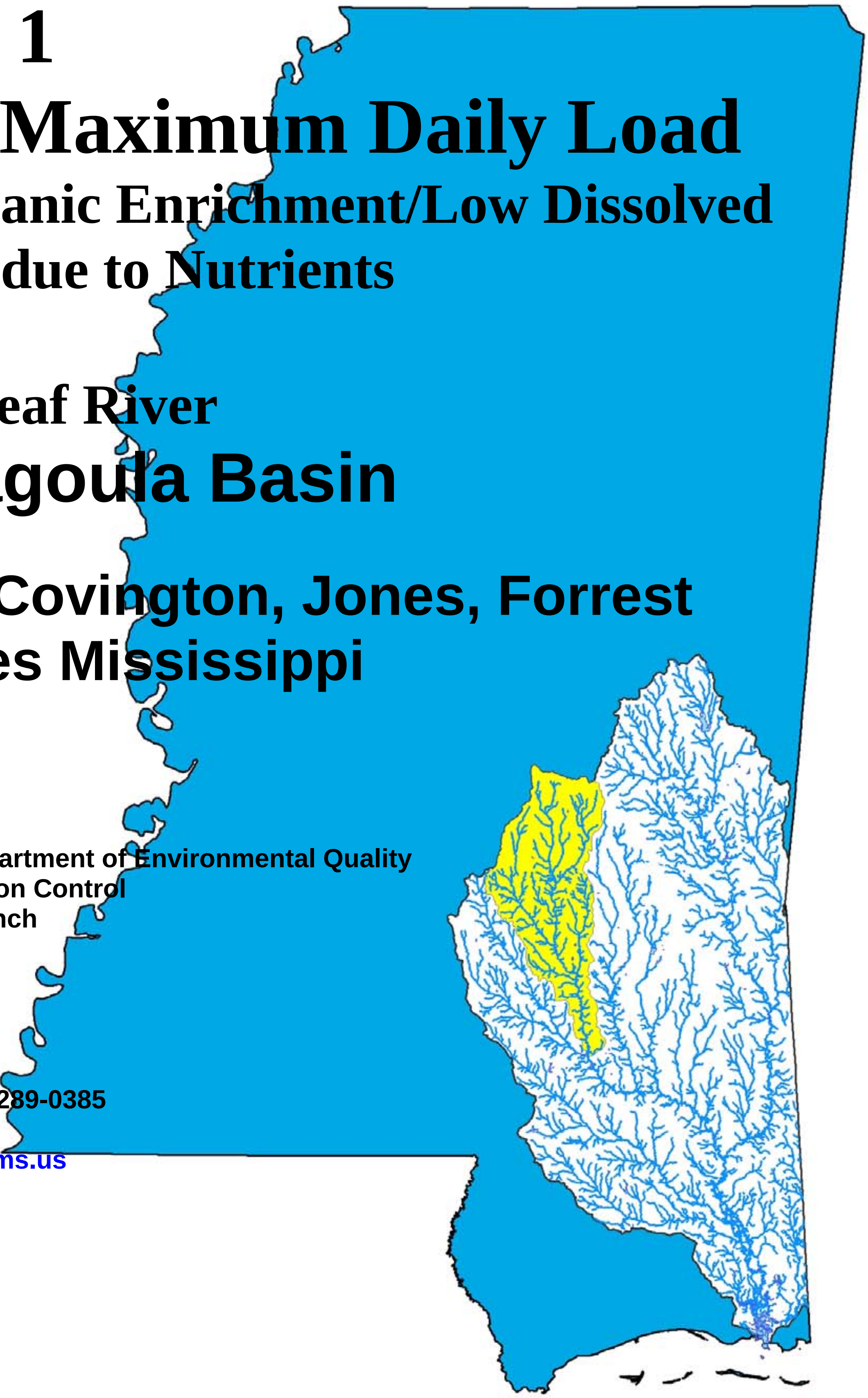
FINAL REPORT
June 2005
ID: 405063004

Phase 1
Total Maximum Daily Load
For Organic Enrichment/Low Dissolved Oxygen due to Nutrients

In the Leaf River
Pascagoula Basin

Smith, Covington, Jones, Forrest Counties Mississippi



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FOREWORD

This report has been prepared in accordance with the schedule contained within the federal consent decree dated December 22, 1998. The report contains one or more Total Maximum Daily Loads (TMDLs) for water body segments found on Mississippi's 1996 §303(d) List of Impaired Water bodies. 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.

Conversion Factors

To convert from	To	Multiply by	To convert from	To	Multiply by
$mile^2$	acre	640.000	acre	ft^2	43560.00
km^2	acre	247.100	days	seconds	86400.00
m^3	ft^3	35.300	meters	feet	3.28
ft^3	gallons	7.480	ft^3	gallons	7.48
ft^3	liters	28.300	hectares	acres	2.47
cfs	gal/min	448.800	miles	meters	1609.30
cfs	MGD	0.646	tonnes	tons	1.10
m^3	gallons	264.200	µg/l * cfs	gm/day	2.45
m^3	liters	1000.000	µg/l * MGD	gm/day	3.79

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	:	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

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i. Listing Information

Name	ID	County	HUC	Cause	Mon/Eval
Leaf River	MS075E	Smith, Covington, Jones	03170004	Nutrients	Evaluated
Near Taylorsville, from HUC boundary 74 to HUC boundary 79					
Leaf River	MS079E	Jones, Covington, and Forrest	03170004	Nutrients	Evaluated
Near Hattiesburg, from confluence with Big Creek to confluence with Bowie River					

ii. Water Quality Standard

Parameter	Beneficial use	Water Quality Criteria
Dissolved Oxygen	Aquatic Life Support	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

iii. NPDES Facilities

NPDES ID	Facility Name	Permitted Discharge (MGD)	Receiving Water
MS0055964	Glendale Utility District	0.375	Leaf River
MS0030601	Happy Acres Packing Co.(Ray's Quality Meat)	0.003	Unnamed Trib of Green's Creek
MS0030201	North Forrest Attendance Center	0.024	Unnamed Trib of Leaf River
MS0031542	Hattiesburg, Laurel Regional Airport	0.020	Unnamed Trib of Leaf River
MS0031259	Moselle Elementary School	0.015	Unnamed Trib of Leaf River
MS0056405	Taylorsville POTW	0.180	Leaf River
MS0046302	Southern Hens Inc.	1.195	Leaf River
MS0028339	MDOT, Interstate 20 East, Rest Area, Scott	0.015	Unnamed Creek thence Jones Creek thence Leaf River

iv. Phase 1 Total Maximum Daily Load for TBODu

WLA (lbs/day)	LA (lbs/day)	MOS (lbs/day)	TMDL (lbs/day)
2,415.9	**2,079.4**	**10,027.5**	**14,522.8**

EXECUTIVE SUMMARY

This TMDL has been developed for two segments of the Leaf River that are on the Mississippi 2002 §303(d) List of Water Bodies as evaluated water body segments. The segments of the Leaf River are listed as evaluated due to nutrients and sediment. Sediment will be addressed in a separate TMDL report. Mississippi currently does not have water quality standards for allowable nutrient concentrations, so a TMDL for specific nutrient species will not be developed. However, because elevated levels of nutrients may cause low levels of dissolved oxygen, this TMDL will be developed for dissolved oxygen. The dissolved oxygen TMDL addresses the potential impact of elevated nutrients in the water bodies. The applicable state standard specifies that the 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. Ammonia nitrogen levels will also be evaluated in this TMDL using criteria established for ammonia nitrogen toxicity. This TMDL has been developed as a phase 1 TMDL so that specific nutrient species may be evaluated when more data are available and nutrient water quality standards are developed.

The Leaf River Watershed is located in southeastern Mississippi in HUC 03170004. The Leaf River, Photo 1, begins south of Forest, MS in Scott County. The river flows for approximately 150 miles in a southern direction, from its headwaters in southeast Scott County to its confluence with the Pascagoula River in George County. It is joined by several major tributaries including the Bowie River near Hattiesburg. The §303(d) listed segment MS075E of the Leaf River begins at HUC boundary 74, which is at the confluence of Keys Mill Creek. Segment MS075E ends at HUC boundary 79, which is at the confluence of Big Creek. Big Creek flows into the Leaf River just north of Highway 588 near Sand Hill, MS. The total length for segment MS075E is approximately 24 miles. The Leaf River MS079E begins at the confluence of Big Creek and continues for approximately 22 miles to the confluence of the Bowie River. The location of the watershed is shown in Figure 1.

Photo 1. Upper Leaf River

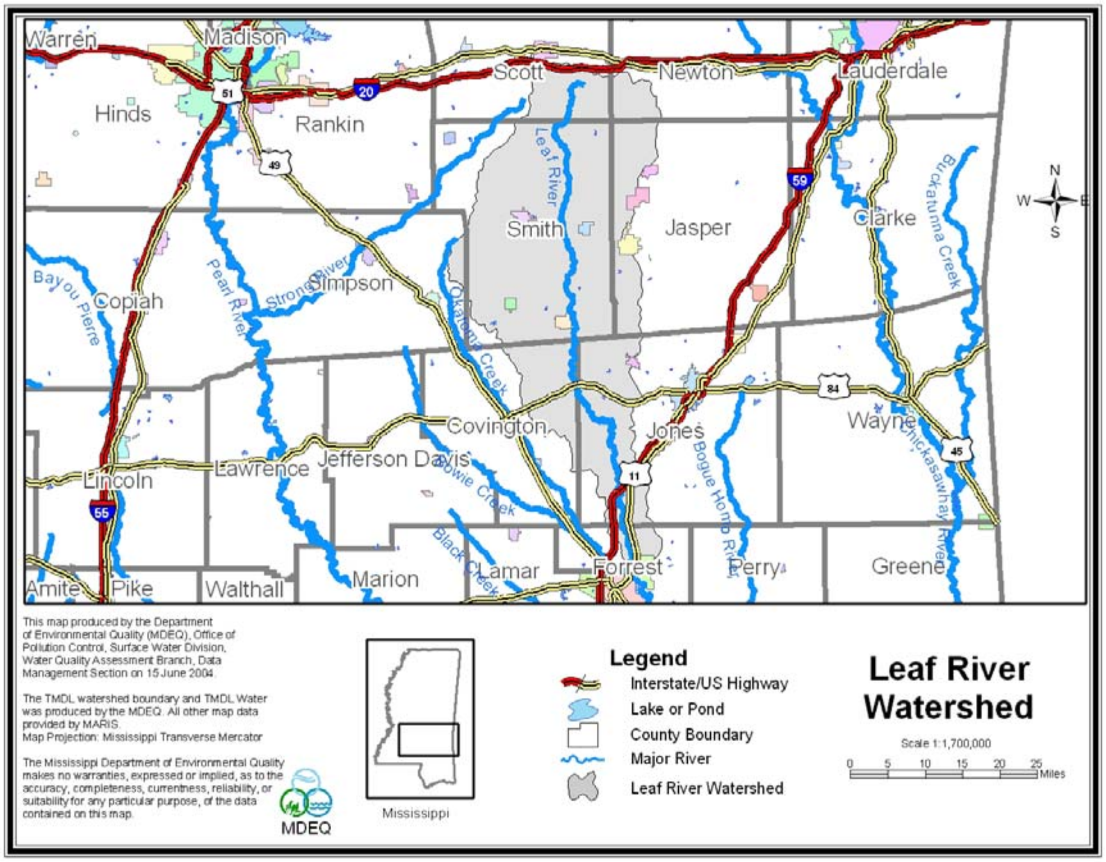


Figure 1. Leaf River Watershed

The predictive model used to calculate this TMDL is based primarily on assumptions described in MDEQ Regulations. A modified Streeter-Phelps dissolved oxygen sag model was selected as the modeling framework for developing the TMDL allocations for this study. A mass-balance approach was used to ensure that the instream concentration of ammonia nitrogen (NH_3-N) did not exceed the water quality criteria. The critical modeling period was determined to occur during the hot, dry summer period.

