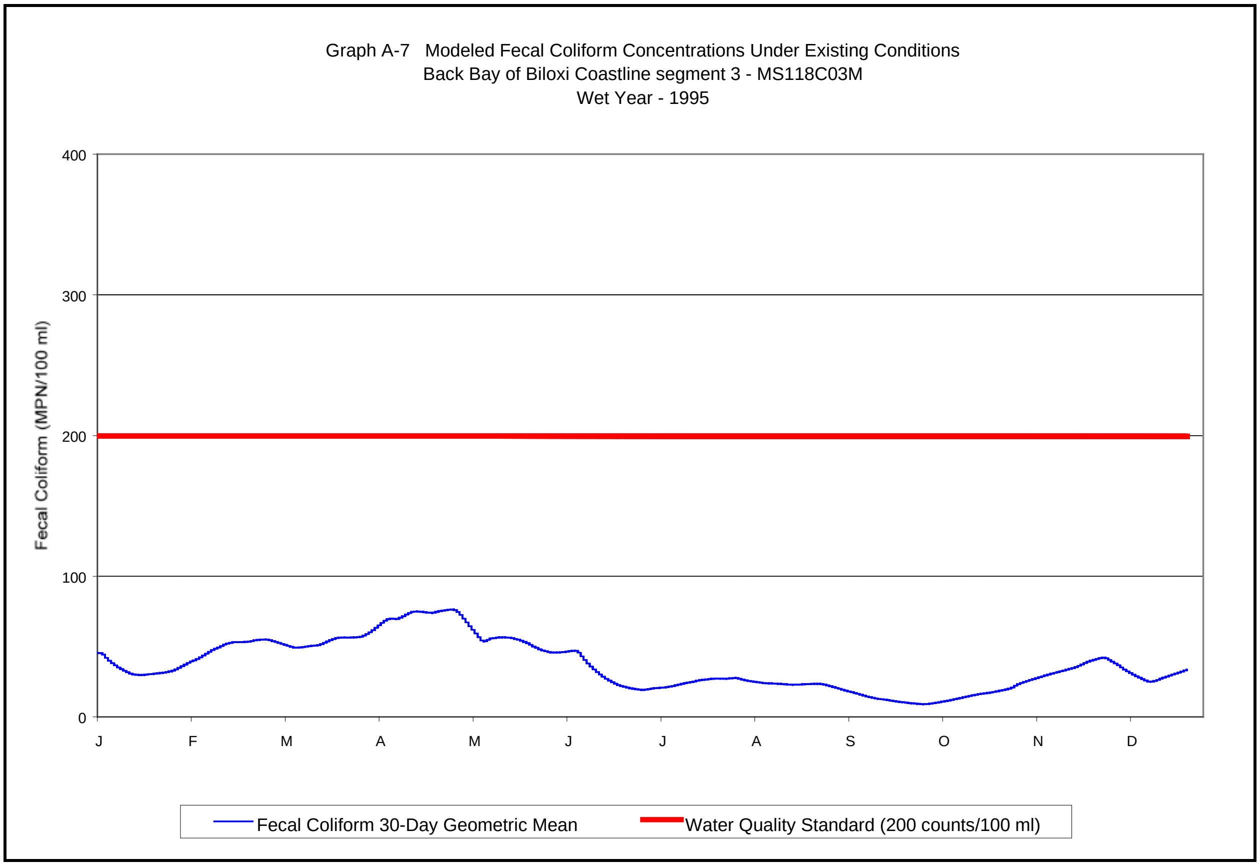

Graph A-2 Modeled Fecal Coliform Concentrations After Application of Reduction Scenario
Biloxi Bay - MS118E03M
Wet Year - 1995
Fecal Coliform (MPN/100 ml)
20
18
16
14
12
10
8
6
4
2
0
J
F
A
M
J
S
O
D
Water Quality Standard (14 MPN/100 ml)
Fecal Coliform 15-Day Running Median

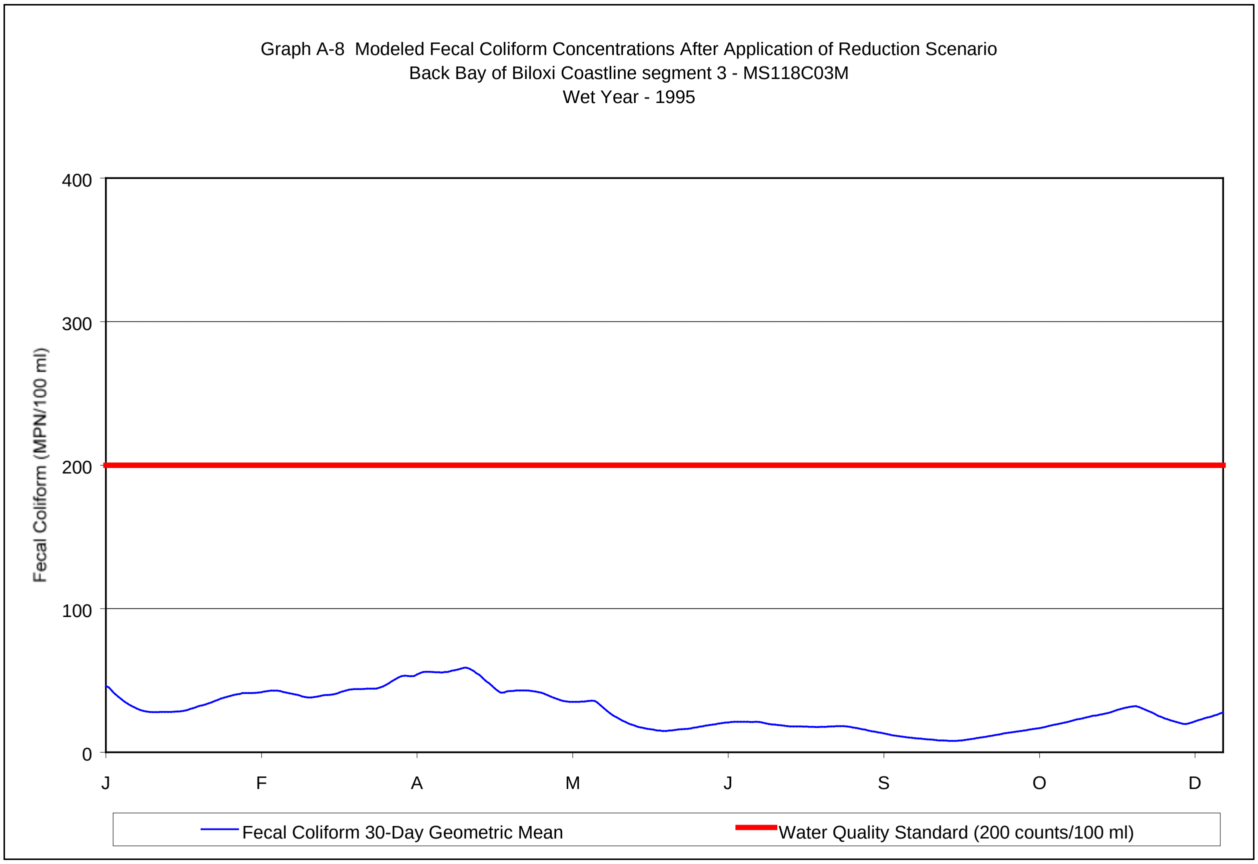

Graph A-3 Modeled Fecal Coliform Concentrations Under Existing Conditions
Back Bay of Biloxi - MS118E02M2
Dry Year - 1986
Fecal Coliform (MPN/100 ml)
400
300
200
100
0
J
F
M
A
M
J
J
A
S
O
N
D
Fecal Coliform 30-Day Geometric Mean
Water Quality Standard (200 counts/100 ml)


Graph A-4 Modeled Fecal Coliform Concentrations Under Existing Conditions
Back Bay of Biloxi - MS118E02M2
Wet Year - 1995
Fecal Coliform (MPN/100 ml)
400
300
200
100
0
J
F
M
A
M
J
J
A
S
O
N
D
Fecal Coliform 30-Day Geometric Mean
Water Quality Standard (200 counts/100 ml)

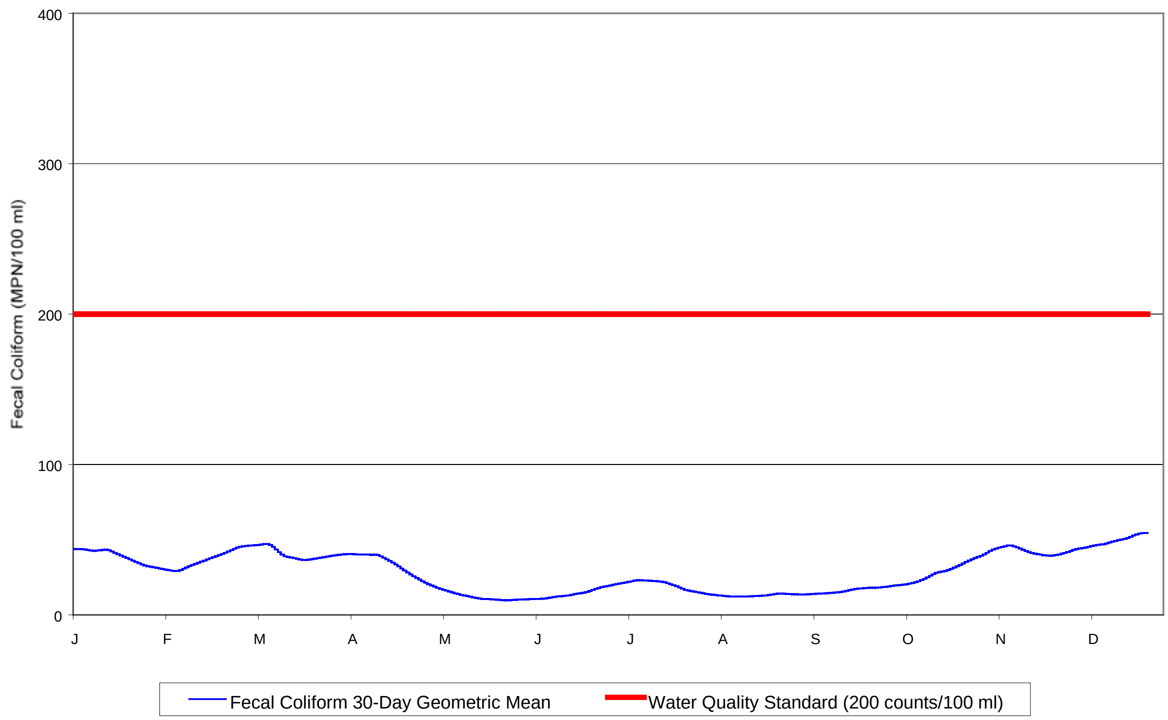

Graph A-5 Modeled Fecal Coliform Concentrations After Application of Reduction Scenario
Back Bay of Biloxi - MS118E02M2
Wet Year - 1995
Fecal Coliform (MPN/100 ml)
400
300
200
100
0
J
F
A
M
J
S
O
D
Fecal Coliform 30-Day Geometric Mean
Water Quality Standard (200 counts/100 ml)


Graph A-6 Modeled Fecal Coliform Concentrations Under Existing Conditions
Back Bay of Biloxi Coastline segment 3 - MS118C03M
Dry Year - 1986
Fecal Coliform (MPN/100 ml)
400
300
200
100
0
J
F
M
A
M
J
J
A
S
O
N
D
Fecal Coliform 30-Day Geometric Mean
Water Quality Standard (200 counts/100 ml)

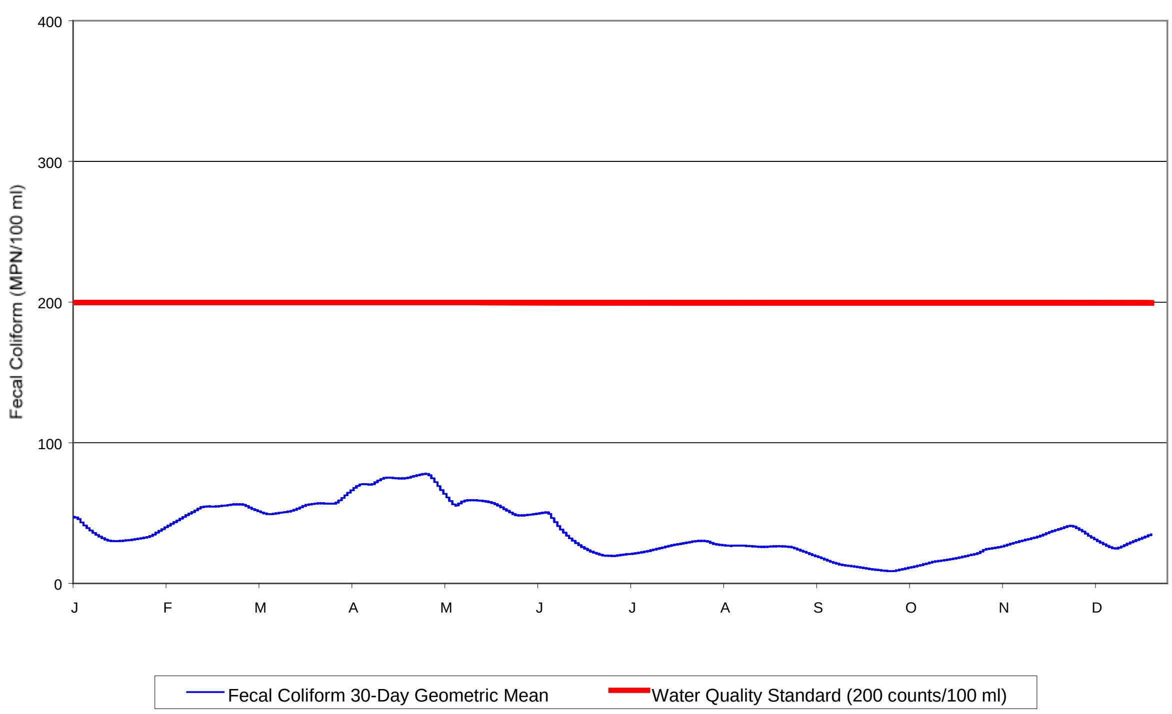

Graph A-7 Modeled Fecal Coliform Concentrations Under Existing Conditions
Back Bay of Biloxi Coastline segment 3 - MS118C03M
Wet Year - 1995
Fecal Coliform (MPN/100 ml)
400
300
200
100
0
J
F
M
A
M
J
J
A
S
O
N
D
Fecal Coliform 30-Day Geometric Mean
Water Quality Standard (200 counts/100 ml)

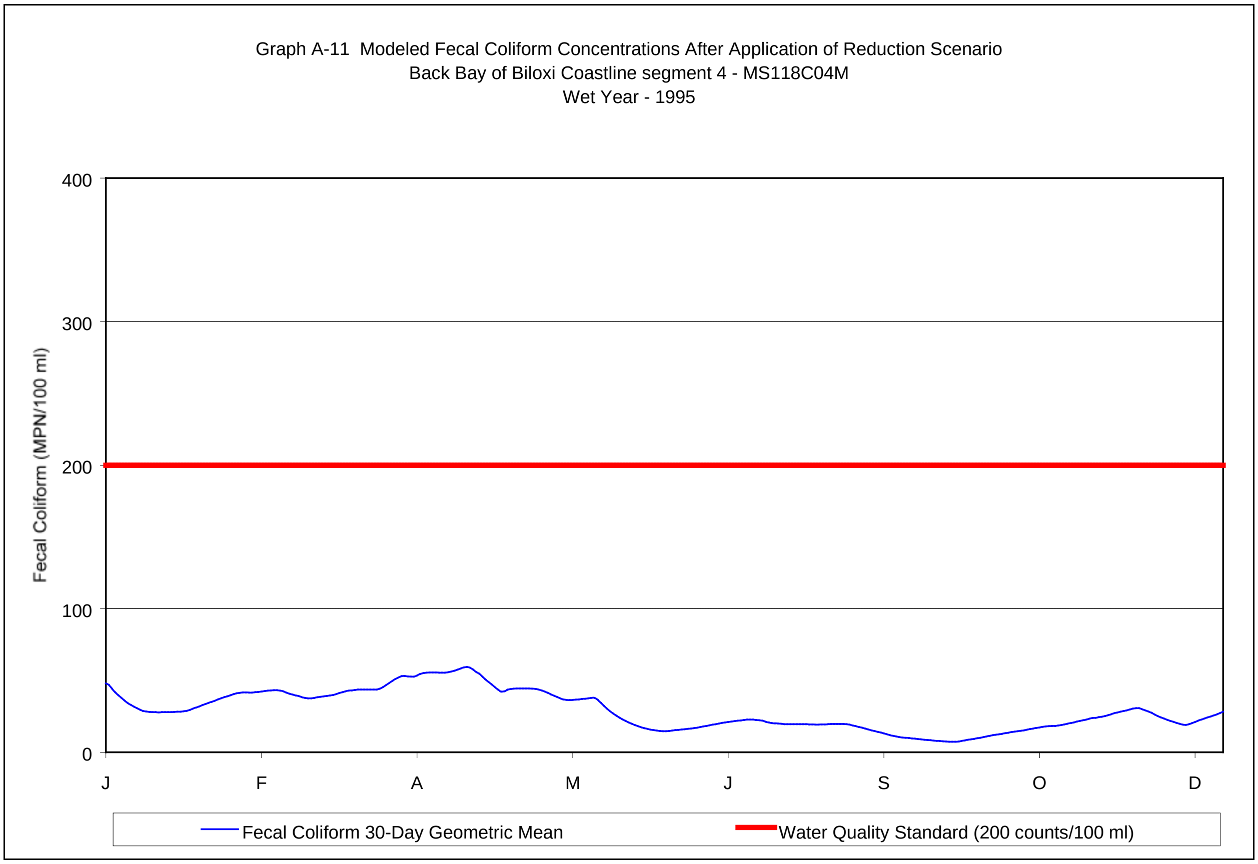

Graph A-8 Modeled Fecal Coliform Concentrations After Application of Reduction Scenario
Back Bay of Biloxi Coastline segment 3 - MS118C03M
Wet Year - 1995
Fecal Coliform (MPN/100 ml)
400
300
200
100
0
J
F
A
M
J
S
O
D
Fecal Coliform 30-Day Geometric Mean
Water Quality Standard (200 counts/100 ml)

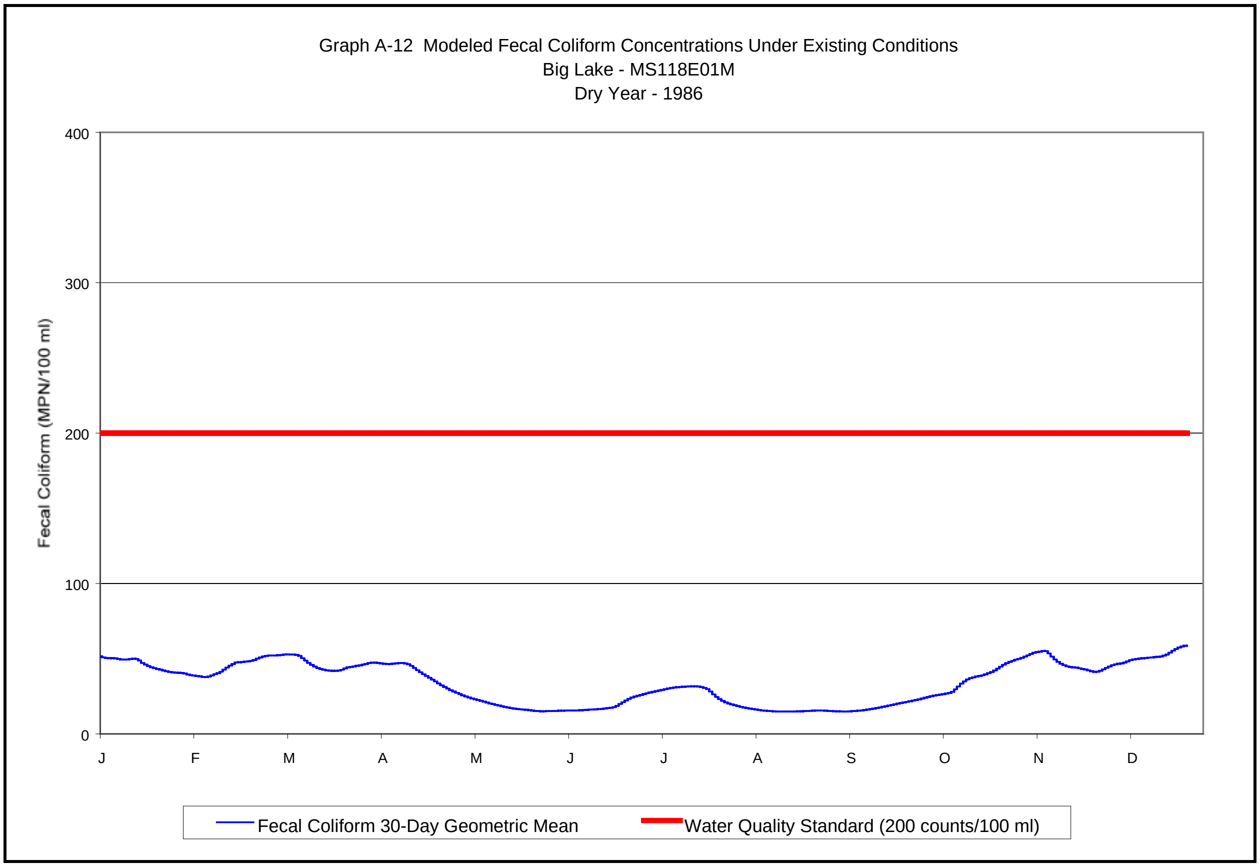
Graph A-9 Modeled Fecal Coliform Concentrations Under Existing Conditions
Back Bay of Biloxi Coastline segment 4 - MS118C04M
Dry Year - 1986

