FINAL REPORT
May 2002
ID: 208050801

Total Maximum Daily Load
Tidewater Bayou

Organic Enrichment/ Low Dissolved Oxygen, and Toxics

Coastal Streams Basin

Jackson County, Mississippi

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FOREWORD

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

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

Conversion Factors

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

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

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EVALUATED SEGMENT IDENTIFICATION

Name:	Tidewater Bayou
Waterbody ID:	MS118TBM
Location:	At Ocean Springs: from headwaters to mouth at Biloxi Bay
County:	Jackson County, Mississippi
USGS HUC Code:	03170009
Use Impairment:	Aquatic Life Support
Causes Noted:	Organic Enrichment/Low Dissolved Oxygen Toxics
NPDES Permits:	There are no NPDES permits issued for facilities that potentially discharge oxidizable organic material in the watershed.
Standards Variance:	None
Pollutant Standard:	Dissolved oxygen concentrations shall be maintained at a daily average of not less than 5.0 mg/l with an instantaneous minimum of not less than 4.0 mg/l in the top 5 feet.
Waste Load Allocation:	0 lbs/day Total Biochemical Oxygen Demand 0 Toxicity Unit
Load Allocation:	424 lbs/day Total Biochemical Oxygen Demand
Margin of Safety:	Implicit modeling assumptions
Total Maximum Daily Load (TMDL):	424 lbs/day Total Biochemical Oxygen Demand 0 Toxicity Unit

EXECUTIVE SUMMARY

Tidewater Bayou is on the Mississippi 1998 Section 303(d) List of Waterbodies as evaluated due to organic enrichment/low dissolved oxygen and toxics. It was originally listed due to a chronic overflow from the city sewer system that drained into the waterbody. Also the Ocean Springs POTW discharged into this waterbody. Closing the city POTW and connecting to the regional sewer authority corrected this problem. This waterbody is now primarily used as a local marina for Ocean Springs. There are commercial fishing docks and several private recreational marina slips. The marinas are equipped with modern pump out facilities and should pose no adverse impact on dissolved oxygen in the waterbody. The annual dredging of the waterbody has helped reduce the leftover sediment load from earlier sewer system failures.


Tidewater Bayou Marina

The TMDLs for this waterbody are based on a monitoring and modeling project that included the Back Bay of Biloxi and its major tributaries. The model, which used the DYNHYD and EUTRO5 components of the Water Quality Analysis Simulation Program-5 (WASP5), was developed by the Civil Engineering Department at Mississippi State University, based on water quality studies of the area which were conducted in September 1994 and April-May 1995. The dataset developed from monitoring data collected in 1994 was used for model calibration, and the dataset developed from monitoring data collected in 1995 was used for model verification. The area included in the Back Bay of Biloxi modeling project is located along the Mississippi Gulf Coast in Jackson and Harrison Counties. Also included in the study were the metropolitan areas of Biloxi, Gulfport, Ocean Springs, and D'Iberville.

The BASINS Nonpoint Source Model (NPSM) and the WASP5 Model were selected as the models for performing the TMDL calculations for this study. The NPSM was used as a watershed model for predicting the amount of runoff from the watershed draining into Tidewater Bayou. The WASP5 model was used as a receiving water model for simulating the water quality conditions in Biloxi Bay in response to the nonpoint source pollutant loadings during critical, low-flow conditions.

Loading estimates of organic substances from nonpoint sources in the watershed were based upon background concentrations measured during the model calibration/verification studies of the Back Bay of Biloxi watershed and the daily average flow due to runoff from the watershed as predicted by the NPSM model. The estimated loadings were incorporated into the WASP5 model. There are no NPDES permitted discharges included as point sources in this portion of the WASP5 model. Under existing, or baseline conditions, output from the model indicated that there were no violations of the dissolved oxygen standard in Tidewater Bayou. In addition, numeric criteria developed for toxicity due to unionized ammonia nitrogen were not exceeded. Thus no reductions of the current loadings will be recommended by this TMDL. New NPDES permitted dischargers will not be allowed in this waterbody. It is not an appropriate discharge waterbody due to its small size, tidal influence, and recreational use.

The toxicity TMDL included in this document is based on the toxicity calculations completed by EPA Region 4 for this waterbody in a previous version of this TMDL. MDEQ will incorporate those calculations in this TMDL report.