The TMDL for organic enrichment/low dissolved oxygen was quantified in terms of total ultimate biochemical oxygen demand (TBODu). The model used in developing this TMDL included both non-point and point sources of TBODu in the Leaf River Watershed. TBODu loading from non-point sources and tributaries of the Leaf River was accounted for by using an estimated background concentration of TBODu. There are several NPDES Permitted discharges located in the watershed that are included as point sources in the model. The model results showed that the DO levels in the Leaf River are above water quality standards and levels of NH_3-N are well below toxicity levels at their current loads. Thus, there are no reductions from the current loadings required by this TMDL.

INTRODUCTION

1.1 Background

Segments of the Leaf River were originally placed on the §303(d) List based on anecdotal information. Mississippi conducted a survey of district conservationists (DC) in 1988 and 1989 to find candidate watersheds for future §319 funding opportunities. MDEQ requested each DC identify the watersheds of concern in their county based on available information including land use. Numerous DCs responded to the survey, and MDEQ created Mississippi's §319 list based on these surveys.

In 1992, MDEQ compiled a §303(d) List based, in part, on the §319 List of watersheds of concern. Therefore, water bodies were included on the §303(d) List based on speculation and not water quality monitoring. MDEQ uses the term "evaluated" to describe these water bodies that were placed on the §303(d) List without monitoring data. At the time, MDEQ considered the evaluated listings from the §319 survey as a placeholder for future monitoring to determine if there was impairment in the watershed.

The surveys asked for the presence of agriculture, urban areas, or forestry in the watershed. MDEQ interpreted potential pollutants present on these land uses and listed several broad potential pollutant categories based on the survey results. Every watershed, for which agriculture was checked, was listed for several pollutants, including sediment, pesticides, organic enrichment/low dissolved oxygen, and nutrients. Segments of the Leaf River were listed for nutrients and siltation based on the survey results. TMDLs for the Leaf River must be developed for these pollutants even though there is little data available.

The identification of water bodies not meeting their designated use and the development of total maximum daily loads (TMDLs) for those water bodies are required by §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 water bodies through the establishment of pollutant specific allowable loads. This TMDL has been developed for the evaluated §303(d) listed segments shown in Figure 2.

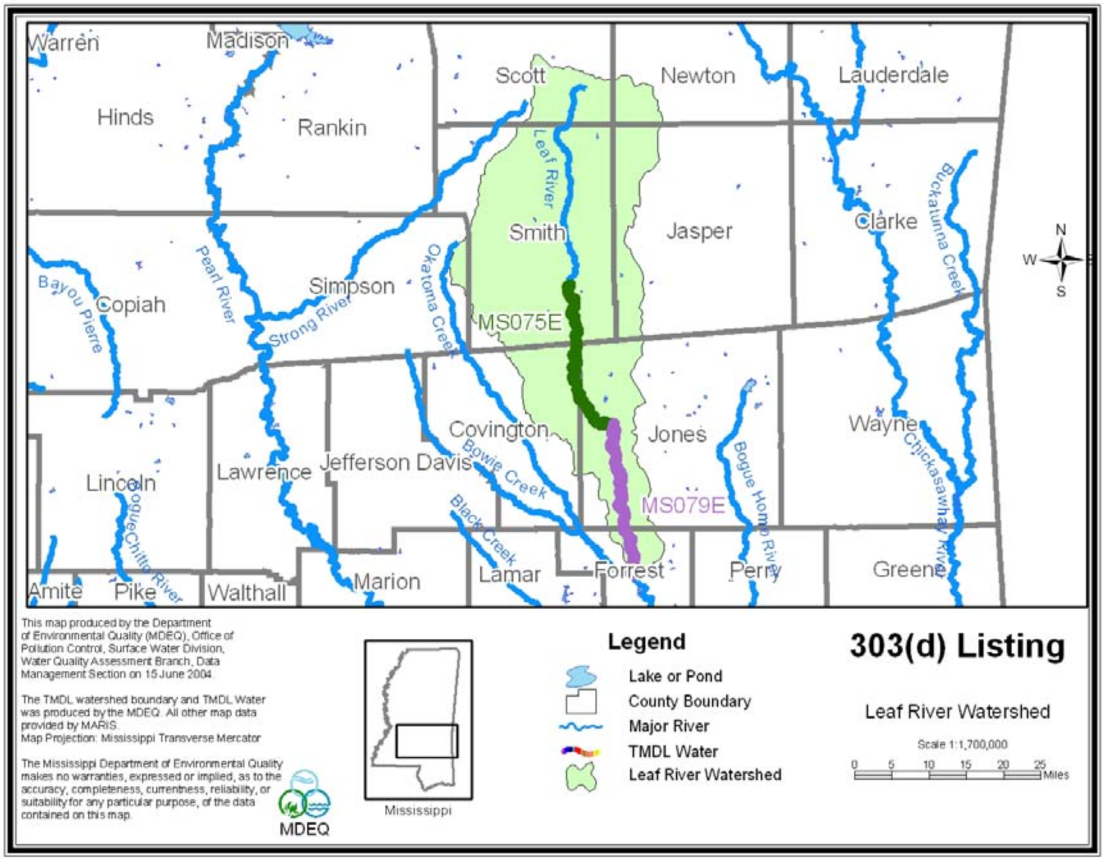


Figure 2. Leaf River 303(d) Listed Segments

1.2 Applicable Water Body Segment Use

The water use classifications are established by the State of Mississippi in the document *Water Quality Criteria for Intrastate, Interstate and Coastal Waters*. The designated beneficial use for the Leaf River is fish and wildlife support.

1.3 Applicable Water Body Segment Standard

The water quality standard applicable to the use of the water body and the pollutant of concern is defined in the *State of Mississippi Water Quality Criteria for Intrastate, Interstate, and Coastal Waters* (MDEQ, 2002). The applicable standard specifies that the dissolved oxygen (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. This water quality standard will be used as a targeted endpoint to evaluate impairments and establish this TMDL.

The water quality standard for ammonia nitrogen toxicity is also included in this TMDL. Ammonia nitrogen concentrations can be evaluated using the criteria given in 1999 Update of Ambient Water Quality Criteria for Ammonia (EPA-822-R-99-014). The maximum allowable instream ammonia nitrogen (NH_3-N) concentration at a pH of 7.0 and stream temperature of 26°C is 2.82 mg/l.

1.4 Selection of a Critical Condition

The critical condition represents the hydrologic and atmospheric conditions in which the pollutants causing impairment of a water body have their greatest potential for adverse effects. Low DO due to elevated nutrient levels typically occurs during seasonal low-flow, high-temperature periods during the late summer and early fall. Elevated oxygen demand and ammonia nitrogen 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 flow at critical conditions is typically defined as the 7Q10 flow, which is the lowest flow for seven consecutive days expected during a 10-year period. The low flow condition for the Leaf River was determined based on data from several USGS gages and information given in *Techniques for Estimating 7-Day, 10-Year Low-Flow Characteristics on Streams in Mississippi* (Telis, 1992).

1.5 Selection of a TMDL Endpoint

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 instream target for ammonia nitrogen is a concentration less than 2.82 mg/l. The instantaneous minimum portion of the DO standard was considered when establishing the instream target for this TMDL. However, it was determined that using the daily average standard with the conservative modeling assumptions would protect the instantaneous minimum standard. The daily average choice is supported by the use of the existing modeling tools in a desktop modeling exercise such as this. More specific modeling and calibration are needed in order to obtain diurnal oxygen levels with any expectation of accuracy. Therefore, based on the limited data available and the relative simplicity of the model, the daily average target is appropriate.

The maximum impact of oxidation of organic material is generally not at the location of the sources, 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. The point of maximum DO deficit, also called the DO sag, will be used to define the endpoint required for this TMDL. The endpoint for this TMDL will be based on a daily average of not less than 5.0 mg/l at the DO sag location during critical conditions.

The TMDL for DO will be quantified in terms of organic enrichment. Organic enrichment is measured in terms of total ultimate biochemical oxygen demand (TBODu). TBODu represents the oxygen consumed by microorganisms while stabilizing or degrading carbonaceous and nitrogenous compounds under aerobic conditions over an extended time period. The carbonaceous compounds are referred to as CBODu, and the nitrogenous compounds are referred to as NBODu. TBODu is equal to the sum of NBODu and CBODu, Equation 1.

$$\textbf{TBODu} = \textbf{CBODu} + \textbf{NBODu} \qquad \textbf{(Equation 1)}$$

WATER BODY ASSESSMENT

This TMDL Report includes an analysis of available water quality data and the identification of all known potential pollutant sources in the Leaf River Watershed. The potential point and non-point pollutant sources were characterized by the best available information, monitoring data, and literature values.

2.1 Discussion of Instream Water Quality Data

There are several sources of data available for the Leaf River Watershed. The most recent available data were collected by MDEQ at the Leaf River near Hebron at Highway 84 (02472000) and the Leaf River near Palmer at Sims Bridge (02473260). The station at Sims Bridge is located below the confluence of Bowie River with Leaf River. The locations of these monitoring stations are shown in Figure 3. Data collected from February 1997 through December 2001 are available at these stations. The data for dissolved oxygen and ammonia nitrogen are given in Tables 1 and 2. Note that the samples were collected once per day and do not reflect the diurnal DO variations that naturally occur in water bodies.

