Phase 1 TMDL

For
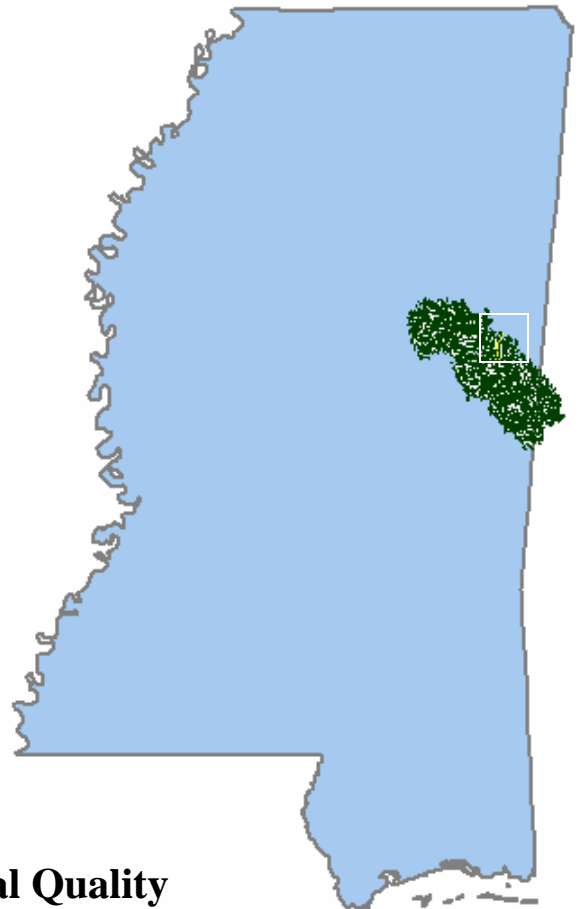## Organic Enrichment/Low Dissolved Oxygen and Ammonia Toxicity

Joes Creek
Tombigbee River Basin
Noxubee County
Mississippi

Prepared By

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

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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 segments addressed are comprised of monitored segments that have data indicating impairment. 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 will 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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TMDL INFORMATION PAGE

Listing Information

Name	ID	County	HUC	Cause	Mon/Eval
Joes Creek	MS038M	Noxubee	03160180	Organic Enrichment/Low Dissolved Oxygen as $CBOD_U$	Monitored
At Brooksville, from Headwaters above Alternate Hwy 45 to mouth at Noxubee River					
Joes Creek	MS038M	Noxubee	03160180	Ammonia Nitrogen as NH_3-N	Evaluated
At Brooksville, from Headwaters above Alternate Hwy 45 to mouth at Noxubee River					

Water Quality Standard

Parameter	Beneficial use	Water Quality Criteria
Dissolved Oxygen	Aquatic Life Support	Dissolved oxygen concentrations shall be maintained at a daily average of not less than 5.0 mg/L with an instantaneous minimum of not less than 4.0 mg/L in streams[1].

NPDES Facilities

NPDES ID	Facility Name	County	Receiving Water	Flow (cfs)
MS0033596	Brooksville POTW	Noxubee	Joes Creek thence into the Noxubee River	0.24

Total Maximum Daily Load, $CBOD_U$

Type	Summer Conditions (May – Oct)	Winter Conditions (Nov – April)	Unit
WLA	0	0	lbs/day $CBOD_U$
LA	4.5	4.5	lbs/day $CBOD_U$
MOS	(implicit)	(implicit)	
TMDL	**4.5**	**4.5**	lbs/day $CBOD_U$

Total Maximum Daily Load, NH_3-N

Type	Summer Conditions (May – Oct)	Winter Conditions (Nov – April)	Unit
WLA	0	0	lbs/day NH_3-N
LA	2.8	2.8	lbs/day NH_3-N
MOS	(implicit)	(implicit)	
TMDL	**2.8**	**2.8**	lbs/day NH_3-N

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1 The modeling tool used for this TMDL gives results for the daily average dissolved oxygen value. This method for developing the WLA calculations is found in MDEQ's regulations. The model does not calculate the minimum or maximum oxygen values for the stream.

EXECUTIVE SUMMARY

Joes Creek is on the Mississippi 1998 Section 303(d) List of Waterbodies as an impaired waterbody. The impairment was detected with water quality sampling and screening-level biological monitoring conducted during a wasteload allocation (WLA) site investigation in 1992. Based on these data, Joes Creek was included in the 1998 Section 303(d) List for biological impairment. An additional field study was conducted on Joes Creek in August 1999 at three monitoring stations. This study confirmed that the creek was biologically impaired and that the biological impairment was due to organic enrichment and elevated levels of ammonia nitrogen.
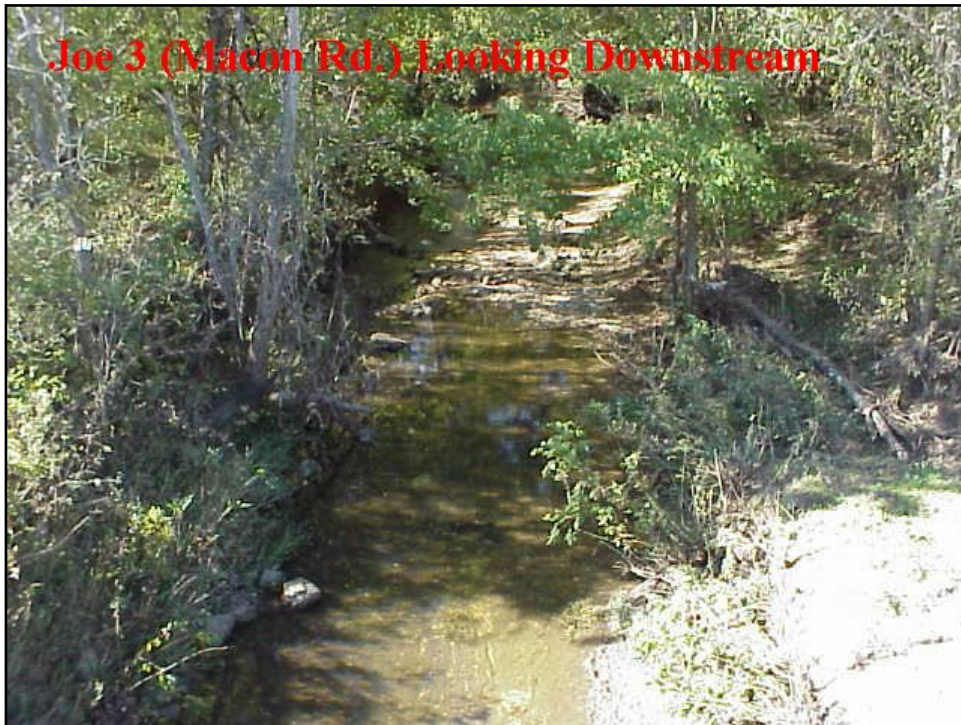
Photo 1.1. Joes Creek at Macon Road

In accordance with MDEQ regulations, a modified Streeter-Phelps dissolved oxygen sag model was selected as the modeling framework for developing the TMDL allocations for this study. The model was developed to account for seasonal variations in stream temperature, dissolved oxygen saturation, and carbonaceous biochemical oxygen demand decay rate. As required in MDEQ regulations, the model was developed for the critical condition and represents the 7Q10 flow (7-day, 10-year low flow). The model includes both point and nonpoint sources of oxygen demanding material and ammonia nitrogen. There is one NPDES permitted point source in the watershed.

The TMDL report concludes that the stream does not have the assimilative capacity for the Brooksville POTW. The POTW already has the strict permit limits typically issued for these types of facilities, however, the POTW has had difficulties in meeting the limits contained in the permit. The TMDL has been prepared as a phased TMDL Report to indicate more work is needed on the model and on the POTW.

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 TMDL process can be used to establish water quality based controls to reduce pollution and restore and maintain the quality of water resources. The Mississippi Department of Environmental Quality (MDEQ) has identified Joes Creek as being impaired for a length of 11 miles as reported in the Mississippi 1998 Section 303(d) List of Waterbodies. The impairment is caused by reduced levels of dissolved oxygen (DO) due to oxidation of organic material and the potential for toxicity due to high levels of ammonia nitrogen in the creek. Thus, this TMDL has been developed for organic enrichment/low DO and ammonia nitrogen. Organic enrichment is measured in terms of carbonaceous biochemical oxygen demand ($CBOD_U$). $CBOD_U$ represents the oxygen consumed by microorganisms while stabilizing or degrading carbonaceous compounds under aerobic conditions over an extended time period

1.2 Segment Location

Joes Creek flows in a southern direction from its headwaters near Brooksville, Mississippi to its

confluence with the Noxubee River. The 11-mile impaired segment is in Noxubee County near Brooksville from above alternate Highway 45 to its confluence with the Noxubee River near Macon, Figure 1.1. The dominant landuses in the area surrounding the creek are fields and pasture. There are no major residential, commercial, or industrial areas in the immediate vicinity. Major roads that are nearby include Highway 14 as well as Highway 45. There are several earthen catfish ponds located near the headwaters of Joe's Creek, just southwest of Alternate Highway 45, (photo 1.2).

Photo 1.2. Catfish Ponds in the Joes Creek Watershed
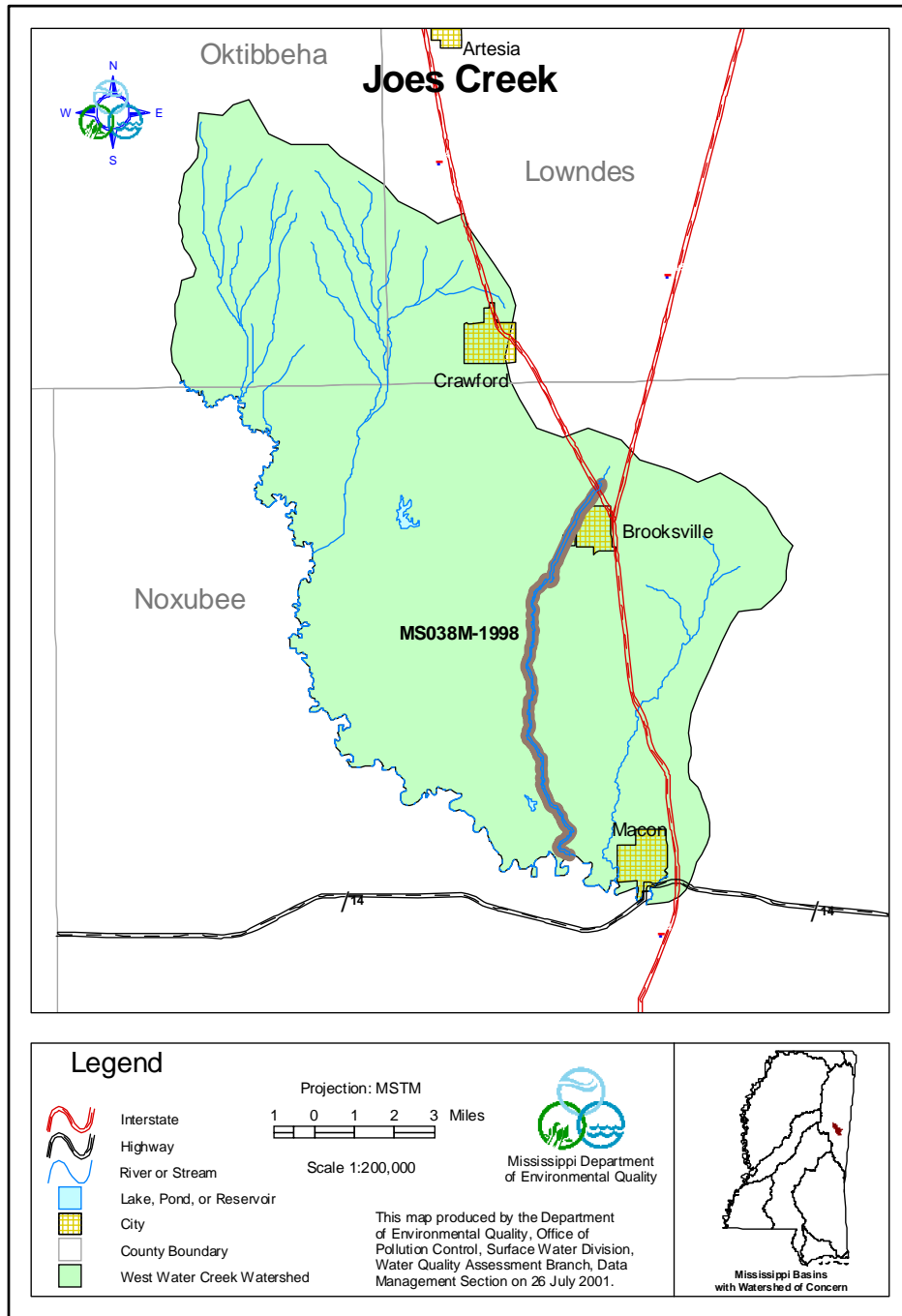
Figure 1.1. Location of 303(d) Listed Segment

