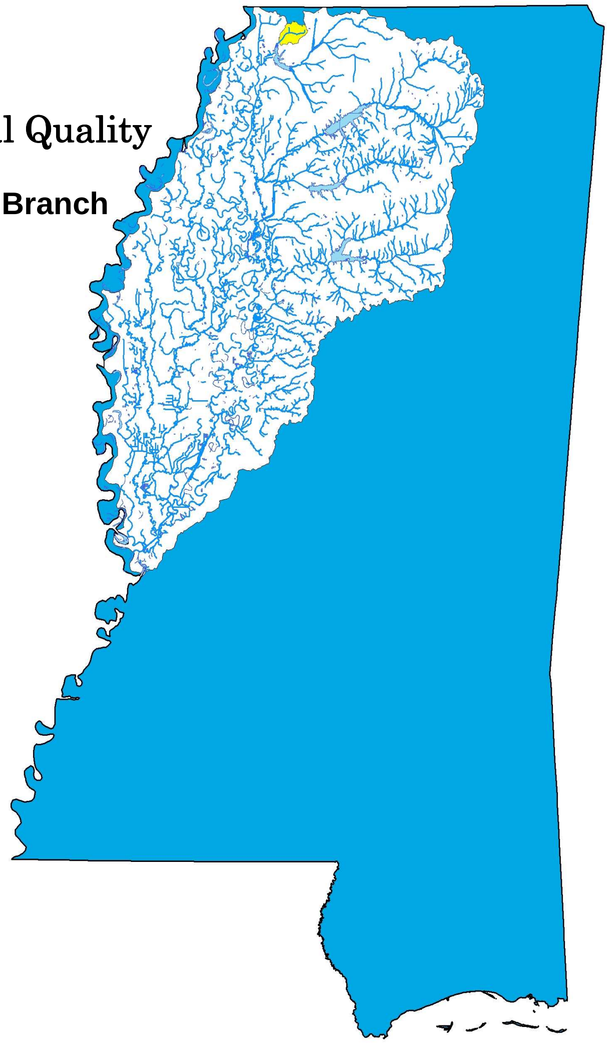
FINAL REPORT
June 2003
ID: 903062402

Total Maximum Daily Load
For Organic Enrichment/Low DO and Nutrients

Hurricane Creek

Yazoo River Basin

DeSoto County, Mississippi



Prepared by

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

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

Prefixes for fractions and multiples of SI units

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

Conversion Factors

To convert from	To	Multiply by	To Convert from	To	Multiply by
Acres	Sq. miles	0.0015625	Days	Seconds	86400
Cubic feet	Cu. Meter	0.028316847	Feet	Meters	0.3048
Cubic feet	Gallons	7.4805195	Gallons	Cu feet	0.133680555
Cubic feet	Liters	28.316847	Hectares	Acres	2.4710538
cfs	Gal/min	448.83117	Miles	Meters	1609.344
cfs	MGD	.6463168	mg/l	ppm	1
Cubic meters	Gallons	264.17205	μg/l * cfs	Gm/day	2.45

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FIGURES

TABLES

TMDL INFORMATION PAGE

i. Listing Information

Name	ID	County	HUC	Cause	Mon/Eval
Hurricane Creek	MS303M1	DeSoto	08030204	Organic Enrichment/Low Do and Nutrients	Monitored
Near Eudora from watershed 307 Boundary to Arkabutla Lake flood Pool					
Unnamed Tributary to Hurricane Creek	MS308M	DeSoto	08030204	Organic Enrichment/Low Do and Nutrients	Evaluated
Near Eudora from headwaters to unnamed tributary (MS308E – DA near Frees Corner) of Hurricane Creek					
Hurricane Creek	MS307E	DeSoto	08030204	Organic Enrichment/Low Do and Nutrients	Evaluated
Hurricane Creek, Portion of DA, Drainage area near Deans Corner					

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	Subwatershed	Receiving Water	Flow (mgd)
MS0029645	Magnolia Hills Mobile Home Park	08030204	Hurricane Creek	0.04
MS0045624	Southern Shriners Club	08030204	Hurricane Creek	0.001
MS0045373	DD Bullard Headstart	08030204	Hurricane Creek	0.015
MS0032484	County Haven Trailer Park	08030204	Hurricane Creek	0.07
MS0026701	Hernando POTW- North	08030204	Hurricane Creek	0.6
MS0055956	The Legends Subdivision	08030204	Hurricane Creek	0.035
MS0047244	On the go Market and Deli	08030204	Hurricane Creek	0.0015
MS0054399	City of Southaven, Trinity Lakes Planned Utilities Development	08030204	Hurricane Creek	0.064
MS0051055	US Post Office, Nesbit	08030204	Hurricane Creek	0.0006
MS0052086	Woodland Estates	08030204	Hurricane Creek	0.0296
MS0048283	Happy Daze Dairy Bar	08030204	Hurricane Creek	0.0015

iv. Total Maximum Daily Load

LA (lbs/day)	WLA (lbs/day)	MOS	TMDL (lbs/day TBODu)
32.65	196.0	Implicit	229.0

EXECUTIVE SUMMARY

A segment of the Hurricane Creek has been placed on the Mississippi 1998 Section 303(d) List of Waterbodies as a monitored waterbody segment, due to organic enrichment/low dissolved oxygen (DO) and nutrients. The applicable state 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. Hurricane Creek is a waterbody in the Yazoo River Basin. Mississippi currently does not have standards for allowable nutrient concentrations, so a TMDL specifically for nutrients will not be developed. However, since elevated levels of nutrients may cause low levels of dissolved oxygen, the TMDL developed for dissolved oxygen also addresses the potential impact of elevated nutrients in Hurricane Creek.

Hurricane Creek is located near Eudora, Mississippi from watershed 307 boundary to the Arkabutla flood pool. This TMDL has been developed for the section of the Hurricane Creek found on the 303(d) List.

The predictive model used to calculate this TMDL is based primarily on assumptions described in MDEQ Regulations. A modified Streeter-Phelps DO sag model was selected as the modeling framework for performing 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 (CBODu) decay rate. A mass-balance approach was used to ensure that the instream concentration of total ammonia (NH_3-N) did not exceed the water quality criteria for toxicity. The critical modeling period was determined to be during low-flow, high-temperature conditions that occur during the summer (May – October) period. The seven-day, ten-year (7Q10) low-flow value was used to establish the hydrologic flow for the modeled segment.

The model used in developing this TMDL included both nonpoint and point sources of total ultimate biochemical oxygen demand (TBODu) in the Hurricane Creek Watershed. The location of the watershed is shown in Figure 1. TBODu loading from nonpoint sources in the watershed was accounted for by using an assumed background concentration of TBODu in the stream as directed in MDEQ Regulations. The background concentration was determined based on *Empirical Stream Model Assumptions for Conventional Pollutants and Conventional Water Quality Models* (MDEQ, 1995). The Hernando POTW facility is the primary point source discharger of TBODu in the watershed. There are ten other NPDES Permitted discharges located in the watershed that are included as point sources in the model. The load and waste load allocations recommend an 18% reduction in the overall load. Thus, there is no assimilative capacity available for additional TBODu loading in this waterbody segment.