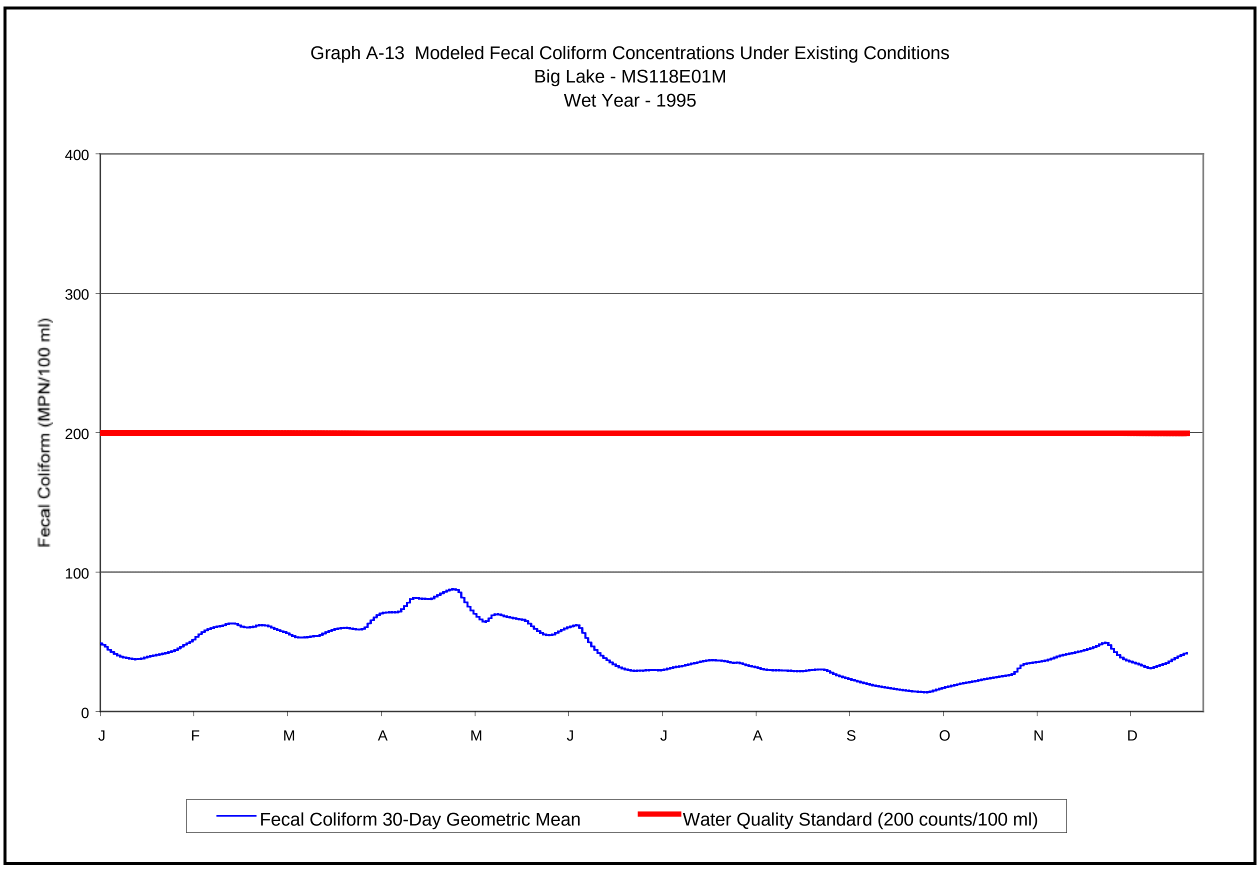


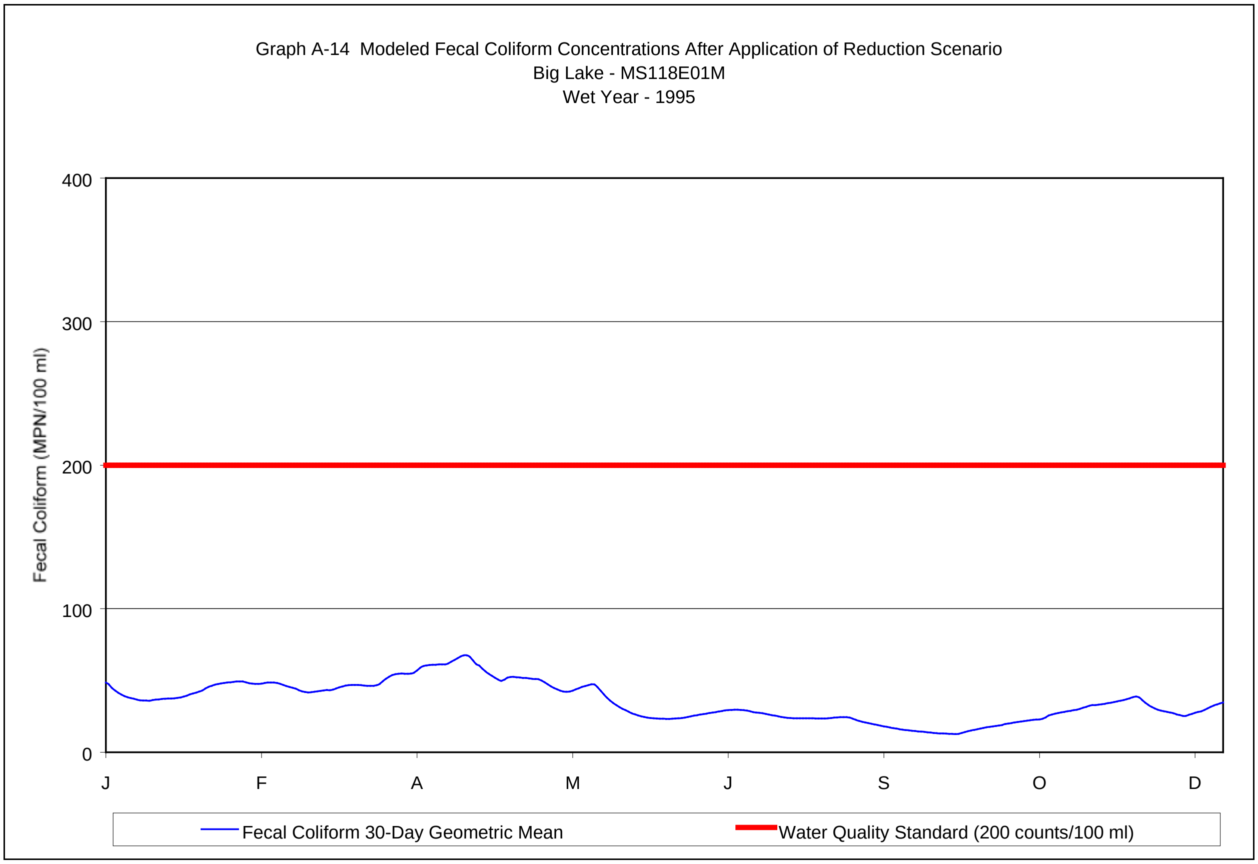
Graph A-10 Modeled Fecal Coliform Concentrations Under Existing Conditions
Back Bay of Biloxi Coastline segment 4 - MS118C04M
Wet Year - 1995

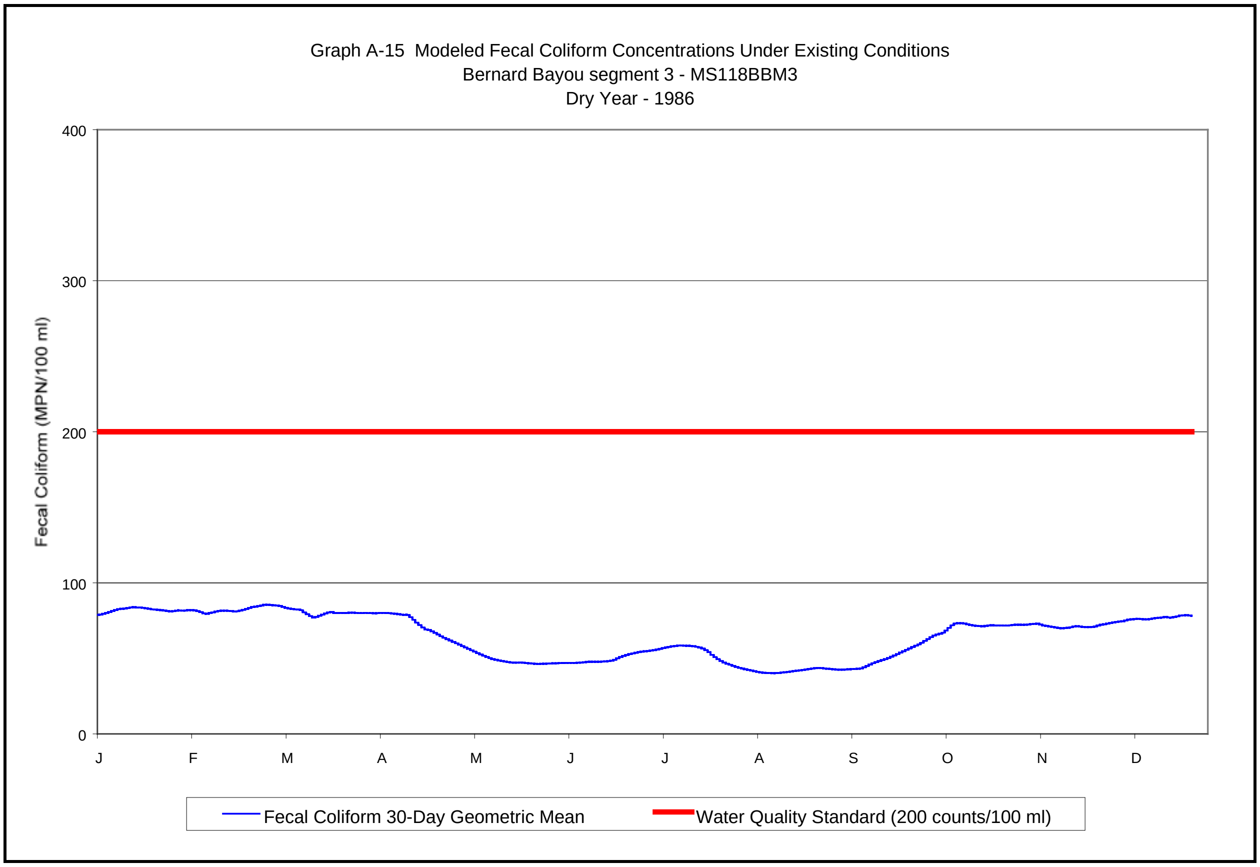


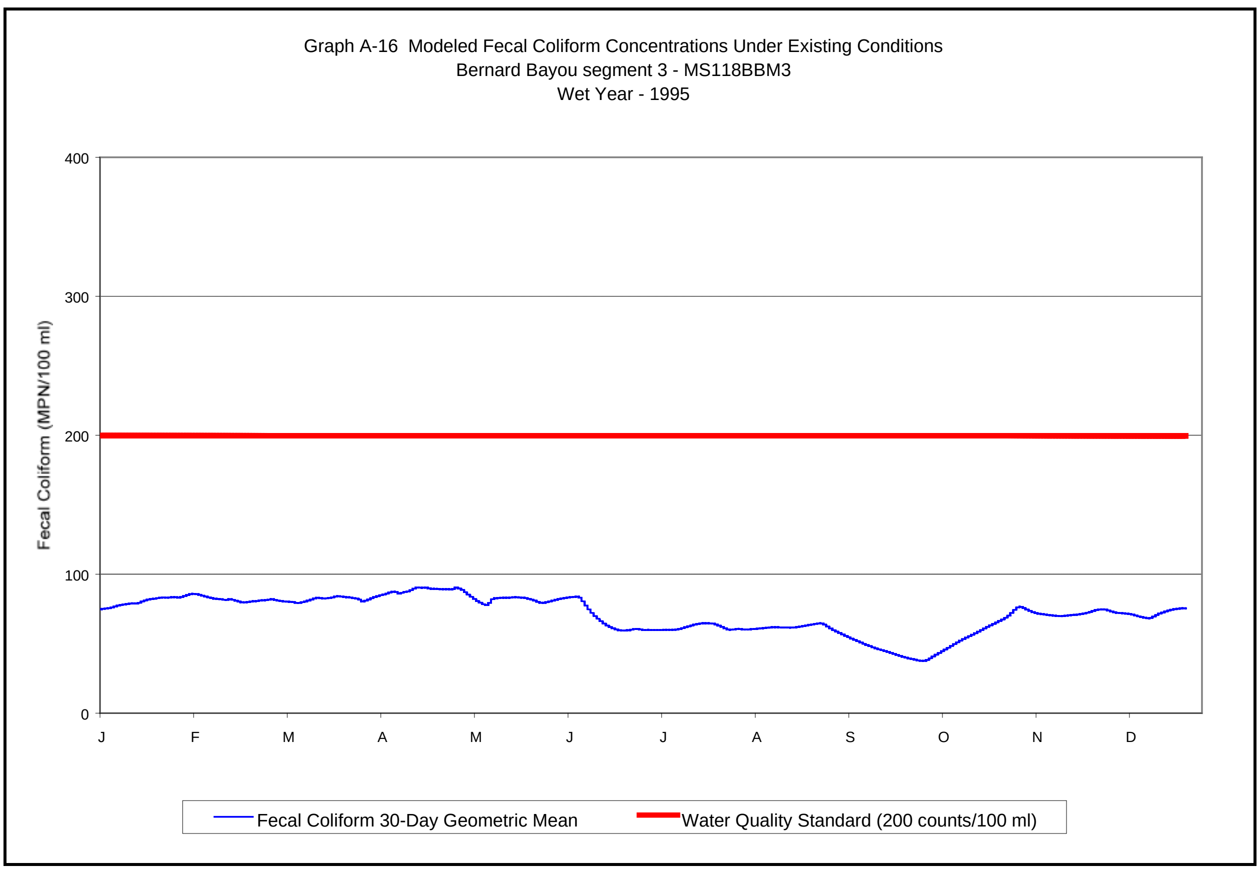

Graph A-11 Modeled Fecal Coliform Concentrations After Application of Reduction Scenario
Back Bay of Biloxi Coastline segment 4 - MS118C04M
Wet Year - 1995
Fecal Coliform (MPN/100 ml)
400
300
200
100
0
J
F
A
M
J
S
O
D
Fecal Coliform 30-Day Geometric Mean
Water Quality Standard (200 counts/100 ml)

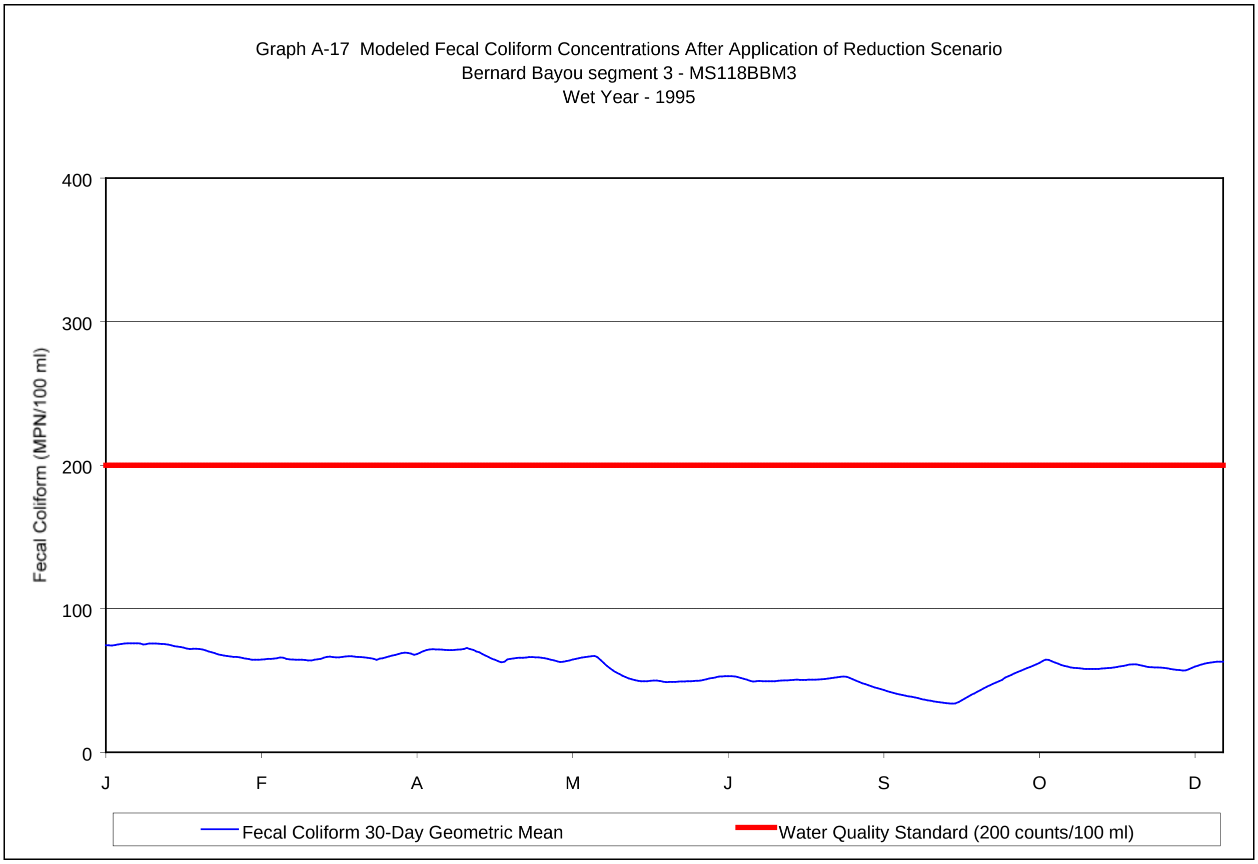

Graph A-12 Modeled Fecal Coliform Concentrations Under Existing Conditions
Big Lake - MS118E01M
Dry Year - 1986
Fecal Coliform (MPN/100 ml)
400
300
200
100
0
J
F
M
A
M
J
J
A
S
O
N
D
Fecal Coliform 30-Day Geometric Mean
Water Quality Standard (200 counts/100 ml)


Graph A-13 Modeled Fecal Coliform Concentrations Under Existing Conditions
Big Lake - MS118E01M
Wet Year - 1995
Fecal Coliform (MPN/100 ml)
400
300
200
100
0
J
F
M
A
M
J
J
A
S
O
N
D
Fecal Coliform 30-Day Geometric Mean
Water Quality Standard (200 counts/100 ml)

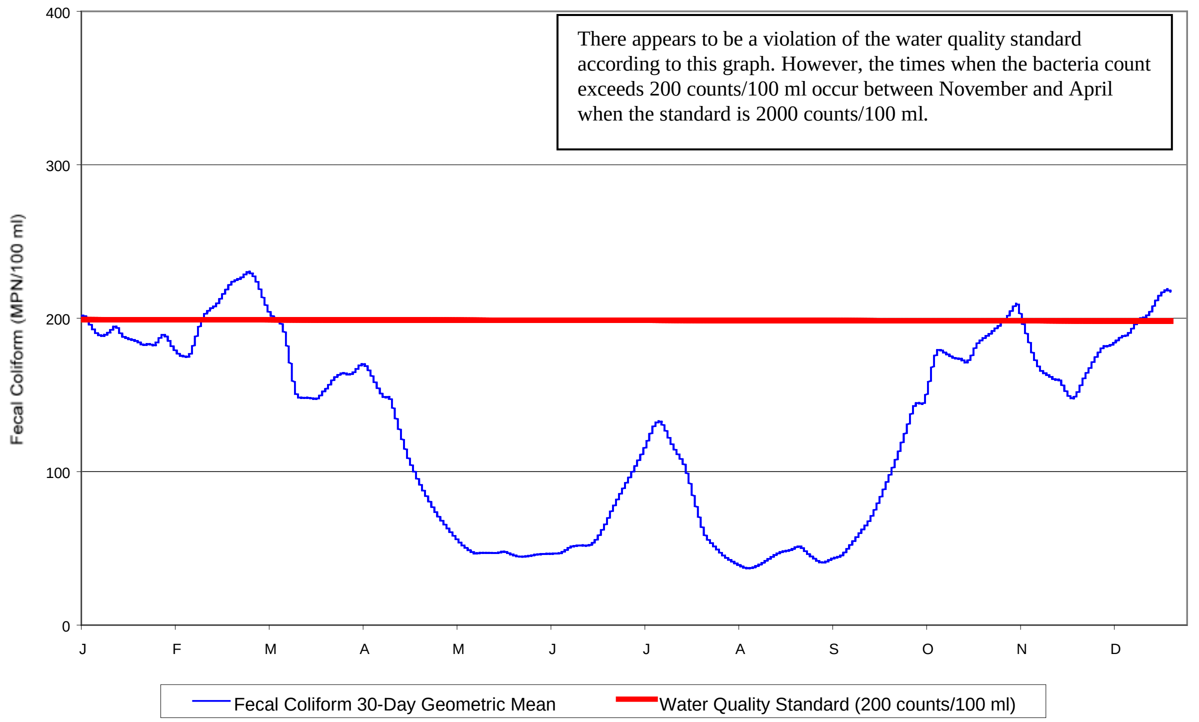

Graph A-14 Modeled Fecal Coliform Concentrations After Application of Reduction Scenario
Big Lake - MS118E01M
Wet Year - 1995
Fecal Coliform (MPN/100 ml)
400
300
200
100
0
J
F
A
M
J
S
O
D
Fecal Coliform 30-Day Geometric Mean
Water Quality Standard (200 counts/100 ml)