A satellite photograph of the Joes Creek Watershed is shown in Figure 1.2 below. The photograph, which was taken in 1995, shows the location of the Brooksville POTW facility, adjacent to Joes Creek. Catfish ponds near the creek are also visible near the top of the photograph.

Figure 1.2. Satellite Photograph of Brooksville, MS

1.3 Discussion of Instream Water Quality 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. Limited water quality data are available for Joes Creek. According to the report, Joes Creek is not supporting the use of aquatic life support. This conclusion was based on water chemistry data and screening-level biological assessment conducted as part of the Joes Creek WLA Investigation in 1992. The 1992 WLA involved sites upstream and downstream of the Brooksville POTW outfall. The study shows the creek was not meeting the standard for dissolved oxygen at sites both upstream and downstream of the outfall. The biology of the creek was rated as very poor based on the family-level biotic screening. DO levels measured in the creek were 3.20 mg/L upstream of the outfall and 0.20 mg/L downstream of the outfall.

Additional water quality sampling and biological assessments were collected in August 1999. During this study, data were collected at three monitoring stations, one above and one below the Brooksville POTW outfall (JOE1 and JOE2) and at Macon Road, which is approximately 3 miles downstream of the outfall (JOE3), Figure 1.3. The objectives of this study were to confirm biological and water quality impairment in Joes Creek and to identify the specific cause and sources of biological impairment if possible. Chemical monitoring included field and laboratory analysis of surface water samples. In-situ water quality measurements were made using multi-parameter water quality instruments. Calibrated field instruments were utilized to measure DO, DO saturation, water temperature, specific conductivity, pH, and total dissolved solids. Instruments were deployed for 24 hours during the study for diurnal measurement of these water quality parameters. A summary of in-situ data collected at each site is given in Table 1.1.

Table 1.1. In-Situ Water Quality Data for Joes Creek

	JOE1 Above Brooksville POTW	JOE2 Below Brooksville POTW	JOE3 At Macon Road
Average Water Temperature (°C)	24.50	24.30	24.00
Average pH	7.43	7.20	7.80
Average Dissolved Oxygen (mg/L)	3.58	0.36	4.90
Average Dissolved Oxygen Saturation (%)	43.50	4.30	59.10
Minimum Dissolved Oxygen (mg/L)	1.97	0.05	3.64
Maximum Dissolved Oxygen (mg/L)	6.02	0.85	8.95
Average Conductivity (μs/cm)	1297.00	709.00	842.00
Average Total Dissolved Solids (mg/L)	830.00	454.00	539.00

Surface water samples were collected three times during the study. Water chemistry parameters selected for laboratory analysis and laboratory results for each station are given in Tables 1.2 through 1.4. The date and times of the sample collection are also shown in the tables.
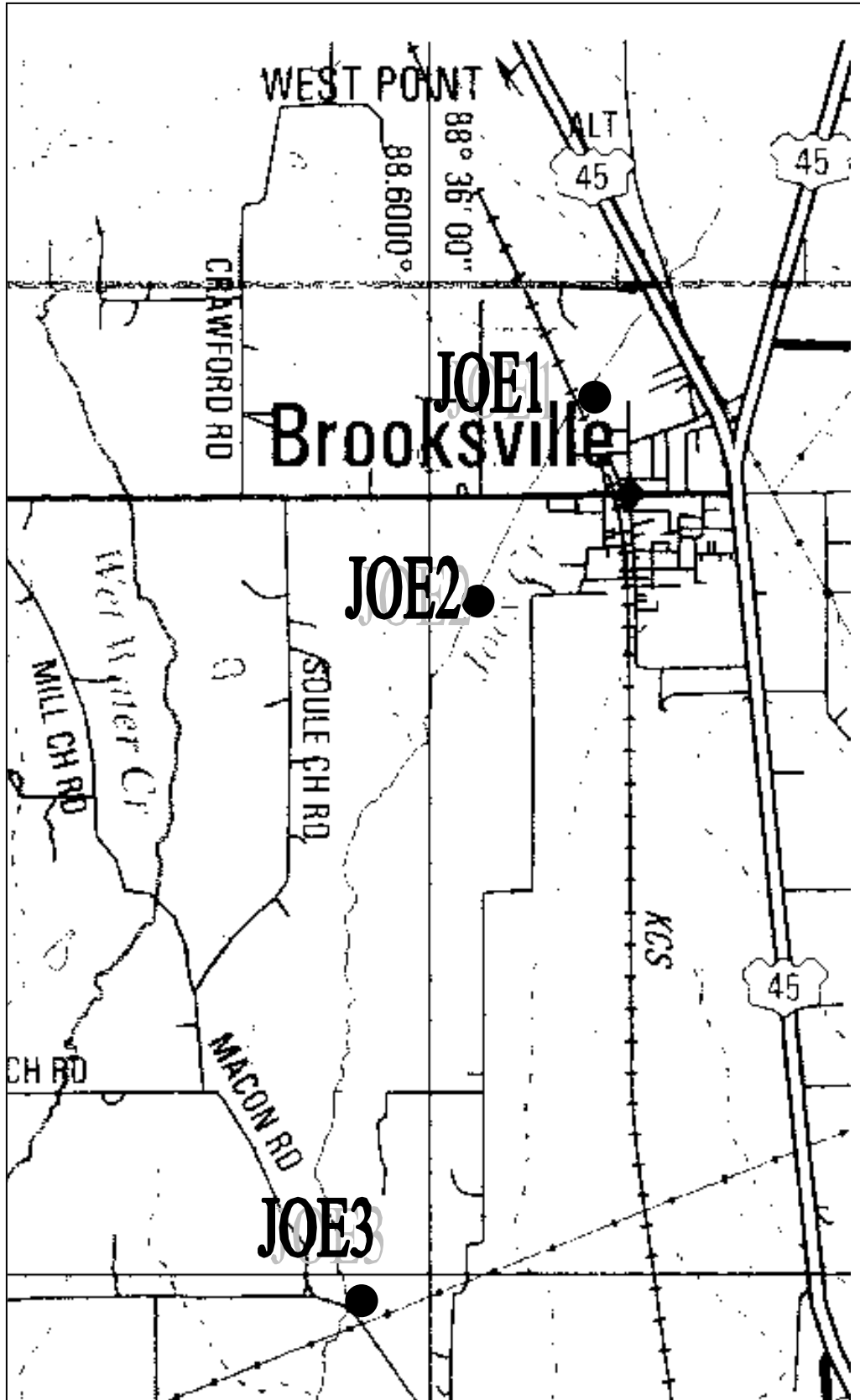
Figure 1.3. Location of Sampling Sites on Joes Creek

Table 1.2. Water Chemistry Data for JOE1

Parameter	8/31/1999 16:55	9/02/1999 12:00	9/2/1999 08:20
Sample Depth, ft	0.60	0.61	0.54
Biochemical Oxygen Demand – 5 Day (BOD$_5$), mg/L	2.00	2.00	-
Total Organic Carbon (TOC), mg/L	5.00	5.00	5.00
Chemical Oxygen Demand, mg/L	18.00	13.00	18.00
Total Phosphorus(as P), mg/L	0.05	0.04	0.05
Total Kjeldahl Nitrogen (TKN), mg/L	0.75	0.70	0.96
Ammonia Nitrogen (as N), mg/L	0.64	0.62	0.7
Nitrite + Nitrate, mg/L	0.08	0.05	0.07
Hardness (as CaCO$_3$), mg/L	423.00	823.00	-
Total Alkalinity (as CaCO$_3$), mg/L	80.60	77.90	38.90
Turbidity (NTU), mg/L	18.30	22.00	19.00
Chlorides, mg/L	199.00	204.00	147.00

Table 1.3. Water Chemistry Data for JOE2

Parameter	8/31/1999 14:00	9/2/1999 11:45	9/2/1999 08:20
Sample Depth, ft	0.70	0.39	-
Biochemical Oxygen Demand – 5 Day (BOD$_5$), mg/L	5.00	2.00	2.00
Total Organic Carbon (TOC), mg/L	11.00	11.00	12.00
Chemical Oxygen Demand, mg/L	41.00	39.00	42.00
Total Phosphorus(as P), mg/L	3.85	3.69	3.50
Total Kjeldahl Nitrogen (TKN), mg/L	8.48	7.61	7.37
Ammonia Nitrogen (as N), mg/L	5.62	5.64	5.34
Nitrite + Nitrate, mg/L	0.05	0.05	0.03
Hardness (as CaCO$_3$), mg/L	109.00	112.00	103.00
Total Alkalinity (as CaCO$_3$), mg/L	211.00	216.00	216.00
Turbidity (NTU), mg/L	14.10	21.00	11.00
Chlorides, mg/L	68.70	69.80	69.40

Table 1.4. Water Chemistry Data for JOE3

Parameter	8/31/1999 15:45	9/1/1999 10:20	9/2/1999 10:00
Sample Depth, ft	-	0.20	0.33
Biochemical Oxygen Demand – 5 Day (BOD$_5$), mg/L	2.00	2.00	2.00
Total Organic Carbon (TOC), mg/L	6.00	5.00	5.00
Chemical Oxygen Demand, mg/L	19.00	11.00	14.00
Total Phosphorus(as P), mg/L	0.12	0.08	0.06
Total Kjeldahl Nitrogen (TKN), mg/L	0.74	0.71	0.64
Ammonia Nitrogen (as N), mg/L	0.57	0.58	0.62
Nitrite + Nitrate, mg/L	0.03	0.03	0.03
Hardness (as CaCO$_3$), mg/L	244.00	278.00	291.00
Total Alkalinity (as CaCO$_3$), mg/L	211.00	228.00	228.00
Turbidity (NTU), mg/L	5.84	2.06	2.00
Chlorides, mg/L	104.00	106.00	108.00

1.4 Cause of Impairment

Joes Creek is listed on the 303(d) list for biological impairment. The term biological impairment describes impairment to waterbodies in which at least one biological assemblage (fish, macroinvertabrates, or algae) indicates less than full support with moderate modification of the biological community noted. Current sampling methods allow MDEQ to make an accurate determination of whether or not the biological community in a specific waterbody is impaired. However, biological sampling often does not identify the specific pollutant or pollutants that are the cause of biological impairment.