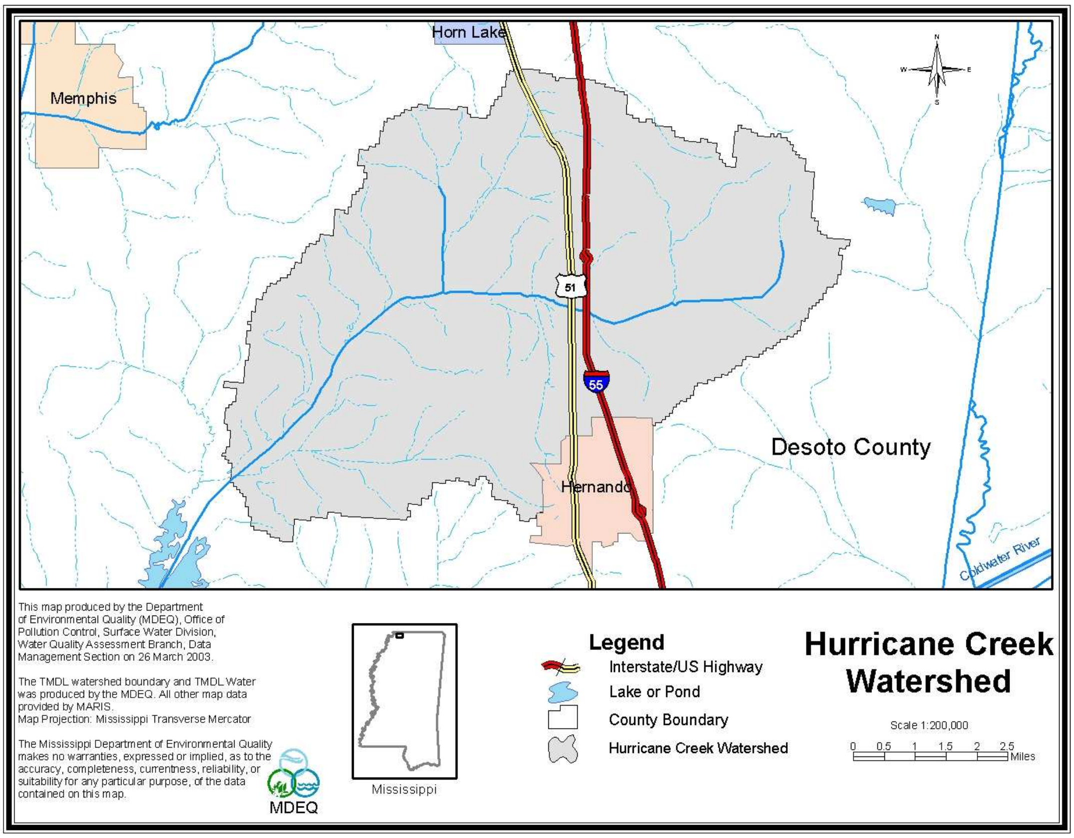


Figure 1. Hurricane Creek Watershed

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 impairment is caused by reduced levels of dissolved oxygen (DO) in the creek due to oxidation of organic material. Thus, this TMDL has been developed for organic enrichment and nutrients. This TMDL was developed for the 303(d) listed segments shown in Figure 2.

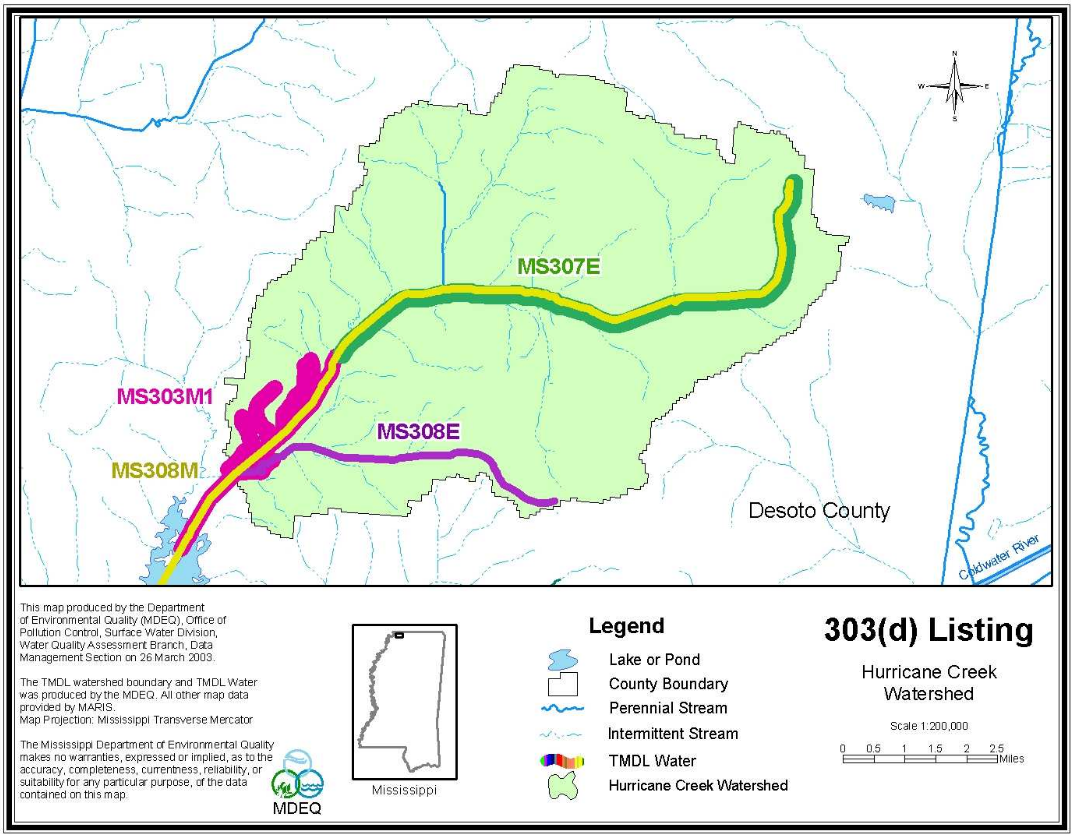


Figure 2. Hurricane Creek Watershed 303(d) Listed Segments

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.

TBODu = CBODu + NBODu **(Equation 1)**

1.2 Applicable Waterbody Segment Use

The water use classification for the listed segment of Hurricane Creek, as established by the State of Mississippi in the *Water Quality Criteria for Intrastate, Interstate and Coastal Waters* regulation, is Fish and Wildlife Support. The designated beneficial uses for Hurricane Creek are Secondary Contact and Aquatic Life Support.