Graph A-15 Modeled Fecal Coliform Concentrations Under Existing Conditions
Bernard Bayou segment 3 - MS118BBM3
Dry Year - 1986
Fecal Coliform (MPN/100 ml)
400
300
200
100
0
J
F
M
A
M
J
J
A
S
O
N
D
Fecal Coliform 30-Day Geometric Mean
Water Quality Standard (200 counts/100 ml)

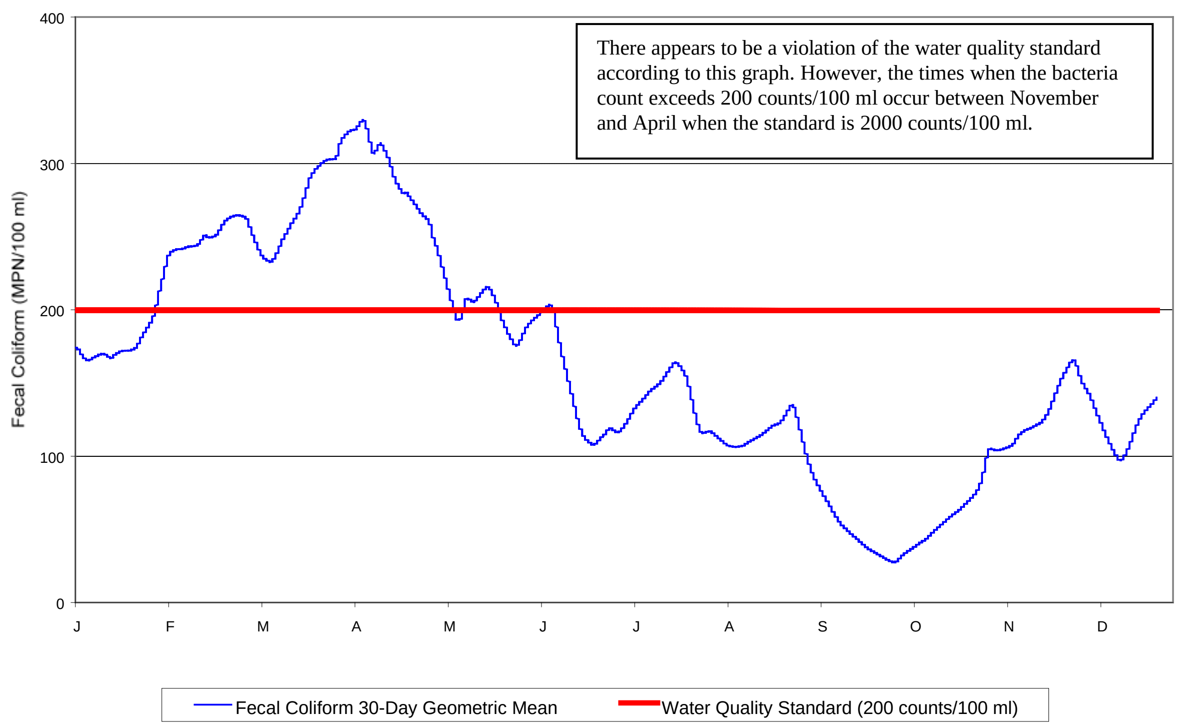

Graph A-16 Modeled Fecal Coliform Concentrations Under Existing Conditions
Bernard Bayou segment 3 - MS118BBM3
Wet Year - 1995
Fecal Coliform (MPN/100 ml)
400
300
200
100
0
J
F
M
A
M
J
J
A
S
O
N
D
Fecal Coliform 30-Day Geometric Mean
Water Quality Standard (200 counts/100 ml)

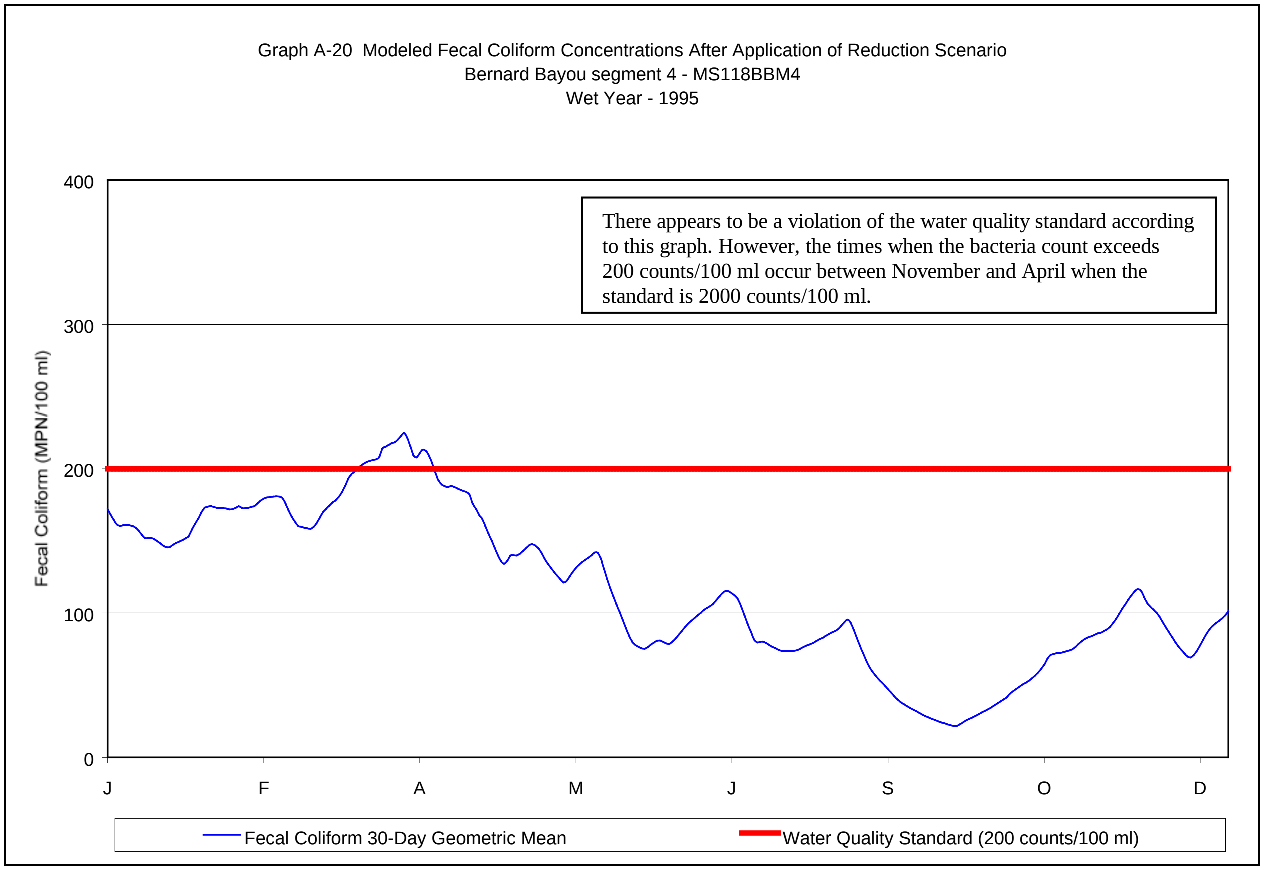

Graph A-17 Modeled Fecal Coliform Concentrations After Application of Reduction Scenario
Bernard Bayou segment 3 - MS118BBM3
Wet Year - 1995
Fecal Coliform (MPN/100 ml)
400
300
200
100
0
J
F
A
M
J
S
O
D
Fecal Coliform 30-Day Geometric Mean
Water Quality Standard (200 counts/100 ml)

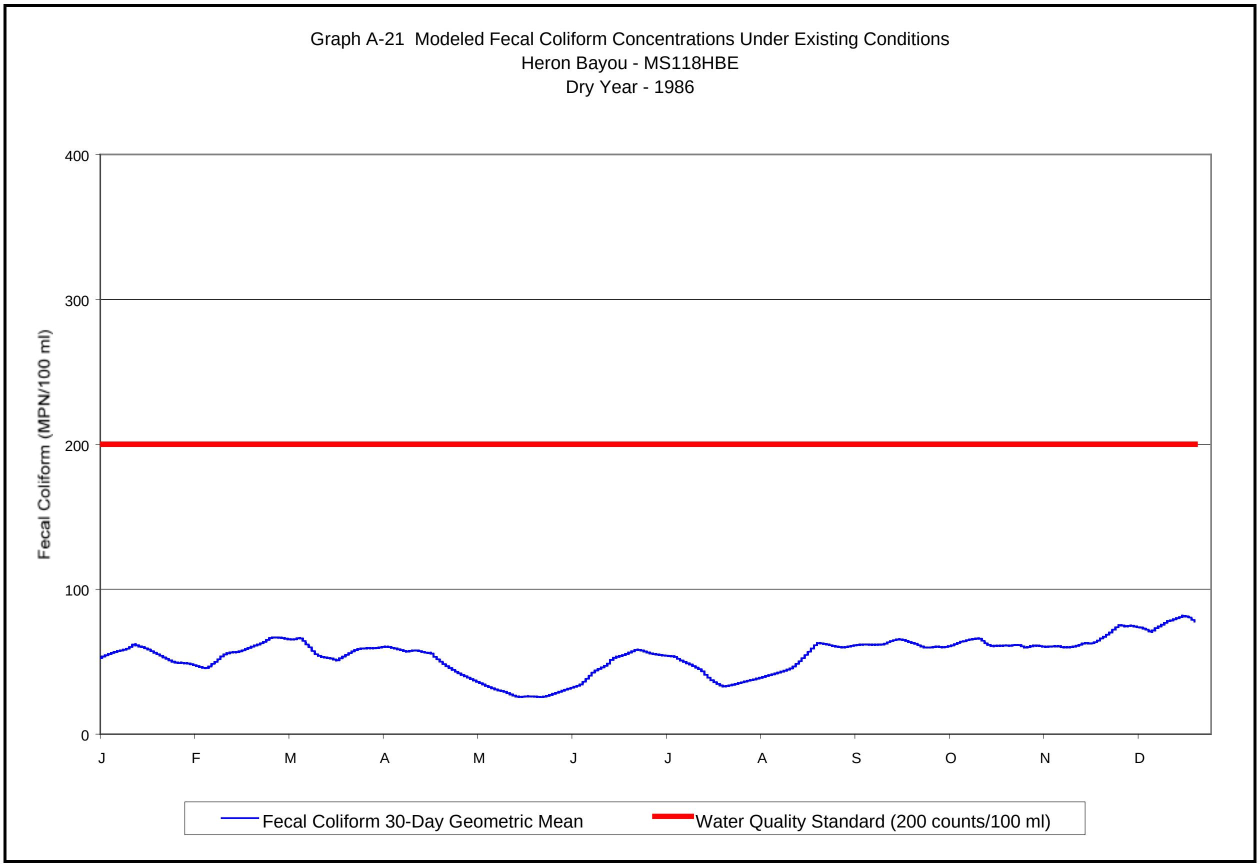
Graph A-18 Modeled Fecal Coliform Concentrations Under Existing Conditions
Bernard Bayou segment 4 - MS118BBM4
Dry Year - 1986

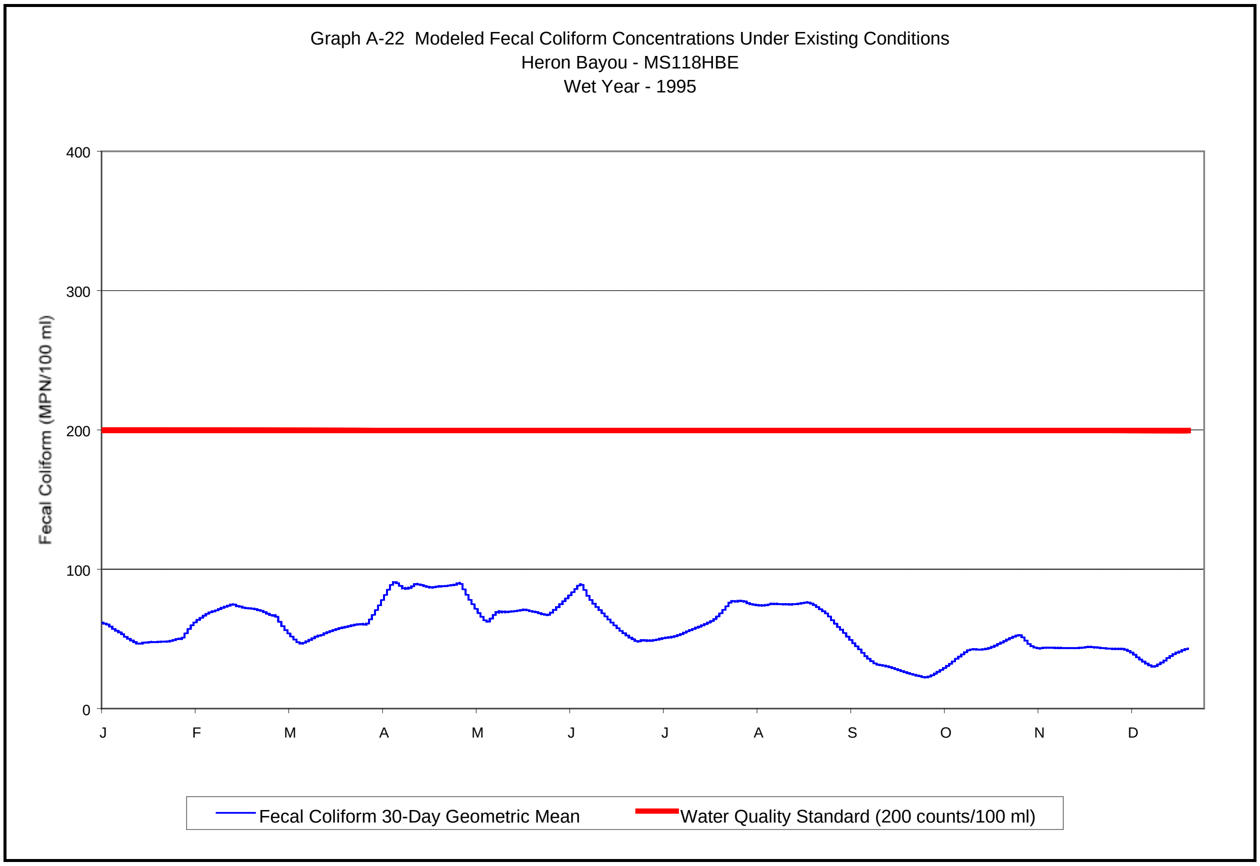


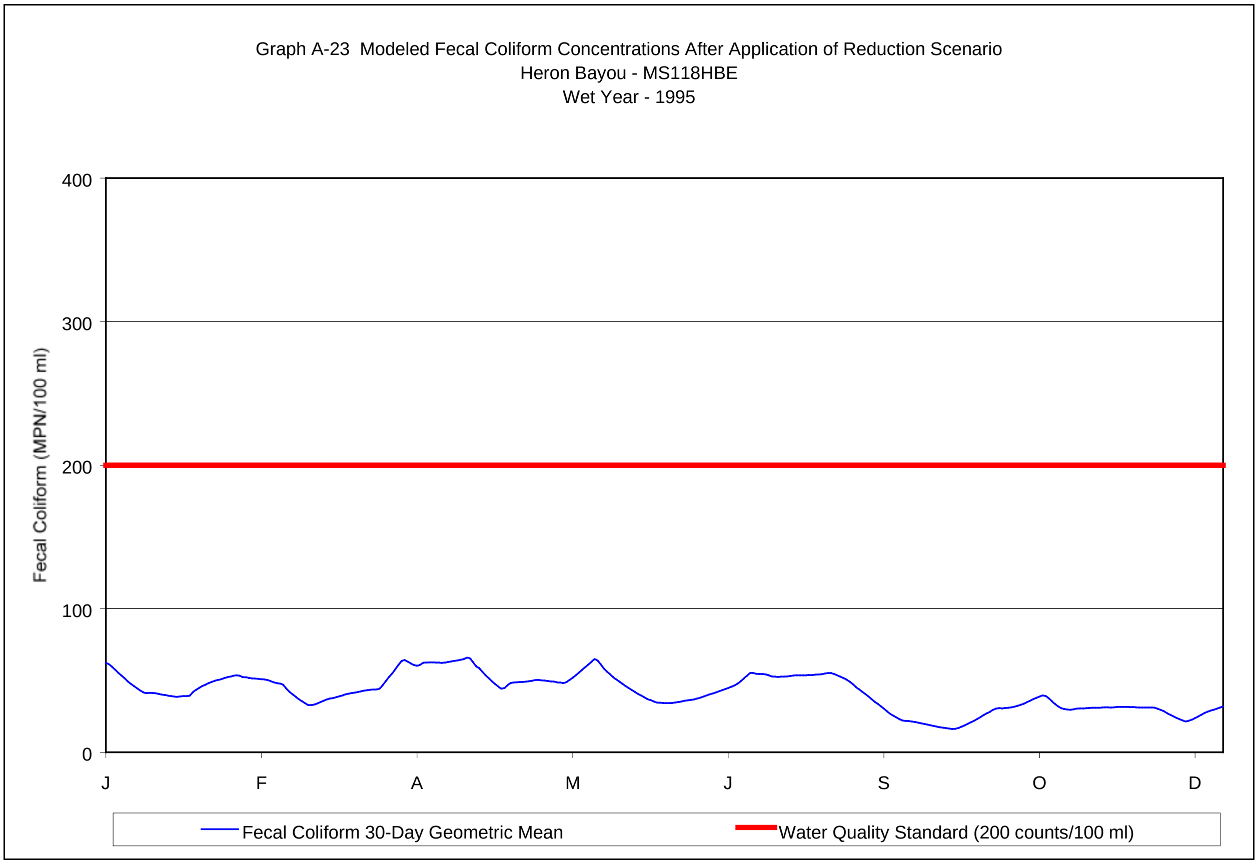
Graph A-19 Modeled Fecal Coliform Concentrations Under Existing Conditions
Bernard Bayou segment 4 - MS118BBM4
Wet Year - 1995