As a result, MDEQ uses a process-of-elimination approach to identify the pollutants causing biological impairment. For the Joes Creek watershed, all available data were analyzed, including water chemistry and in-situ data, photographs of the waterbody, and inventories of landuse and point source dischargers. Analysis of these data eliminated causes such as erosion and sedimentation because evidence of stream bank erosion was not visible, and water chemistry did not show elevated levels of turbidity or dissolved solids. Measurements of pH, alkalinity, hardness, and chlorides were all within the expected range for waterbodies in Mississippi although the chloride levels at JOE1 were higher than at the other two stations. Measurements of DO collected during the field study in 1999 showed that DO levels in Joes Creek were low. Diurnal variations in the creek's DO levels ranged from 1.97 to 6.02 mg/L at JOE1 and from 0.05 to 0.85 mg/L at JOE2, indicating that the levels of organic material in the creek were elevated. In addition, levels of ammonia nitrogen and phosphorous in the waterbody at JOE2 were significantly elevated.

The decreased DO levels found at JOE1 are not due to a known point source discharger. Because JOE1 is upstream of any point sources, the low DO levels are likely caused by factors that cannot be easily controlled such as low velocity of the water due to beaver dams, trees, and snags in the stream channel. Stream flow appeared to be extremely low in this section of Joes Creek, Photo 1.3. There is often very little water in the stream channel, especially in the upper reaches of the creek. In addition, water is being withdrawn from the creek for use in catfish

ponds near Alternate Highway 45. This practice likely contributes to low velocity in the stream channel near JOE1. Removal of the withdrawal could improve the reaeration in the stream and could provide additional capacity for discharge to the stream.

Evidence indicates that the biological impairment found in Joes Creek below the Brooksville POTW discharge point, at JOE2, is due to elevated amounts of organic material and ammonia nitrogen in the creek which results in decreased DO levels. Ammonia nitrogen, however, must not only be considered due to its effect on DO in the receiving water, but also its toxicity potential. Instream ammonia concentrations in excess of 3.0 mg/L (at a pH of 7.0 and temperature of 25°C) can have toxic effects on fish and invertebrates in the waterbody according to *the 1999 Update of Ambient Water Quality Criteria for Ammonia* (EPA 822-R-99-014). This level of instream ammonia nitrogen is exceeded at JOE2. Subsequently, the Joes Creek TMDL was developed for ammonia nitrogen toxicity as well as organic enrichment/low DO.

Photo 1.3. Upstream Reach of Joes Creek

TMDL ENDPOINT

2.1 Segment Use and Pollutant Standard

Designated beneficial uses and water quality standards are established by the *State of Mississippi Water Quality Criteria for Intrastate, Interstate, and Coastal Waters* regulations. The designated use for Joes Creek as defined by the regulations is Fish and Wildlife Support. Waters designated for use as Fish and Wildlife support must also be suitable for secondary contact, which is defined as incidental contact with the water. 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 applicable standard specifies that the DO concentrations shall be maintained at a daily average of not less than 5.0 mg/L with an instantaneous minimum of not less than 4.0 mg/L.

According to *Empirical Stream Model Assumptions for Conventional Pollutants and Conventional Water Quality Models* (MDEQ, 1994), the allocations for effluent ammonia nitrogen (NH_3-N) concentrations were developed so as to meet the water quality criteria given in *1999 Update of Ambient Water Quality Criteria for Ammonia* (EPA 822-R-99-014). Allowable instream ammonia nitrogen concentrations are defined in this document based on the pH and temperature of the receiving waterbody. MDEQ regulations state that the allowable ammonia nitrogen limit should be developed for a pH of 7.0 and a temperature of 25°C. At these conditions the maximum allowable ammonia nitrogen concentration is 3.01 mg/L.

2.2 Selection of TMDL Endpoint and Critical Conditions

2.2.1 Dissolved Oxygen

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 meeting the load and wasteload allocations specified in the TMDL. The endpoints allow for a comparison between observed instream conditions and conditions that are expected to restore designated uses. The instream DO target for this TMDL is a daily average of not less than 5.0 mg/L.

The standard contains additional requirements of a minimum instantaneous limit of 4.0 mg/L. The modeling tool used for this TMDL only gives results for the daily average dissolved oxygen value. Since the tool only delivers one average value per day, this value also represents the minimum value of the standard for the WLA application of this model for this TMDL calculation. In addition, there was no need to specifically evaluate the 4.0 mg/L DO standard because available data showed that the 5.0 mg/L standard was not attainable.

Low DO typically occurs during seasonal low-flow periods of late summer and early fall. Elevated oxygen demand is of primary concern during low-flow periods because the effects of minimum dilution and high temperatures combine to produce the worst-case potential effect on water quality (USEPA, 1997). The low-flow, high-temperature period is referred to as the critical condition. The maximum impact of oxidation of organic material is generally not at the location of the point source discharge, but at some distance downstream, where the maximum

DO deficit occurs. The DO deficit is defined as the difference between the DO concentration at 100% saturation and the actual DO.

2.2.2 Ammonia Nitrogen

Ammonia nitrogen (NH_3-N) concentrations in effluent may be more restricted due to the potential for toxicity than due to their potential to cause low dissolved oxygen levels. The maximum allowable instream NH_3-N concentration at a pH of 7.0 and stream temperature of 25°C is 3.01 mg/L NH_3-N. Based on this instream limit, a mass balance calculation was used to determine the maximum allowable NH_3-N concentration in the Brooksville POTW effluent (Figure 2.1). This calculation showed that the permit limit for NH_3-N for the Brooksville POTW should be no greater than 3.0 mg/L.

$$C_E = \frac{(C_T * Q_T) - (C_H * Q_H)}{Q_E}$$

$$C_E = \frac{(3.01 * 0.371) - (0.65 * 0.001)}{0.370}$$

$$C_E = 3.02 \text{ mg/L } NH_3\text{-N}$$

Where: C_E = allowable effluent NH_3-Nconcentration, mg/L
C_T = NH_3-N criteria, 3.01 mg/l
Q_T = stream flow after mixing, 0.371 cfs
C_H = background NH_3-N concentration, 0.65 mg/L
Q_H = background 7Q10 flow, 0.001 cfs
Q_E = effluent flow, 0.37 cfs

Figure 2.1. Mass-Balance Calculation

Source Assessment

This TMDL Report includes the identification of all known potential pollutant sources in the Joes Creek Watershed and an analysis of available water quality data available for these sources. The source assessment was used as the basis of development for the model and analysis of the TMDL allocation. The potential point and nonpoint pollutant sources were characterized by the best available information, monitoring data, and literature values.

3.1 Assessment of Point Sources

Photo 3.1. Lagoon at Brooksville POTW

The first step in assessing pollutant sources in the Joes Creek watershed was locating the National Pollutant Discharge Elimination System (NPDES) permitted sources in the watershed. The Brooksville POTW is the only source permitted to discharge treated wastewater into Joes Creek, Photo 3.1. The largest industry in the town of Brooksville, Peco Foods, has a pretreatment permit to discharge into the Brooksville POTW. The effluent from the Brooksville POTW facility was characterized based on all available data including information on the facility's wastewater treatment system, permit limits, and discharge monitoring reports. The Brooksville POTW consists of a lagoon system with three aerated lagoon cells followed by overland flow through two wetland cells. Prior to discharge, the effluent is aerated. The current permit limits for the Brooksville POTW are given in Table 3.1. Recent DMR data are shown in Table 3.2.

Table 3.1. Permit Limits for Brooksville POTW

Parameter	Monthly Average (lbs/day)	Max Weekly Average (lbs/day)	Monthly Average	Max Weekly Average
Flow – MGD	-	-	0.24	-
BOD$_5$	20	30	10 mg/L	15 mg/L
Suspended Solids	60	90	30 mg/L	45 mg/L
DO	-	-	6 mg/L	6 mg/L

Table 3.2. DMR Data for the Brooksville POTW

Date	Monthly Average Flow (MGD)	Effluent DO (mg/L)	Monthly Average BOD_5 (mg/L)
30-SEP-2001	0.217	**2.4**	10
30-JUN-2001	0.209	**2.8**	**29**
31-MAR-2001	0.226	6.1	**11**
31-DEC-2000	0.218	6.7	**41**
30-SEP-2000	0.196	**5.2**	**18**
30-JUN-2000	0.203	**5.7**	**15**
31-MAR-2000	0.21	6.7	**11**
31-DEC-1999	0.19	6.7	**24**
30-SEP-1999	0.17	6.3	**42**
30-JUN-1999	0.19	7.1	**27**
31-DEC-1998	0.17	6.4	**38**
30-SEP-1998	0.14	6.2	**23**
30-JUN-1998	0	6.7	**20**
31-MAR-1998	0.17	6.1	**37**
AVERAGE	0.18		**24.7**

*Bold indicates a violation of the NPDES Permit

Comparing the permit limits to the DMR data shows that the Brooksville POTW often does not meet its permit limits for BOD_5. MDEQ's environmental permit division has been working with the City of Brooksville to address the compliance problems and develop an acceptable solution. The city of Brooksville is currently under an administrative order from the Mississippi Commission on Environmental Quality (See Appendix A) to attain compliance with the permit including upgrading their treatment facilities or relocating their effluent discharge location. Solving the inadequate treatment and compliance problems with the Brooksville POTW facility will be imperative to improving water quality in Joes Creek.

3.2 Assessment of Nonpoint Sources

Nonpoint loading of $CBOD_U$ and ammonia nitrogen in a waterbody results from the transport of pollutants into receiving waters by overland surface runoff and groundwater infiltration. Landuse activities within the drainage basin, such as agriculture, aquaculture, silvaculture, and urbanization contribute to nonpoint source loading. Other nonpoint pollution sources include atmospheric deposition and natural weathering of rocks and soil. The 15,286-acre drainage area of Joes Creek contains many different landuse types, including urban, forest, cropland, pasture, water, and wetlands. The landuse information is based on data collected by the State of Mississippi's Automated Resource Information System (MARIS). This data set is based on Landsat Thematic Mapper digital images taken between 1992 and 1993. Agriculture is the dominant landuse within this watershed, Table 3.2.