1.3 Applicable Waterbody Segment Standard

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

1.4 Selection of a TMDL Endpoint and Critical Condition

One of the major components of a TMDL is the establishment of instream numeric endpoints, which are used to evaluate the attainment of acceptable water quality. Instream numeric endpoints, therefore, represent the water quality goals that are to be achieved by 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 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 be sufficiently protective of the instantaneous minimum standard.

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. The point of maximum DO deficit, also called the DO sag, will be use 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 DO at the DO sag during critical conditions in Hurricane Creek.

WATERBODY ASSESSMENT

This TMDL Report includes an analysis of available water quality data and the identification of all known potential pollutant sources in the Hurricane Creek watershed. The potential point and nonpoint pollutant sources were characterized by the best available information, monitoring data, and literature values. This section documents the available information for Hurricane Creek.

2.1 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 the listed segments of Hurricane Creek. According to the report, Hurricane Creek is partially supporting for the use of aquatic life support. The data collected by the Army Corps of Engineers (COE) at station A0528 are given in Table 1 and Table 2.

Table 1. Water Quality Data for Hurricane Creek, COE Station A0528

Date	Specific Conductivity (umhos/cm)	Dissolved Oxygen (mg/l)	pH
1/8/1990	83.0	5.56	7.39
1/23/1990	65.0	5.62	7.40
2/6/1990	35.0	3.44	6.0
2/20/1990	41.0	3.32	7.27
3/6/1990	53.0	6.8	5.57
3/20/1990	12.0	6.18	6.00
4/3/1990	81.0	5.57	6.43
4/17/1990	129.0	11.65	7.39
5/1/1990	61.0	6.40	6.82
5/15/1990	54.0	2.67	7.58
8/6/1991	50.0	4.80	6.80
9/4/1991	56.0	8.80	6.85
10/2/1991	103.0	7.40	6.55
11/11/1991	133.0	5.47	7.74
12/10/1991	27.0	6.97	7.07
1/15/1992	34.0	9.78	8.49
2/10/1992	120.0	9.61	7.04
3/9/1992	34.0	7.17	6.37
4/15/1992	269.0	4.67	6.97
5/12/1992	427.0	2.80	6.91
6/9/1992	51.0	7.19	6.51

Table 2. Water Quality Data for Hurricane Creek, COE Station A0528, Continued

Date	TKN (mg/l)	Nitrate Nitrogen Total (mg/l)	Total Phosphorus (mg/l)
1/8/1990	0.39	1.05	0.20
1/23/1990	0.39	1.03	0.19
2/6/1990	0.39	0.52	0.29
2/20/1990	0.36	0.44	0.36
3/6/1990	0.45	0.40	0.13
3/20/1990	1.06	0.77	0.18
4/3/1990	0.22	0.50	0.21
4/17/1990	0.45	1.12	1.00
5/1/1990	0.39	1.42	0.24
5/15/1990	0.20	0.40	0.17
8/6/1991	0.56	.395	0.16
9/4/1991	0.98	0.30	-----
10/2/1991	0.62	0.576	0.13
11/11/1991	1.06	0.3352	0.08
12/10/1991	0.56	0.5586	0.55
1/15/1992	----	------	----
2/10/1992	----	------	-----
3/9/1992	----	------	-----
4/15/1992	0.45	0.0081	0.13
5/12/1992	0.11	0.0161	0.07
6/9/1992	0.67	0.0143	0.31

2.2 Assessment of Point Sources

The first step in assessing pollutant sources in the Hurricane Creek watershed was locating the NPDES permitted sources. There are eleven sources permitted to discharge into Hurricane Creek, Table 3. 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 (DMRs). DMRs are vital to characterizing effluent from each facility. The average flows, BOD_5, and NH_3-N concentrations, as reported in the DMRs for the past two years are given in Table 3.

Table 3. Identified NPDES Permitted Facilities

Name	NPDES Permit	Permitted Discharge (mgd)	Actual Average Discharge (mgd)	Permitted BOD_5 (mg/l)	Actual BOD5 (mg/l)	Actual NH_3-N (mg/l)
Magnolia Hills Mobile Home Park	MS0029645	.04	.03	30	NA	No Data
Southern Shriners Club	MS0045624	.0015	No Discharge	30	No Discharge	No Data
DD Bullard Headstart	MS0045373	.0015	.002	30	35	No Data
County Haven Trailer Park	MS0032484	.07	.17	30	4.0	No Data
Hernando POTW- North	MS0026701	.60	.44	15	16.13	No Data
The Legends Subdivision	MS0055956	.035	No Discharge	30	No Discharge	No Data
On the go Market and Deli	MS0047244	.0015	No Data	30	No Data	No Data
City of Southaven, Trinity Lakes Planned Utilities Development	MS0054399	.032	.014	10	8.5	2.0
US Post Office, Nesbit	MS0051055	.0005	No Data	30	No Data	No Data
Woodland Estates	MS0052086	.03	.007	.03	18	No Data
Happy Daze Dairy Bar	MS0048283	.0017	.0006	30	5	No Data

2.3 Assessment of Nonpoint Sources

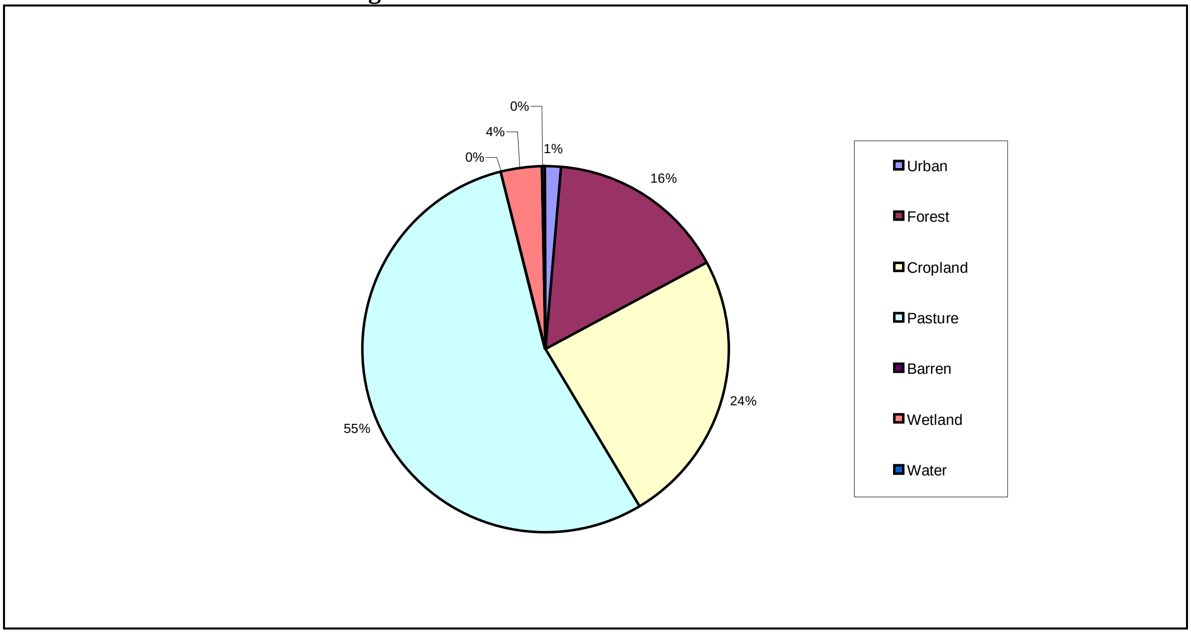
Nonpoint loading of TBODu in a waterbody results from the transport of the pollutants into receiving waters by overland surface runoff and groundwater infiltration. Landuse activities within the drainage basin, such as agriculture, silviculture, and urbanization contribute to nonpoint source loading. Other nonpoint pollution sources include atmospheric deposition and natural weathering of rocks and soil.