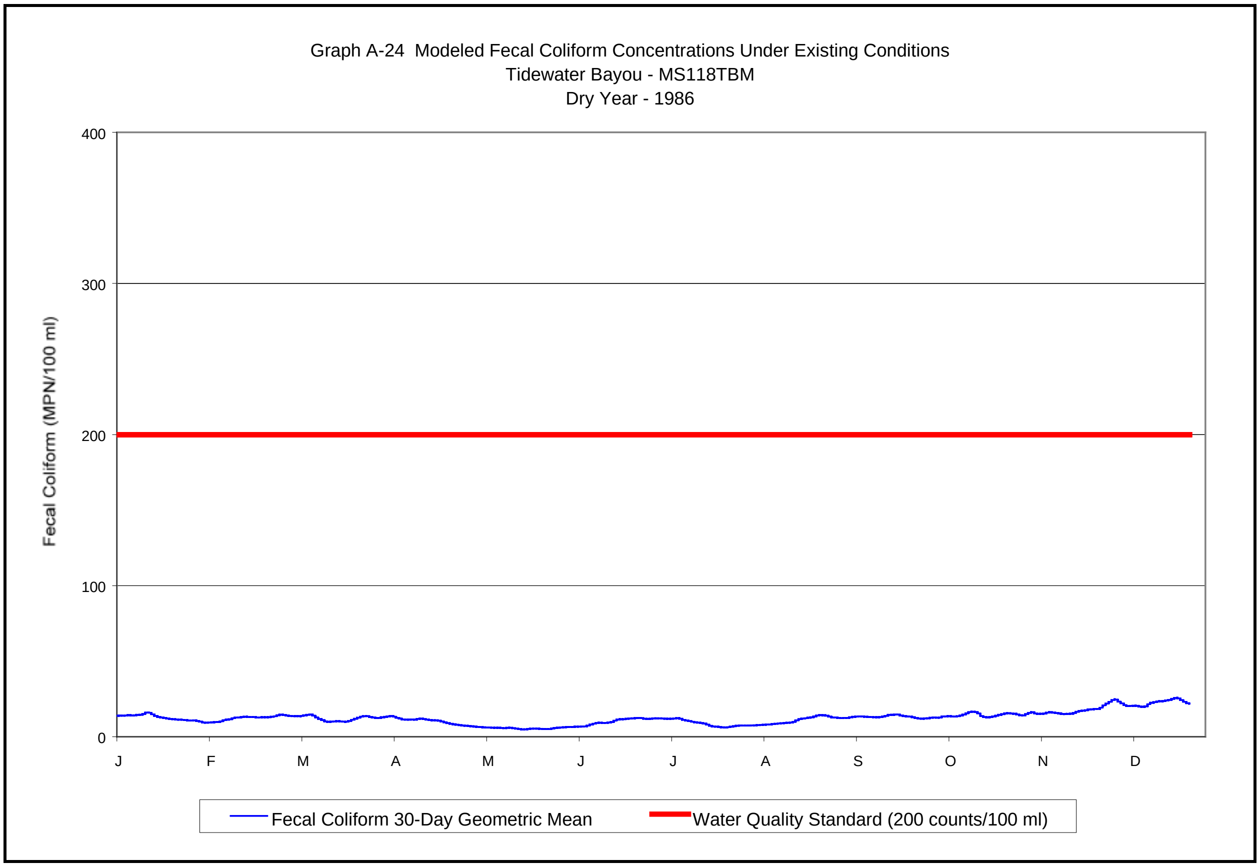


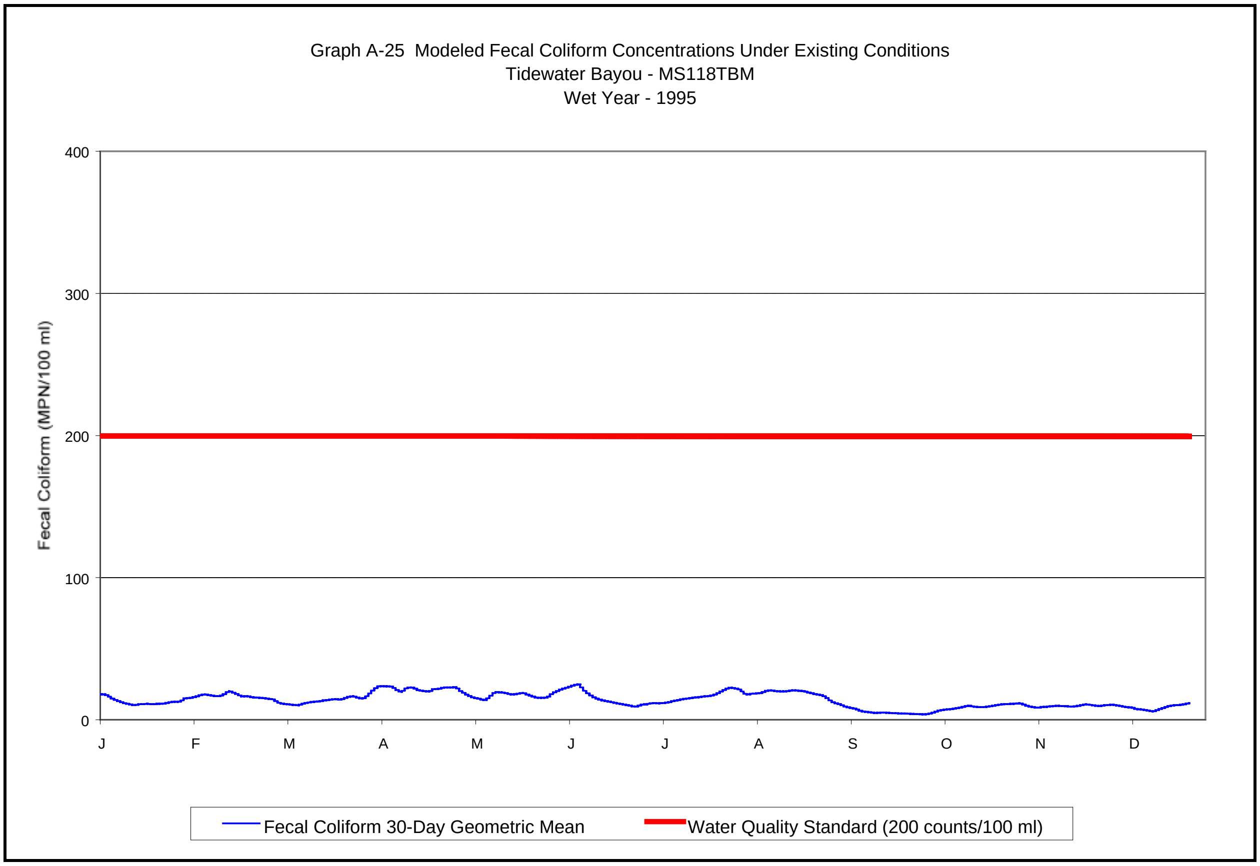

Graph A-20 Modeled Fecal Coliform Concentrations After Application of Reduction Scenario
Bernard Bayou segment 4 - MS118BBM4
Wet Year - 1995
There appears to be a violation of the water quality standard according to this graph. However, the times when the bacteria count exceeds 200 counts/100 ml occur between November and April when the standard is 2000 counts/100 ml.
Fecal Coliform (MPN/100 ml)
400
300
200
100
0
J
F
A
M
J
S
O
D
Fecal Coliform 30-Day Geometric Mean
Water Quality Standard (200 counts/100 ml)

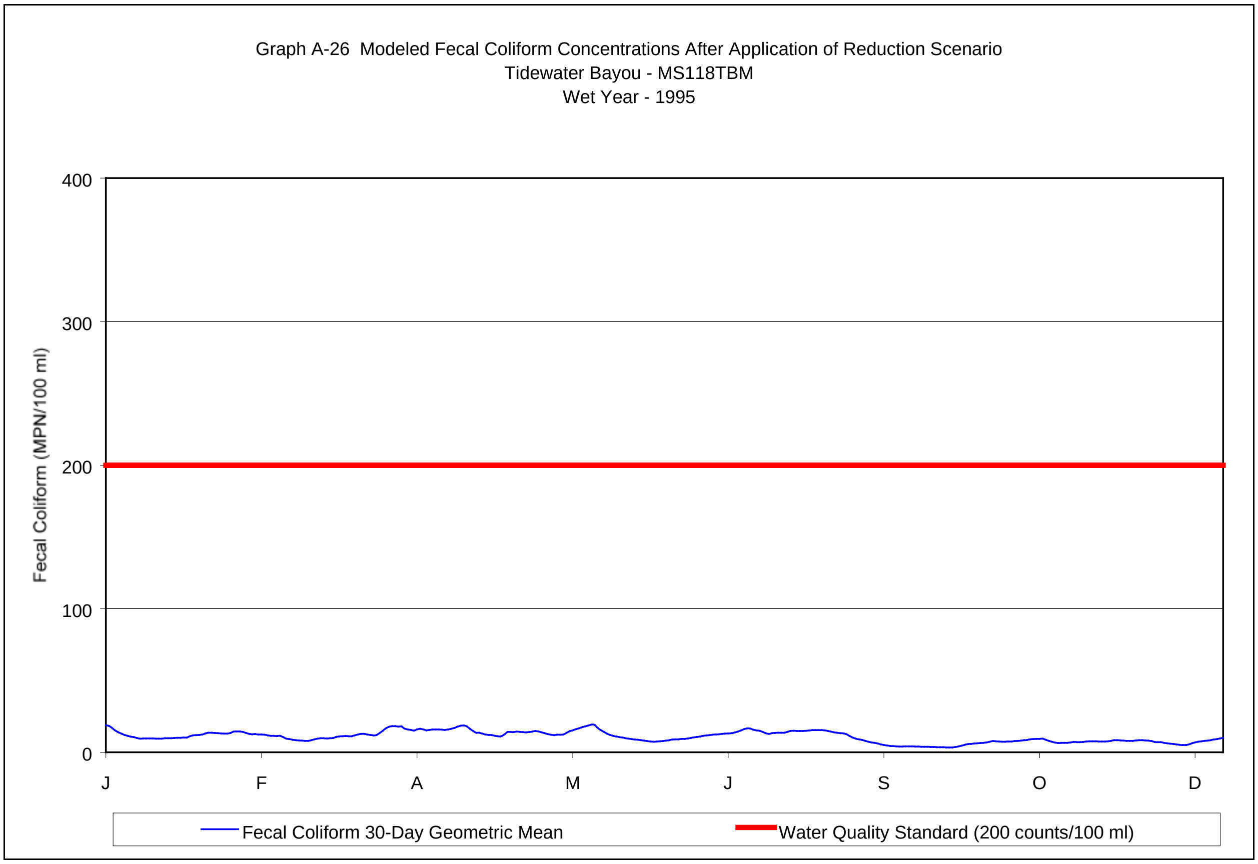

Graph A-21 Modeled Fecal Coliform Concentrations Under Existing Conditions
Heron Bayou - MS118HBE
Dry Year - 1986
Fecal Coliform (MPN/100 ml)
400
300
200
100
0
J
F
M
A
M
J
J
A
S
O
N
D
Fecal Coliform 30-Day Geometric Mean
Water Quality Standard (200 counts/100 ml)

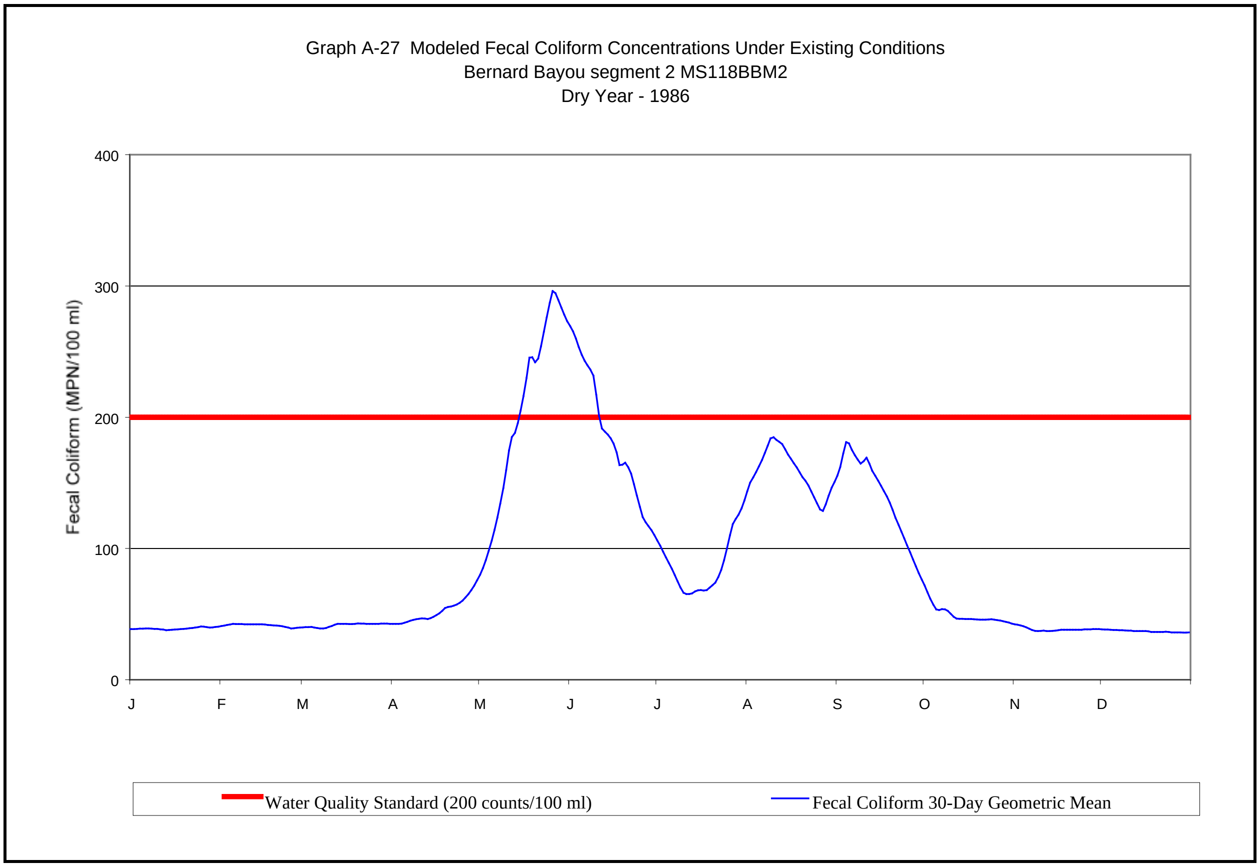

Graph A-22 Modeled Fecal Coliform Concentrations Under Existing Conditions
Heron Bayou - MS118HBE
Wet Year - 1995
Fecal Coliform (MPN/100 ml)
400
300
200
100
0
J
F
M
A
M
J
J
A
S
O
N
D
Fecal Coliform 30-Day Geometric Mean
Water Quality Standard (200 counts/100 ml)

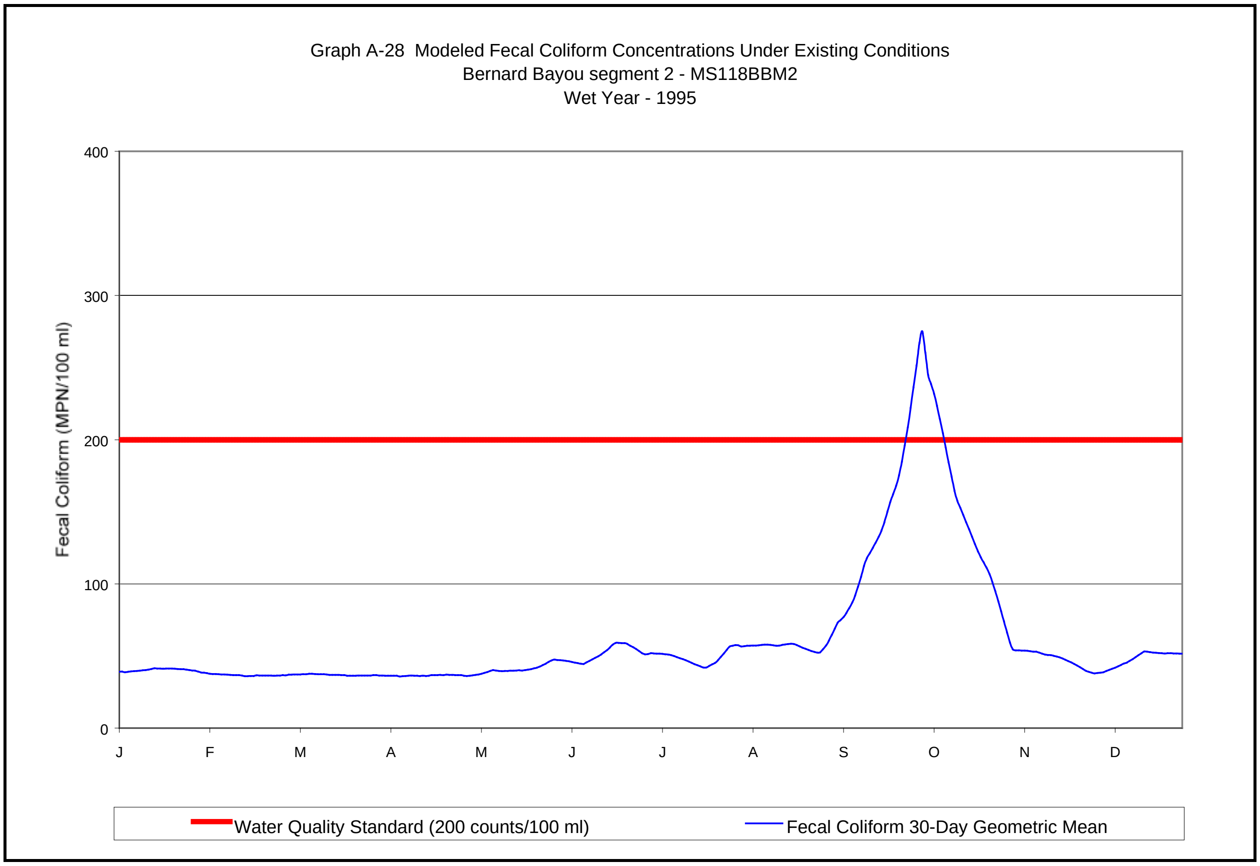

Graph A-23 Modeled Fecal Coliform Concentrations After Application of Reduction Scenario
Heron Bayou - MS118HBE
Wet Year - 1995
Fecal Coliform (MPN/100 ml)
400
300
200
100
0
J
F
A
M
J
S
O
D
Fecal Coliform 30-Day Geometric Mean
Water Quality Standard (200 counts/100 ml)

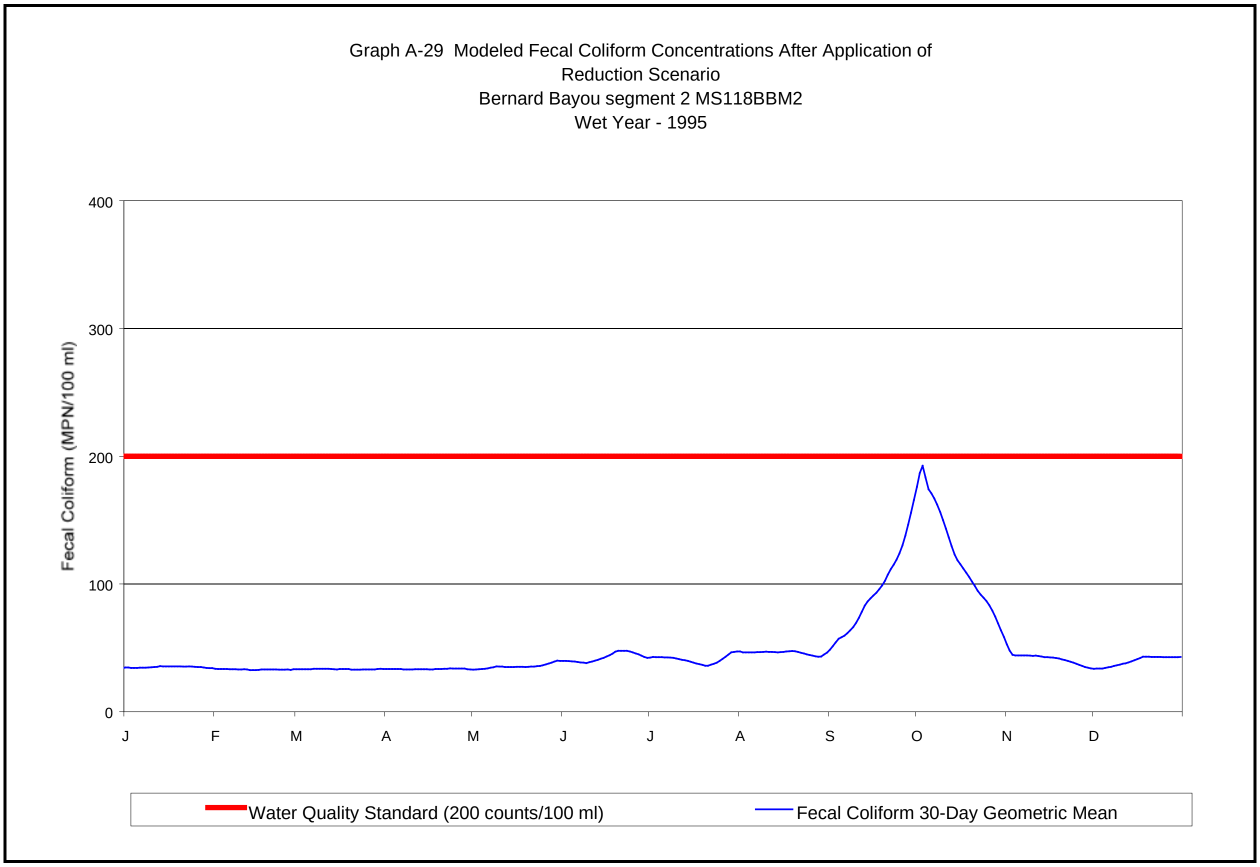

Graph A-24 Modeled Fecal Coliform Concentrations Under Existing Conditions
Tidewater Bayou - MS118TBM
Dry Year - 1986
Fecal Coliform (MPN/100 ml)
400
300
200
100
0
J
F
M
A
M
J
J
A
S
O
N
D
Fecal Coliform 30-Day Geometric Mean
Water Quality Standard (200 counts/100 ml)