Tidewater Small Craft Marina and Boardwalk

1.0 INTRODUCTION

1.1 Background

The identification of waterbodies not meeting their designated use and the development of total maximum daily loads (TMDLs) for those waterbodies are required by Section 303(d) of the Clean Water Act and the Environmental Protection Agency's (EPA) Water Quality Planning and Management Regulations (40 CFR part 130). The TMDL process is designed to restore and maintain the quality of those impaired waterbodies through the establishment of pollutant specific allowable loads. The pollutants of concern for this TMDL are oxidizable organic matter and toxics.

Organic enrichment is measured in terms of total ultimate biochemical oxygen demand ($TBOD_U$). $TBOD_U$ is 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 $CBOD_U$, and the nitrogenous compounds are referred to as $NBOD_U$. $TBOD_U$ is equal to the sum of $CBOD_U$ and $NBOD_U$, Equation 1.

$$\boxed{\mathbf{CBOD_U + NBOD_U = TBOD_U}} \qquad \text{Equation 1}$$

Elevated levels of nutrients, as well as oxidizable material will cause a decrease in the level of dissolved oxygen in a waterbody due to the acceleration of eutrophication. Eutrophication, or nutrient enrichment of a waterbody, results in an undesirable abundance of plant growth, particularly phytoplankton and macrophytes. Excessive plant growth can cause impairment to aquatic life and fisheries when microorganisms, via an oxygen demanding process, break down dead plant material. Eventually the level of oxygen in a waterbody can be depleted to the extent that desirable aquatic life are stressed or eliminated. Microbial breakdown of dead plant matter can also produce unionized ammonia, through a process called ammonification, which can adversely affect aquatic life. Nuisance plant growth in many lakes and rivers can be limited by the availability of phosphorus and nitrogen. For this reason, the model developed for this TMDL also considers nitrogen concentrations as indicators.

Boardwalk on Tidewater Bayou

The listed segment of Tidewater Bayou is in the Coastal Streams Basin Hydrologic Unit Code (HUC) 03170009 in south Mississippi. The drainage area of the listed segments is approximately 8,000 acres; and lies within Jackson County.

1.2 Applicable Waterbody Segment Use

The water use classification for Tidewater Bayou, as established by the State of Mississippi in the *Water Quality Criteria for Intrastate, Interstate and Coastal Waters* regulation, is Fish and Wildlife Support. Waters with this classification are intended for fishing and propagation of fish, aquatic life, and wildlife. Waters that meet the Fish and Wildlife Support criteria should also be suitable for secondary contact, which is defined as incidental contact with water including wading and occasional swimming.

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 state standard for dissolved oxygen specifies that the dissolved oxygen shall be maintained at a daily average of not less than 5.0 mg/l with an instantaneous minimum of not less than 4.0 mg/l in estuaries and in the tidally affected portions of streams. This water quality standard will be used as the targeted endpoint to evaluate impairments and to establish this TMDL for organic enrichment/low dissolved oxygen.