Table 3.2. Landuse Distribution for Joes Creek Watershed

Urban	Forest	Agriculture	Barren	Water	Wetlands	Total
312	1,569	13,154	14	87	150	15,286
2.0%	**10.5%**	**86.0%**	**0.0%**	**0.5%**	**1.0%**	**100.0%**

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. The link can be established through a range of techniques, from qualitative assumptions based on sound scientific principles to sophisticated modeling techniques. Ideally, the linkage will be supported by monitoring data that allow the TMDL developer to associate certain waterbody responses to flow and loading conditions. In this section, the selection of the modeling tools, setup, and model application are discussed.

4.1 Modeling Framework Selection

A mathematical model, named AWFWUL1, for DO distribution in freshwater streams was used for developing the TMDL. The use of AWFWUL1 is promulgated in the *Wastewater Regulations for National Pollutant Discharge Elimination System (NPDES) Permits, Underground Injection Control (UIC) Permits, State Permits, Water Quality Based Effluent Limitations and Water Quality Certification* (MDEQ, 1994). This model has been approved by EPA and has been used extensively at MDEQ. A key reason for using the AWFWUL1 model in TMDL development is its ability to assess instream water quality conditions in response to point and nonpoint source loadings.

The model is a steady-state, daily average computer model that utilizes a modified Streeter-Phelps DO sag equation. Instream processes simulated by the model include $CBOD_U$ decay, nitrification, reaeration, and sediment oxygen demand. Figure 4.1 shows how these processes are related in a typical DO model. Reaction rates for the instream processes are input by the user and corrected for temperature by the model. The model output includes flow and daily average water quality conditions in each computational element for DO, $CBOD_U$, and NH_3-N concentrations. The hydrological processes simulated by the model include stream velocity and flow from point sources and spatially distributed inputs.

The model tool used for this TMDL only gives results for the daily average dissolved oxygen value. Since the tool only delivers one average value per day, this value also represents the minimum value of the standard for the WLA application of this model for this TMDL calculation. In other words, the model does not give any information on the 4.0 mg/L instantaneous minimum value in the standard.

The model was set up to calculate reaeration within each reach using the Tsivoglou formulation, which is recommended for small streams with flow less than 10 cfs. The Tsivoglou formulation calculates reaeration (Ka) within each reach according to Equation 4.1.

$$\textbf{Ka = CSU}$$ (Equation 4.1)

Were S is the slope in ft/mile, U is the reach velocity in mile/day, and C is the escape coefficient, which is 0.11 for streams with flow less than 10 cfs.
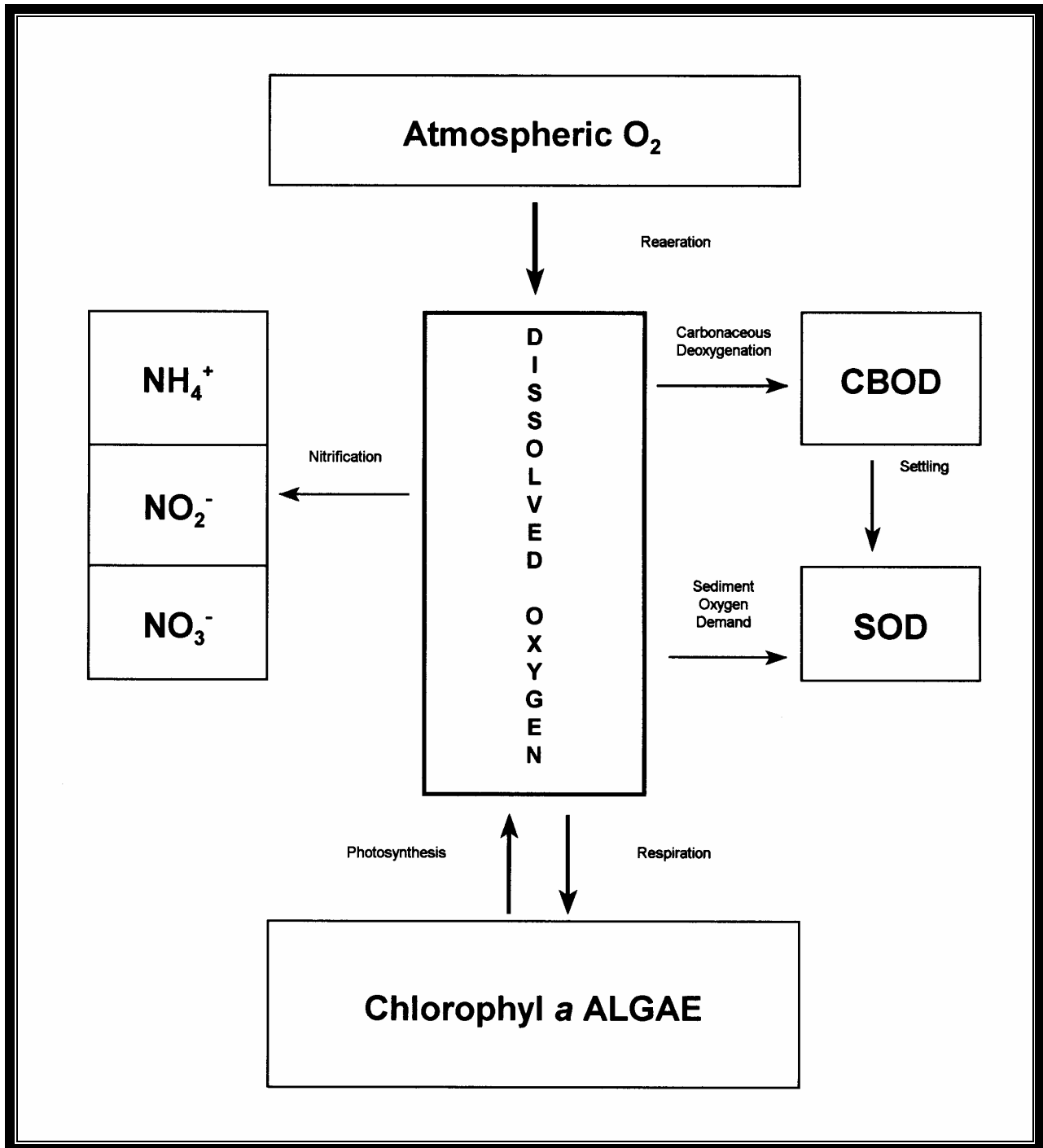
Figure 4.1. Instream Processes in a Typical DO Model

4.2 Model Setup

The Joes Creek TMDL model simulates the hydrology and water quality in Joes Creek beginning above the Brooksville discharge point. The modeled waterbody was divided into reaches for input into the AWFWUL model. Reach divisions were made at any major change in the hydrology of the waterbody, such as a significant change in slope or the confluence of a tributary or point source discharge. The slope of each reach was estimated from USGS quad maps and

input into the model in units of feet/mile. Within each reach, the modeled segments were divided into computational elements of 0.1 mile. The model calculated the hydrological and water quality characteristics for each computational element. Joes Creek was modeled according to the diagram shown in Figure 4.2, beginning at river mile 9.6 above the Brooksville POTW outfall and the JOE1 monitoring station. The numbers on the figure represent the river mile at which point sources discharges or reach divisions are located. River miles are assigned to waterbodies, beginning with zero at the mouth. The locations of the monitoring stations are also shown.
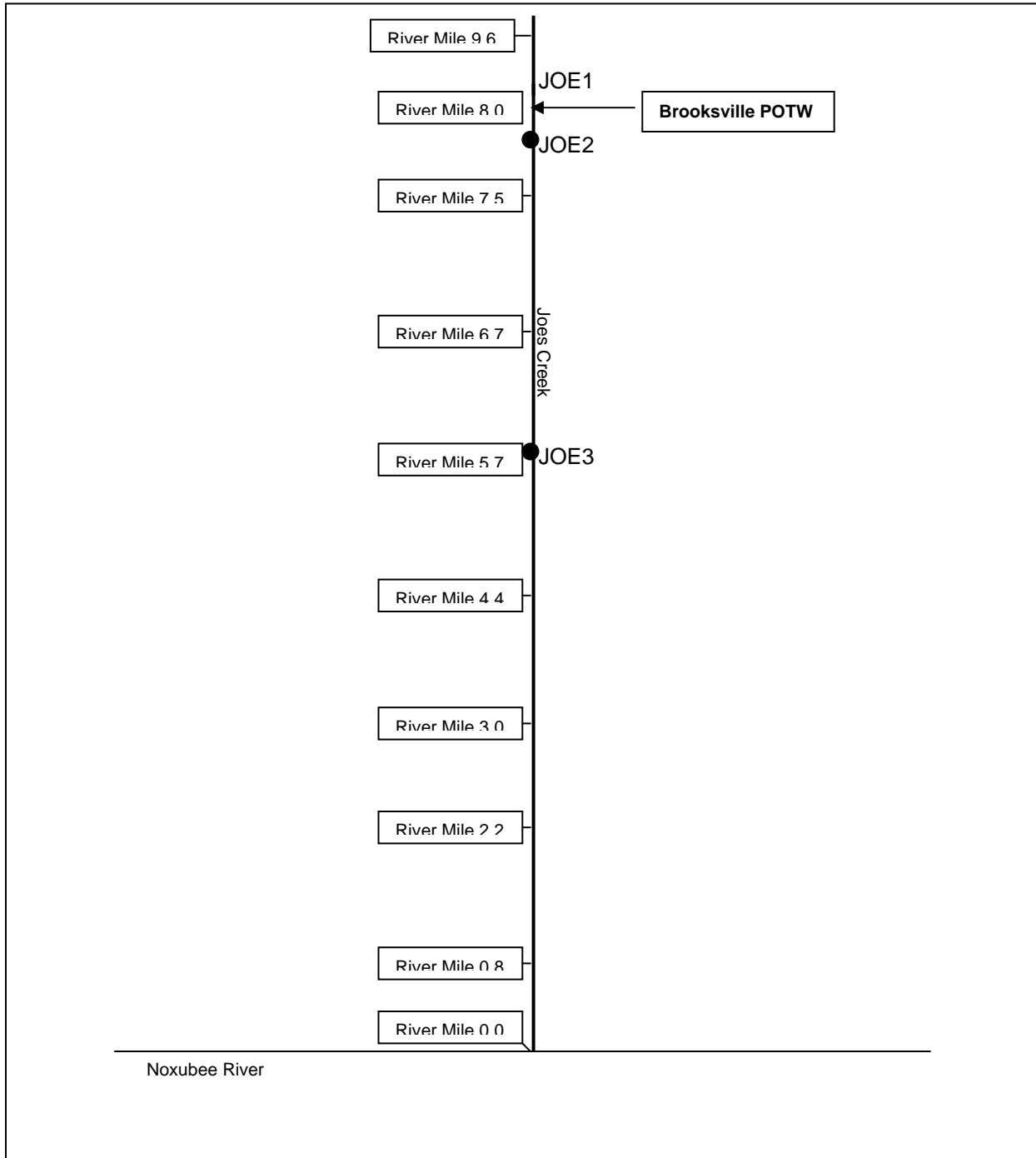

Figure 4.2. Joes Creek Model Setup (Note: Figure not to Scale)

The conditions measured for JOE1 were assumed to be the background conditions in Joes Creek, upstream of the Brooksville POTW outfall. We observed several large beaver dams and snags in the creek due to fallen trees and collection of debris during our stream studies. Due to these channel obstructions, the upper reach of creek is a series of pools with a very slow velocity. Due to these hydrological characteristics, the stream does not naturally meet the current standard of 5.0 mg/L of dissolved oxygen above the POTW discharge point.