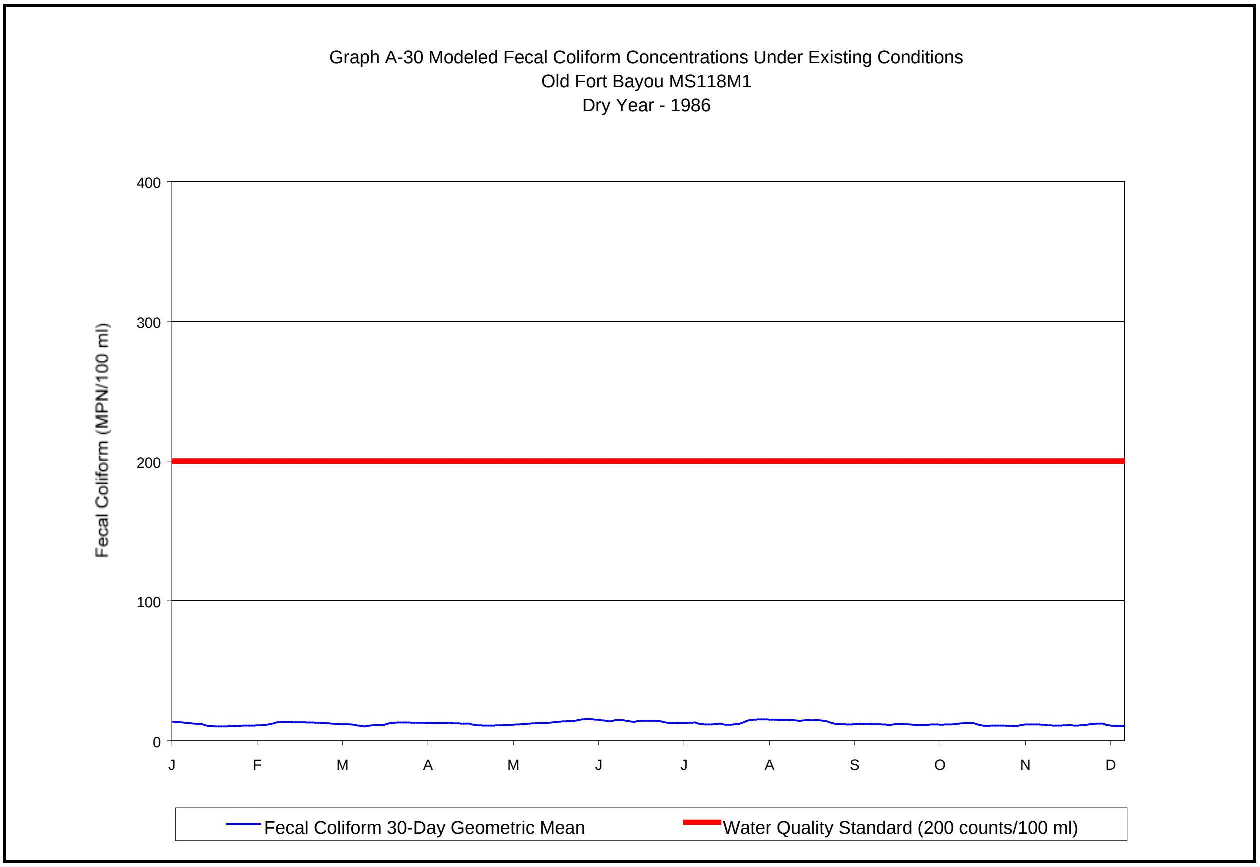

Graph A-25 Modeled Fecal Coliform Concentrations Under Existing Conditions
Tidewater Bayou - MS118TBM
Wet Year - 1995
Fecal Coliform (MPN/100 ml)
400
300
200
100
0
J
F
M
A
M
J
J
A
S
O
N
D
Fecal Coliform 30-Day Geometric Mean
Water Quality Standard (200 counts/100 ml)

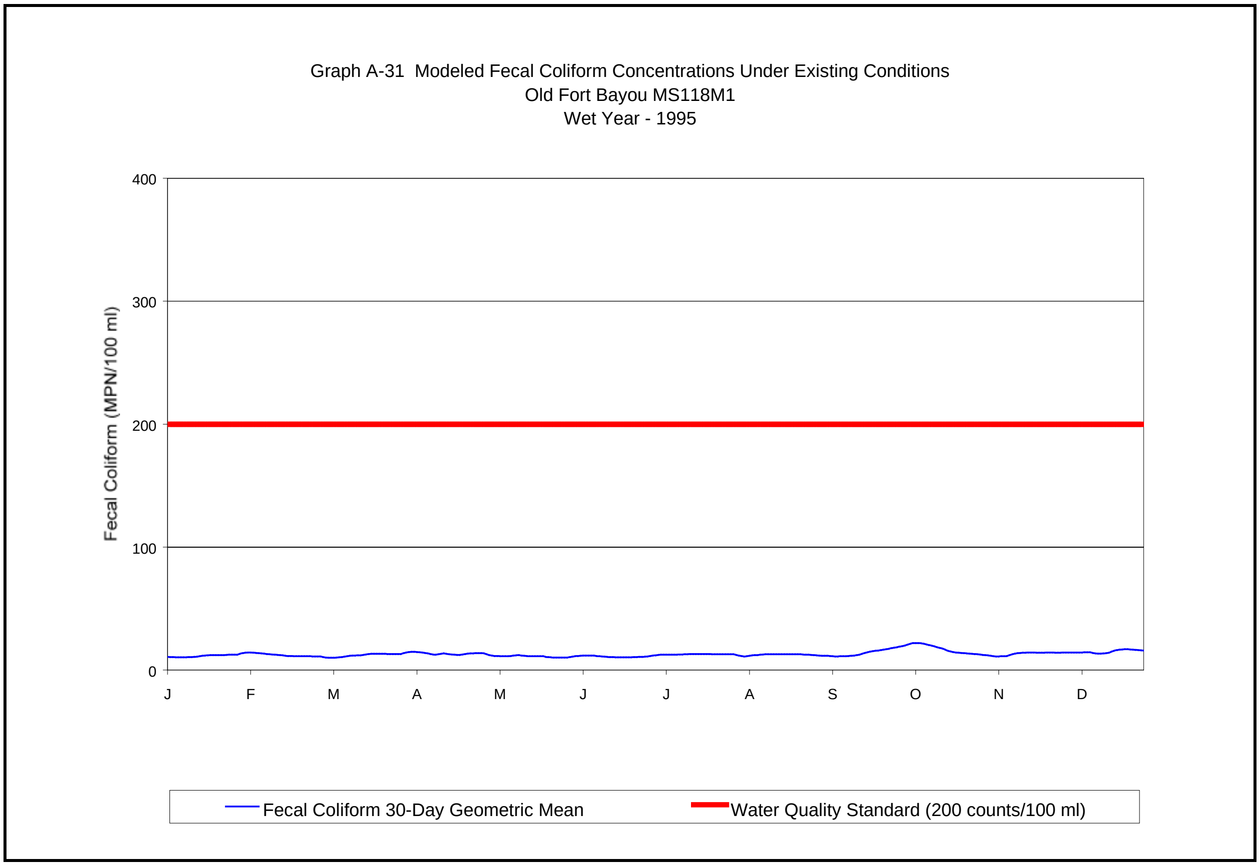

Graph A-26 Modeled Fecal Coliform Concentrations After Application of Reduction Scenario
Tidewater Bayou - MS118TBM
Wet Year - 1995
Fecal Coliform (MPN/100 ml)
400
300
200
100
0
J
F
A
M
J
S
O
D
Fecal Coliform 30-Day Geometric Mean
Water Quality Standard (200 counts/100 ml)


Graph A-27 Modeled Fecal Coliform Concentrations Under Existing Conditions
Bernard Bayou segment 2 MS118BBM2
Dry Year - 1986
Fecal Coliform (MPN/100 ml)
400
300
200
100
0
J
F
M
A
M
J
J
A
S
O
N
D
Water Quality Standard (200 counts/100 ml)
Fecal Coliform 30-Day Geometric Mean


Graph A-28 Modeled Fecal Coliform Concentrations Under Existing Conditions
Bernard Bayou segment 2 - MS118BBM2
Wet Year - 1995
Fecal Coliform (MPN/100 ml)
400
300
200
100
0
J
F
M
A
M
J
J
A
S
O
N
D
Water Quality Standard (200 counts/100 ml)
Fecal Coliform 30-Day Geometric Mean


Graph A-29 Modeled Fecal Coliform Concentrations After Application of
Reduction Scenario
Bernard Bayou segment 2 MS118BBM2
Wet Year - 1995
Fecal Coliform (MPN/100 ml)
400
300
200
100
0
J
F
M
A
M
J
J
A
S
O
N
D
Water Quality Standard (200 counts/100 ml)
Fecal Coliform 30-Day Geometric Mean


Graph A-30 Modeled Fecal Coliform Concentrations Under Existing Conditions
Old Fort Bayou MS118M1
Dry Year - 1986
Fecal Coliform (MPN/100 ml)
400
300
200
100
0
J
F
M
A
M
J
J
A
S
O
N
D
Fecal Coliform 30-Day Geometric Mean
Water Quality Standard (200 counts/100 ml)


Graph A-31 Modeled Fecal Coliform Concentrations Under Existing Conditions
Old Fort Bayou MS118M1
Wet Year - 1995
Fecal Coliform (MPN/100 ml)
400
300
200
100
0
J
F
M
A
M
J
J
A
S
O
N
D
Fecal Coliform 30-Day Geometric Mean
Water Quality Standard (200 counts/100 ml)

APPENDIX B

Appendix B includes water quality data for the waterbodies addressed within this TMDL document. The data provided were collected by MDEQ through the ambient monitoring network and a special study of the Back Bay of Biloxi. As stated in the Section 2.2.1, according to the 1998 305(b) Report, the waterbody segments included in this report are not supporting their designated uses of Secondary Contact and Shellfishing. This conclusion was based on data collected from 1991 to 1996 through the MDEQ ambient monitoring network, the 1994–1995 Back Bay of Biloxi Model Study data (MDEQ), and MDMR Resources Shellfish Sanitation Program classifications.

Back Bay of Biloxi Model Calibration Study
Low Flow Intensive of September 1994

Waterbody Name	Station Name	Latitude	Longitude	Date	Time	Fecal Coliform (# colonies/100 ml)
Biloxi Bay	S1NO	30 24 25.8	88 50 36.0	09/13/1994	15:30	20
				09/13/1994	23:00	10
				09/14/1994	6:00	50
				09/14/1994	11:10	80
				09/19/1994	22:40	20
				09/20/1994	7:15	20
Biloxi Bay	S1MC(t)	30 24 16.8	88 50 42.0	09/13/1994	15:50	10
				09/13/1994	23:15	10
				09/14/1994	6:10	440
				09/14/1994	11:20	50
				09/19/1994	22:45	10
				09/20/1994	7:20	2
Biloxi Bay	S1MC(b)	30 24 16.8	88 50 42.0	09/13/1994	15:50	40
				09/13/1994	23:15	10
				09/14/1994	6:10	10
				09/14/1994	11:20	50
				09/19/1994	22:45	10
				09/20/1994	7:20	10
Back Bay of Biloxi	S4MC(t)	30 25 13.8	88 53 28.8	09/13/1994	16:40	10
				09/14/1994	0:00	10
				09/14/1994	6:50	4300
				09/14/1994	11:50	20
				09/19/1994	23:15	100
				09/20/1994	8:00	10
Back Bay of Biloxi	S4MC(b)	30 25 13.8	88 53 28.8	09/13/1994	16:40	10
				09/14/1994	0:00	200
				09/14/1994	6:50	70
				09/14/1994	11:50	60
				09/19/1994	23:15	50
				09/20/1994	8:00	10
Back Bay of Biloxi	S4SO	30 24 55.2	88 53 25.8	09/13/1994	16:30	10
				09/13/1994	23:45	720
				09/14/1994	6:40	40
				09/14/1994	11:40	20
				09/19/1994	23:00	60
				09/20/1994	7:45	20
Back Bay of Biloxi	S6NO	30 25 25.8	88 55 15.0	09/13/1994	17:05	10
				09/14/1994	0:20	1600
				09/14/1994	7:25	40
				09/14/1994	12:15	40
				09/19/1994	23:45	60
				09/20/1994	8:20	40
Back Bay of Biloxi	S6MC(t)	30 25 19.2	88 55 12.0	09/13/1994	17:35	20
				09/14/1994	0:45	370
				09/14/1994	7:35	20
				09/14/1994	12:30	10
				09/20/1994	0:00	70

Back Bay of Biloxi Model Calibration Study
Low Flow Intensive of September 1994

Waterbody Name	Station Name	Latitude	Longitude	Date	Time	Fecal Coliform (# colonies/100 ml)
Back Bay of Biloxi	S6MC(b)	30 25 19.2	88 55 12.0	09/13/1994	17:35	10
				09/14/1994	0:45	10
				09/14/1994	7:35	30
				09/14/1994	12:30	40
				09/20/1994	0:00	250
				09/20/1994	8:10	20
Back Bay of Biloxi	S6SO	30 25 12.0	88 55 10.8	09/13/1994	17:25	10
				09/14/1994	7:15	1300
				09/14/1994	12:25	40
				09/19/1994	23:50	70
				09/20/1994	8:30	20
Back Bay of Biloxi	S9NO	30 25 15.0	88 57 19.2	09/13/1994	15:00	10
				09/14/1994	0:15	360
				09/14/1994	7:10	20
				09/14/1994	11:50	30
				09/19/1994	23:55	130
				09/20/1994	8:05	30
Back Bay of Biloxi	S9MC(t)	30 25 10.2	88 57 16.2	09/13/1994	15:45	30
				09/14/1994	0:25	620
				09/14/1994	7:20	380
				09/14/1994	12:00	90
				09/20/1994	0:05	50
				09/20/1994	8:15	20
Back Bay of Biloxi	S9MC(b)	30 25 10.2	88 57 16.2	09/13/1994	15:40	40
				09/14/1994	0:25	240
				09/14/1994	7:20	410
				09/14/1994	12:00	30
				09/20/1994	0:05	120
				09/20/1994	8:15	20
Back Bay of Biloxi (Big Lake)	S13NO	----	----	91394	1605	70
				91394	2340	50
				91494	640	110
				91494	1130	30
				91994	2320	100
				92094	745	80
Back Bay of Biloxi (Big Lake)	S13MC(t)	30 24 58.8	88 59 24.0	09/13/1994	16:20	90
				09/13/1994	23:50	250
				09/14/1994	6:50	560
				09/14/1994	11:35	40
				09/19/1994	23:35	160
				09/20/1994	7:50	50
Back Bay of Biloxi (Big Lake)	S13MC(b)	30 24 58.8	88 59 24.0	09/13/1994	16:15	160
				09/13/1994	23:50	50
				09/14/1994	6:50	170
				09/14/1994	11:35	300
				09/19/1994	23:35	140
				09/20/1994	7:50	100

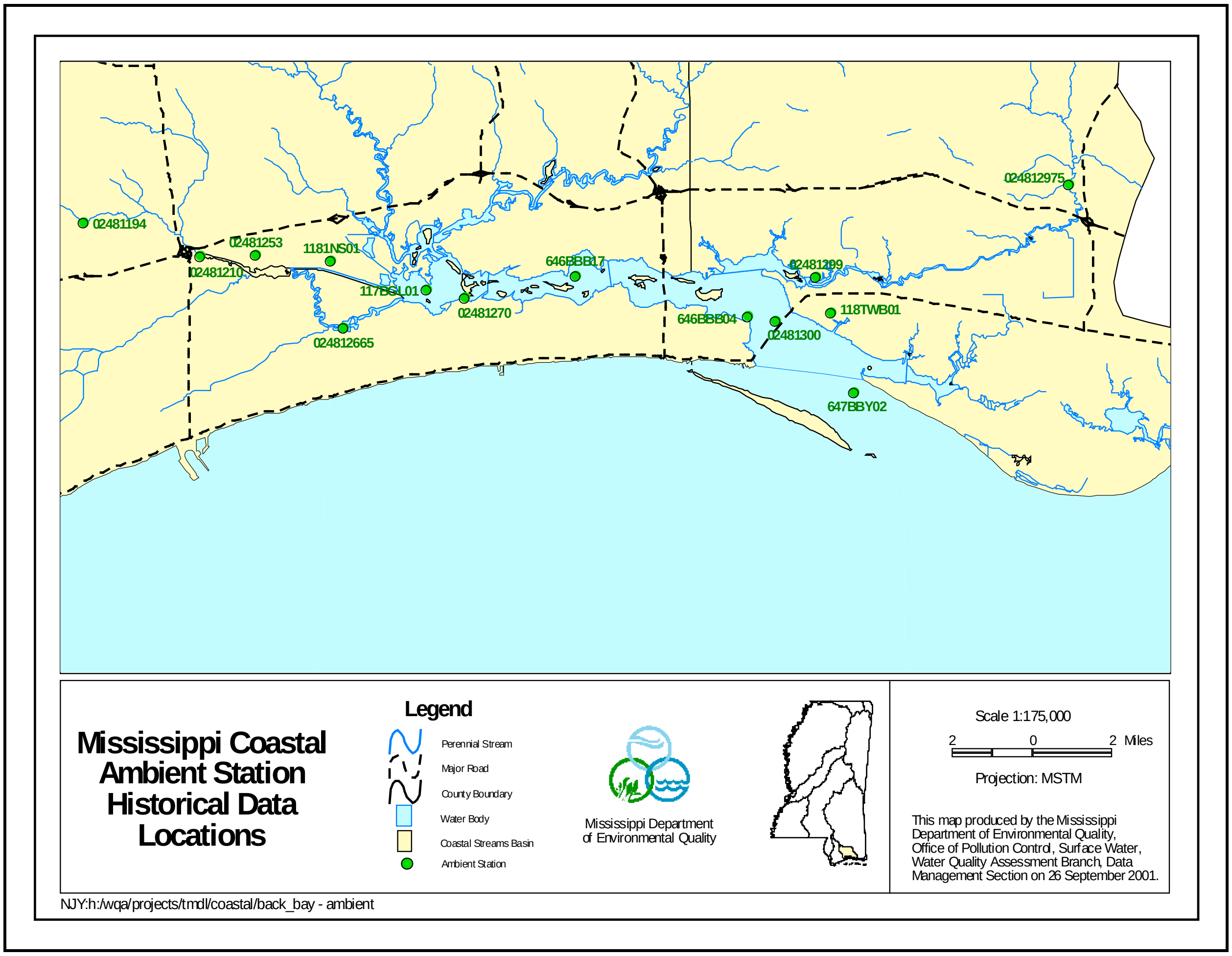
Back Bay of Biloxi Model Calibration Study
Low Flow Intensive of September 1994

Waterbody Name	Station Name	Latitude	Longitude	Date	Time	Fecal Coliform (# colonies/100 ml)
Industrial Seaway	S15MC(t)	----	----	09/13/1994	16:40	40
				09/13/1994	23:30	10
				09/14/1994	6:25	240
				09/14/1994	11:15	20
				09/19/1994	23:10	90
				09/20/1994	7:25	8
Industrial Seaway	S15MC(b)	----	----	09/13/1994	16:35	100
				09/13/1994	23:30	60
				09/14/1994	6:25	280
				09/14/1994	11:15	20
				09/19/1994	23:10	250
				09/20/1994	7:25	160
Bernard Bayou (Gulfport Lake)	S17MC(t)	----	----	09/13/1994	17:00	120
				09/13/1994	23:00	500
				09/14/1994	5:55	270
				09/14/1994	10:55	20
				09/19/1994	22:40	110
				09/20/1994	6:55	180
Bernard Bayou (Gulfport Lake)	S17MC(b)	----	----	09/13/1994	16:55	100
				09/13/1994	23:00	500
				09/14/1994	5:55	210
				09/14/1994	10:55	80
				09/19/1994	22:40	90
				09/20/1994	6:55	960
Bernard Bayou	S18MC	----	----	09/20/1994	0:15	395
				09/20/1994	8:25	460
Bernard Bayou	S18MC(t)	----	----	09/13/1994	19:37	108
				09/14/1994	0:50	700
				09/14/1994	6:40	780
				09/14/1994	13:25	150
Bernard Bayou	S18MC(b)	----	----	09/13/1994	19:40	570
				09/14/1994	1:00	240
				09/14/1994	6:50	660
				09/14/1994	13:30	140
Biloxi River	S19MC	----	----	09/13/1994	19:04	2300
				09/14/1994	0:20	580
				09/14/1994	6:00	120
				09/14/1994	12:55	220
				09/19/1994	23:40	330
				09/20/1994	7:50	260
Tchoutacabouffa River	S20MC	----	----	09/13/1994	18:08	360
				09/13/1994	23:45	1600
				09/14/1994	5:20	250
				09/14/1994	12:25	140
				09/19/1994	22:50	280
				09/20/1994	7:15	90