The 31,632-acre drainage area of Hurricane 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) 1997. This data set is based on Landsat Thematic Mapper digital images taken between 1992 and 1993. Pasture and cropland are the dominant landuses within the Hurricane Creek watershed. The landuse distribution within the Hurricane Creek Watershed is shown in Table 4 and Figure 3.

Table 4. Landuse Distribution

	Urban	Cropland	Forest	Pasture	Water	Wetlands	Total
Area (acres)	449	7,520.27	4,954	17,151	129	1,102	31,305
Percentage	1%	24%	16%	55%	0%	4%	100%

Figure 3. Hurricane Creek Watershed Landuse



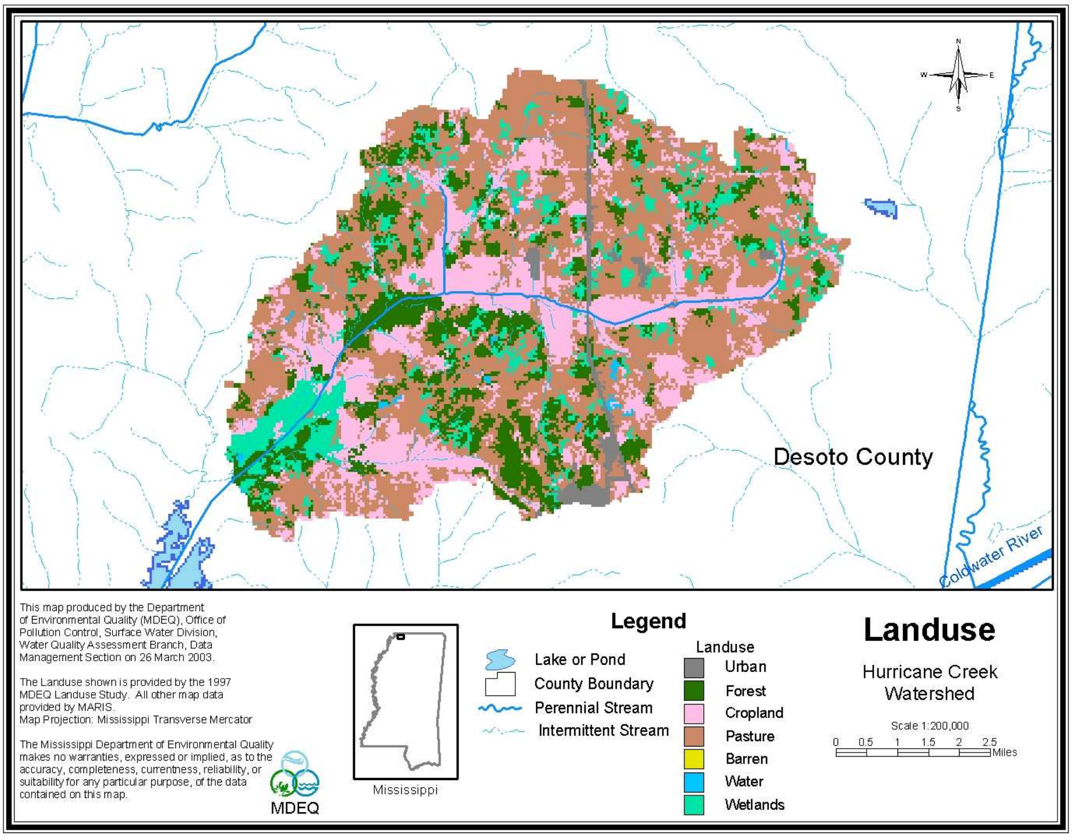


Figure 4. Landuse Distribution Map for Hurricane Creek Watershed

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 waterbody 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, 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.