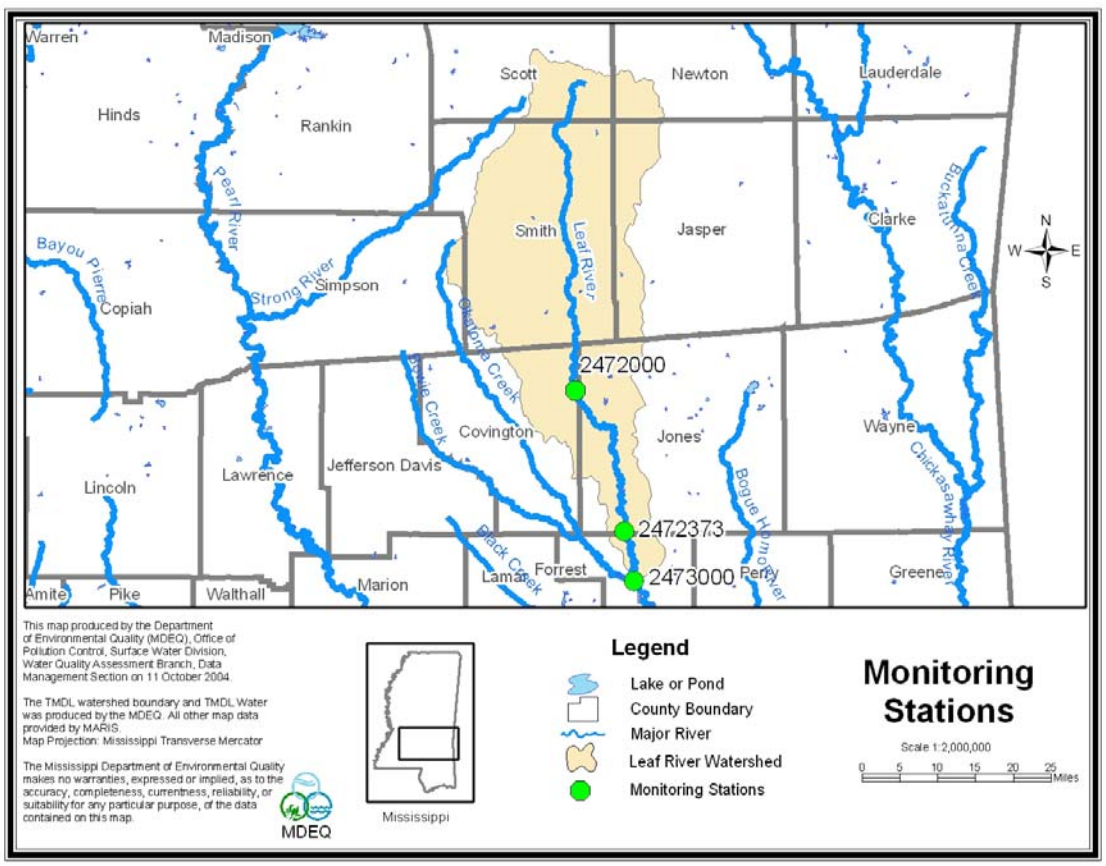


Figure 3. Leaf River Watershed Monitoring Stations

Table 1. Water Quality Data Collected at the Leaf River near Hebron (02472000)

Sample Date	Time	Dissolved Oxygen (mg/l)	Ammonia Nitrogen (mg/l)
9-Dec-96	9:00	9.42	0.10
9-Jan-97	9:36	10.70	0.10
6-Feb-97	10:18	10.30	0.19
6-Mar-97	10:13	9.60	0.21
7-Apr-97	10:15	8.10	0.26
8-May-97	9:25	8.15	0.17
4-Jun-97	8:27	7.40	0.18
2-Jul-97	11:05	7.10	0.16
5-Aug-97	9:14	7.54	0.14
3-Sep-97	11:42	7.21	0.23
1-Oct-97	11:18	7.94	0.10
12-Nov-97	11:30	8.59	0.23
3-Dec-97	10:33	10.33	0.20
5-Jan-98	11:58	9.93	0.46
2-Feb-98	11:10	11.35	0.41
2-Mar-98	11:23	8.76	0.40
7-Apr-98	12:18	8.72	0.19
1-Jun-98	11:00	7.60	0.15
7-Jul-98	11:20	6.98	0.10
12-Aug-98	10:07	7.55	0.10
14-Sep-98	9:58	7.62	0.10
28-Oct-98	10:20	10.37	0.16
9-Nov-98	11:06	10.33	0.10
3-Dec-98	10:14	9.12	0.10
25-Jan-99	10:21	9.63	0.30
17-Feb-99	10:49	9.96	0.13
9-Mar-99	10:39	8.68	0.33
29-Mar-99	11:18	9.38	0.18
5-May-99	10:35	8.87	0.10
3-Jun-99	10:20	8.00	0.17
22-Jul-99	11:01	8.76	0.42
30-Aug-99	11:37	8.52	0.64
16-Sep-99	12:10	8.58	0.38
11-Oct-99	11:25	7.52	0.76
13-Dec-99	11:30	9.87	0.15
10-Jan-00	10:45	10.01	0.24
17-Feb-00	10:33	9.86	0.12
4-Apr-00	11:30	7.49	0.21
2-May-00	11:15	8.94	0.10
15-Jun-00	10:52	8.34	0.13
12-Jul-00	10:35	8.41	0.16
26-Sep-00	10:11	8.19	0.16
12-Oct-00	10:15	10.10	0.18
8-Nov-00	10:00	10.76	0.24
16-Nov-00	12:29	--	0.14
5-Dec-00	9:50	11.53	0.23
9-Apr-01	11:47	7.53	0.21
7-May-01	11:46	8.84	0.14
4-Jun-01	12:05	7.45	0.13
9-Jul-01	12:24	7.14	0.10
25-Sep-01	11:49	8.69	0.10
11-Oct-01	12:10	9.05	0.10
8-Nov-01	11:31	10.69	0.10
6-Dec-01	11:24	10.06	0.10

Table 2. Water Quality Data Collected at the Leaf River near Palmer (02473260)

Sample Date	Time	Dissolved Oxygen (mg/l)	Ammonia Nitrogen (mg/l)
25-Jan-99	8:55	9.34	0.44
24-Feb-99	8:25	11.43	0.31
15-Mar-99	8:50	9.87	0.31
1-Apr-99	8:55	9.18	0.20
11-May-99	9:00	7.08	0.16
8-Jun-99	10:23	7.45	0.14
22-Jul-99	9:15	5.60	0.49
4-Aug-99	1:35	6.12	0.26
16-Sep-99	1:40	6.41	0.46
28-Oct-99	11:00	8.60	0.29
23-Nov-99	12:20	9.39	0.29
13-Dec-99	12:58	9.71	0.22
19-Jan-00	8:24	8.78	0.30
19-Jan-00	8:23	8.78	0.26
23-Feb-00	8:45	8.88	0.33
11-Apr-00	10:40	8.42	0.21
8-May-00	9:00	7.00	0.29
26-May-00	8:33	6.20	0.27
16-Jun-00	11:15	6.13	0.36
17-Jul-00	10:35	5.27	0.37
12-Oct-00	8:53	7.20	0.32
12-Dec-00	8:52	9.77	0.36
11-Apr-01	9:15	13.58	0.21
9-May-01	9:30	7.53	0.10
12-Jun-01	10:20	7.27	0.22
12-Jul-01	9:45	5.90	0.12
20-Sep-01	9:54	6.98	0.10
4-Oct-01	10:43	8.24	0.10
8-Nov-01	13:03	10.37	0.10
6-Dec-01	13:22	9.69	0.10

Additional monitoring data are available for MDEQ stations located on the Leaf River at Eastabutchie (02472373). Data are available for the Leaf River near Eastaubtchie from January 1975 through December 1997. The recently collected data from this station are given in Table 3.

Table 3. Water Quality Data Collected at the Leaf River at Eastabutchie (02472373)

Sample Date	Time	Dissolved Oxygen (mg/l)	Ammonia Nitrogen (mg/l)
24-Jun-97	8:20	7.32	0.16
16-Dec-97	12:12	12.85	0.16

2.2 Assessment of Point Sources

An important step in assessing pollutant sources in the Leaf River watershed is locating the NPDES permitted sources. There are 8 facilities permitted to discharge organic material into the Leaf River or its tributaries, Table 4. These facilities serve a variety of activities in the watershed, including municipalities, industries, and other businesses. The location of the facilities is shown in Figure 4.

Table 4. NPDES Permitted Facilities Treatment Types

Number	Name	NPDES Permit	Treatment Type
1	Glendale Utility District	MS0055964	aerated lagoon
2	Happy Acres Packing Co.(Ray's Quality Meat)	MS0030601	conventional lagoon
3	North Forrest Attendance Center	MS0030201	aerated lagoon
4	Hattiesburg, Laurel Regional Airport	MS0031542	activated sludge
5	Moselle Elementary School	MS0031259	conventional lagoon
6	Taylorsville POTW	MS0056405	conventional lagoon
7	Southern Hens Inc.	MS0046302	aerated lagoon
8	MDOT, Interstate 20 East, Rest Area, Scott	MS0028339	activated sludge plant

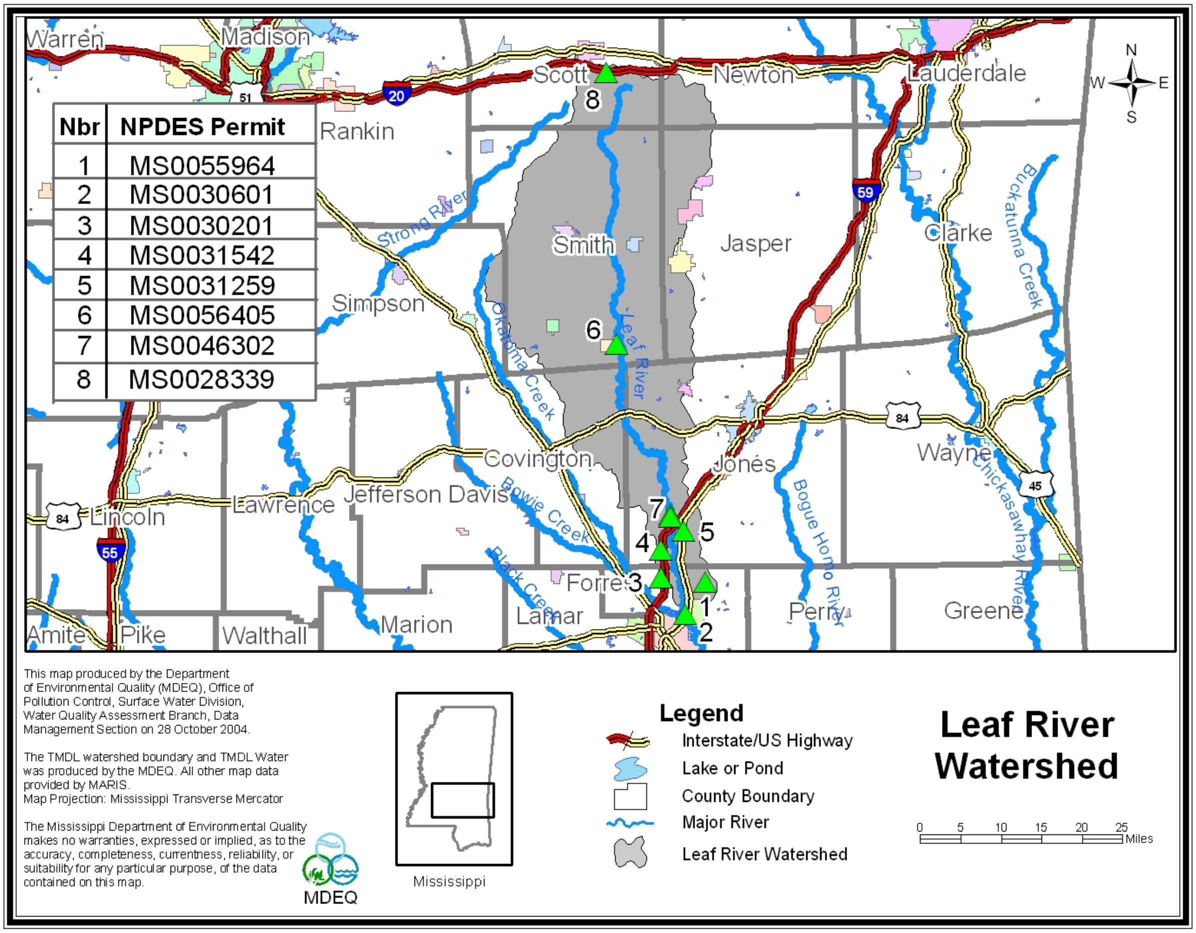


Figure 4. Point Source Location Map for the Leaf River Watershed

The current condition of the effluent from each facility was characterized based on all available data including information on each facility's wastewater treatment system, permit limits, and discharge monitoring reports. The permit limits as well as the average flows and BOD_5 concentrations, as reported in available discharge monitoring reports (DMRs) for the past several years, are given in Table 5. Ammonia nitrogen permit limits and monitoring are required for some of the facilities.