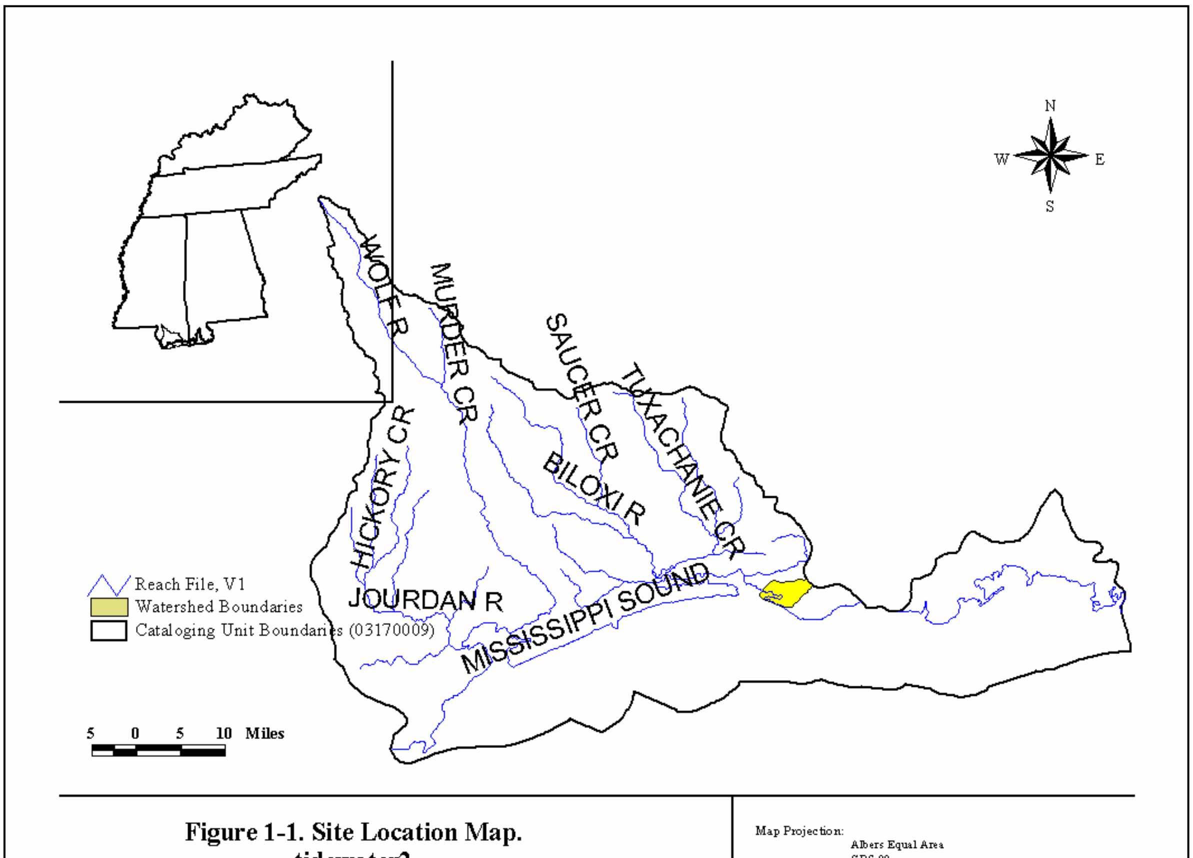


Figure 1-1. Site Location Map.
tidewater2

2.0 TMDL ENDPOINT AND WATER QUALITY ASSESSMENT

2.1 Selection of a TMDL Endpoint and Critical Condition

Small Boat Marina in Tidewater Bayou

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 waste load 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 target used for this TMDL is a daily average dissolved oxygen concentration of not less than 5.0 mg/l. This instream dissolved oxygen target will be used to calculate allowable loads of organic material in the waterbody. MDEQ regulations do not specify the maximum instream concentrations of organic substances. The dissolved oxygen target will be used to quantify the maximum allowable loads of these substances by quantifying the maximum oxygen depletion allowed caused by these substances.

Low dissolved oxygen typically occurs during seasonal low-flow periods of late summer and early fall. Elevated oxygen demand can be a primary concern during dry periods because the effects of low-flow, 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 for this TMDL. The dissolved oxygen target applicable for Tidewater Bayou will be maintained during critical conditions when it receives the loads of oxidizable organic material discussed in this TMDL.

Ammonia must not only be considered due to its effect on the level of dissolved oxygen in the receiving water, but also its toxicity potential. According to *Empirical Stream Model Assumptions for Conventional Pollutants and Conventional Water Quality Models* (MDEQ 1994), allowable ammonia nitrogen concentrations should meet the water quality criteria given in *Quality Criteria for Water, 1986* (EPA 440/5-86-001) for a pH of 7.0 and a temperature of 25°C. The maximum allowable instream ammonia nitrogen concentration under these conditions is a 4-day average of less than 1.20 mg/l. This ammonia nitrogen concentration will be used as a water quality target for this TMDL. Model output will be analyzed to ensure that the ammonia nitrogen concentrations do not exceed the target level under the loads allowed in this TMDL.

2.2 Discussion and Inventory of Instream Water Quality Data

MDEQ recently assessed the data available for Tidewater Bayou and determined that the waterbody is fully supporting the designated use. Previous assessments of the waterbody were based on all available dissolved oxygen data, regardless of the depth at which the data were collected. However, a revised assessment methodology has been developed by MDEQ. According to the methodology, the state standard for dissolved oxygen must be maintained within the top five feet in tidally influenced portions of streams. Considering this, the state standard for dissolved oxygen is met in Tidewater Bayou.