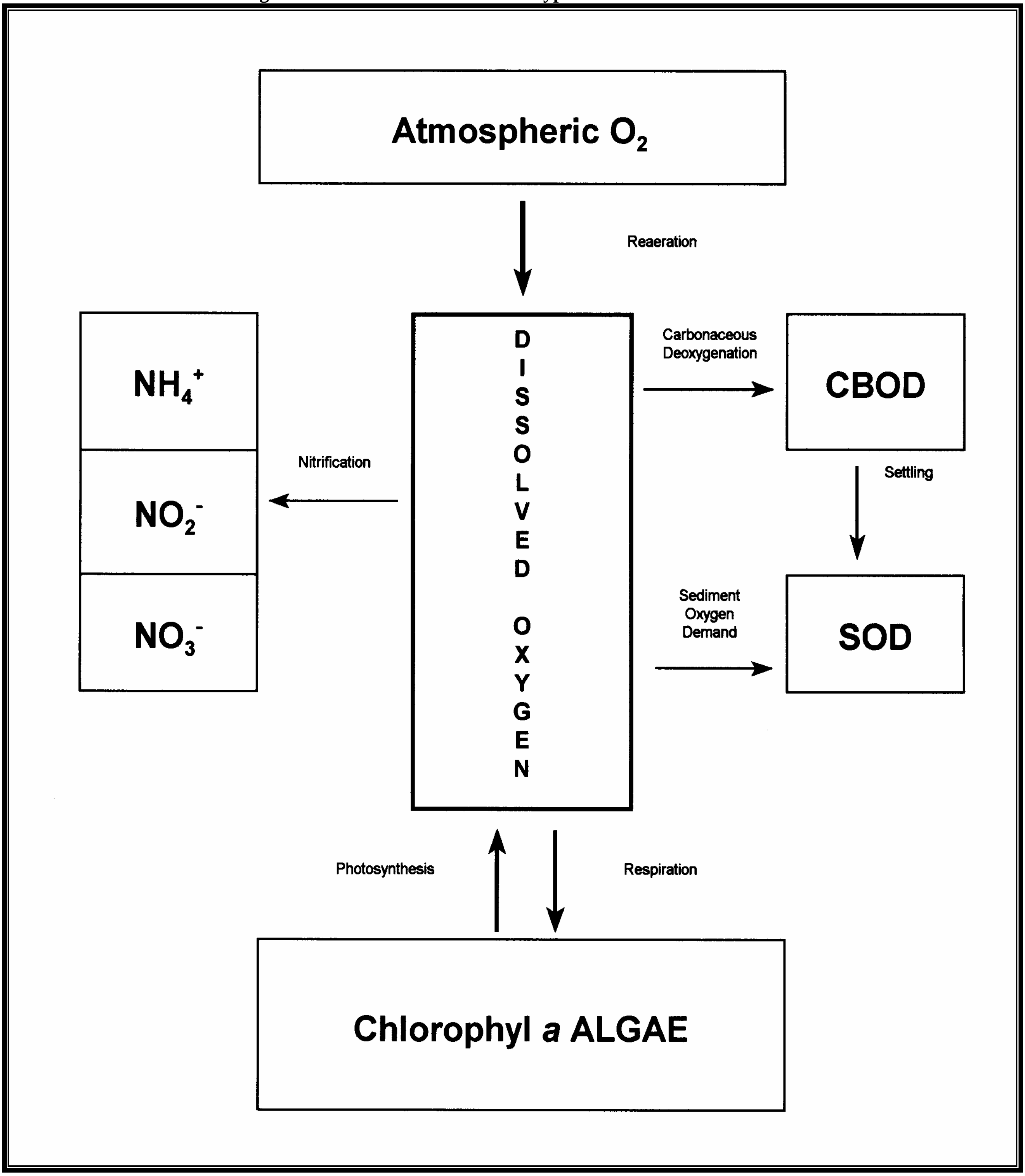
The model is a steady state, daily average computer model that utilizes a modified Streeter-Phelps DO sag equation. Instream processes simulated by the model include CBODu decay, nitrification, reaeration, sediment oxygen demand, and respiration and photosynthesis of algae. Figure 4 shows how these processes 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 reaeration (Ka) within each reach according to Equation 2.

$$\mathbf{Ka = CSU} \qquad \textbf{(Equation 2)}$$

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 reaches with flow less than 10 cfs and 0.0597 for reaches with flow greater than 10 cfs and less than 280 cfs. The slope of each reach was estimated from USGS quad maps and input into the model in units of feet/mile.

Figure 5. Instream Processes in a Typical DO Model



3.2 Model Setup

The Hurricane Creek TMDL model includes the 303(d) listed portions of Hurricane Creek. The modeled water bodies were divided into reaches for input into the AWFWUL1 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 watershed was modeled according to the diagram shown in Figure 5. As shown in Figure 5, there are eleven NPDES permitted point sources that discharge into Hurricane Creek. The numbers on the figure represent river miles at which point sources discharges or confluence of the creeks are located. River miles are assigned to water bodies, beginning with zero at the mouth. Within each reach, the modeled segments were divided into computational elements of 0.1 mile. The hydrological and water quality characteristics are calculated and output by the model for each computational element.

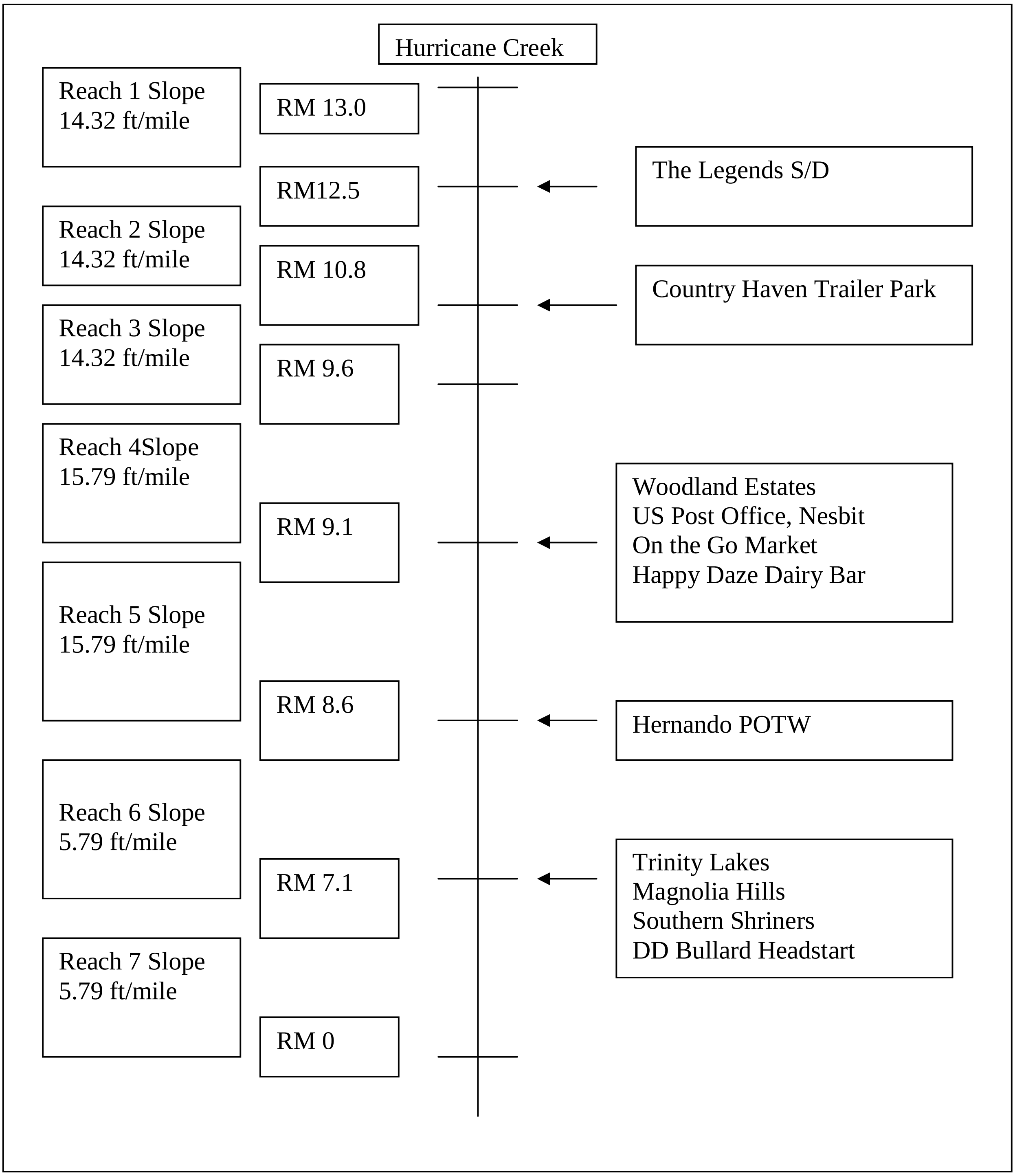


Figure 6. Hurricane Creek Model Setup (Note: Figure not to Scale)

The model was setup to simulate low-flow, high-temperature conditions, which was determined to be the critical condition for this TMDL. The temperature used in the model is 26°C . 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.

$$\mathbf{Kd_{(T)} = Kd_{(20°C)}(1.047)^{T-20}} \qquad \textbf{(Equation 3)}$$

Where Kd 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).