Table 5. Identified NPDES Permitted Facilities

Name	NPDES Permit	Permitted Discharge (MGD)	Actual Average Discharge (MGD)	Permitted Average BOD_5 (mg/l)	Actual Average BOD_5 (mg/l)	Permitted NH_3-N (mg/l)	Actual Average NH_3-N (mg/l)
Glendale Utility District	MS0055964	0.375	0.140	30	25.0	Report	0.46
Happy Acres Packing Co.(Ray's Quality Meat)	MS0030601	0.003	No discharge	45	No discharge	2.04 (lbs/day)	No discharge
North Forrest Attendance Center	MS0030201	0.024	*0.016	30	*4.0	--	--
Hattiesburg, Laurel Regional Airport	MS0031542	0.002	0.012	10	11.3	--	4.27
Moselle Elementary School	MS0031259	0.015	No discharge	30	No discharge	--	--
Taylorsville POTW	MS0056405	0.180	0.168	40	28.3	15.00	1.39
Southern Hens Inc.	MS0046302	1.195	0.742	45	2.6	--	2.62
MDOT, Interstate 20 East, Rest Area, Scott	MS0028339	0.015	0.008	30	63.1	--	--

*Only one measurement reported

2.3 Assessment of Non-Point Sources

Non-point loading of nutrients and organic material in a water body results from the transport of the pollutants into receiving waters by overland surface runoff and groundwater infiltration. Non-point pollution sources of concern are storm drainage from urban areas including the City of Hattiesburg and runoff from agricultural areas. The Leaf River near Hattiesburg is shown in Photo 2. Overland surface runoff and groundwater infiltration results in the transport of TBODu into receiving waters. Landuse activities within the drainage basin, such as agriculture, and urbanization can contribute to non-point source loading.

Photo 2. Leaf River near Hattiesburg

The drainage area of the Leaf River is approximately 692,696 acres. The watershed contains many different landuse types, including urban, forest, cropland, pasture, scrub/barren, water, and wetlands. The landuse information given below is based on data collected by 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. Forest is the dominant landuse within the watershed. The landuse distribution is shown in Table 6 and Figure 5.

Table 6. Landuse Distribution, Leaf River Watershed

	Urban	Forest	Cropland	Pasture	Scrub/Barren	Water	Wetlands
Area (acres)	2,223	345,301	20,378	154,994	105,538	4,778	59,484
Percentage	0.3	49.9	2.9	22.4	15.2	0.7	8.6

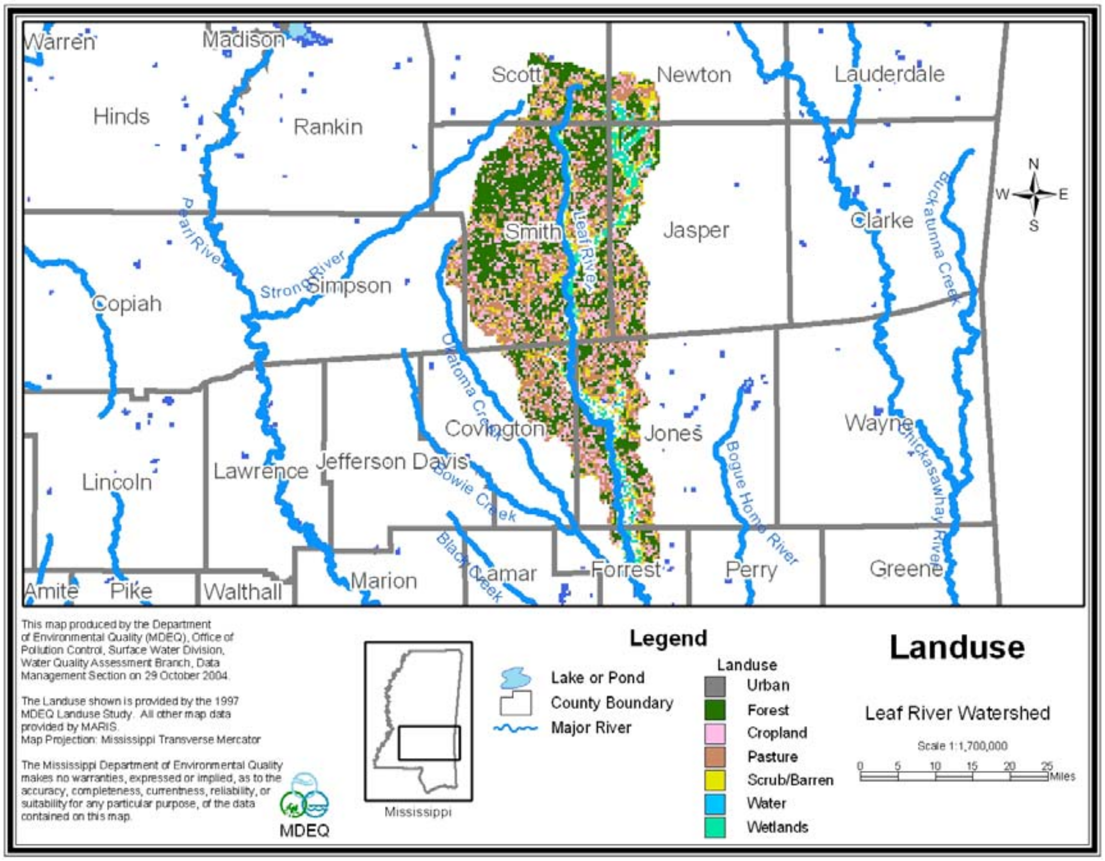


Figure 5. Landuse Distribution for the Leaf River Watershed

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 water body responses to flow and loading conditions. In this section, the selection of the modeling tools, setup, and model application are discussed.

3.1 Modeling Framework Selection

A mathematical model, STeady Riverine Environmental Assessment Model (STREAM), for DO distribution in freshwater streams was used for developing the TMDL. STREAM is an updated version of the AWFWUL1 model, which had been used by MDEQ for many years. 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 STREAM model in TMDL development is its ability to assess instream water quality conditions in response to point and non-point source loadings.

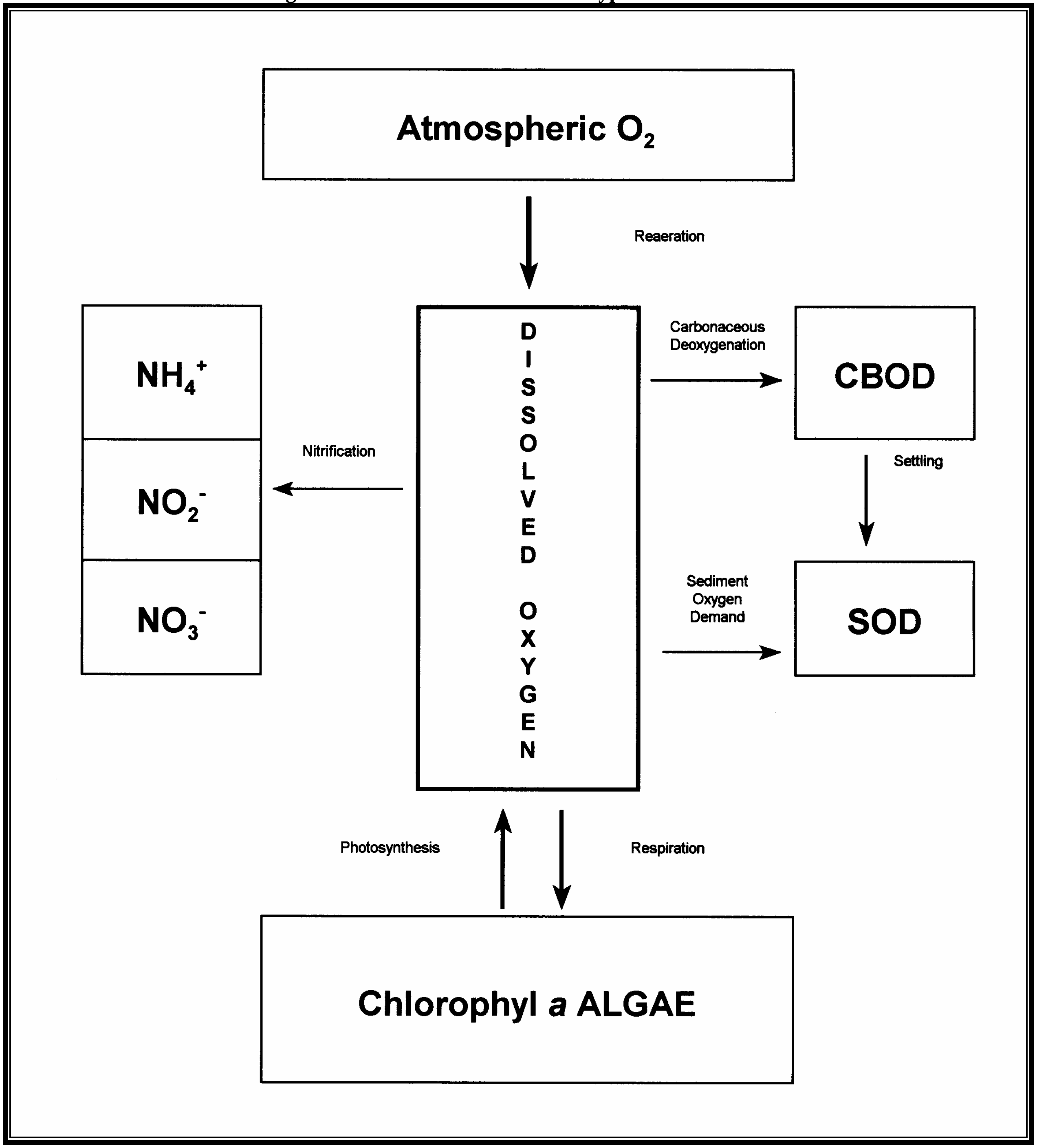
STREAM is a steady-state, daily average computer model that utilizes a modified Streeter-Phelps DO sag equation. Instream processes simulated by the model include CBODu decay, nitrification, reaeration, sediment oxygen demand, and respiration and photosynthesis of algae. Figure 6 shows how these processes 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 water quality conditions in each computational element for DO, CBODu, 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 was set up to calculate reaeration within each reach using the Tsivoglou formulation. The Tsivoglou formulation calculates the reaeration rate, K_a (day^{-1} base *e*), within each reach according to Equation 2.

$$\mathbf{K_a = C*S*U} \qquad \textbf{(Equation 2)}$$

C is the escape coefficient, U is the reach velocity in mile/day, and S is the average reach slope in ft/mile. The value of the escape coefficient is assumed to be 0.11 for stream reaches with flows less than 10 cfs and 0.0597 for stream reaches with flows greater than 10 cfs. Reach velocities were calculated using an equation based on slope. Slopes for the Leaf River typically range from 1 to 6 ft/mile.