MDEQ collected continuous data from deployment of a data-sonde on dissolved oxygen. This devise was not adjusted for depth during the tidal cycle. However, the data indicate an overall average dissolved oxygen level of 5.1 mg/l in Tidewater Bayou.

The TMDL and water quality modeling are based on data collected during several intensive studies of the Back Bay of Biloxi performed by the Water Quality Assessment Branch of MDEQ and EPA Region 4. In order to investigate the impact of pollutant sources during both low-flow and high-flow conditions and provide two sets of data for calibration and verification of the model, the water quality studies were conducted during a low-flow, high-temperature period in September1994 and a higher flow period in April-May 1995. Data collected during these studies consist of water chemistry sampling, and continuous in-situ monitoring of water quality parameters. In addition, flow, water velocity, and freshwater inflow were measured. Details of the sampling activities, as well as much of the data are available in *Water Quality and Hydrodynamic Models for Back Bay of Biloxi, Volume II – Calibration/Verification, 1994/1995 Data* (Shindala et al. 1996).

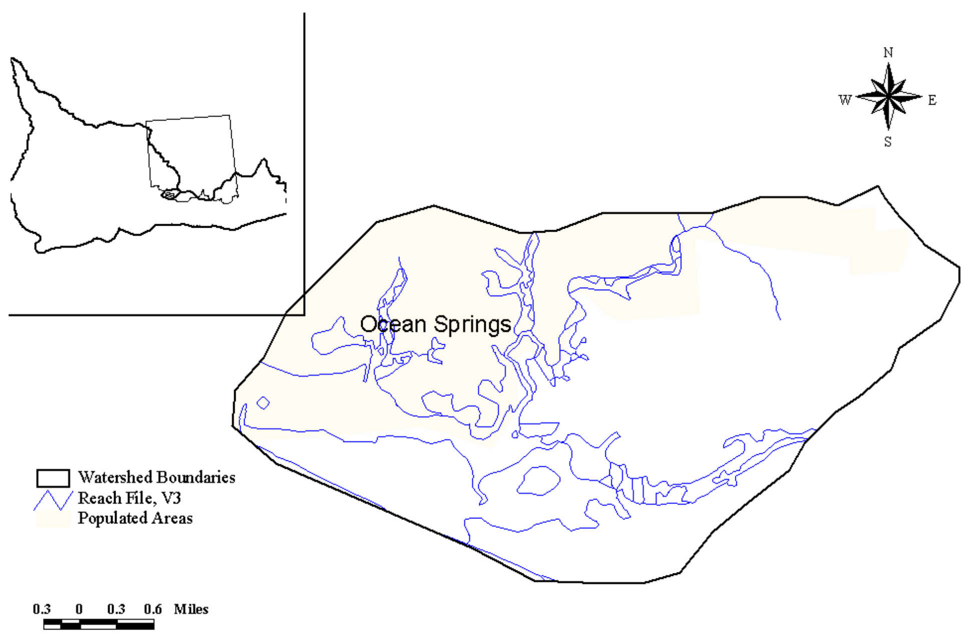


Figure 2-1. Watershed Boundaries
tidewater2

Map Projection:
Albers Equal Area
GRS 80

3.0 SOURCE ASSESSMENT

The TMDL evaluation summarized in this report examined all known potential sources of organic substances in Tidewater Bayou. The source assessment was used as the basis of development for the model and ultimate analysis of the TMDL allocation options. Sources were characterized with the best available information, monitoring data, literature values, and local management activities. This section documents the available information.

3.1 Assessment of Point Sources

There are no facilities permitted to discharge in Tidewater Bayou. The marinas and homes located in the area discharge to the regional sewer system. The original listing of this waterbody was based on the presence of a POTW that discharged into this waterbody. Additionally, this city system had a chronic sewer overflow problem that led to direct sewer bypasses into Tidewater Bayou. The city POTW was taken offline when Ocean Springs connected to the regional sewer system. Also the new pump stations for the regional system corrected the chronic overflow problem.