3.3 Source Representation

Both point and nonpoint sources were represented in the model. The loads from NPDES permitted sources were added as direct inputs into the appropriate reach of the waterbody as a flow in cubic feet per second and a load of CBODu and ammonia nitrogen in lbs/day. Spatially distributed loads, which represent nonpoint sources of flow, CBODu, and ammonia nitrogen were distributed evenly into each computational element of Hurricane Creek and its tributaries.

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 predictive models used for TMDL development 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, 1995). 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. A ratio of 1.5:1 was used for all eleven of the facilities included in the model.

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 (NO_3) 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 NBODu load. The sum of

CBODu and NBODu is equal to the point source load of TBODu. The loads of TBODu from each of the existing point sources are given in Table 5. The loads were based on the maximum allowable loads according to NPDES permits and data from discharge monitoring reports, which represents another conservative assumption.

Table 5. Point Source Loads as Input into the Model

Facility	Flow (cfs)	$CBOD_5$ (mg/l)	$CBOD_u$:$CBOD_5$ Ratio	CBODu (lbs/day)	NH_3-N (mg/l)	NBODu (lbs/day)	TBODu (lbs/day)
Magnolia Hills Mobile Home Park	.06	30	1.5	14.56	2	2.96	17.51
Southern Shriners Club	.002	30	1.5	0.49	2	0.10	0.58
DD Bullard Headstart	.002	30	1.5	0.49	2	0.10	.58
County Haven Trailer Park	.11	30	1.5	26.69	2	5.42	32.11
Hernando POTW-North	.93	15	1.5	112.81	2	45.83	158.63
The Legends Subdivision	.05	30	1.5	12.13	2	2.46	14.59
On the go Market and Deli	.002	30	1.5	0.49	2	0.10	0.58
City of Southaven, Trinity Lakes Planned Utilities Development	.05	10	1.5	4.04	2	2.46	6.51
US Post Office, Nesbit	.0007	30	1.5	0.19	2	0.04	0.22
Woodland Estates	.05	30	1.5	12.13	2	2.46	14.59
Happy Daze Dairy Bar	.003	30	1.5	0.73	2	0.15	0.88
Total				**184.75**		**60.13**	**247.0**

Direct measurements of nonpoint source loads of CBODu and NH_3-N were not available for the Hurricane Creek Watershed. The background contributions of CBODu and total ammonia as nitrogen (NH_3–N) were estimated based on *Empirical Stream Model Assumptions for Conventional Pollutants and Conventional Water Quality Models* (MDEQ, 1994). According to these regulations, the background concentrations used in modeling are CBODu = 2.0 mg/l and NH_3-N = 0.1 mg/l.

Due to lack of data, the nonpoint source flows in Hurricane Creek were also estimated. According to *Techniques for Estimating 7-Day, 10-Year Low Flow Characteristics for Ungaged Sites on Streams in Mississippi*, the 7Q10 flow coefficient for the Hurricane Creek Watershed is 0.05 cfs/square mile of drainage area. After determining the drainage area of the Hurricane Creek Watershed, the 7Q10 flow coefficient (7Q10 value in cfs/drainage area in square miles) was used to estimate the amount of water draining into Hurricane Creek and its tributaries during low-flow conditions. The estimated flows were multiplied by the background concentrations of CBODu and NH_3-N to calculate the nonpoint source loads in the model, Table 6. The contributing drainage area of Hurricane Creek, 49.43 square miles, was used to determine the low flow coefficient as shown below.

Low-Flow in Hurricane Creek = .05 cfs/square mile * 49.43 square miles = 2.47 cfs

After determining the drainage area of Hurricane Creek Watershed, the low-flow coefficient (low-flow value in cfs/drainage area in square miles) was used to estimate the amount of water draining into each modeled reach of Hurricane Creek during low-flow conditions. The estimated flows were multiplied by the background concentrations of CBODu and NH3-N to calculate the nonpoint source loads in the model, Table 6. It was assumed that the nonpoint source loads were evenly distributed within each reach.

Table 6. Nonpoint Source Loads as Input into the Model

Watershed	Flow (cfs)	$CBOD_5$ (mg/l)	CBODu:$CBOD_5$ Ratio	CBODu (lbs/day)	NH_3-N (mg/l)	NBODu (lbs/day)	TBODu (lbs/day)
1	.103	1.3	1.5	1.11	.1	0.25	1.36
2	.319	1.3	1.5	3.43	.1	0.79	4.22
3	.228	1.3	1.5	2.45	.1	0.56	3.01
4	.093	1.3	1.5	1.00	.1	0.23	1.23
5	.087	1.3	1.5	0.94	.1	0.21	1.15
6	.300	1.3	1.5	3.23	.1	0.74	3.97
7	1.340	1.3	1.5	14.41	.1	3.30	17.71
Total				**26.57**		**6.08**	**32.65**

3.4 Model Results

Once the model setup was complete, the model was used to predict water quality conditions in Hurricane Creek and its tributaries. The model was first run under baseline conditions. Under baseline conditions, the loads from NPDES permitted point sources were set at their permit load scenarios as determined from the NPDES permit, Table 5. Thus, baseline model runs reflect the critical condition of Hurricane Creek without any reduction of TBODu loads. The model was then run using a trial-and-error process to determine the maximum TBODu loads from the point source facilities which would not violate water quality standards for DO. These model runs are called maximum load scenarios.

3.4.1 Baseline Model Runs

The model result from the baseline model run is shown in Figure 7. The figure shows the modeled daily average DO in Hurricane Creek. The red line represents the DO standard of 5.0 mg/l. Figure 7 shows the daily average instream DO concentrations in Hurricane Creek under existing summer conditions, beginning with river mile 13.0 and ending with river mile 0.0 (the mouth of Arkabutla Lake). The DO sag, or maximum DO deficit, occurs in Hurricane Creek below the discharges from the NPDES Permitted facilities around river mile 6.7.