4.3 Source Representation

Both point and nonpoint sources were represented in the model. The load from the point source was added as a direct input into the appropriate reach of the waterbody as a flow in cfs and a load of $CBOD_U$ and ammonia nitrogen in lbs/day. Loads for nonpoint sources were input into the model as spatially distributed input. Spatially distributed loads, which represent nonpoint sources of flow, $CBOD_U$, and ammonia nitrogen were calculated to represent the nonpoint source load for the entire watershed, including the areas upstream of the outfall of the Brooksville POTW. The loads were distributed evenly into each computational element of Joes Creek.

Organic materials discharged to a stream from an NPDES permitted point source are typically quantified as 5-day biochemical oxygen demand (BOD_5). BOD_5 is a measure of the oxidation of carbonaceous and nitrogenous material over a 5-day incubation period. However, oxidation of nitrogenous material, called nitrification, usually does not take place within the 5-day period because the bacteria that are responsible for nitrification are normally not present in large numbers and have slow reproduction rates (Metcalf and Eddy, 1991). Thus, BOD_5 is generally considered equal to $CBOD_5$. Because permits for point source facilities are written in terms of BOD_5 while predictive models used for TMDL development are typically developed using $CBOD_U$, a ratio between the two terms is needed, Equation 4.2. Assumed values of the $CBOD_U$ to $CBOD_5$ ratio are given in *Empirical Stream Model Assumptions for Conventional Pollutants and Conventional Water Quality Models* (MDEQ, 1995). The value of the ratio depends on the treatment type used in the wastewater treatment facility. A ratio of 1.5 is used for mechanical secondary treatment. This value is recommended for use by MDEQ regulations when actual field data are not available.

$$CBOD_U = CBOD_5 * Ratio$$ (Equation 4.2)

In order to convert the ammonia nitrogen (NH_3-N) loads to an oxygen demand, a factor of 4.57 pounds of oxygen per pound of NH_3-N oxidized to nitrate nitrogen (NO_3-N) was used. Using this factor is a conservative modeling assumption because it assumes that all of the ammonia is converted to nitrate through nitrification, which is not necessarily accurate. The oxygen demand caused by nitrification of ammonia is equal to the $NBOD_U$ load. The $CBOD_U$ and $NBOD_U$ loads calculated for the point source at its maximum permit limits are shown in Table 4.1.

Table 4.1. Point Source Loads

Facility	Flow (cfs)	CBOD$_5$ (mg/L)	CBOD$_5$/ CBOD$_U$ Ratio	CBOD$_U$ (lbs/day)	NH$_3$-N (mg/L)	NH$_3$-N (lbs/day)	NBOD$_U$ (lbs/day)
Brooksville POTW	0.37	10.0	1.5	29.9	2.0	4.0	21.8

Direct measurements of nonpoint source loads of $CBOD_U$ and NH_3-N were not available for the Joes Creek Watershed. The nonpoint contributions of $CBOD_U$ and NH_3–N were estimated based on what was measured at JOE1. The DO was 3.6 mg/L and the $CBOD_U$ and NH_3-N levels are shown in Table 4.2 on page 19.

4.4 Selection of Representative Modeling Periods

In order to account for seasonal variations in stream temperature and the stream temperature's effect on the $CBOD_U$ decay rate and DO saturation, the model was run for both summer and winter temperature conditions. The temperatures used in the model are 26°C in the summer (May through October) and 20°C in the winter (November through April). The headwater instream DO was assumed to be 85% of saturation at the stream temperature. The instream $CBOD_U$ decay rate is dependent on temperature, according to Equation 4.3.

$$Kd_{(T)} = Kd_{(20°C)}(1.047)^{T-20} \qquad \text{(Equation 4.3)}$$

Where Kd is the $CBOD_U$ decay rate and T is the assumed instream temperature. The assumptions regarding the instream temperatures, background DO saturation, and $CBOD_U$ decay rate are given in the *Empirical Stream Model Assumptions for Conventional Pollutants and Conventional Water Quality Models* (MDEQ, 1994). The temperatures, $CBOD_U$ decay rates, and DO saturation values used in the model are given in Table 4.2.

Table 4.2 Seasonal Model Inputs

Season	Temperature (°C)	$CBOD_U$ Decay Rate (Day^{-1})	85% DO Saturation (mg/L)
Summer (May – Oct)	26	0.39	6.9
Winter (Nov – April)	20	0.30	7.7

4.5 Model Calibration Process

4.5.1 Water Quality

The model of Joes Creek was initially set up to simulate the conditions that were measured in Joes Creek during the August 1999 WLA study. The BOD_5, DO, and NH_3-N concentrations measured at JOE1 were used to set the background conditions for the model. Also, the concentrations of BOD_5, DO, and NH_3-N measured in a 24-hour composite sample of effluent from the Brooksville POTW were used to calculate the point source loads used in the model calibration process, Table 4.3. Note that these loads are not the same as the maximum permit limits for the facility.

Table 4.3. Brooksville POTW Loads Measured During the 1999 WLA Study

Facility	Flow (cfs)	$CBOD_5$ (mg/L)	$CBOD_5$/ $CBOD_U$ Ratio	$CBOD_U$ (lbs/day)	NH_3-N (mg/L)	NH_3-N (lbs/day)	$NBOD_U$ (lbs/day)
Brooksville POTW	0.37	4.0	1.5	11.97	5.54	11.05	50.50

Several of the model inputs, such as the $CBOD_U$ and $NBOD_U$ decay rates and the 5-day to ultimate $CBOD_U$ ratio were based on assumptions found in *Empirical Stream Model*

Assumptions for Conventional Pollutants and Conventional Water Quality Models (MDEQ, 1994). According to this document, the $CBOD_U$ decay rate was set at 0.3/day and the $NBOD_U$ decay rate was set at 0.4/day. The 5-day to ultimate ratio was 1.5. A rate of sediment oxygen demand (SOD) was also input into the model for the reach immediately below the Brooksville POTW discharge point. The modeled DO is highly dependent on SOD. However, SOD is extremely difficult to measure due to the spatial variability in the sediment material along stream reaches. For this reason, the SOD rate was estimated using literature values found in *Surface Water-Quality Modeling* as 2.0 to 4.0 g/m^2/day (3.3 to 6.6 mg/L/day for an estimated depth of 2.0 ft) downstream from a wastewater treatment plant outfall (Chapra, 1997). This range of values was used as a starting point for the model. The SOD in the reach below the Brooksville POTW outfall was adjusted until the modeled DO matched the daily average DO measured during the study as closely as possible. A SOD value of 6.0 mg/L/day was selected for this reach. A graph of the modeled DO concentration compared to the measured values is shown in Figure 4.3. Although the figure shows that the observed and predicted data do not match exactly, the predicted values are reasonably close, indicating that the model accurately simulates the principal water quality processes.

Figure 4.3. Model Calibration for DO
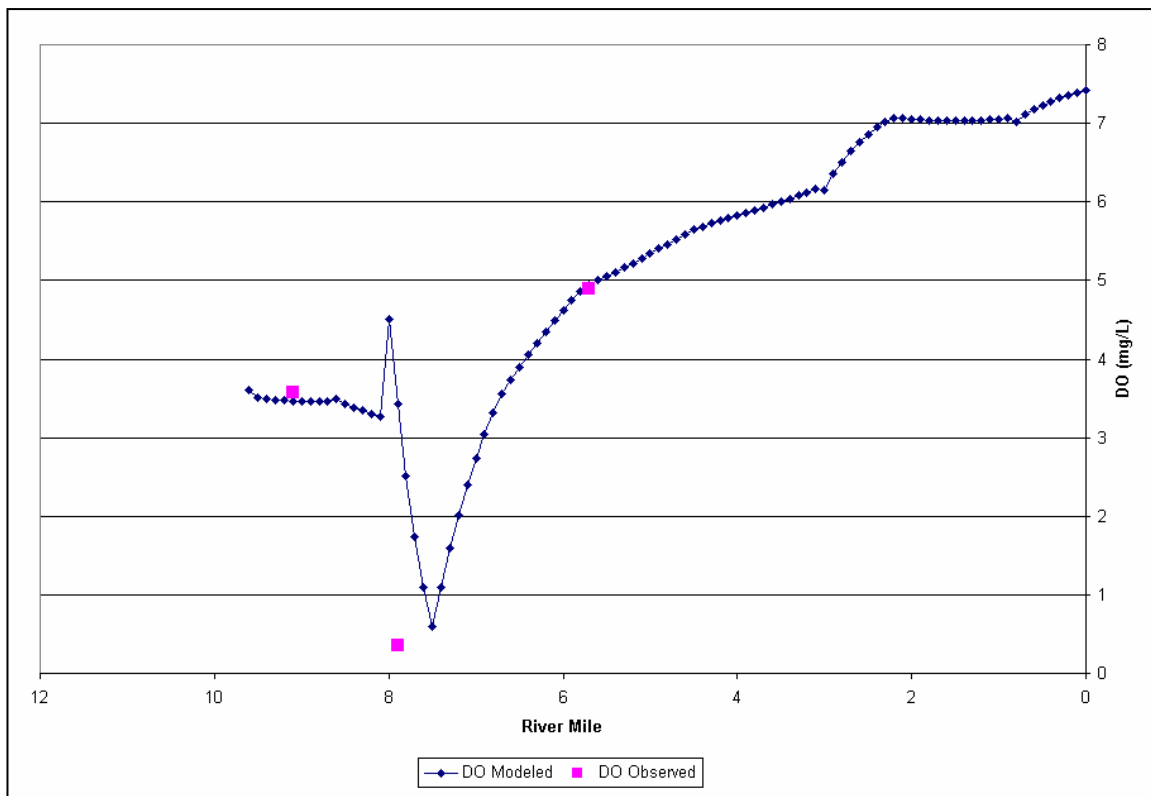
4.5.2 Hydrology

The hydrological portion of the model was calibrated to simulate low-flow, critical conditions in Joes Creek. Long-term records of flow are not available for Joes Creek. However, data collected in a nearby watershed were used to evaluate the low-flow condition in the Joes Creek watershed. Nonpoint source flows are typically estimated using a 7Q10 flow coefficient. The 7Q10 flow is the lowest 7-day average flow expected to occur within a 10-year time period. According to MDEQ Regulations, the 7Q10 flow is used in models to simulate low flow conditions and develop wasteload allocations. 7Q10 flow coefficients (7Q10 value in cfs/drainage area in square miles) are used to estimate the amount of water draining into a watershed due to groundwater infiltration and other nonpoint sources during low-flow conditions. USGS flow data, which were collected on the Noxubee River near Macon, were used to estimate the 7Q10 flow coefficient for the Joes Creek Watershed. According to *Techniques for Estimating 7-Day, 10-Year Low Flow Characteristics for Ungaged Sites on Streams in Mississippi*, estimates of the 7Q10 for ungaged sites can be transferred from a gaged site on the basis of the drainage area using Equation 4.4.

$$7Q10_0 = (A_0/A_1)*7Q10_1$$

Equation 4.4

The Noxubee River at Macon, MS is the nearest gaged site to Joes Creek. Joes Creek drains into the Noxubee River a few miles upstream of Macon, MS. Thus, because it is a subwatershed of the Noxubee River, it was assumed that the transfer equation would be applicable for determining the 7Q10 of Joes Creek. Using this equation, the $7Q10_1$ flow for the Noxubee River at Macon is 32.0 cfs. The watershed of the Noxubee River at Macon, A_1, is 768 square miles. The Joes Creek watershed, A_0, is 20.9 square miles. Thus from Equation 4.4, the $7Q10_0$ for Joes Creek is (20.9 square miles/768 square miles)*32 cfs = 0.87 cfs.