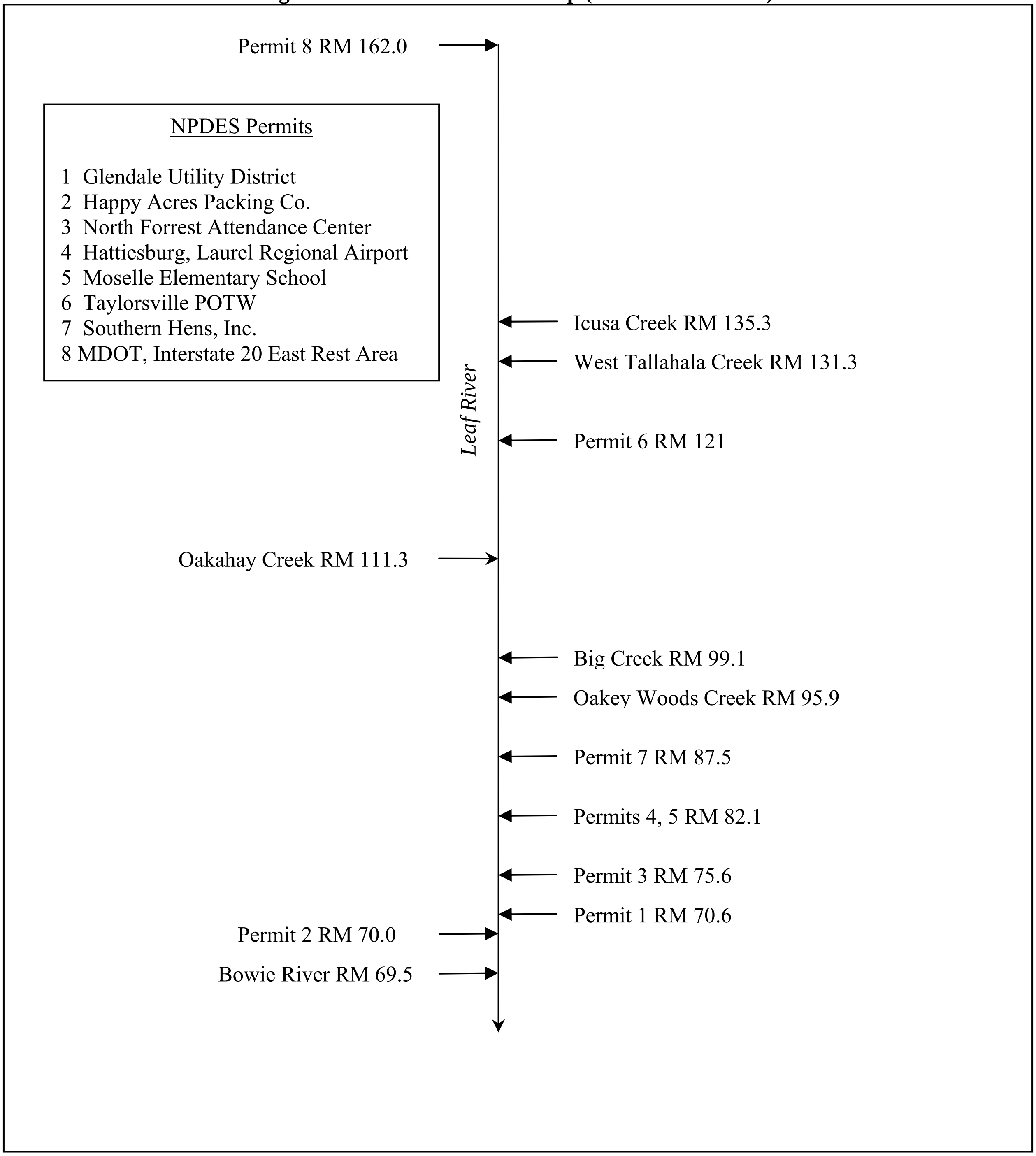
Figure 6. Instream Processes in a Typical DO Model



3.2 Model Setup

The model for the Leaf River was developed beginning with its headwaters near Forrest, MS to its confluence with the Bowie River. This model includes several major tributaries; Icusa Creek, West Tallahala Creek, Oakahay Creek, Big Creek, and Oakey Woods Creek. All of these tributaries were included as point load contributions and were not modeled separately. A diagram showing the model setup for the Leaf River is shown in Figure 7. The locations of the confluence of point sources and significant tributaries are shown. The point sources are labeled with numbers assigned in Table 4 and repeated on the figure below. Arrows represent the direction of flow in each segment. The numbers on the figure represent approximate river miles (RM). River miles are assigned to water bodies with the highest number at the upstream point and decreasing to zero at the mouth.

Figure 7. Leaf River Model Setup (Note: Not to Scale)



The modeled water bodies are divided into reaches for modeling purposes. Reach divisions are made at locations where there is a significant change in hydrological and water quality characteristics, such as the confluence of a point source or tributary. Within each reach, the modeled segments are divided into computational elements of 0.1 mile. The simulated hydrological and water quality characteristics are calculated and output by the model for each computational element.

The STREAM model was setup to simulate flow and temperature conditions, which were determined to be the critical condition for this TMDL. The temperature used in the model varies with flow. In accordance with MDEQ regulations, the temperature is set to 26°C for flows less than 50 cfs and 28°C for flows between 50 and 300 cfs. The headwater instream DO was assumed to be 85% of saturation at the stream temperature. The instream CBODu decay rate is dependent on temperature, according to Equation 3.

$$K_{d(T)} = K_{d(20°C)}(1.047)^{T-20} \quad \textbf{(Equation 3)}$$

Where K_d is the CBODu decay rate and T is the assumed instream temperature. The assumptions regarding the instream temperatures, background DO saturation, and CBODu decay rate are required by the *Empirical Stream Model Assumptions for Conventional Pollutants and Conventional Water Quality Models* (MDEQ, 1994). Also based on MDEQ Regulations, the rates for photosynthesis, respiration, and sediment oxygen demand were set to zero because data for these model parameters were not available.

The flow in the Leaf River system was modeled at 7Q10 conditions based on data available from the USGS (Telis, 1992). There are several partial record flow gauging stations located in the Leaf River Watershed. The Leaf River at Hattiesburg is a real-time flow gauging station. The stations and their 7Q10 flows are given in Table 7. The model was set up so that the modeled flow equaled the 7Q10 flow at monitoring locations in the system.

Table 7. 7Q10 Flow Data for the Leaf River Watershed

Station	Location	Drainage Area (square miles)	7Q10 Flow (cfs)
02471150	Ichusa Creek near Sylvarena	46.3	0.05
02471200	West Tallahala Creek near Sylvarena	149.0	0.10
02471900	Oakahay Creek at Hot Coffee	244.0	41.00
02472100	Big Creek near Laurel	102.0	15.00
02472200	Oakey Woods Creek near Collins	14.4	0.80
02472000	Leaf River near Collins	743.0	72.00
02573000	Leaf River at Hattiesburg (below the confluence of Bowie River)	1,748.0	347.00

3.3 Source Representation

Both point and non-point sources were represented in the model. The loads from NPDES permitted sources and tributaries were added as direct inputs into the appropriate reach of the modeled water bodies as a flow in cfs and concentration of $CBOD_5$ and ammonia nitrogen in mg/L. Spatially distributed loads, which represent non-point sources of flow, $CBOD_5$, and ammonia nitrogen were distributed evenly into each computational element of the modeled water bodies.

Organic material discharged to a stream from an NPDES permitted point source is 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 TMDLs are typically developed using CBODu, a ratio between the two terms is needed, Equation 4.

$$\mathbf{CBODu = CBOD_5 * Ratio} \qquad \textbf{(Equation 4)}$$

The CBODu to $CBOD_5$ ratios are given in *Empirical Stream Model Assumptions for Conventional Pollutants and Conventional Water Quality Models* (MDEQ, 1994). These values are recommended for use by MDEQ regulations when actual field data are not available. The value of the ratio depends on the treatment type of wastewater. For secondary treatment systems (conventional and aerated lagoons), this ratio is 1.5. A CBODu to $CBOD_5$ ratio of 1.5 is appropriate for all of the facilities in the Leaf River Watershed, with the exception of Hattiesburg, Laurel Regional Airport (MS0031542), MDOT, Interstate 20 East Rest Area, Scott (MS0028339), and Southern Hens, Inc. (MS0046302). MDEQ regulations specify that a ratio of 2.3 should be used for activated sludge facilities and a ratio of 2.5 for poultry processing plants.

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 ammonia nitrogen (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. The oxygen demand caused by nitrification of ammonia is equal to the NBODu load. The sum of CBODu and NBODu is equal to the point source load of TBODu. The maximum permitted loads of TBODu from each of the existing point sources are given in Table 8. Note that most of the permitted $CBOD_5$ concentrations are greater than the concentrations, as reported in the DMR data, Table 9. Because most the facilities are not required to report values for ammonia nitrogen an assumed value of 2.0 mg/L was used to calculate the NBODu load for these facilities. Comparison of Tables 8 and 9 shows that the currently discharged TBODu load is approximately one-sixth that of the maximum permitted load.

Table 8. Point Sources, Maximum Permitted Loads

Facility	Flow (MGD)	$CBOD_5$ (mg/l)	NH_3-N (mg/L)	$CBOD_u$:$CBOD_5$ Ratio	CBODu (lbs/day)	NH_3-N (lbs/day)	NBODu (lbs/day)	TBODu (lbs/day)
Glendale Utility District	0.375	30	0.46	1.5	140.7	1.4	6.6	147.3
Happy Acres Packing Co.(Ray's Quality Meat)	0.003	45	--	1.5	1.7	2.0	9.3	11
North Forrest Attendance Center	0.024	30	2.00	1.5	9.0	0.4	1.8	10.8
Hattiesburg, Laurel Regional Airport	0.020	10	2.00	2.3	3.8	0.3	1.5	5.3
Moselle Elementary School	0.015	30	2.00	1.5	5.6	0.3	1.1	6.7
Taylorsville POTW	0.180	40	15.00	1.5	90.1	22.5	102.9	193
Southern Hens Inc.	1.195	45	20.00	2.5	1121.2	199.3	910.9	2032.1
MDOT, Interstate 20 East, Rest Area, Scott	0.015	30	2.00	2.3	8.6	0.3	1.1	9.7
	1.827				**1380.7**	**226.5**	**1035.2**	**2415.9**

Table 9. Point Sources, Loads Based on Averages of DMR Data

Facility	Flow (MGD)	$CBOD_5$ (mg/l)	NH_3-N (mg/L)	$CBOD_u$:$CBOD_5$ Ratio	CBODu (lbs/day)	NH_3-N (lbs/day)	NBODu (lbs/day)	TBODu (lbs/day)
Glendale Utility District	0.140	25.0	0.46	1.5	43.8	0.5	2.5	46.2
Happy Acres Packing Co.(Ray's Quality Meat)	0.000	0.0	0.00	1.5	0.0	0.0	0.0	0.0
North Forrest Attendance Center	0.016	4.0	2.00	1.5	0.8	0.3	1.2	2.0
Hattiesburg, Laurel Regional Airport	0.012	11.3	4.27	2.3	2.6	0.4	2.0	4.6
Moselle Elementary School	0.000	0.0	0.00	1.5	0.0	0.0	0.0	0.0
Taylorsville POTW	0.168	28.3	1.39	1.5	59.5	1.9	8.9	68.4
Southern Hens Inc.	0.742	2.6	2.62	1.5	24.1	16.2	74.1	98.2
MDOT, Interstate 20 East, Rest Area, Scott	0.008	63.1	2.00	2.3	9.7	0.1	0.6	10.3
	1.086				**140.5**	**19.4**	**89.3**	**229.7**

Direct measurements of background concentrations of CBODu and NH_3-N were not available for the Leaf River. Because there were no data available, the background concentration of CBODu was estimated based on *Empirical Stream Model Assumptions for Conventional Pollutants and Conventional Water Quality Models* (MDEQ, 1994). According to these regulations, the background concentration used in modeling is CBODu = 2.0 mg/L. The concentration of ammonia nitrogen (NH_3-N) was estimated from available monitoring data on the Leaf River. The average NH_3-N concentration at monitoring site 02472000 was determined to be 0.2 mg/l. This concentration was assumed for the Leaf River. The background concentrations were used to establish the headwater conditions for the Leaf River. They were also used as estimates of the CBODu and NH_3-N concentrations in water entering the water body through non-point sources and tributaries.