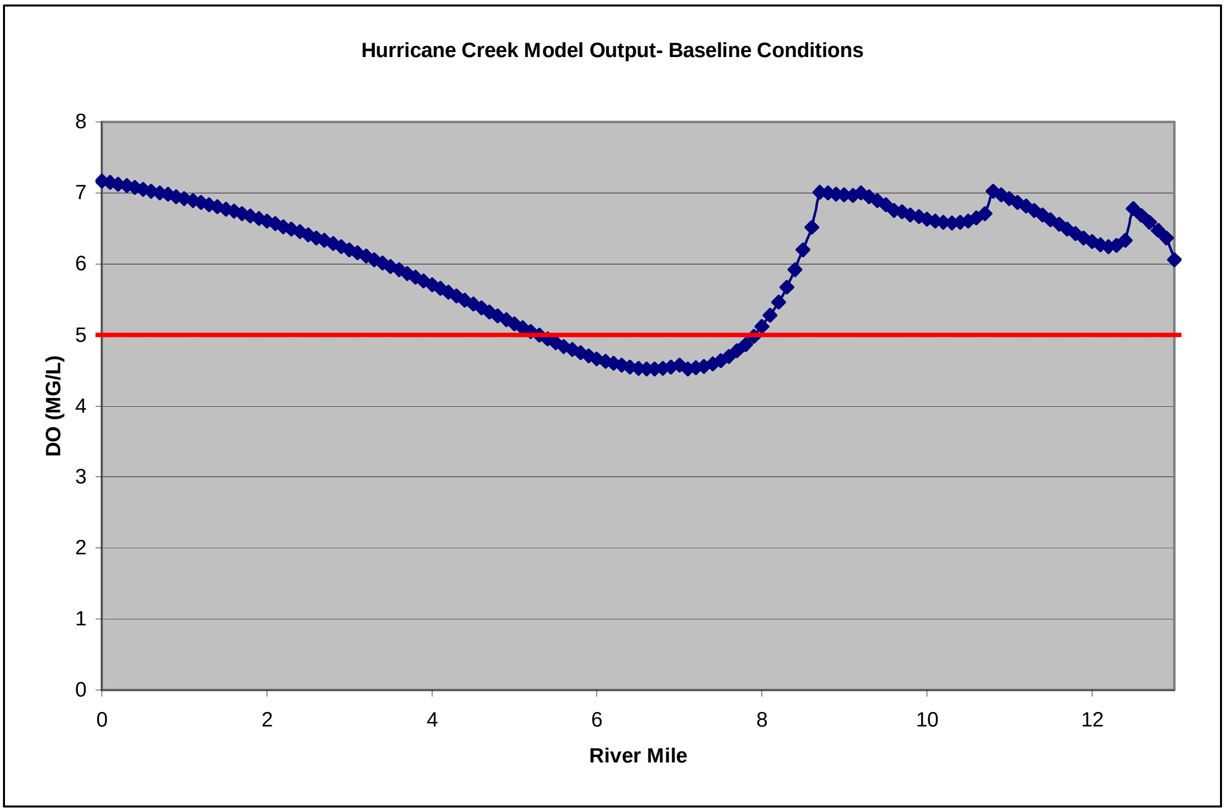


Figure 7. Baseline Model Output for Hurricane Creek

3.4.2 Maximum Load Scenarios

The graphs of the baseline model output show that the predicted DO falls below the DO standard in Hurricane Creek during critical conditions. Thus, reductions from the baseline loads of TBODu are necessary in order to maintain a daily average DO of at least 5.0 mg/l.

The maximum load scenarios involved running the model using a trial-and-error process. The maximum load, that allowed the maintenance of water quality standards, was selected. The loads from the permitted point sources were reduced equally among the dischargers by 20%. The maximum load that allowed the maintenance of water quality standards was selected. The maximum load was used to develop the load and wasteload allocations proposed in this TMDL. Figure 8 shows the daily average instream DO concentrations in Hurricane Creek after application of the selected maximum load scenario for the critical condition. The TBODu loads included in the maximum load scenario are given in Table 7.

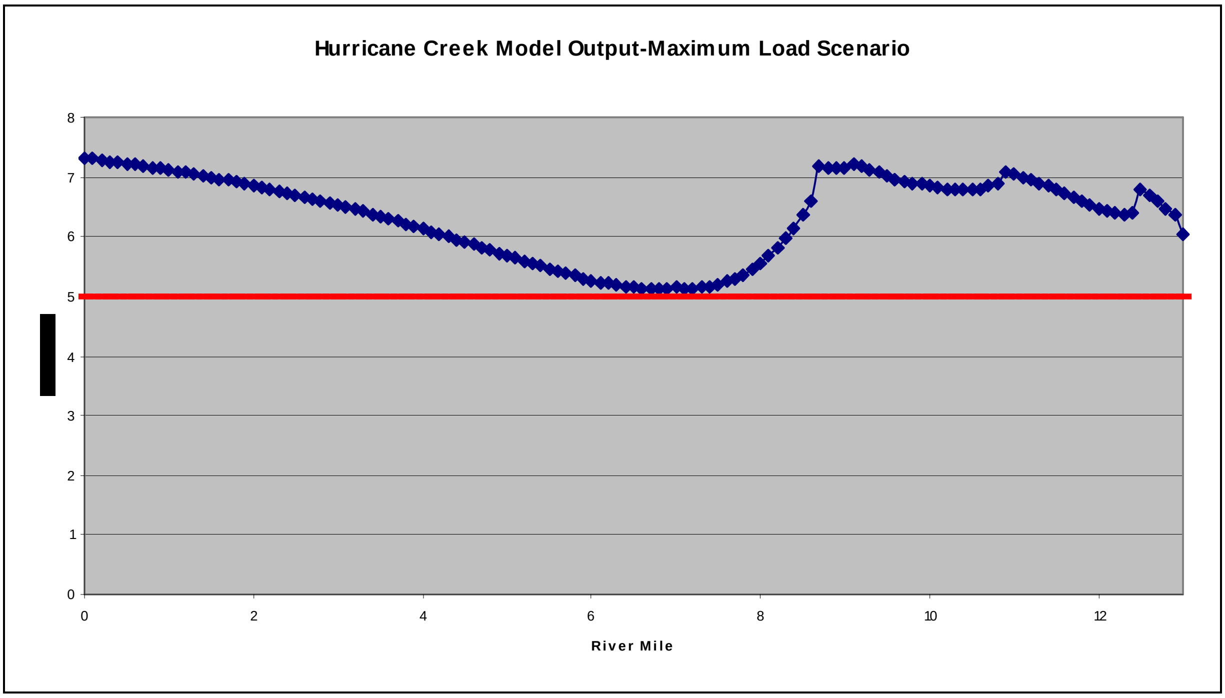


Figure 8. Model Output for Hurricane Creek after Application of Maximum Load Scenario

Table 7. Maximum Load Scenario, Critical Conditions

Source	$CBOD_5$ (mg/l)	NBODu (lbs/day)	TBODu (lbs/day)	Percent Reduction
NPDES Permits	148.0	48.3	196.0	20%
Nonpoint Sources	26.57	6.08	32.65	0%
Total	174.6	54.42	229.0	18%

ALLOCATION

The allocation for this TMDL involves a wasteload allocation for point sources and a load allocation for nonpoint sources necessary for attainment of water quality standards in segments MS303M1, MS308M, and MS307E.