3.2 Assessment of Nonpoint Sources

Shrimp Boat Docked in Tidewater Bayou Marina

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

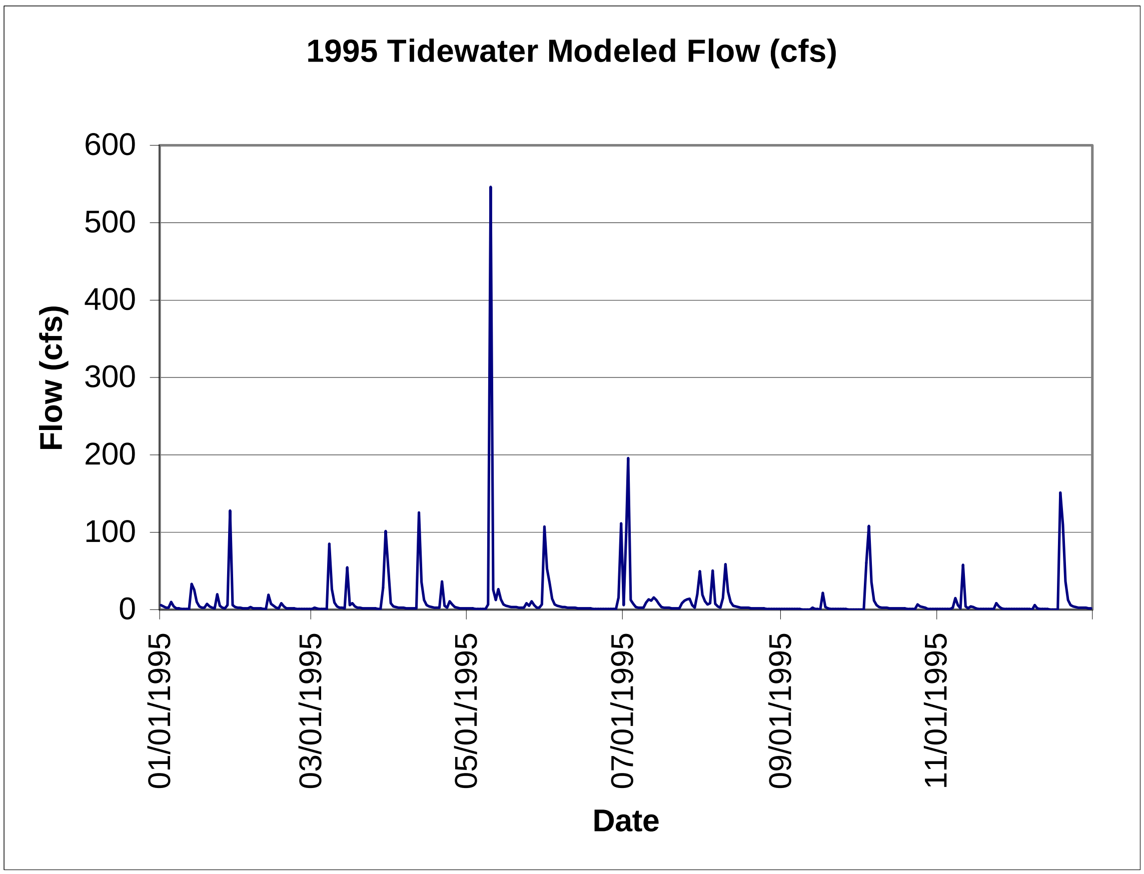
As described in *Protocol for Developing Nutrient TMDLs*, using site-specific data collected at monitoring stations upstream of the area of concern can be used to estimate boundary conditions and nonpoint source loads. Load estimates at the upstream monitoring station can typically be derived from measurements of flow and concentrations of organic materials and nutrients. These relationships can be used to estimate the loads. In the EUTRO5 model, constant concentrations were specified for each water quality constituent at each upstream boundary. A freshwater inflow study conducted during the period of May 1993 to August 1994, in conjunction with the Back Bay of Biloxi model study, was used as the source of data for the model boundary conditions. Table 3.1 shows the boundary concentrations established for Tidewater Bayou. The concentrations were taken from Simmons Bayou and Davis Bayou, which were measured and are similar in size and location to Tidewater Bayou.