The non-point and tributary flows were estimated based on USGS data for the 7Q10 flow condition for the Leaf River at Hattiesburg (02473000) of 347.0 cfs. This flow monitoring station is located just below the confluence of the Bowie River. To estimate the amount of flow in the Leaf River just upstream from the confluence with the Bowie River, the flow at the mouth of the Bowie River was subtracted from the flow at station 02473000. The 7Q10 flow at mouth of the Bowie is approximately 198.8 cfs. Thus, the flow in the Leaf River just upstream from the confluence of the Bowie River is 148.2 cfs (347.0 cfs = 198.8 cfs = 148.2 cfs). The flow of 148.2 is contributed to the Leaf River from both non-point sources and tributaries. The total flow from tributaries is 57.0 cfs (see Table 11). Thus, the non-point source flow is 91.2 cfs (148.2 cfs – 57.0 cfs = 91.2 cfs).

Non-point source flows entering the Leaf River were included in the model to account for water entering due to groundwater infiltration, overland flow, and small, unmeasured tributaries. The non-point source flows were assumed to be distributed evenly throughout the modeled reaches. A ratio was calculated by dividing the total 7Q10 flow due to non-point sources by the length of the modeled section of the Leaf River. This ratio is equal to 0.986 cfs/river mile (91.2 cfs/92.5 river miles = 0.986 cfs/river mile). Then, the ratio was used to determine the amount of non-point source flow entering each reach. The flows were multiplied by the background concentrations of CBODu and NH_3-N to calculate the non-point source loads going into the Leaf River, Table 10.

Table 10. Non-Point Source Loads Input into the Model

Reach	Flow (cfs)	CBODu (mg/L)	CBODu (lbs/day)	NH_3-N (mg/l)	NBODu (lbs/day)	TBODu (lbs/day)
RM 162 – RM 153.5	8.4	2.0	90.3	0.2	41.3	131.6
RM 153.5 – RM 141.8	11.5	2.0	124.4	0.2	56.8	181.2
RM 141.8 – RM 136.1	5.6	2.0	60.6	0.2	27.7	88.3
RM 136.1 – RM 135.3	0.8	2.0	8.5	0.2	3.9	12.4
RM 135.3 – RM 132.3	3.0	2.0	31.9	0.2	14.6	46.5
RM 132.3 – RM 131.3	1.0	2.0	10.6	0.2	4.9	15.5
RM 131.3 – RM 128.5	2.8	2.0	29.8	0.2	13.6	43.4
RM 128.5 – RM 121.0	7.4	2.0	79.7	0.2	36.4	116.1
RM 121.0 – RM 116.3	4.6	2.0	50.0	0.2	22.8	72.8
RM 116.3 – RM 111.3	4.9	2.0	53.1	0.2	24.3	77.4
RM 111.3 – RM 107.0	4.2	2.0	45.7	0.2	20.9	66.6
RM 107.0 – RM 99.1	7.8	2.0	84.0	0.2	38.4	122.3
RM 99.1 – RM 95.9	3.2	2.0	34.0	0.2	15.5	49.6
RM 95.9 – RM 87.5	8.3	2.0	89.3	0.2	40.8	130.1
RM 87.5 – RM 82.1	5.3	2.0	57.4	0.2	26.2	83.6
RM 82.1 – RM 78.6	3.5	2.0	37.2	0.2	17.0	54.2
RM 78.6 – RM 75.6	3.0	2.0	31.9	0.2	14.6	46.5
RM 75.6 – RM 70.6	4.9	2.0	53.1	0.2	24.3	77.4
RM 70.6 – RM 70.0	0.6	2.0	6.4	0.2	2.9	9.3
RM 70.0 – RM 69.5	0.5	2.0	5.3	0.2	2.4	7.7
	91.2		**983.2**		**449.3**	**1,432.5**

Tributary flows were included in the model for several major tributaries. These tributaries were not modeled individually. But, their flows and loads of CBODu and NH_3-N were added as point sources into the Leaf River. The tributary flows and loads are shown in Table 11. The background assumptions of 2.0 mg/l CBODu and 0.2 mg/l NH_3-N were used for all tributaries with the exception of Oakahay Creek. A separate TMDL has been developed for biological impairment due to organic enrichment/low DO and nutrients in Oakahay Creek (MDEQ, 2004). As described in the TMDL report for Oakahay Creek, a model of Oakahay Creek was developed for two separate flow conditions, the 7Q10 flow and a higher flow condition. Model output from the 7Q10 flow condition at river mile 0.0 of Oakahay Creek was used to estimate the flow and loads contributed to the Leaf River from Oakahay Creek.

Table 11. Tributary Loads Input into the Model

Water Body	Flow (cfs)	$CBOD_u$ (mg/L)	CBODu (lbs/day)	NH_3-N (mg/l)	NBODu (lbs/day)	TBODu (lbs/day)
Icusa Creek	0.05	2.0	0.5	0.20	0.2	0.8
West Tallahala Creek	0.10	2.0	1.1	0.20	0.5	1.6
Big Creek near Laurel	15.00	2.0	161.7	0.20	73.9	235.6
Oakey Woods Creek	0.80	2.0	8.6	0.20	3.9	12.6
Oahahay Creek	41.00	1.2	265.2	0.13	131.3	396.5
	57.00		**437.1**		**209.9**	**647.0**

3.4 Model Results

Once the model setup was complete, the model was used to predict water quality conditions in the Leaf River. The model was first run under baseline conditions. Under baseline conditions, the loads from NPDES permitted point sources were set at their existing loads as determined from the discharge monitoring reports, Table 9. Thus, baseline model runs reflect the current condition of the water body. The baseline condition model was run again with the permits set at the maximum loads allowed in the NPDES permits. Model runs with permits at existing loads and maximum permitted loads showed that the water quality standard for dissolved oxygen was not violated at any point in the Leaf River. Finally, the maximum allowable load was determined by increasing the non-point source loads. The model was run using a trial-and-error process to determine the maximum TBODu loads that would not violate water quality standards for DO. These model results are called the maximum load scenario.

3.4.1 Baseline Model Results

The baseline model results are shown in Figures 8 and 9. Figure 8 shows the modeled daily average DO with the NPDES permits at their current loads based on DMR data. The figure shows the daily average instream DO concentrations, beginning with river mile 162 and ending with river mile 69.5 in the Leaf River. As shown, the model predicts that the DO stays well above the standard of 5.0 mg/l. Also, the model output does not show a DO sag in Leaf River due to the point source dischargers. Baseline model output for ammonia nitrogen is shown in Figure 9.

The baseline model output for DO and ammonia nitrogen concentrations in the Leaf River was compared with available data from monitoring station 02472000, the Leaf River near Hebron at Highway 84 (located at approximately river mile 109.2). Comparison of the available data shows that the predicted daily average DO and NH_3-N levels are in the same range as recently collected monitoring data. The points on Figures 8 and 9 represent the average measured value, while the bars represent the minimum and maximum values measured.