4.1 Wasteload Allocation

Eleven NPDES Permitted facilities in the Hurricane Creek watershed are included in the wasteload allocation, Table 8. The loads given in Table 8 are equal to the load reduction scenarios for the critical condition. The loads from the permitted point sources (shown in Table 5) were reduced by 20%. This is the maximum load that allows for the maintenance of water quality standards. The maximum load was used to develop the load and wasteload allocations proposed in this TMDL.

Table 8. Wasteload Allocation

Facility	CBODu (lbs/day)	NBODu (lbs/day)	TBODu (lbs/day)
Magnolia Hills Mobile Home Park	11.64	2.36	13.54
Southern Shriners Club	0.39	0.08	0.45
DD Bullard Headstart	0.39	0.08	0.45
County Haven Trailer Park	21.35	4.34	25.68
Hernando POTW-North	90.25	36.66	126.91
The Legends Subdivision	9.70	1.97	11.67
On the go Market and Deli	0.39	0.08	0.45
City of Southaven, Trinity Lakes Planned Utilities Development	3.23	1.97	4.81
US Post Office, Nesbit	0.15	0.03	0.17
Woodland Estates	9.70	1.97	11.28
Happy Daze Dairy Bar	0.58	.12	0.68
Total	**148.0**	**48.3**	**196.0**

4.2 Load Allocation

The headwater and spatially distributed loads are included in the load allocation. The TBODu concentrations of these loads were determined by using an assumed $CBOD_5$ concentration of 1.33 mg/l and an NH_3-N concentration of 0.1 mg/l. These concentrations should be assumed when reliable field data are not available, according to *Empirical Stream Model Assumptions for Conventional Pollutants and Conventional Water Quality Models* (MDEQ, 1994). The headwater and spatially distributed flows were calculated for the Hurricane Creek Watershed by delineating the drainage area into subwatersheds. Flows from each subwatershed were based on the 7Q10 flow coefficient for the watershed and the watershed size. Then, the load allocations were calculated to determine the CBODu and NBODu loads in lbs/day, Table 9.

Table 9. Load Allocations-Nonpoint Sources

Subwatershed	Flow (cfs)	$CBOD_5$ (mg/l)	CBODu:$CBOD_5$ Ratio	CBODu (lbs/day)	NH_3-N (mg/l)	NBODu (lbs/day)	TBODu (lbs/day)
1	.103	1.33	1.5	1.11	0.1	0.25	1.36
2	.319	1.33	1.5	3.43	0.1	0.79	4.22
3	.228	1.33	1.5	2.45	0.1	0.56	3.01
4	.093	1.33	1.5	1.00	0.1	0.23	1.23
5	.087	1.33	1.5	0.94	0.1	0.21	1.15
6	.300	1.33	1.5	3.23	0.1	0.74	3.97
7	1.340	1.33	1.5	14.41	0.1	3.30	17.71
Total				**26.57**		**6.80**	**32.65**

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 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 which 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. In addition, the TMDL is based on the critical condition of the waterbody which is represented by the estimated low-flow condition. The estimated low-flow condition for Hurricane Creek is very small. Therefore, modeling the waterbody at this flow provides protection in the worst-case scenario.

4.4 Calculation of the TMDL

The TMDL was calculated based on Equation 5.

$$\textbf{TMDL = WLA + LA + MOS} \qquad \textbf{(Equation 5)}$$

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 TMDL for TBODu was calculated based on the maximum allowable loading of the pollutants in Hurricane Creek and its tributaries, according to the model. The TMDL calculations are shown in Table 10. 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 headwaters and spatially distributed TBODu and NH_3-N contributions 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.

Table 10. TMDL for TBODu, for Critical Conditions in Hurricane Creek

	WLA (lbs/day)	LA-Nonpoint Sources (lbs/day)	MOS	TMDL (lbs/day)
CBODu	148	26.57	Implicit	**174.6**
NBODu	48.3	6.08	Implicit	**54.4**
TBODu	**196**	**32.65**	**Implicit**	**229**

4.5 Seasonality

Seasonal variation may be addressed in the TMDL by using seasonal water quality standards or developing model runs 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. The 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.

4.6 Reasonable Assurance

This component of TMDL development does not apply to this TMDL Report. There are no point sources (WLA) requesting a modification of permit limits based on promised Load Allocation components and reductions.

CONCLUSION

This TMDL will place restrictions on NPDES permitting activities in The Hurricane Creek Watershed and its tributaries, such that the overall loading specified in this TMDL will not be exceeded. Steps need to be taken to ensure that the overall load of TBODu placed in this waterbody from point and nonpoint sources does not exceed the waterbody's assimilative capacity. The maximum load of TBODu, as determined by this TMDL, is 229 lbs/day. The 229 lbs/day was determined by reducing the point source loads by 20%. This is only one allocation proposal of many available. Prior to implementation of this TMDL, stakeholders and MDEQ will establish the actual waste load allocation for each facility. It is noted that upon establishing new waste load allocations for the facilities, any proposed changes in the waste load allocations will be public-noticed, providing the public with an opportunity to comment on the proposed changes, and submitted to EPA for approval.

The DeSoto County Utility Authority is responsible for wastewater treatment in DeSoto County. As explained in the 201 facilities plan, the eleven permitted facilities listed in this TMDL should connect to the regional treatment plant soon after it comes online. This will eliminate each of these smaller discharges from this watershed and should restore water quality.

5.1 Future Monitoring

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 Yazoo Basin, Hurricane Creek will receive additional monitoring to identify any change in water quality.

Additional monitoring may also be conducted in Hurricane Creek in order to provide a data set for calibration of the water quality model used to develop the phase 1 TMDL. Parameters such as flow, water velocity, and background concentrations of CBODu and NH_3-N during the critical modeling period would be beneficial. Also, measurements of rates of CBODu decay, algal photosynthesis and respiration, and sediment oxygen demand would allow for a more accurate model. Finally, additional characterization of the effluent from point source facilities, such as determinations of CBODu to $CBOD_5$ ratios, would increase the model's accuracy. The additional monitoring would allow confirmation of the assumptions used in the model used for calculating the TMDL. If additional data show that the assumptions used in the phase 1 model were not accurate, the model and the TMDL will be updated.

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 meeting 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.

REFERENCES

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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

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

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

RBA .... Rapid Biological Assessment

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

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

WWTP .... Wastewater Treatment Plant