The nonpoint source flow was divided into contributions for each reach based on watershed size. The flow was evenly distributed in each reach in the model. The nonpoint source loads were then calculated using the assumed concentrations of $CBOD_5$ and NH_3-N, Table 4.2. Also the DO concentration in the nonpoint source flow was assumed to be 3.60 mg/L. Because it is not possible to measure the DO of water flowing into the creek through infiltration, the assumed DO was set as the daily average DO measured at JOE1.

Table 4.2. Nonpoint Source Loads

Reach	Flow (cfs)	$CBOD_5$ (mg/L)	$CBOD_5$/ $CBOD_U$ Ratio	$CBOD_U$ (lbs/day)	NH_3-N (mg/L)	NH_3-N (lbs/day)	$NBOD_U$ (lbs/day)
1 (RM 9.6 to 8.6)	0.091	1.33	1.50	0.98	0.65	0.05	0.22
2 RM (8.6 to 8.0)	0.054	1.33	1.50	0.58	0.65	0.19	0.86
3 (RM 8.0 to 7.5)	0.044	1.33	1.50	0.47	0.65	0.15	0.70
4 (RM 7.5 to 6.7)	0.074	1.33	1.50	0.80	0.65	0.26	1.19
5 (RM 6.7 to 5.7)	0.093	1.33	1.50	1.00	0.65	0.33	1.49
6 (RM 5.7 to 4.4)	0.114	1.33	1.50	1.23	0.65	0.40	1.83
7 (RM 4.4 to 3.0)	0.130	1.33	1.50	1.40	0.65	0.46	2.08
8 (RM 3.0 to 2.2)	0.071	1.33	1.50	0.76	0.65	0.25	1.14
9 (RM 2.2 to 0.8)	0.126	1.33	1.50	1.36	0.65	0.44	2.02
10 (RM 0.8 to 0.0)	0.073	1.33	1.50	0.79	0.65	0.26	1.17
All Reaches	**0.870**			**9.36**		**2.78**	**12.70**

4.6 Model Results

Once the model setup and calibration were complete, the model was used to predict water quality conditions in Joes Creek. The model was first run under baseline conditions. Under baseline conditions, the load from the point source was set at its maximum permit limits, Table 4.1. The model was then run using a trial-and-error process to determine the maximum loads from the point source facilities which would not violate water quality standards for DO. These trial-and-error model runs are called load reduction scenarios. In this case, it was determined that complete removal of the POTW would not allow the stream to meet the standard.

4.6.1 Baseline Model Runs

Figure 4.4 shows the model results from the baseline model run. The baseline model run was setup to simulate summer temperature conditions only, since the summer temperatures represent critical conditions when the dissolved oxygen saturation is lower and the $CBOD_U$ decay rate is greater. The figure shows the modeled daily average DO in Joes Creek. The dashed line on each figure represents the DO standard of 5.0 mg/L. The DO sag, or maximum DO deficit, occurs in Joes Creek below the discharges from the Brooksville POTW, at river mile 7.5. As shown in the chart, the modeled DO reaches zero below the outfall of the Brooksville POTW.
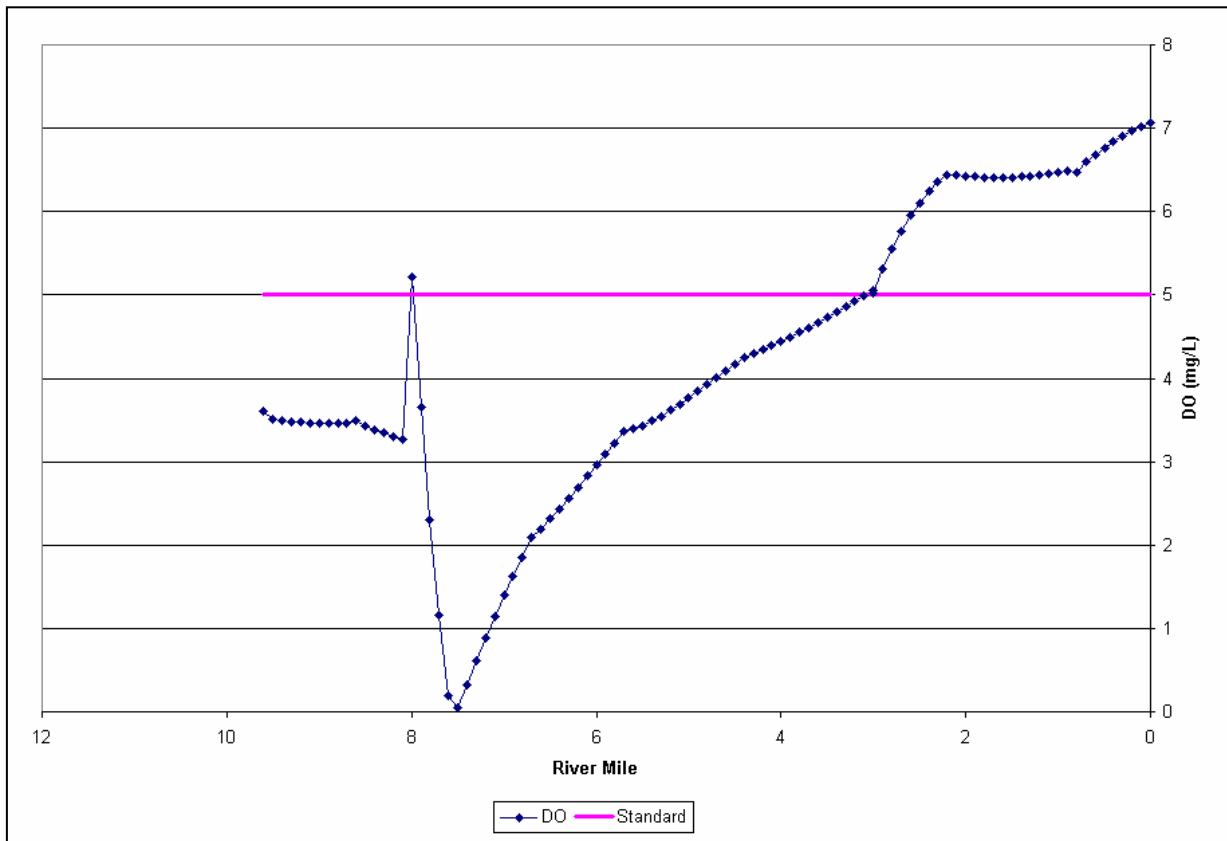

Figure 4.4. Baseline Model Output, Joes Creek

4.6.2 Load Reduction Scenarios

The graphs of baseline model output show that the predicted DO falls below the DO standard in Joes Creek during critical conditions. As a result, reductions from the baseline loads of $CBOD_U$ were studied in order to maintain a daily average DO of at least 5.0 mg/L. However, it was determined that the DO standard can not be maintained under critical conditions even if the point source were to be completely removed from Joes Creek. Based on the model runs without the point source, the maximum attainable DO in the creek is 3.4 mg/L in the summer and 4.0 mg/L DO in the winter.

Figure 4.5 shows the daily average instream DO concentrations in Joes Creek after the removal of the point source during summer conditions. The lowest DO concentration in the creek, which is 3.4 mg/L, occurs at river mile 7.5. Figure 4.6 shows the modeled daily average DO in Joes Creek during the winter conditions. The lowest DO during the winter, 4.0 mg/L occurs within the upstream reach at river mile 9.6. This is primarily due to the assumed DO concentration of 3.6 mg/L of the nonpoint source flow. The DO decreases slightly below the current location of the Brooksville POTW due to the sediment oxygen demand in this reach. Even if the point source were removed from Joes Creek, the SOD would likely remain. This is because deposits of organic material cause the high SOD in this reach. These deposits would continue to exert an oxygen demand for some time. Because the background DO condition in Joes Creek was not known in the winter, the background DO was set at 7.72 mg/L. According to MDEQ regulations, when background DO concentrations are not known, they should be set at a value of 85% of the DO saturation at the modeled temperature.
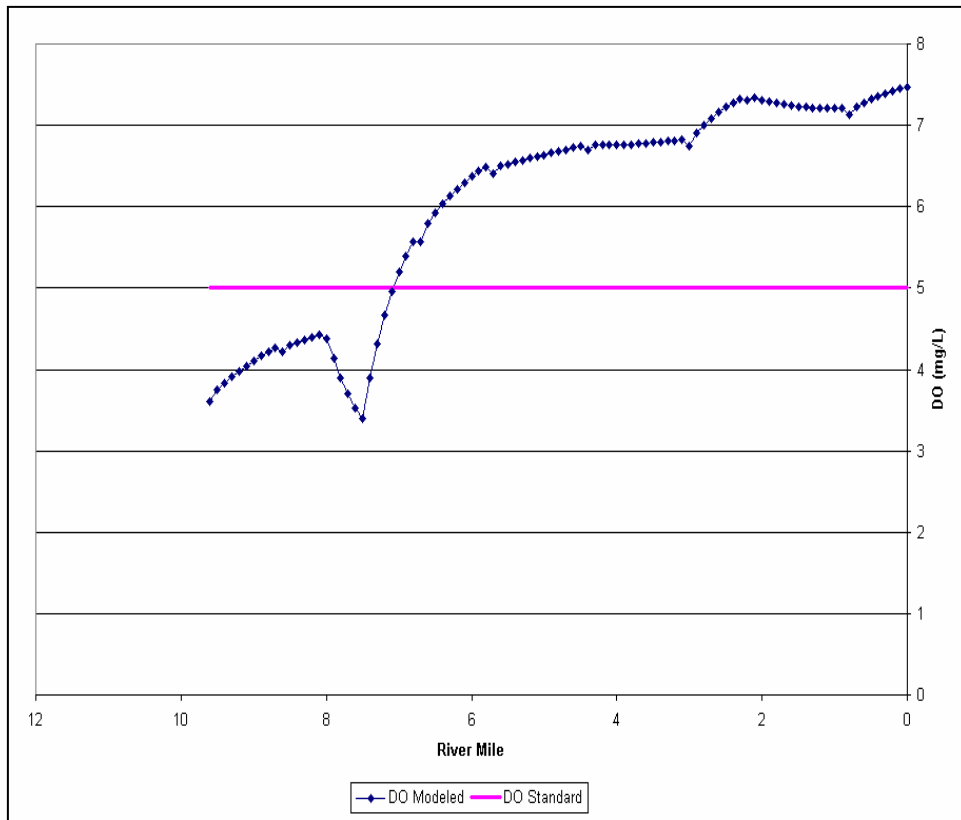
Figure 4.5. Summer Conditions
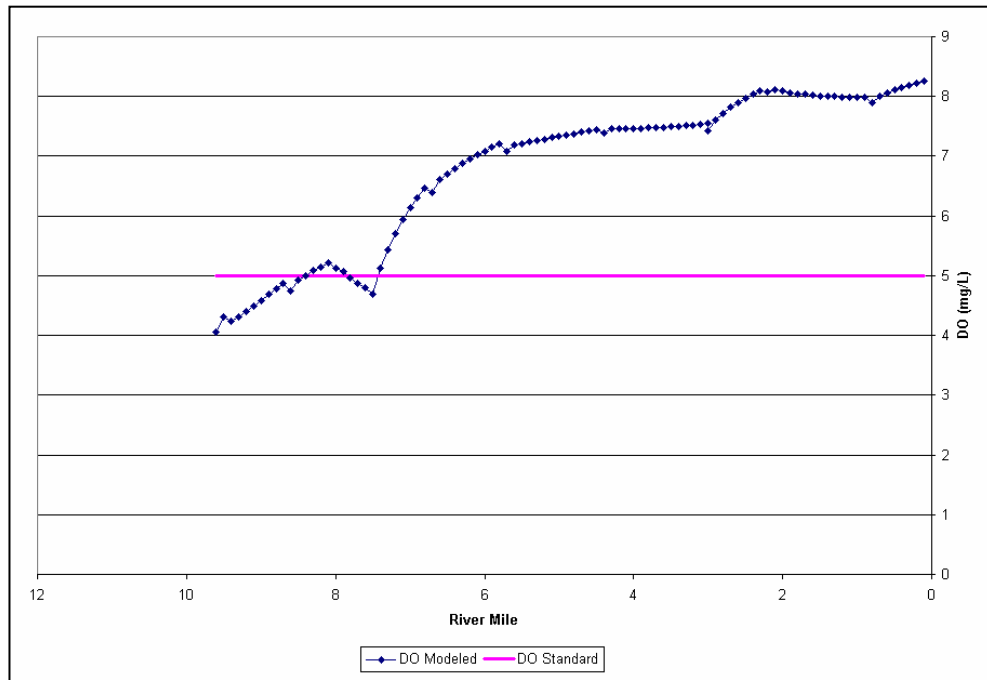
Figure 4.6. Winter Conditions