Back Bay of Biloxi Model Calibration Study Low Flow Intensive of September 1994						
Waterbody Name	**Station Name**	**Latitude**	**Longitude**	**Date**	**Time**	**Fecal Coliform (# colonies/100 ml)**
Old Fort Bayou	S21MC	----	----	09/13/1994	17:03	540
				09/13/1994	23:15	6000
				09/14/1994	4:15	540
				09/14/1994	11:45	370
				09/19/1994	20:15	540
				09/20/1994	6:40	1180
Bernard Bayou (above Gulfport Lake)	2481212	----	----	09/20/1994	7:10	320

MDEQ Ambient Monitoring Network Data				
Waterbody Name	**Station ID**	**Date**	**Time**	**Fecal Coliform (# colonies/100 ml)**
Bernard Bayou	02481194	01/11/1994	9:52 AM	1700
		02/08/1994	8:04 AM	170
		03/08/1994	8:48 AM	110
		04/05/1994	8:12 AM	40
		06/07/1994	8:14 AM	970
		08/01/1994	6:58 PM	64
		08/23/1994	10:42 AM	2600
		01/31/1995	9:23 AM	110
		04/04/1995	9:48 AM	70
Bernard Bayou	02481210	03/16/1998	10:06 AM	130
		08/03/1998	1:40 PM	130
Bernard Bayou	02481253	03/04/1998	10:33 AM	13
		08/05/1998	11:06 AM	23
Bernard Bayou	024812665	08/03/1998	2:06 PM	170
Back Bay of Biloxi	02481270	01/08/1991	12:20 PM	5000
		03/04/1991	1:45 PM	1700
		05/06/1991	12:38 PM	300
		07/08/1991	1:20 PM	1300
		09/09/1991	1:35 PM	40
		11/04/1991	2:10 PM	20
		03/04/1992	2:00 PM	80
		05/04/1992	1:35 PM	20
		07/13/1992	1:30 PM	230
		09/14/1992	1:50 PM	20
		11/02/1992	1:45 PM	300
		12/11/1996	11:25 AM	49
		01/08/1997	11:30 AM	1600
		02/05/1997	11:19 AM	220
		03/05/1997	11:17 AM	130
		04/03/1997	11:25 AM	46
		05/06/1997	10:36 AM	22
		06/10/1997	10:52 AM	130
		08/11/1997	10:45 AM	2
		09/04/1997	10:50 AM	27
		10/01/1997	10:46 AM	23
		11/17/1997	12:57 PM	130
		01/06/1998	11:10 AM	1600
		02/03/1998	1:58 PM	170
		03/04/1998	11:17 AM	22
		04/15/1998	10:04 AM	11
		06/22/1998	9:43 AM	23
		07/20/1998	2:03 PM	33
		08/11/1998	9:36 AM	13
		09/17/1998	10:30 AM	49
		10/12/1998	1:47 PM	22
		11/17/1998	8:46 AM	540
		12/07/1998	2:10 PM	79

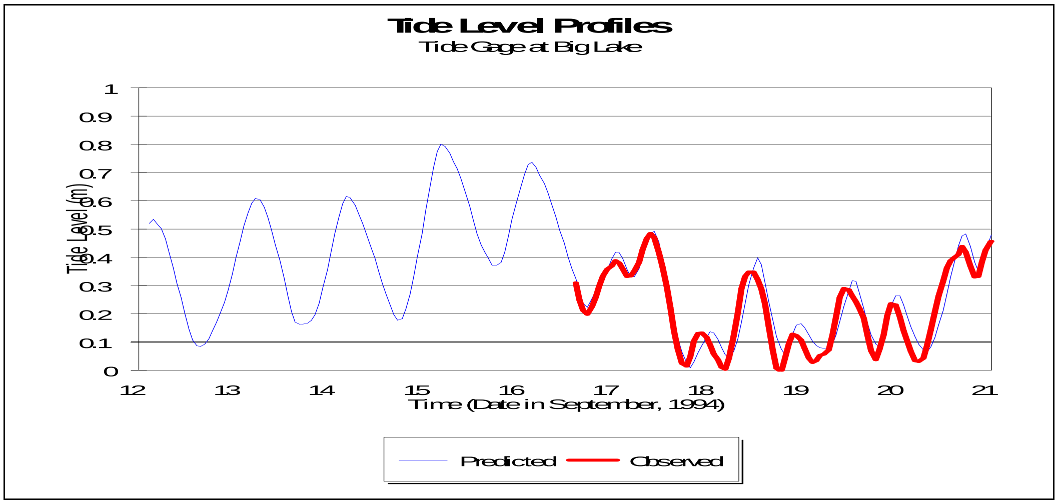
MDEQ Ambient Monitoring Network Data				
Waterbody Name	**Station ID**	**Date**	**Time**	**Fecal Coliform (# colonies/100 ml)**
Old Fort Bayou	024812975	04/17/1997	3:25 PM	49
		10/02/1997	2:40 PM	49
		01/15/1998	11:14 AM	1600
		04/14/1998	12:20 PM	49
		08/20/1998	2:18 PM	21
		10/26/1998	11:25 AM	14
Old Fort Bayou	02481299	02/04/1998	12:14 PM	79
		08/11/1998	2:30 PM	23
Back Bay of Biloxi	02481300	02/19/1998	8:30 AM	350
		08/26/1998	10:46 AM	23
Big Lake	117BGL01	02/19/1998	11:43 AM	920
		08/11/1998	11:20 AM	7
Industrial Seaway	118INS01	02/03/1998	1:18 PM	79
		08/05/1998	11:40 AM	350
Tidewater Bayou	118TWB01	02/10/1998	12:35 PM	240
		08/04/1998	8:09 AM	130
Back Bay of Biloxi	646BBB04	04/15/1997	9:00 AM	49
		07/15/1997	1:21 PM	11
		10/09/1997	11:40 AM	70
		01/15/1998	12:51 PM	920
		04/15/1998	8:46 AM	33
		08/26/1998	10:20 AM	11
		10/12/1998	2:31 PM	17
Back Bay of Biloxi	646BBB17	02/19/1998	11:16 AM	350
		08/11/1998	10:23 AM	2
Biloxi Bay	647BBY02	04/15/1997	----	33
		04/15/1997	8:15 AM	33
		07/15/1997	12:48 PM	17
		10/08/1997	10:58 AM	5
		01/15/1998	2:40 PM	1600
		05/14/1998	10:21 AM	2
		10/26/1998	1:59 PM	2

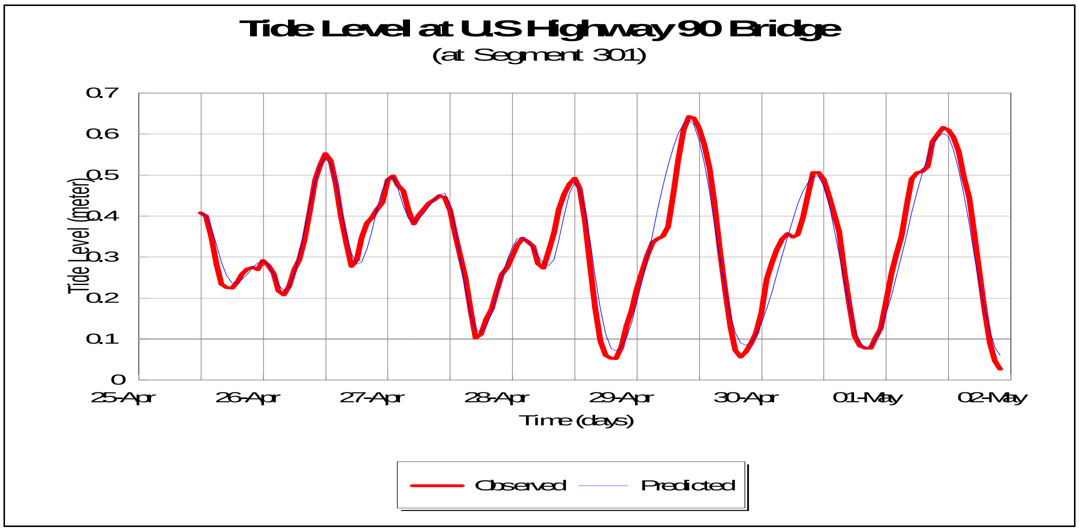


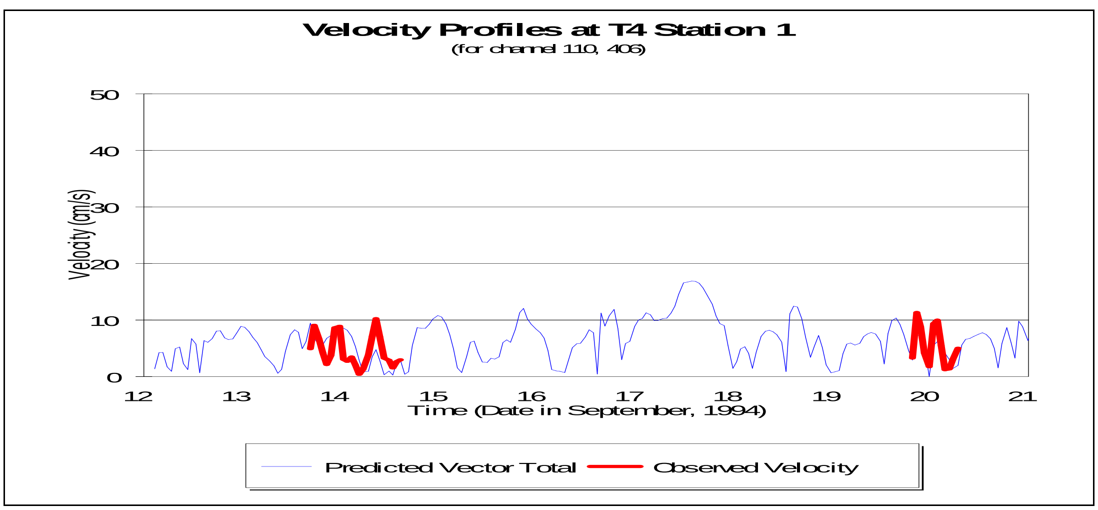
Ambient Monitoring Station Locations

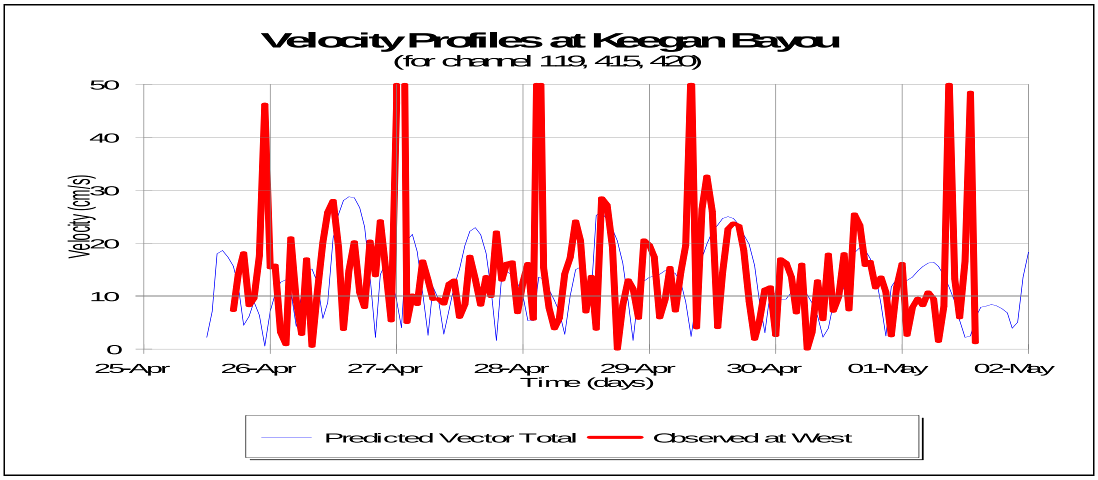
APPENDIX C

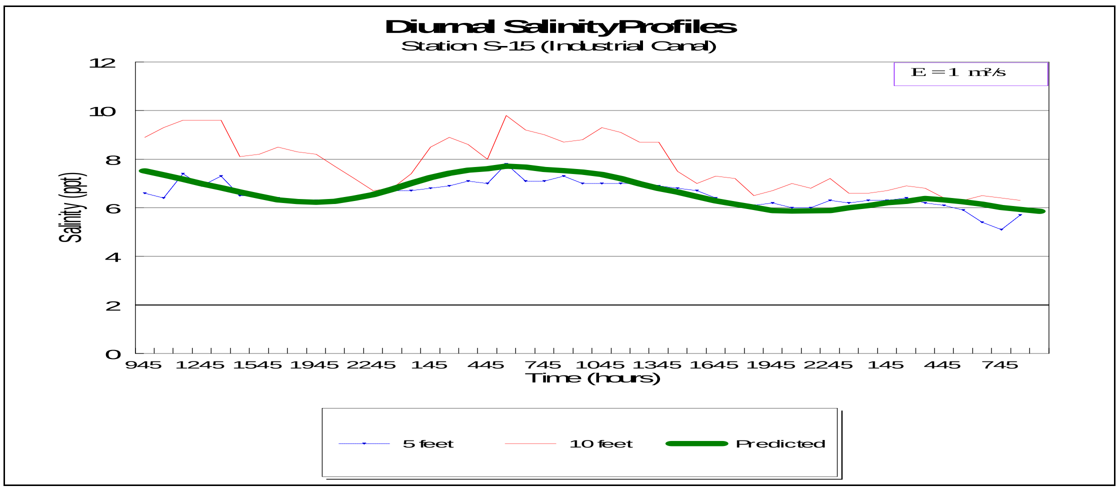
Appendix C includes sample hydrodynamic calibration/verification profiles for tidal heights, velocity, and salinity. These profiles represent the hydrodynamic parameters used for DYNHYD5. This appendix also includes the results of the EUTRO5 water quality calibration/verification. The model runs are compared to data collected by MDEQ during September 12-20, 1994 (calibration period) and April 25-May 2, 1995 (verification period).

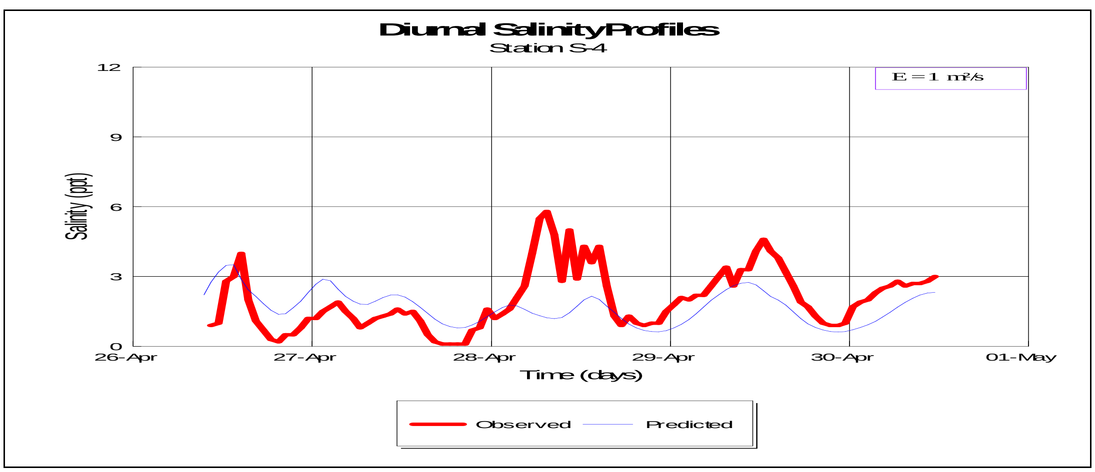

Tide Level Profiles
Tide Gage at Big Lake
Tide Level (m)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
12
13
14
15
16
17
18
19
20
21
Time (Date in September, 1994)
Predicted
Observed

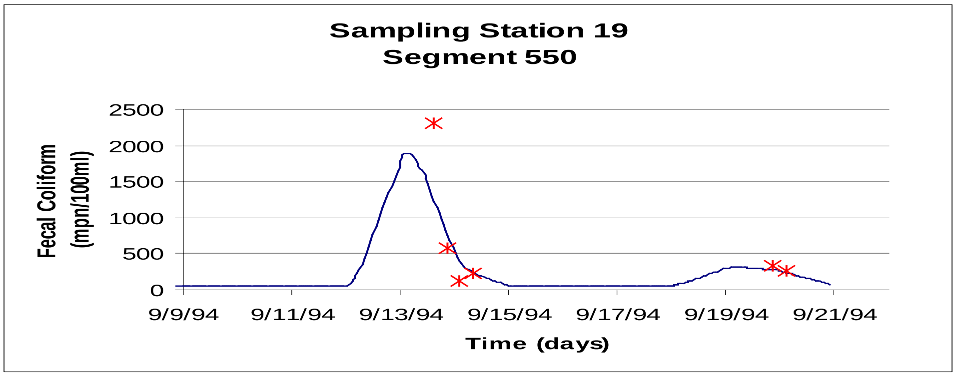

Tide Level at U.S Highway 90 Bridge
(at Segment 301)
Tide Level (meter)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
25-Apr
26-Apr
27-Apr
28-Apr
29-Apr
30-Apr
01-May
02-May
Time (days)
Observed
Predicted

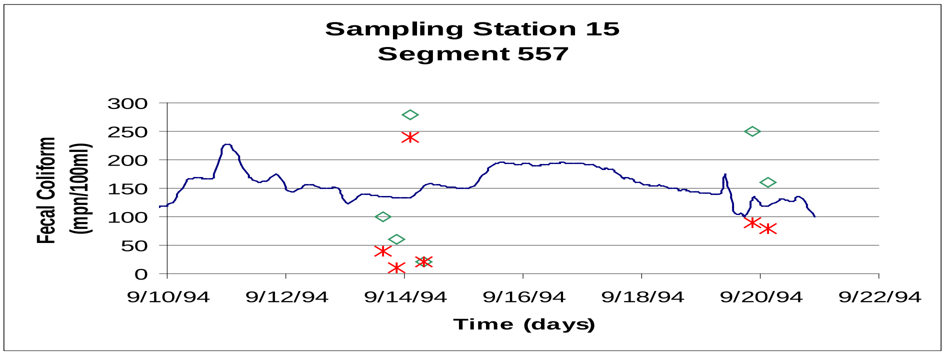

Velocity Profiles at T4 Station 1
(for channel 110, 406)
Velocity (cm/s)
50
40
30
20
10
0
12
13
14
15
16
17
18
19
20
21
Time (Date in September, 1994)
Predicted Vector Total
Observed Velocity

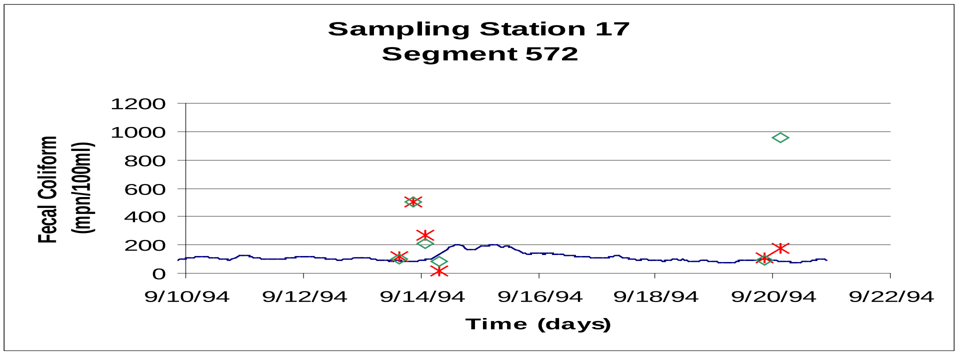

Velocity Profiles at Keegan Bayou
(for channel 119, 415, 420)
Velocity (cm/s)
0
10
20
30
40
50
25-Apr
26-Apr
27-Apr
28-Apr
29-Apr
30-Apr
01-May
02-May
Time (days)
Predicted Vector Total
Observed at West

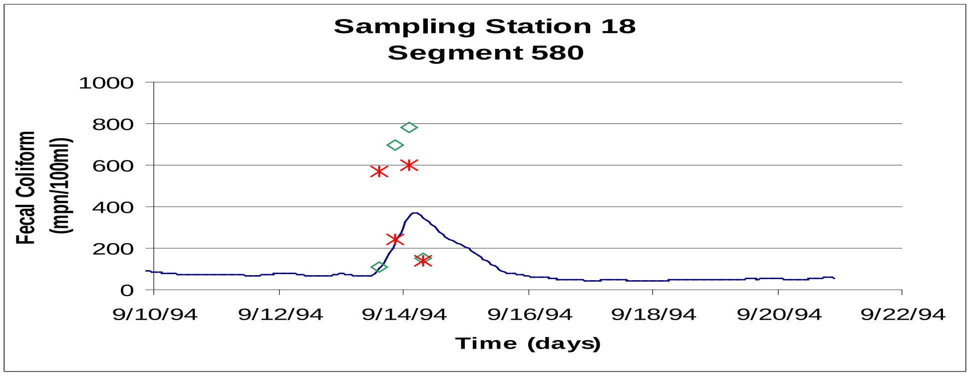

Diurnal Salinity Profiles
Station S-15 (Industrial Canal)
E = 1 m²/s
Salinity (ppt)
0
2
4
6
8
10
12
945
1245
1545
1945
2245
145
445
745
1045
1345
1645
1945
2245
145
445
745
Time (hours)
5 feet
10 feet
Predicted