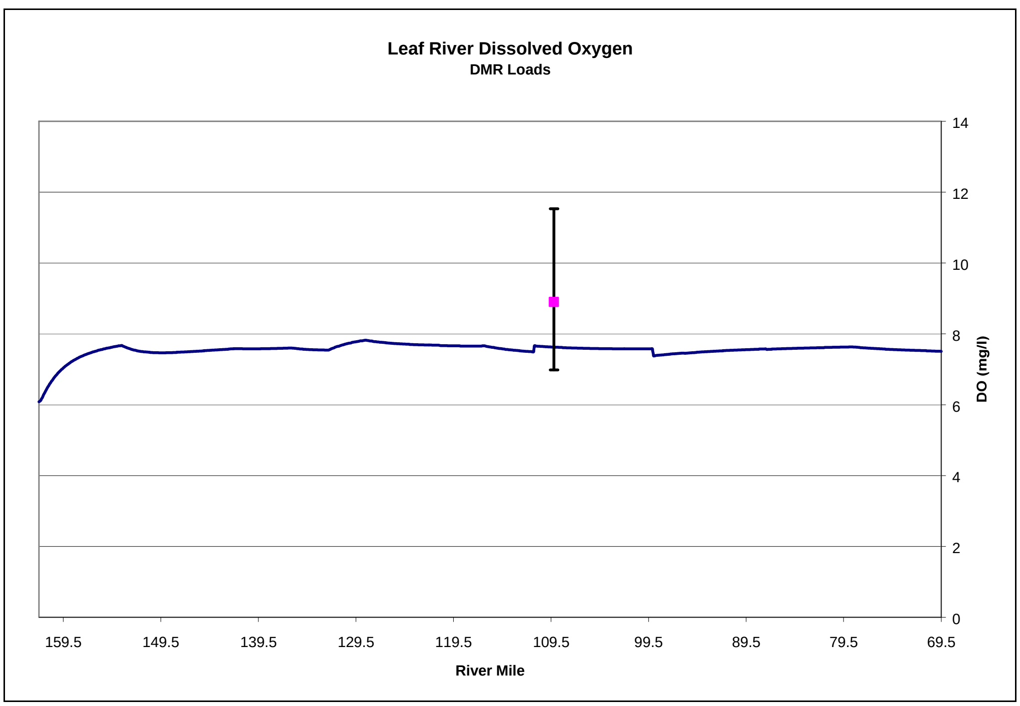


Figure 8. Baseline Model Output for DO in Leaf River

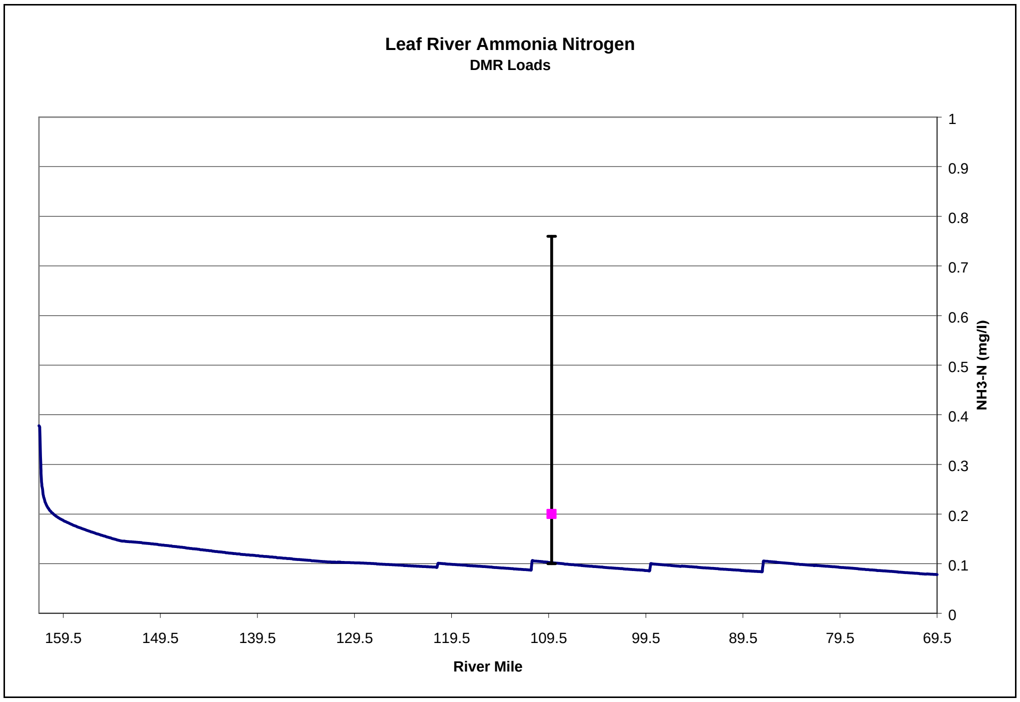


Figure 9. Baseline Model Output for NH_3-N in the Leaf River

3.4.2 Model Results at NPDES Permit Limits

A second model run was completed in order to predict the dissolved oxygen in the Leaf River if the NPDES permits were discharging at their maximum permit limits. The results of this model run are shown in Figure 10. The red line on the graph represents the daily average DO limit of 5.0 mg/l. As shown, the modeled DO stays above the daily average standard. The increased load is well within the assimilative capacity of the water body. The water body has remaining assimilative capacity beyond the increased loading. Thus, this TMDL does not limit future growth in this area.

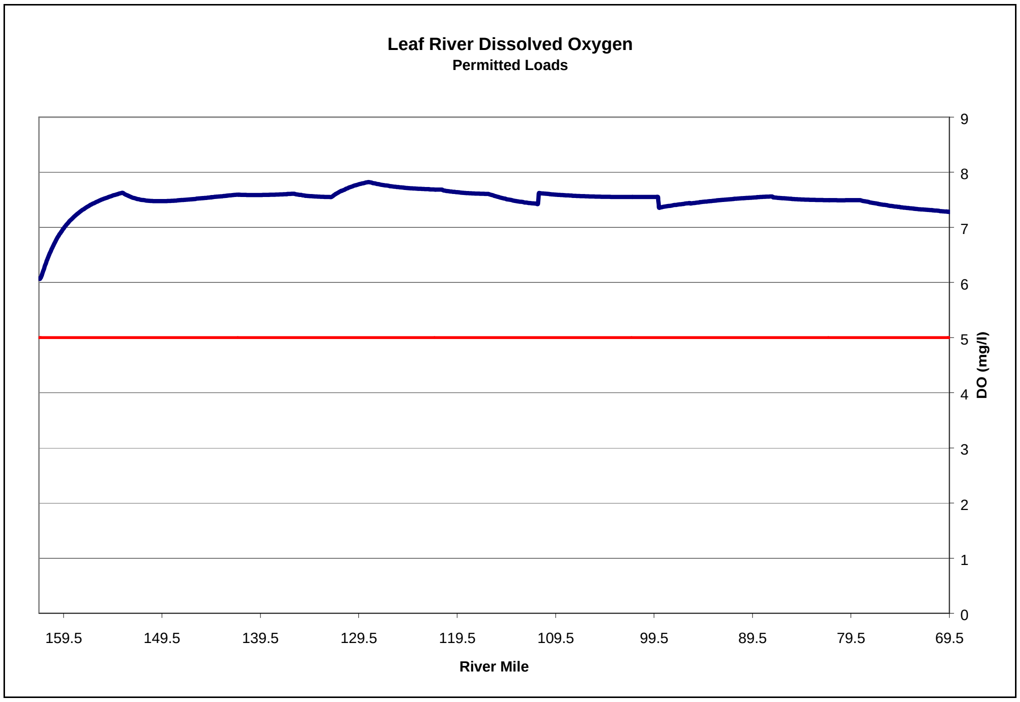


Figure 10. Model Output for the Leaf River at Permitted Loads

3.4.3 Maximum Load Scenario

Calculating maximum allowable load of TBODu involved increasing the non-point loads and running the model using a trial-and-error process until the modeled DO was just above 5.0 mg/l. The maximum loads from the point sources and tributaries were not increased. However, the baseline non-point source loads were increased by a factor of 8. The increased non-point source loads are shown in Table 12. The increased loads were used to develop the allowable maximum daily load for this report. The difference between the baseline and maximum non-point source loads will be used to calculate the margin of safety. The model output for DO with the increased loads is shown in Figure 11.

Table 12. Non-Point Source Loads Input into the Model, Maximum Load Scenario

Reach	Flow (cfs)	$CBOD_u$ (mg/L)	CBODu (lbs/day)	NH_3-N (mg/l)	NBODu (lbs/day)	TBODu (lbs/day)
RM 162.0 – RM 153.5	8.4	2.0	722.8	0.2	330.3	1053.1
RM 153.5 – RM 141.8	11.5	2.0	994.9	0.2	454.7	1449.5
RM 141.8 – RM 136.1	5.6	2.0	484.7	0.2	221.5	706.2
RM 136.1 – RM 135.3	0.8	2.0	68.0	0.2	31.1	99.1
RM 135.3 – RM 132.3	3.0	2.0	255.1	0.2	116.6	371.7
RM 132.3 – RM 131.3	1.0	2.0	85.0	0.2	38.9	123.9
RM 131.3 – RM 128.5	2.8	2.0	238.1	0.2	108.8	346.9
RM 128.5 – RM 121.0	7.4	2.0	637.7	0.2	291.4	929.2
RM 121.0 – RM 116.3	4.6	2.0	399.7	0.2	182.6	582.3
RM 116.3 – RM 111.3	4.9	2.0	425.2	0.2	194.3	619.5
RM 111.3 – RM 107.0	4.2	2.0	365.6	0.2	167.1	532.7
RM 107.0 – RM 99.1	7.8	2.0	671.8	0.2	307.0	978.8
RM 99.1 – RM 95.9	3.2	2.0	272.1	0.2	124.4	396.5
RM 95.9 – RM 87.5	8.3	2.0	714.3	0.2	326.4	1040.7
RM 87.5 – RM 82.1	5.3	2.0	459.2	0.2	209.8	669.0
RM 82.1 – RM 78.6	3.5	2.0	297.6	0.2	136.0	433.6
RM 78.6 – RM 75.6	3.0	2.0	255.1	0.2	116.6	371.7
RM 75.6 – RM 70.6	4.9	2.0	425.2	0.2	194.3	619.5
RM 70.6 – RM 70.0	0.6	2.0	51.0	0.2	23.3	74.3
RM 70.0 – RM 69.5	0.5	2.0	42.5	0.2	19.4	61.9
	91.2		**7,865.5**		**3,594.5**	**11,460.1**

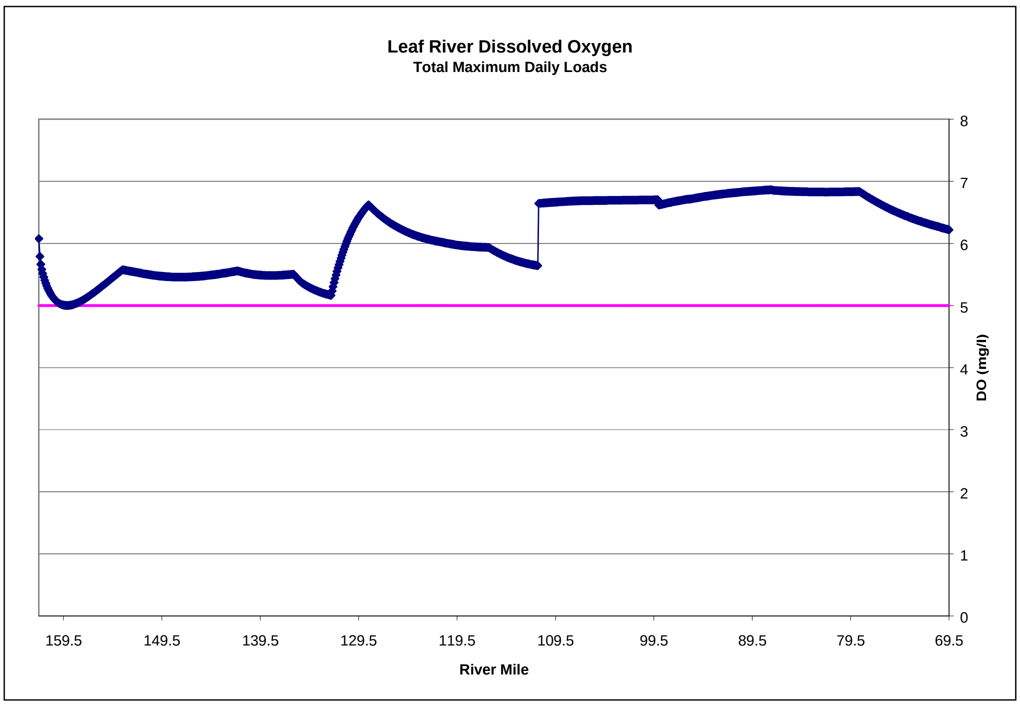


Figure 11. Model Output for the Leaf River at Maximum Load Scenario

3.5 Evaluation of Ammonia Toxicity

Ammonia must not only be considered due to its effect on dissolved oxygen in the receiving water, but also its toxicity potential. Ammonia nitrogen concentrations can be evaluated using the criteria given in 1999 Update of Ambient Water Quality Criteria for Ammonia (EPA-822-R-99-014). The maximum allowable instream ammonia nitrogen (NH_3-N) concentration at a pH of 7.0 and stream temperature of 26°C is 2.82 mg/l. Based on the model results for the maximum load scenario, Figure 12, this standard was not exceeded in the Leaf River.