4.6.3 Ammonia Toxicity Modeling

The modeled concentrations of ammonia nitrogen were also compared to the instream standard for ammonia nitrogen toxicity, 3.0 mg/L. Figure 4.7 shows the ammonia nitrogen concentrations predicted at baseline conditions in Joes Creek.   As shown in the figure, the modeled concentrations do not exceed the standard for toxicity, represented by the dashed line. Thus, it can be assumed that ammonia nitrogen will not cause toxicity in the stream as long as the ammonia nitrogen concentration in the effluent from the Brooksville POTW is less than 2.0 mg/L.
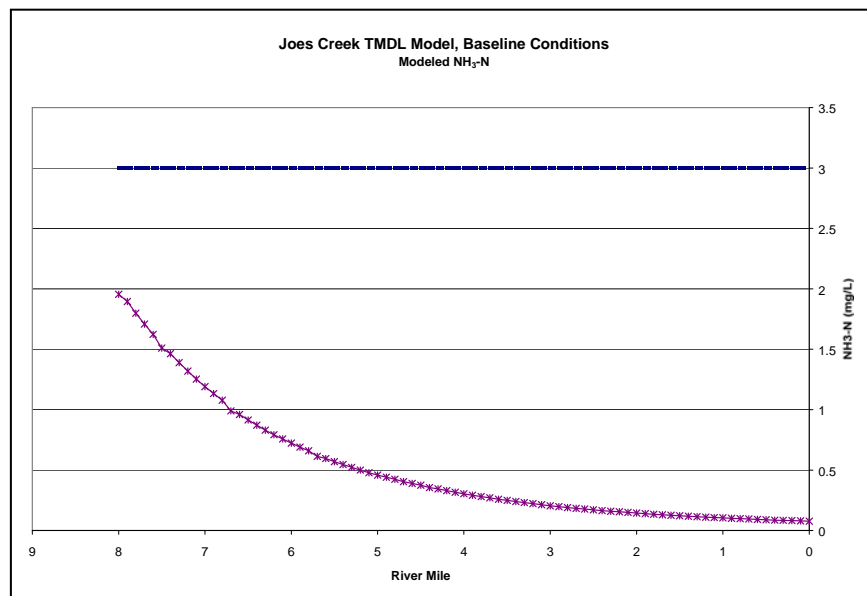
Figure 4.7. Baseline Model Output, Joes Creek

Allocation

The allocation for this TMDL involves a wasteload allocation, necessarily set to zero, for the point source and a load allocation for nonpoint sources necessary for attainment of water quality standards in segment MS038M. One component of the load allocation, the reduction of sediment oxygen demand, represents a negative load. Seasonality was addressed in the TMDL by running the model for both summer and winter conditions.

5.1 Wasteload Allocation

Modeling indicates that complete removal of this POTW will not restore the stream to the dissolved oxygen standard of 5.0 mg/L. Currently the NPDES Permit is very restrictive with limits of 10 mg/L of BOD_5. Since complete removal of the waste load from the stream does not restore the stream to the standard, the WLA must be set to zero for this stream for the current standard.

Table 5.1 Wasteload Allocations for MS038M

Season	$CBOD_U$ (lbs/day)	NH_3-N (lbs/day)
Summer (May – October)	0	0
Winter (November – April)	0	0

5.2 Load Allocation

There are two components to the load allocation for this TMDL, the nonpoint source loads and reductions of the sediment oxygen demand. The nonpoint source loads are modeled as spatially distributed flows in each reach. The flows were based on the 7Q10 flow coefficient for the watershed and the reach drainage area. The flows were used to calculate the nonpoint source load as $CBOD_U$ and NH_3-N loads in lbs/day, Table 5.2. Because the loads do not vary by season, they are given for an annual basis.

Table 5.2 NPS Loads for MS038M

Reach	$CBOD_U$ (lbs/day)	NH_3-N (lbs/day)
1 (RM 9.6 to 8.6)	0.98	0.05
2 RM (8.6 to 8.0)	0.58	0.19
3 (RM 8.0 to 7.5)	0.47	0.15
4 (RM 7.5 to 6.7)	0.80	0.26
5 (RM 6.7 to 5.7)	1.00	0.33
6 (RM 5.7 to 4.4)	1.23	0.40
7 (RM 4.4 to 3.0)	1.40	0.46
8 (RM 3.0 to 2.2)	0.76	0.25
9 (RM 2.2 to 0.8)	1.36	0.44
10 (RM 0.8 to 0.0)	0.79	0.26
All Reaches	**9.36**	**2.78**

The remaining component of the LA is not a straightforward calculation. Because the modeled DO in Joes Creek was below the standard even with the complete removal of the point source, the sediment oxygen demand also had to be decreased in order to meet the standard. Because it is modeled as a reduction of SOD, the SOD component of the LA was calculated as a negative number. To calculate this component, the SOD value in the model was manipulated until the

modeled stream achieved the DO standard. The difference between the SOD values in the calibrated model and this model run were calculated to give the SOD load reduction in terms of DO use.

In order for the waterbody to achieve a 5.0 mg/L daily average of dissolved oxygen in the stream, the modeled load of oxygen demanding substances was reduced. To accomplish this, the SOD load was reduced from 6.0 mg/L-day to 1.0 mg/L-day. In order to calculate the negative load associated with this reduction, the difference of 5.0 mg/L-day was multiplied by the flow and conversion factor. This resulted in a reduction of -4.9 lbs/day DO use.

$$- 5 \text{ mg/L-day} * (0.18 \text{ cfs} / 1.574 \text{ cfs/MGD}) * (8.34) = -4.9 \text{ lbs/day DO use}$$

Combining both components of the LA, gives a net allocation of 4.5 lbs/day (9.4 lbs/day $CBOD_U$ + -4.9 lbs/day DO use = 4.5 lbs/day). Since oxygen demand or $CBOD_U$ is defined as the amount of DO used by bacteria while oxidizing a substance, and the SOD reduction was calculated in terms of DO use, the two terms can be added directly.

5.3 Incorporation of a Margin of Safety

The margin of safety is a required component of a TMDL and accounts for the uncertainty about the relationship between pollutant loads and the quality of the receiving waterbody. The two types of MOS development are to implicitly incorporate the MOS using conservative model assumptions or to explicitly specify a portion of the total TMDL as the MOS. The MOS selected for this model is implicit. Conservative assumptions that place a higher demand of DO on the waterbody than may actually be present are considered part of the margin of safety. The assumption that all of the ammonia nitrogen present in the waterbody is oxidized to nitrate nitrogen, for example, is a conservative assumption. The maximum effect of this conservative assumption can be illustrated by calculating the $NBOD_U$ load, the theoretical amount of oxygen consumed during the oxidation of ammonia nitrogen. The sum of the wasteload allocation and load allocation for NH_3-N, as shown in Tables 5.1 and 5.2 is 2.8 lbs/day NH_3-N. Since 4.57 pounds of oxygen are used per pound of NH_3-N oxidized to NO_3-N, the $NBOD_U$ load for the TMDL is 2.8 lbs/day * 4.57 = 12.8 lbs/day.

5.4 Calculation of the TMDL

The TMDL was calculated with TMDL = WLA + LA + MOS. Where WLA is the wasteload allocation, LA is the load allocation, and MOS is the margin of safety. All units are in lbs/day. The TMDL calculations are shown in Tables 5.4 and 5.5. The load allocations include the headwaters and spatially distributed loads from surface runoff and groundwater infiltration as well as the SOD reduction. The implicit margin of safety for this TMDL is derived from the conservative assumptions used in setting up the model.

Table 5.4. TMDL for $CBOD_U$ and NH_3-N, for Summer Conditions (May – October)

	WLA (lbs/day)	LA (lbs/day)	MOS	TMDL (lbs/day)
$CBOD_U$	0	4.5	Implicit	4.5
NH_3-N	0	2.8	Implicit	2.8

Table 5.5. TMDL for $CBOD_U$ and NH_3-N, for Winter Conditions (November - April)

	WLA (lbs/day)	LA (lbs/day)	MOS	TMDL (lbs/day)
$CBOD_U$	0	4.5	Implicit	4.5
NH_3-N	0	2.8	Implicit	2.8

CONCLUSION

This Phase 1 TMDL recommends that no additional NPDES permit be issued for Joes Creek. No increase in the current loadings specified in Brookville's existing permit will be allowed. Also, no NPDES permits for new facilities will be issued for the Joes Creek Watershed unless it can be shown that the discharge will not cause impairment in the creek. Further steps are needed to ensure that the overall loads of $CBOD_U$ and NH_3-N placed in this waterbody from point and nonpoint sources do not exceed the waterbody's assimilative capacity.