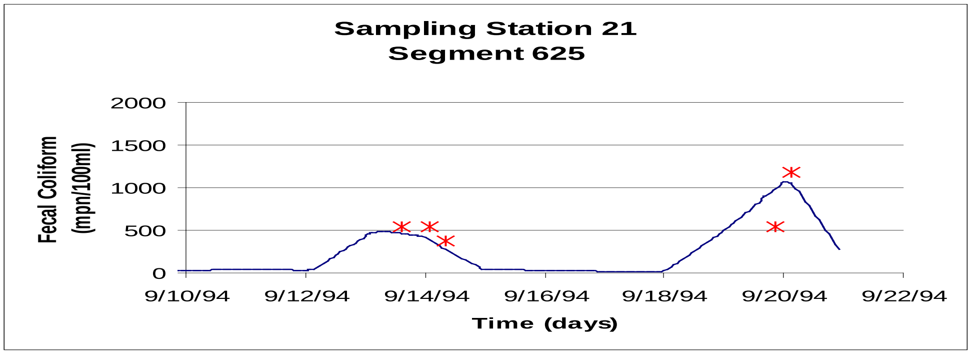

Diurnal Salinity Profiles
Station S-4
E = 1 m²/s
Salinity (ppt)
0
3
6
9
12
26-Apr
27-Apr
28-Apr
29-Apr
30-Apr
01-May
Time (days)
Observed
Predicted

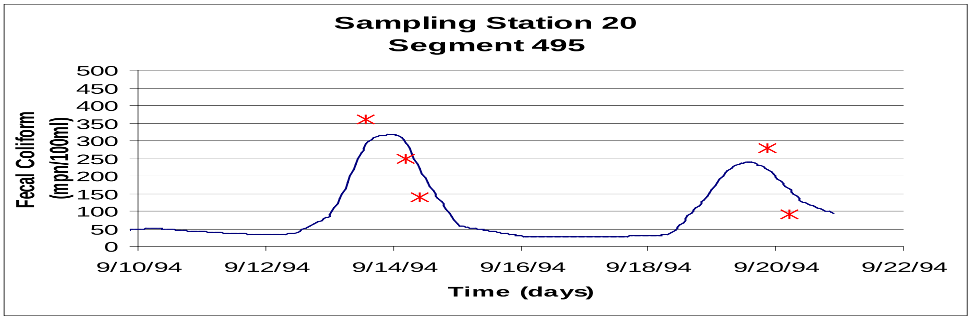

Sampling Station 19
Segment 550
Fecal Coliform (mpn/100ml)
2500
2000
1500
1000
500
0
9/9/94
9/11/94
9/13/94
9/15/94
9/17/94
9/19/94
9/21/94
Time (days)

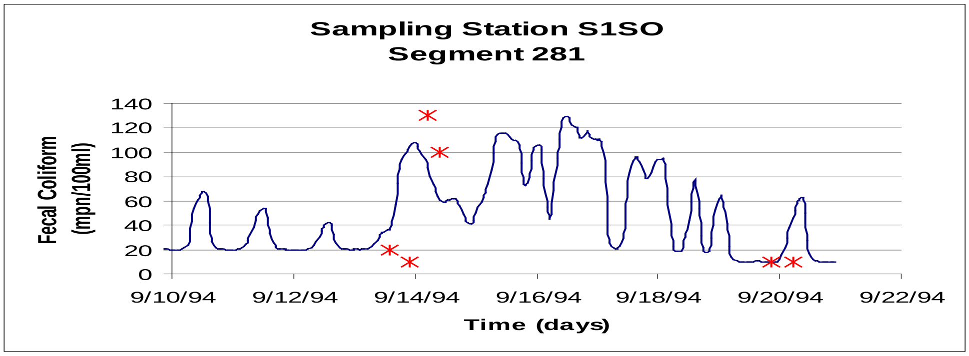

Sampling Station 15
Segment 557
Fecal Coliform (mpn/100ml)
300
250
200
150
100
50
0
9/10/94
9/12/94
9/14/94
9/16/94
9/18/94
9/20/94
9/22/94
Time (days)

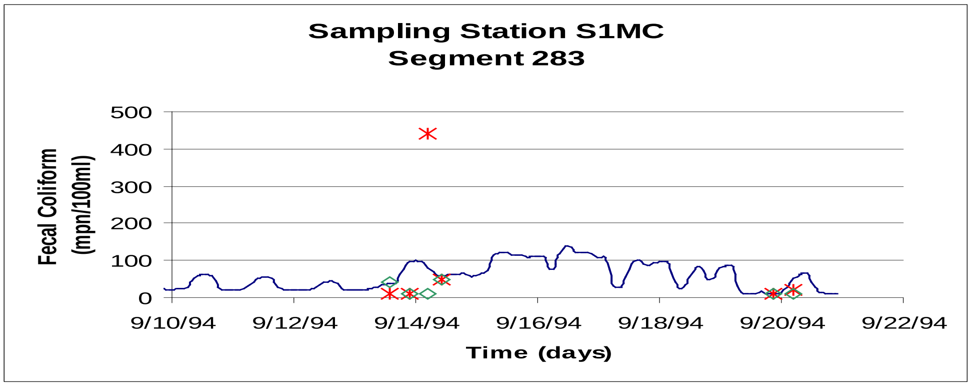

Sampling Station 17
Segment 572
Fecal Coliform (mpn/100ml)
1200
1000
800
600
400
200
0
9/10/94
9/12/94
9/14/94
9/16/94
9/18/94
9/20/94
9/22/94
Time (days)

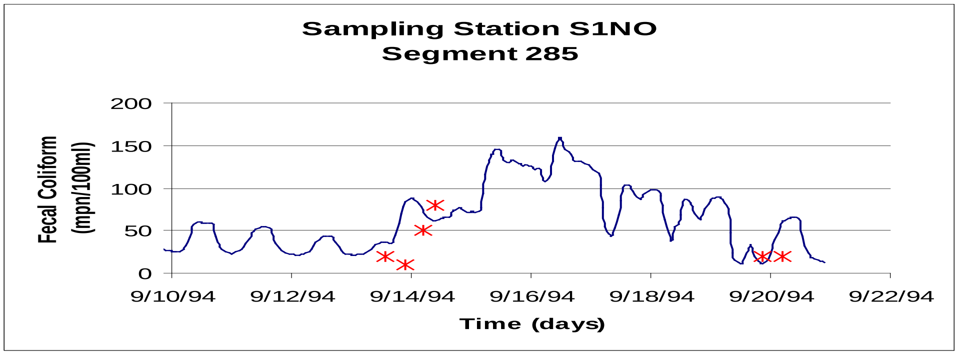

Sampling Station 18
Segment 580
Fecal Coliform (mpn/100ml)
1000
800
600
400
200
0
9/10/94
9/12/94
9/14/94
9/16/94
9/18/94
9/20/94
9/22/94
Time (days)

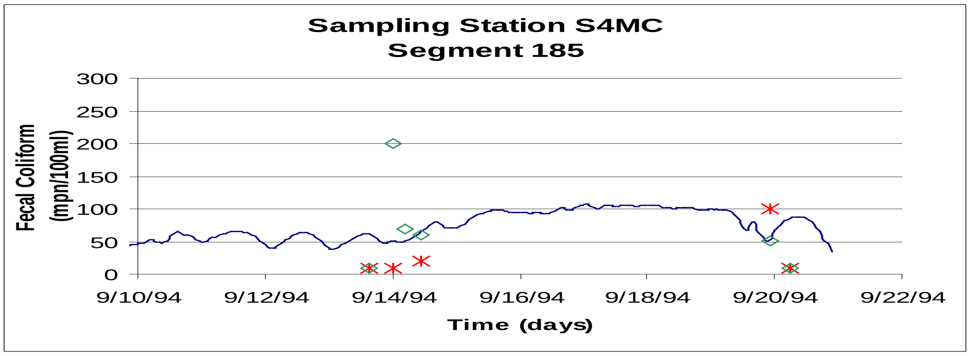

Sampling Station 21
Segment 625
Fecal Coliform (mpn/100ml)
2000
1500
1000
500
0
9/10/94
9/12/94
9/14/94
9/16/94
9/18/94
9/20/94
9/22/94
Time (days)

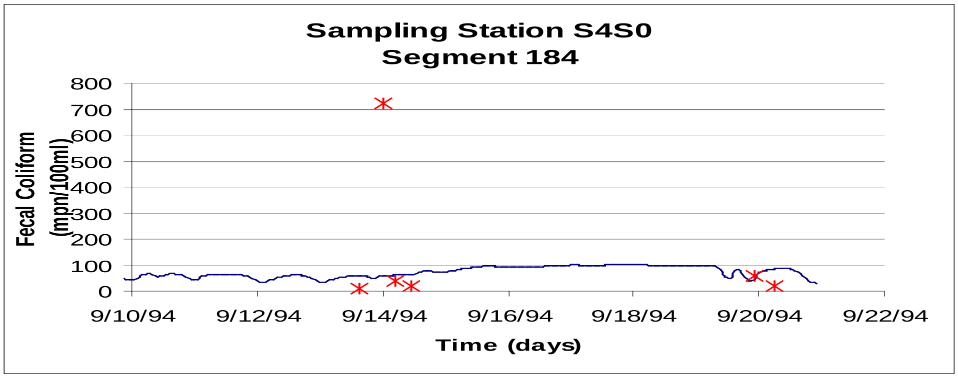

Sampling Station 20
Segment 495
Fecal Coliform (mpn/100ml)
500
450
400
350
300
250
200
150
100
50
0
9/10/94
9/12/94
9/14/94
9/16/94
9/18/94
9/20/94
9/22/94
Time (days)

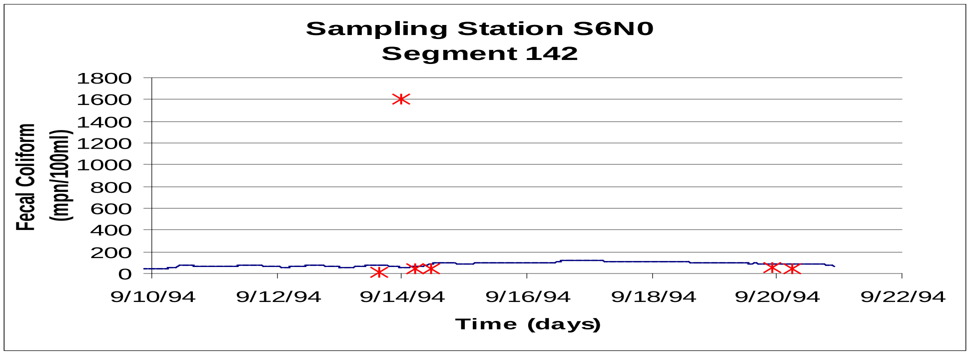

Sampling Station S1SO
Segment 281
Fecal Coliform (mpn/100ml)
140
120
100
80
60
40
20
0
9/10/94
9/12/94
9/14/94
9/16/94
9/18/94
9/20/94
9/22/94
Time (days)

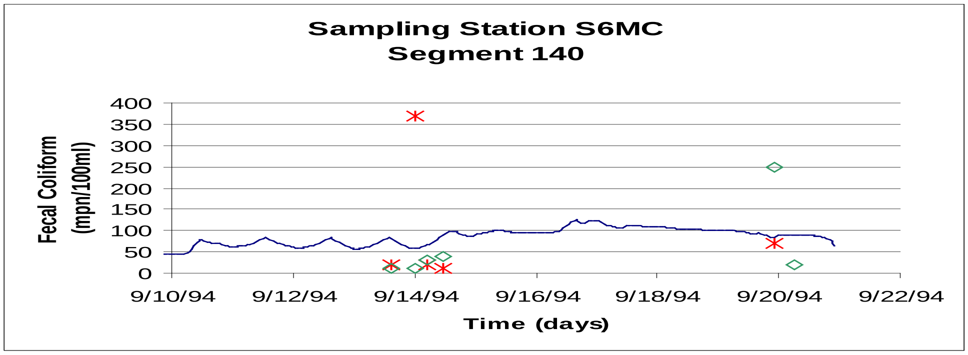

Sampling Station S1MC
Segment 283
Fecal Coliform (mpn/100ml)
500
400
300
200
100
0
9/10/94
9/12/94
9/14/94
9/16/94
9/18/94
9/20/94
9/22/94
Time (days)

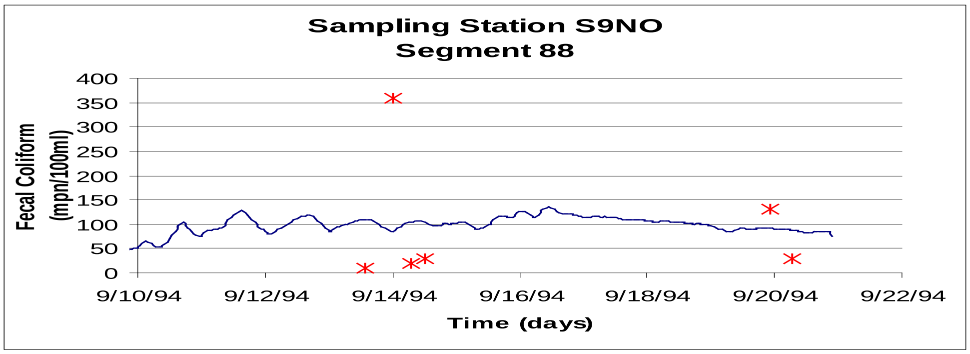

Sampling Station S1NO
Segment 285
Fecal Coliform (mpn/100ml)
200
150
100
50
0
9/10/94
9/12/94
9/14/94
9/16/94
9/18/94
9/20/94
9/22/94
Time (days)

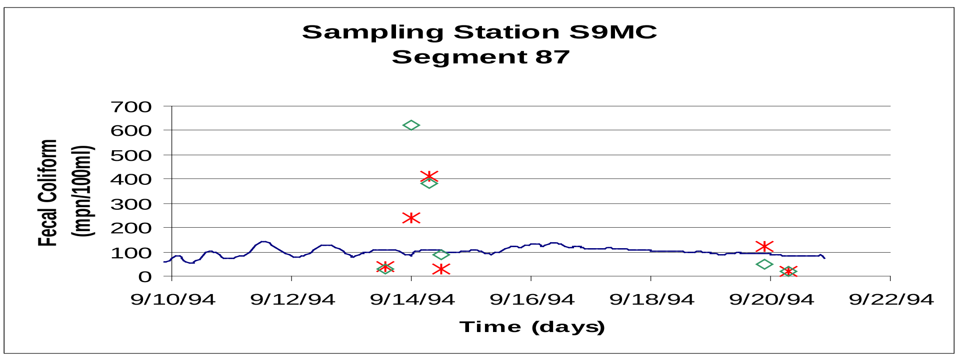

Sampling Station S4MC
Segment 185
Fecal Coliform (mpn/100ml)
300
250
200
150
100
50
0
9/10/94
9/12/94
9/14/94
9/16/94
9/18/94
9/20/94
9/22/94
Time (days)

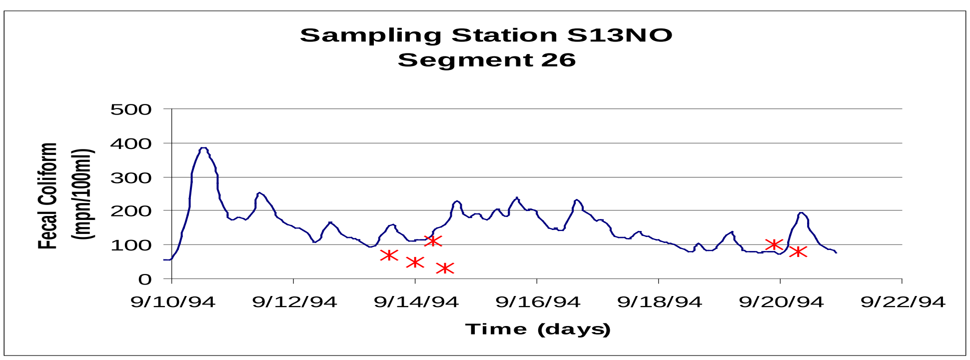

Sampling Station S4S0
Segment 184
Fecal Coliform (mpn/100ml)
800
700
600
500
400
300
200
100
0
9/10/94
9/12/94
9/14/94
9/16/94
9/18/94
9/20/94
9/22/94
Time (days)

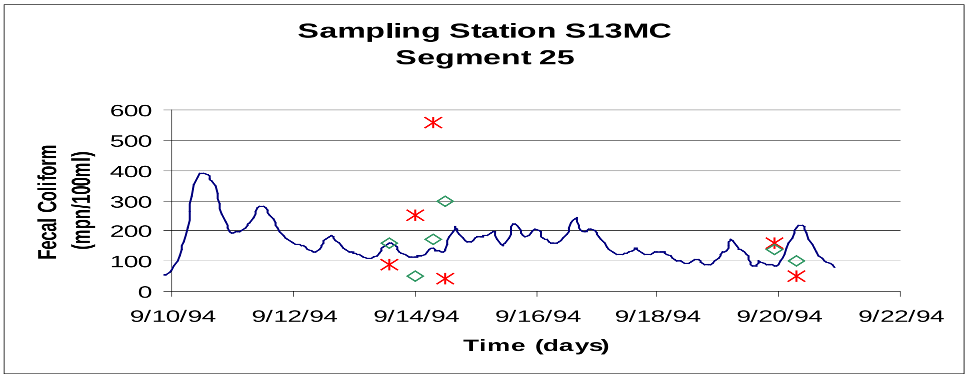

Sampling Station S6N0
Segment 142
Fecal Coliform (mpn/100ml)
1800
1600
1400
1200
1000
800
600
400
200
0
9/10/94
9/12/94
9/14/94
9/16/94
9/18/94
9/20/94
9/22/94
Time (days)

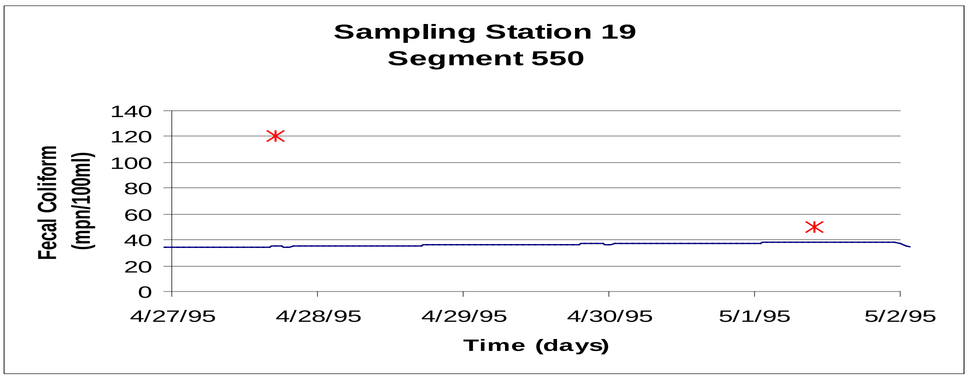

Sampling Station S6MC
Segment 140
Fecal Coliform (mpn/100ml)
400
350
300
250
200
150
100
50
0
9/10/94
9/12/94
9/14/94
9/16/94
9/18/94
9/20/94
9/22/94
Time (days)

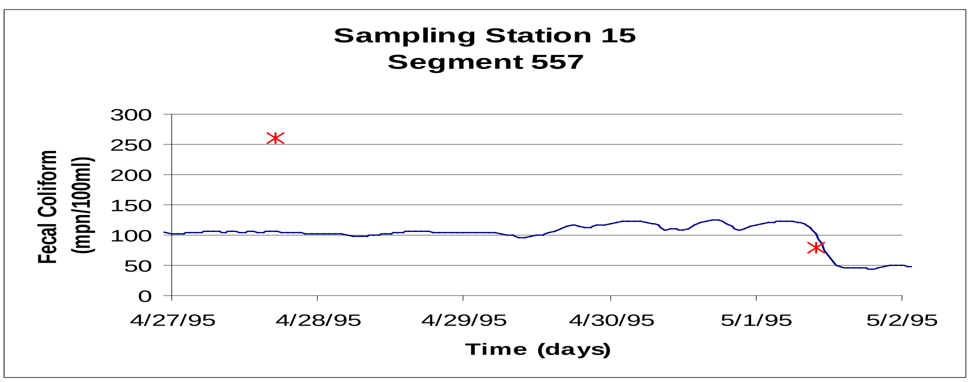

Sampling Station S9NO
Segment 88
Fecal Coliform (mpn/100ml)
400
350
300
250
200
150
100
50
0
9/10/94
9/12/94
9/14/94
9/16/94
9/18/94
9/20/94
9/22/94
Time (days)