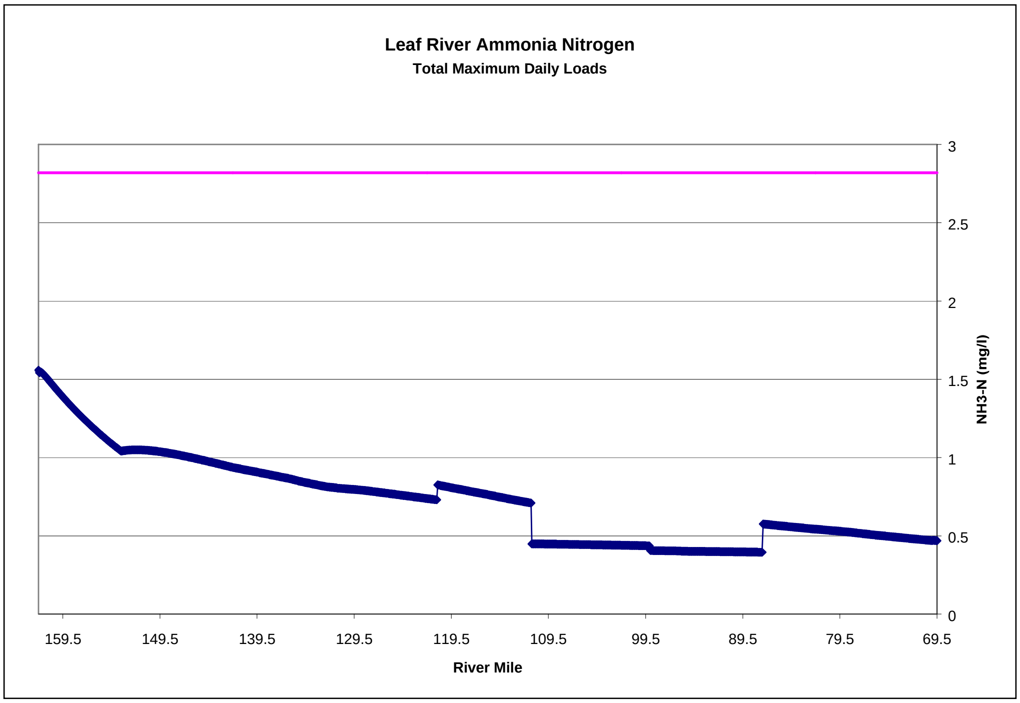


Figure 12. Model Output for Ammonia Nitrogen in the Leaf River at Maximum Load Scenario

ALLOCATION

The allocation for this TMDL involves a wasteload allocation for point sources and a load allocation for non-point sources necessary for attainment of water quality standards in the Leaf River. The TMDL also includes a margin of safety to ensure that water quality standards will be maintained under all conditions. The load and wasteload allocations and margin of safety are given in terms of TBODu for this phase 1 TMDL. When water quality standards and additional information become available, future TMDLs may be developed for the Leaf River that address specific nutrient species.

4.1 Wasteload Allocation

Federal regulations require that effluent limits developed to protect water quality criteria are consistent with the assumptions and requirements of any available wasteload allocation for the discharge prepared by the state and approved by EPA. The NPDES Permitted facilities that discharge BOD_5 and ammonia nitrogen in the Leaf River are included in the wasteload allocation, Table 13. No reduction of the permitted TBODu load is needed in order for the model to show compliance with the TMDL endpoint.

Table 13. Wasteload Allocation

Facility	CBODu (lbs/day)	NBODu (lbs/day)	TBODu (lbs/day)
Glendale Utility District	140.7	6.6	147.3
Happy Acres Packing Co.(Ray's Quality Meat)	1.7	9.3	11.0
North Forrest Attendance Center	9.0	1.8	10.8
Hattiesburg, Laurel Regional Airport	3.8	1.5	5.3
Moselle Elementary School	5.6	1.1	6.7
Taylorsville POTW	90.1	102.9	193
Southern Hens Inc.	1121.2	910.9	2032.1
MDOT, Interstate 20 East, Rest Area, Scott	8.6	1.1	9.7
	1,380.7	**1,035.2**	**2,415.9**

Although this wasteload allocation is based on the permit limits of facilities present in the Leaf River watershed, it is not intended to prevent the issuance of permits for future facilities. This is because the model results show that the Leaf River has additional assimilative capacity for organic material. Future permits will be considered on a case-by-case basis.

4.2 Load Allocation

The background and non-point source loads are included in the load allocation. This TMDL does not require a reduction of the load allocation. In Table 14 the load allocation is shown for the non-point and tributary loads in the Leaf River. Note that the non-point source loads are reflected in the model output from the baseline scenario and are equal to the loads given in Table 10. The baseline non-point source loads represent an approximation of the loads currently going into the Leaf River at low-flow conditions based on data and regulatory assumptions

Table 14. Load Allocation

Source	CBODu (lbs/day)	NBODu (lbs/day)	TBODu (lbs/day)
Leaf River Non-Point Source Loads	983.2	449.2	1,432.5
Tributary Loads	437.1	209.9	647.0
	1,420.3	**659.1**	**2,079.5**

4.3 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 water body. 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 TMDL includes both an implicit and explicit component.

Conservative assumptions which place a higher demand of DO on the water body than may actually be present are considered part of the implicit margin of safety. The assumption that all of the ammonia nitrogen present in the water body is oxidized to nitrate nitrogen, for example, is a conservative assumption. In addition, the TMDL is based on the critical condition of the water body represented by the low-flow, high-temperature condition. Modeling the water body at this flow provides protection during the worst-case scenario.

The explicit MOS for this report is the difference between the non-point loads calculated in the maximum load scenario and the baseline non-point loads. The baseline non-point source loads represent an approximation of the loads currently going into the Leaf River at low-flow conditions based on flow data and regulatory assumptions. The maximum non-point source loads are the maximum TBODu loads that allow maintenance of water quality standards under 7Q10 flow conditions. MDEQ has set the MOS as the difference in these loads to account for the uncertainty in the desktop model that was used to develop this Phase 1 TMDL. There were very little data available to set up the model, and many assumptions based on regulations and literature values were used. The rate of sediment oxygen demand, for example, was set to zero due to lack of monitoring data. Sediment oxygen demand, however, can be a significant factor in the DO balance of a large water body such as the Leaf River. The STREAM model is a steady state, daily average model that assumes complete mixing throughout the water column. There is some uncertainty in applying this type of model to large rivers such as the Leaf River. Due to the uncertainty in the model, MDEQ set a large, explicit MOS instead of increasing either the WLA or LA to express the maximum assimilative capacity determined for the water body.

For this TMDL the explicit MOS will be set as the difference between these two load scenarios, 10,027.5 lbs/day TBODu. The calculation of the MOS is shown in Table 15.

Table 15. Calculation of the Explicit Margin of Safety

	Maximum Non-Point Load	Baseline Non-Point Load	Margin of Safety
CBODu (lbs/day)	7,865.5	983.2	6,882.3
NBODu (lbs/day)	3,594.5	449.3	3,145.2
TBODu (lbs/day)	**11,460.0**	**1,432.5**	**10,027.5**

4.4 Seasonality

Seasonal variation may be addressed in the TMDL by using seasonal water quality standards or developing model scenarios to reflect seasonal variations in temperature and other parameters. Mississippi's water quality standards for dissolved oxygen, however, do not vary according to the seasons. This model was set up to simulate dissolved oxygen during the critical condition period, the low-flow, high-temperature period that typically occurs during the summer season. Since the critical condition represents the worst-case scenario, the TMDL developed for critical conditions is protective of the water body at all times. Thus, this TMDL will ensure attainment of water quality standards for each season

4.5 Calculation of the TMDL

The TMDL was calculated based on Equation 5.

TMDL = WLA + LA + MOS **(Equation 5)**

Where WLA is the wasteload allocation, LA is the load allocation, and MOS is the margin of safety. All units are in lbs/day of TBODu. The phase 1 TMDL for TBODu was calculated based on the current loading of pollutant in the Leaf River. The TMDL calculations are shown in Table 16. As shown in the table, TBODu is the sum of CBODu and NBODu. The wasteload allocations incorporate the CBODu and NH_3-N contributions from identified NPDES Permitted facilities. The load allocations include the background and non-point sources of TBODu and NH_3-N from surface runoff and groundwater infiltration. The implicit margin of safety for this TMDL is derived from the conservative assumptions used in setting up the model. An explicit margin of safety has also been included in the TMDL.

Table 16. Phase 1 TMDL for TBODu in the Leaf River Segments MS075E and MS079E

	WLA (lbs/day)	LA (lbs/day)	MOS (lbs/day)	TMDL (lbs/day)
CBODu	1380.7	1,420.3	6,882.3	9683.3
NBODu	1035.2	659.1	3,145.2	4839.5
TBODu	**2,415.9**	**2,079.4**	**10,027.5**	**14,522.8**

The TMDL presented in this report represents the current load of a pollutant allowed in the water body. Although it has been developed for critical conditions in the water body, the allowable load is not tied to any particular combination of point and non-point loads. The LA given in the TMDL applies to all non-point sources and does not assign loads to specific sources. Also, the WLA does not dictate a specific distribution of the loads among individual point sources.

4.6 Reasonable Assurance

This component of the TMDL development does not apply to this TMDL Report. There are no point sources (WLA) requesting a reduction based on promised LA components and reductions.

CONCLUSION

This Phase 1 TMDL is based on a desktop model using MDEQ's regulatory assumptions and literature values in place of actual field data. The model results indicate that the Leaf River is meeting the water quality standard for dissolved oxygen at the present loading of TBODu. Thus, this TMDL does not limit the expansion of existing permits or issuance of new permits in the watershed as long as new facilities do not cause impairment in the Leaf River. This TMDL has been developed as a Phase 1 TMDL so that specific nutrient species may be evaluated when more data are available and water quality standards are developed for nutrients.

5.1 Future Monitoring

Additional monitoring needed for model refinement may be prioritized by the local stakeholders, MDEQ, and EPA. MDEQ has adopted the Basin Approach to Water Quality Management, a plan that divides Mississippi's major drainage basins into five groups. During each year-long cycle, MDEQ's resources for water quality monitoring will be focused on one of the basin groups. During the next monitoring phase in the Pascagoula River Basin, the Leaf River Watershed will receive additional monitoring to identify any change in water quality.

5.2 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. 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 Greg Jackson at (601) 961-5098 or Greg_Jackson@deq.state.ms.us.

All comments received during the public notice period and at any public hearings become a part of the record of this TMDL. All comments will be considered in the 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 water body may be based upon a similar, unaltered or least impaired, water body or on historical pre-alteration data.

Biological Impairment: Condition in which at least one biological assemblages (e.g. , fish, macroinvertebrates, 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 water body.

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 water body 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 water body 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 water body 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 Water body: Any water body 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 non-point source pollution from the land surface to the receiving stream.

Load Allocation (LA): The portion of receiving water's loading capacity attributed to or assigned to non-point 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.

Non-point 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.

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 water bodies 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 water body 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 water body 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

BMP .... Best Management Practice

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

CBODu .... Carbonaceous Ultimate Biochemical Oxygen Demand

CWA .... Clean Water Act

DMR .... Discharge Monitoring Report

DO .... Dissolved Oxygen

EPA .... Environmental Protection Agency

GIS .... Geographic Information System

HCR .... Hydrograph Controlled Release

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

NBODu .... 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

POTW .... Public Owned Treatment Works

RBA .... Rapid Biological Assessment

TBODu..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