This Phase 1 TMDL is based on a desktop model using our regulated assumptions and literature values in place of actual field data. The results and the limited data, however, indicate impairment in the stream. The Mississippi Commission on Environmental Quality has entered an order against the Brooksville POTW, which requires the city to meet the limits in the NPDES Permit. The city must comply with the order and consistently meet the limits of the permit. The pretreatment permit for Peco foods must also be reviewed to ensure the industry is not overloading the Brooksville POTW. The obstructions of Joes Creek upstream of the POTW may need to be removed to restore adequate flow to the stream.

6.1 Future Monitoring

The Commission order requires Brooksville to improve the treatment to meet the discharge limits in the NPDES permit. In order to develop a calibrated model for this stream, future monitoring will be needed. Phase 2 of this TMDL will be based on this monitoring and modeling. A calibrated model can then be used to assess the POTW's impact on the stream. This effort will be completed after Brooksville complies with the Commission order.

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. The public will be given an opportunity to review the TMDL and submit comments. At the end of the 30-day period, MDEQ will determine the level of interest in the TMDL and make a decision on the necessity of holding a public meeting.

MDEQ also distributes all TMDLs at the beginning of the public notice to those members of the public who have requested to be included on a TMDL mailing list. TMDL mailing list members may request to receive the TMDL reports through either, email or the postal service. Anyone wishing to become a member of the TMDL mailing list should contact Linda Burrell at (601) 961-5062 or Linda_Burrell@deq.state.ms.us.

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

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DEFINITIONS

5-Day Biochemical Oxygen Demand: Also called BOD_5, the amount of oxygen consumed by microorganisms while stabilizing or degrading carbonaceous or nitrogenous compounds under aerobic conditions over a period of 5 days.

Activated Sludge: A secondary wastewater treatment process that removes organic matter by mixing air and recycled sludge bacteria with sewage to promote decomposition

Aerated Lagoon: A relatively deep body of water contained in an earthen basin of controlled shape which is equipped with a mechanical source of oxygen and is designed for the purpose of treating wastewater.

Ammonia: Inorganic form of nitrogen (NH_3); product of hydrolysis of organic nitrogen and denitrification. Ammonia is preferentially used by phytoplankton over nitrate for uptake of inorganic nitrogen.

Ammonia Nitrogen: The measured ammonia concentration reported in terms of equivalent ammonia concentration; also called total ammonia as nitrogen (NH_3-N)

Ammonia Toxicity: Under specific conditions of temperature and pH, the unionized component of ammonia can be toxic to aquatic life.   The unionized component of ammonia increases with pH and temperature.

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.

Biological Impairment: Condition in which at least one biological assemblages (e.g. , fish, macroinvertabrates, or algae) indicates less than full support with moderate to severe modification of biological community noted.

Carbonaceous Biochemical Oxygen Demand: Also called CBODu, the amount of oxygen consumed by microorganisms while stabilizing or degrading carbonaceous compounds under aerobic conditions over an extended time period.

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

Conventional Lagoon: An un-aerated, relatively shallow body of water contained in an earthen basin of controlled shape and designed for the purpose of treating water.

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.

Dissolved Oxygen: The amount of oxygen dissolved in water. It also refers to a measure of the amount of oxygen that is available for biochemical activity in a water body. The maximum concentration of dissolved oxygen in a waterbody depends on temperature, atmospheric pressure, and dissolved solids.

Dissolved Oxygen Deficit: The saturation dissolved oxygen concentration minus the actual dissolved oxygen concentration.

DO Sag: Longitudinal variation of dissolved oxygen representing the oxygen depletion and recovery following a waste load discharge into a receiving water.

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.

First Order Kinetics: Describes a reaction in which the rate of transformation of a pollutant is proportional to the amount of that pollutant in the environmental system.

Groundwater: Subsurface water in the zone of saturation. Groundwater infiltration describes the rate and amount of movement of water from a saturated formation.

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

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

Mass Balance: An equation that accounts for the flux of mass going into a defined area and the flux of mass leaving a defined area, the flux in must equal the flux out.

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; silvaculture; surface mining; disposal of wastewater; hydrologic modifications; and urban development.

Nitrification: The oxidation of ammonium salts to nitrites via *Nitrosomonas* bacteria and the further oxidation of nitrite to nitrate via *Nitrobacter* bacteria.

Nitrogenous Biochemical Oxygen Demand: Also called NBODu, the amount of oxygen consumed by microorganisms while stabilizing or degrading nitrogenous compounds under aerobic conditions over an extended time period.

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.

Photosynthesis: The biochemical synthesis of carbohydrate based organic compounds from water and carbon dioxide using light energy in the presence of chlorophyll.

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.

Reaeration: The net flux of oxygen occurring from the atmosphere to a body of water across the water surface.

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.

Respiration: The biochemical process by means of which cellular fuels are oxidized with the aid of oxygen to permit the release of energy required to sustain life. During respiration, oxygen is consumed and carbon dioxide is released.

Sediment Oxygen Demand: The solids discharged to a receiving water are partly organics, which upon settling to the bottom decompose aerobically, removing oxygen from the surrounding water column.

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

Streeter-Phelps DO Sag Equation: An equation, which uses a mass balance approach to determine the DO concentration in a waterbody downstream of a point source discharge. The equation assumes that the stream flow is constant and that CBODu exertion is the only source of DO deficit while reaeration is the only sink of DO deficit.

Total Ultimate Biochemical Oxygen Demand: Also called TBODu, the amount of oxygen consumed by microorganisms while stabilizing or degrading carbonaceous or nitrogenous compounds under aerobic conditions over an extended time period.

Total Kjeldahl Nitrogen: Also called TKN, organic nitrogen plus ammonia nitrogen.

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

$CBOD_5$ .... 5-Day Carbonaceous Biochemical Oxygen Demand

$CBOD_U$ .... Carbonaceous Ultimate Biochemical Oxygen Demand

CWA ....Clean Water Act

DMR .... Discharge Monitoring Report

EPA...Environmental Protection Agency

GIS .... Geographic Information System

HUC ....Hydrologic Unit Code

LA .... Load Allocation

MARIS..Mississippi Automated Resource Information System

MDEQ.. Mississippi Department of Environmental Quality

MGD .... Million Gallons per Day

MOS... Margin of Safety

$NBOD_U$ .... Nitrogenous Ultimate Biochemical Oxygen Demand

NH_3 ....Total Ammonia

NH_3-N ....Total Ammonia as Nitrogen

$NO_2 + NO_3$ ....Nitrite Plus Nitrate

NPDES... National Pollution Discharge Elimination System

RBA .... Rapid Biological Assessment

$TBOD_5$ ....5-Day Total Biochemical Oxygen Demand

$TBOD_U$..Total Ultimate Biochemical Oxygen Demand

TKN ....Total Kjeldahl Nitrogen

TN ....Total Nitrogen

TOC...Total Organic Carbon

TP.. Total Phosphorous

USGS .... United States Geological Survey

WLA .... Waste Load Allocation

APPENDIX A

BEFORE THE MISSISSIPPI COMMISSION
ON ENVIRONMENTAL QUALITY

MISSISSIPPI COMMISSION ON
ENVIRONMENTAL QUALITY

COMPLAINANT

VS.   ORDER NO. **3967   99**

THE TOWN OF BROOKSVILLE
NOXUBEE COUNTY

RESPONDENT

AGREED ORDER

COME NOW THE Mississippi Commission on Environmental Quality (Commission), Complainant, and the Town of Brooksville, Respondent, in the above captioned cause and agree as follows:

1.

Respondent was contacted by Complainant beginning August 20, 1996, and notified of violations of its BOD_5 limitations of NPDES Permit No. MS0033596.

A.   Respondent has violated the BOD_5 quantity limitation of no more than 20 pounds per day as a monthly average for the monitoring periods of January-March 1997, April-June 1997, October-December 1997, January-March 1998, April-June 1998, July-September 1998, October-December 1998, January-March 1999, and April-June 1999, with reported values of 298 lbs/day, 42 lbs/day, 151 lbs/day, 52.05 lbs/day, 26.7 lbs/day, 26.86

lbs/day, 53.91 lbs/day, 48.07 lbs/day, and 42.81 lbs/day, respectively.

B.   Respondent has violated the BOD_5 concentration limitation of no more than 10 milligrams per liter as a monthly average for the monitoring periods of April-June 1996, July-September 1996, October-December 1996, January-March 1997, April-June 1997, July-September 1997, October-December 1997, January-March 1998, April-June 1998, July-September 1998, October-December 1998, January-March 1999, and April-June 1999, with the reported values of 14 mg/l, 25 mg/l, 20 mg/l, 32 mg/l, 17 mg/l, 13 mg/l, 45 mg/l, 37 mg/l, 20 mg/l, 23 mg/l, 38 mg/l, 36 mg/l, and 27 mg/l, respectively.

2.

In lieu of a formal enforcement hearing concerning the violations listed above, Complainant and Respondent agree to settle this matter as follows:

A.   On or before July 1, 2000, Respondent shall return to compliance with the BOD_5 loading and concentration limitations set forth in NPDES Permit No. MS0033596.

B.   Respondent agrees to pay a penalty in the amount of $3125, said penalty to be held in abeyance. If Respondent complies with Paragraph 2.A. above, the penalty will not be collected. If Respondent fails to comply, then the penalty will be due immediately upon noncompliance, payable to the Complainant.

3.

In the event Respondent fails to comply with any of the terms of this Agreed Order, the Agreed Order shall become fully enforceable through the appropriate chancery court. The Mississippi Department of Environmental Quality, acting on behalf of the Commission, may proceed in chancery court and may submit an affidavit to the chancery court, along with an appropriate complaint to enforce this Agreed Order of the Commission, and such affidavit shall be <u>prima</u> <u>facie</u> evidence upon which to obtain a final judgement against Respondent in favor of the Mississippi Commission on Environmental Quality.

4.

Nothing in this Agreed Order shall limit the rights of the Mississippi Department of Environmental Quality or the Mississippi Commission on Environmental Quality in the event Respondent fails to comply with this Agreed Order. The Agreed Order shall be strictly construed to apply to those matters expressly resolved herein.

5.

Nothing contained in this Agreed Order shall limit the rights of Complainant to take enforcement or other actions against Respondent for violations not addressed herein and for future violations of environmental laws, rules, and regulations.

6.

Respondent understands and acknowledges that it is entitled to an evidentiary hearing before the Commission pursuant to Section 49-17-31 of the Mississippi Code Annotated (Supp. 1998), and that it has made an informed waiver of that right.

ORDERED, this the 22nd day of ___Dec___,
1999.

MISSISSIPPI COMMISSION ON
ENVIRONMENTAL QUALITY

BY: _____
CHARLES H. CHISOLM
ACTING EXECUTIVE DIRECTOR
MISSISSIPPI DEPARTMENT
OF ENVIRONMENTAL QUALITY

AGREED, this the 6th day of ___December___, 1999.

BY: _____
RESPONDENT