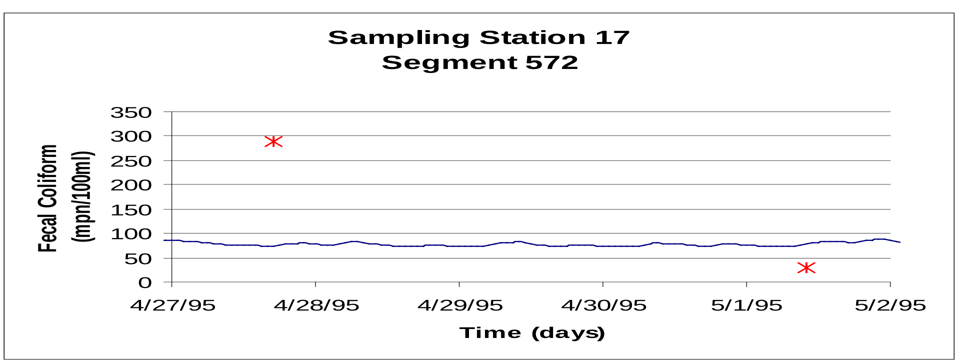

Sampling Station S9MC
Segment 87
Fecal Coliform (mpn/100ml)
700
600
500
400
300
200
100
0
9/10/94
9/12/94
9/14/94
9/16/94
9/18/94
9/20/94
9/22/94
Time (days)

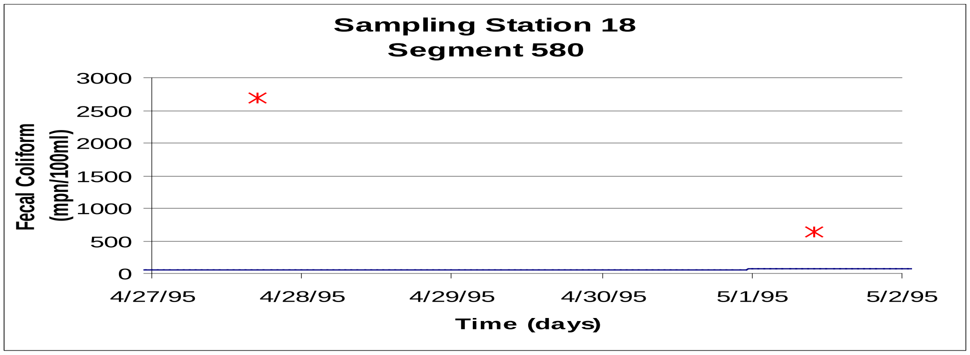

Sampling Station S13NO
Segment 26
Fecal Coliform (mpn/100ml)
500
400
300
200
100
0
9/10/94
9/12/94
9/14/94
9/16/94
9/18/94
9/20/94
9/22/94
Time (days)

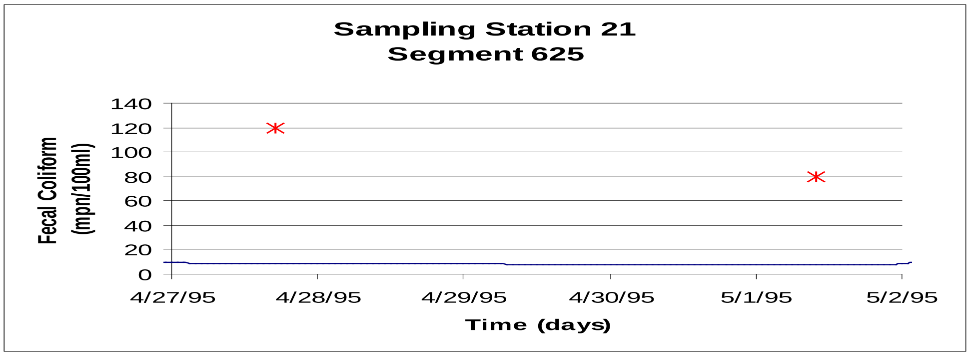

Sampling Station S13MC
Segment 25
Fecal Coliform (mpn/100ml)
600
500
400
300
200
100
0
9/10/94
9/12/94
9/14/94
9/16/94
9/18/94
9/20/94
9/22/94
Time (days)

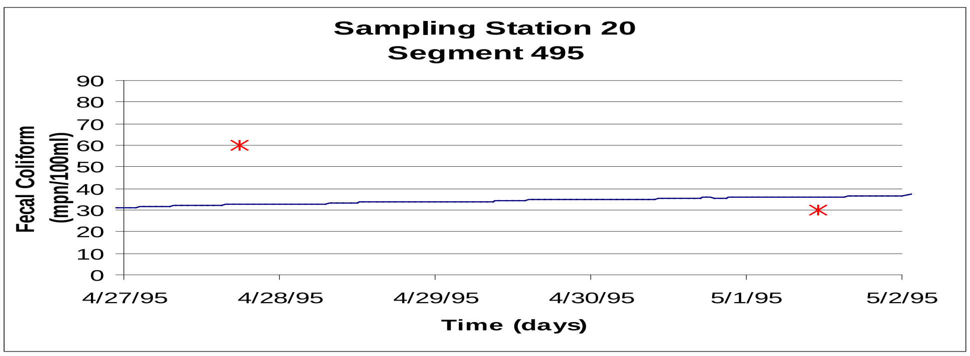

Sampling Station 19
Segment 550
Fecal Coliform (mpn/100ml)
140
120
100
80
60
40
20
0
4/27/95
4/28/95
4/29/95
4/30/95
5/1/95
5/2/95
Time (days)

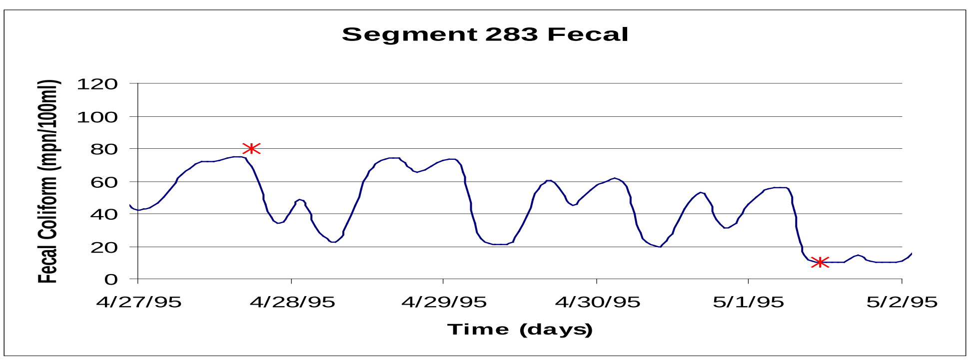

Sampling Station 15
Segment 557
Fecal Coliform (mpn/100ml)
300
250
200
150
100
50
0
4/27/95
4/28/95
4/29/95
4/30/95
5/1/95
5/2/95
Time (days)

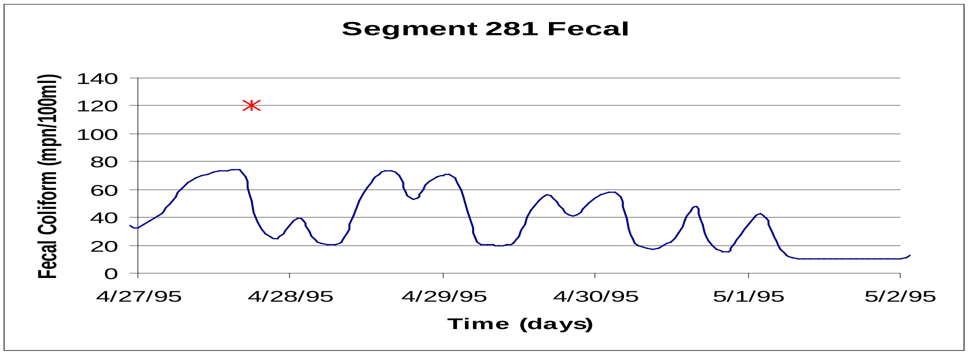

Sampling Station 17
Segment 572
Fecal Coliform (mpn/100ml)
350
300
250
200
150
100
50
0
4/27/95
4/28/95
4/29/95
4/30/95
5/1/95
5/2/95
Time (days)

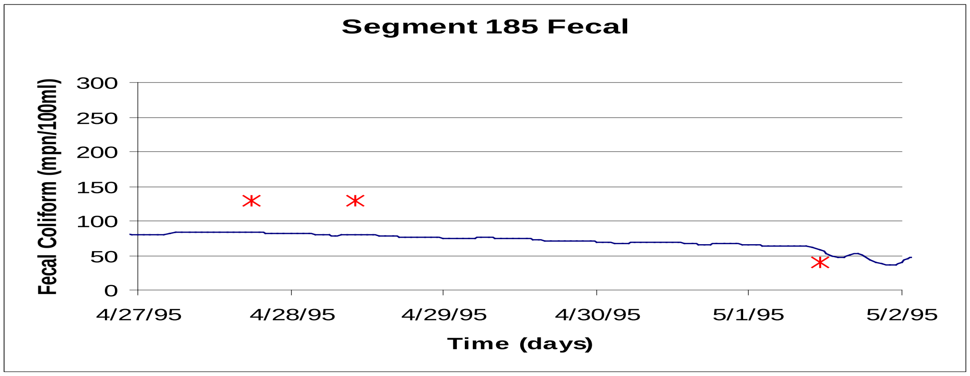

Sampling Station 18
Segment 580
Fecal Coliform (mpn/100ml)
3000
2500
2000
1500
1000
500
0
4/27/95
4/28/95
4/29/95
4/30/95
5/1/95
5/2/95
Time (days)

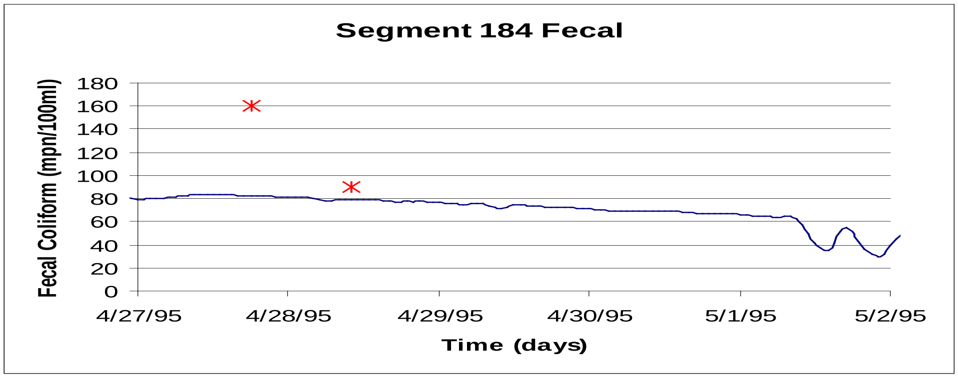

Sampling Station 21
Segment 625
Fecal Coliform (mpn/100ml)
140
120
100
80
60
40
20
0
4/27/95
4/28/95
4/29/95
4/30/95
5/1/95
5/2/95
Time (days)

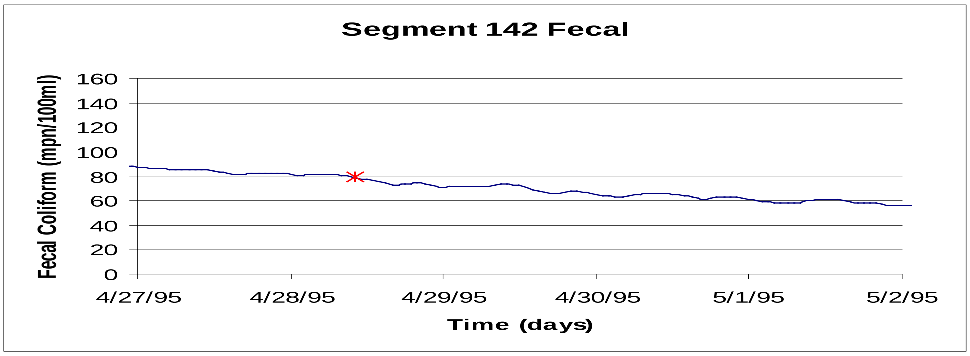

Sampling Station 20
Segment 495
Fecal Coliform (mpn/100ml)
90
80
70
60
50
40
30
20
10
0
4/27/95
4/28/95
4/29/95
4/30/95
5/1/95
5/2/95
Time (days)

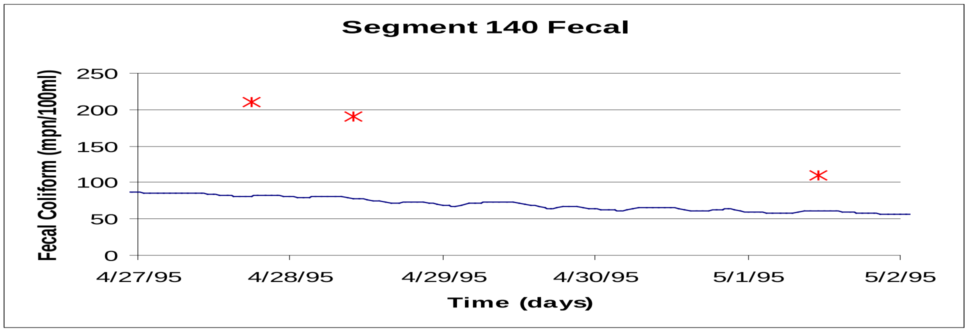

Segment 283 Fecal
Fecal Coliform (mpn/100ml)
120
100
80
60
40
20
0
4/27/95
4/28/95
4/29/95
4/30/95
5/1/95
5/2/95
Time (days)

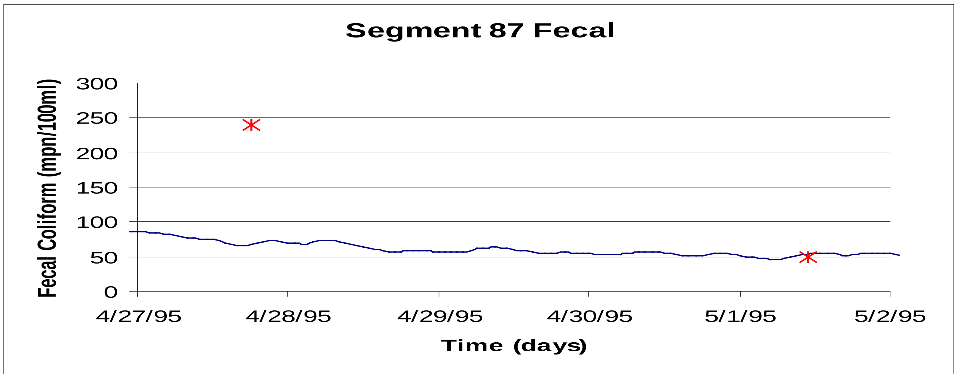

Segment 281 Fecal
Fecal Coliform (mpn/100ml)
140
120
100
80
60
40
20
0
4/27/95
4/28/95
4/29/95
4/30/95
5/1/95
5/2/95
Time (days)

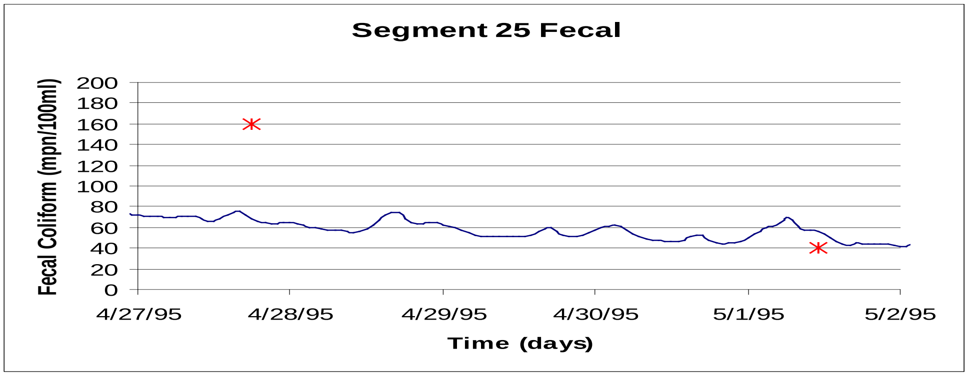

Segment 185 Fecal
Fecal Coliform (mpn/100ml)
300
250
200
150
100
50
0
4/27/95
4/28/95
4/29/95
4/30/95
5/1/95
5/2/95
Time (days)

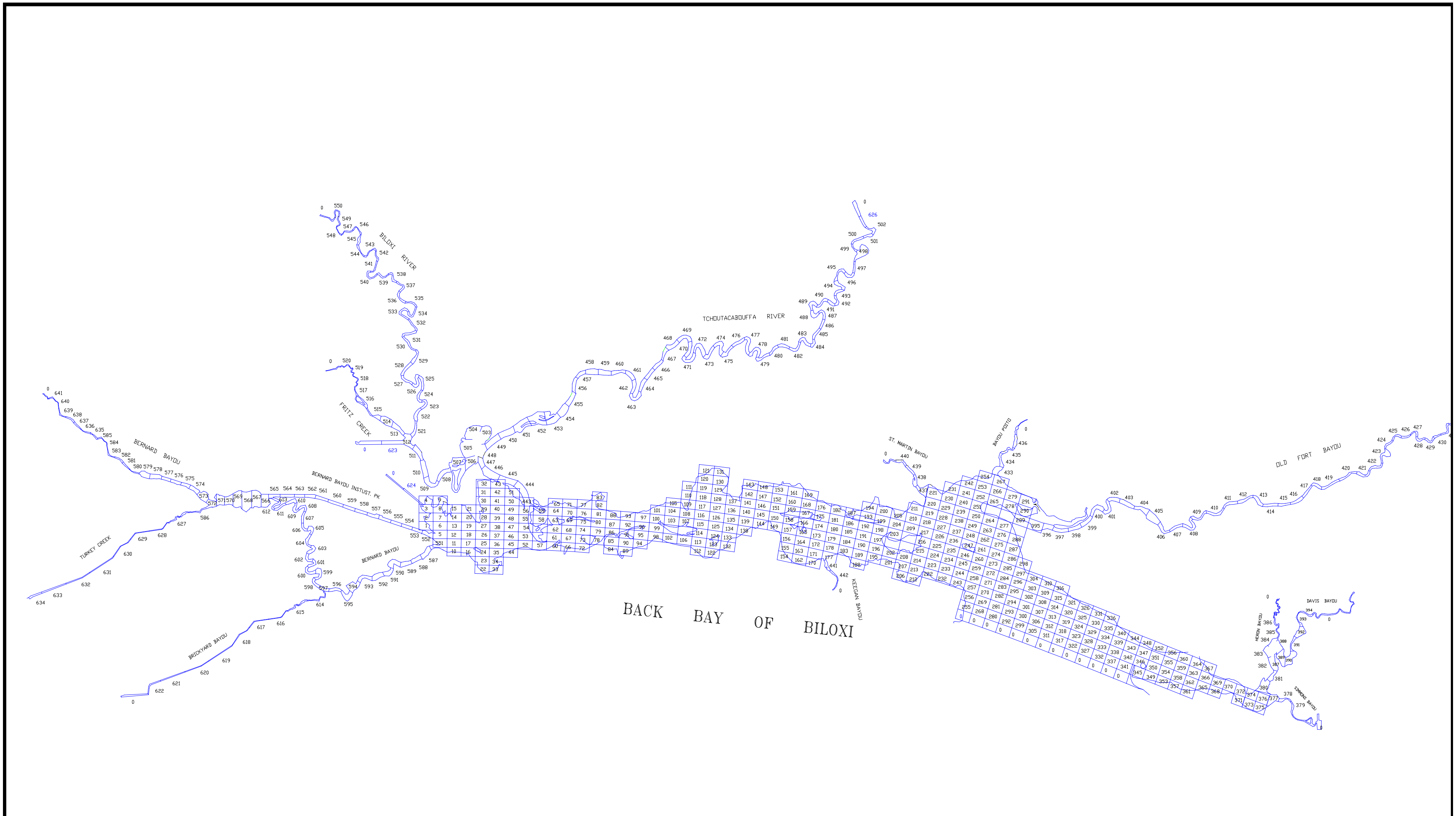

Segment 184 Fecal
Fecal Coliform (mpn/100ml)
180
160
140
120
100
80
60
40
20
0
4/27/95
4/28/95
4/29/95
4/30/95
5/1/95
5/2/95
Time (days)


Segment 142 Fecal
Fecal Coliform (mpn/100ml)
160
140
120
100
80
60
40
20
0
4/27/95
4/28/95
4/29/95
4/30/95
5/1/95
5/2/95
Time (days)


Segment 140 Fecal
Fecal Coliform (mpn/100ml)
250
200
150
100
50
0
4/27/95
4/28/95
4/29/95
4/30/95
5/1/95
5/2/95
Time (days)


Segment 87 Fecal
Fecal Coliform (mpn/100ml)
300
250
200
150
100
50
0
4/27/95
4/28/95
4/29/95
4/30/95
5/1/95
5/2/95
Time (days)


Segment 25 Fecal
Fecal Coliform (mpn/100ml)
200
180
160
140
120
100
80
60
40
20
0
4/27/95
4/28/95
4/29/95
4/30/95
5/1/95
5/2/95
Time (days)



EUTRO5 Model Segmentation