Table 3.1. Boundary Conditions estimated for Tidewater Bayou

NH_3-N (mg/l)	NO_3-N (mg/l)	PO_4 (mg/l)	$CBOD_U$ (mg/l)	DO (mg/l)	ON (mg/l)	OP (mg/l)
0.1	0.04	0.01	7.6	5.0	0.51	0.01

Using these boundary conditions, nonpoint source loads were estimated on a subwatershed basis by using yearly average runoff for each subwatershed. Yearly average runoff was calculated from output from the NPSM for 1995. The year 1995 was chosen because it was a wet-year, and thus would give a greater average daily flow. Figure 3.1 shows the hydrograph modeled for 1995 for freshwater in Tidewater Bayou. The average flow was 10.36 cfs. The load allocation is calculated by multiplying the flow times the concentration to get the load. The load allocation equals 424 pounds per day.

Figure 3.1 Hydrograph for Tidewater Bayou from 1995



The 8,000-acre drainage area of Tidewater Bayou contains many different landuse types, including urban, forest, cropland, pasture, water, and wetlands. The landuse information for the entire watershed is based on the State of Mississippi's Automated Resource Information System (MARIS 1997). This data set is based on Landsat Thematic Mapper digital images taken between 1992 and 1993. The land use distribution is shown in Table 3.2. Forest and wetland areas represent the largest percentage of landuses within the watershed.

Table 3.2. Landuse Distribution in Acres for Tidewater Bayou Watershed

	Urban	**Forest**	**Cropland**	**Pasture**	**Water**	**Wetland**	**Total**
Area (acres)	898	3925	303	725	760	1380	7991
% Area	11.2	49.1	3.8	9.1	9.5	17.3	100.0

4.0 MODELING PROCEDURE: LINKING THE SOURCES TO THE ENDPOINT

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

4.1 Modeling Framework Selection

The TMDL for Tidewater Bayou was developed using two computer simulation models. The NPSM model, which simulated the hydrology of the watershed, was used to calculate the yearly average runoff and nonpoint source pollutant loadings from the watershed. The loads were input into the Water Quality Analysis Simulation Program 5 (WASP5). WASP5 was used to simulate hydrodynamics, salinity, and water quality conditions in Tidewater Bayou. The WASP5 model consists of three stand-alone computer programs, DYNHYD, EUTRO5, and TOXI5. These programs can be run in conjunction with the others or separately. The hydrodynamics program, DYNHYD, was used to simulate the movement of water, while the water quality program, EUTRO5, was used to simulate the movement and interaction of the pollutants within the water. This TMDL report gives a brief description of the model setup and application of the models used for developing this TMDL. Detailed information about the NPSM is available in *Better Assessment Science Integrating Point and Nonpoint Sources, BASINS, Version 2.0 User's Manual* (USEPA 1998). Additional details of the model setup and calibration of the WASP5 model are available in *Water Quality and Hydrodynamic Models for Back Bay of Biloxi, Volume I – Model Documentation* (Shindala et al. 1996).

4.2 Model Setup

The BASINS model platform and the NPSM model were used to model the watershed hydrology and load wash off from the Tidewater Bayou watershed. BASINS is a multipurpose environmental analysis system for use in performing watershed and water quality-based studies. A geographic information system (GIS) provides the integrating framework for BASINS and allows for the display and analysis of a wide variety of landscape information such as landuses, monitoring stations, and stream descriptions. The calibrated NPSM model simulated nonpoint source runoff from selected subwatersheds in order to isolate the major stream reaches and to allow for the relative contribution of nonpoint sources to be addressed within each subwatershed. The weather data used for the NPSM were collected at several locations in the study area. The representative hydrologic period used for the NPSM was a wet year, 1995, as determined by an analysis of mean annual rainfall distributions at several weather stations including Biloxi, Gulfport Naval Center, Merril, Ocean Springs, Saucier Experimental Forest Station, Vancleave, and Wiggins Ranger Station.

WASP5 is a dynamic model that can be used to simulate water quality processes in aquatic systems. The model incorporates the time-varying processes of advection, dispersion, and boundary exchange in simulating both the water column and benthic systems. In order to set up the water quality portion of the model, the Back Bay of Biloxi and its major tributaries were divided into 641 segments.

The representative hydrologic period used for the WASP5 Model was a low-flow, high-temperature period in August – September 1994. Both point and nonpoint sources were represented in the model. Pollutant loadings from point and nonpoint sources were added as a direct input into the appropriate segment of the EUTRO model. Loads were represented as a constant source, and input into the model in units of lbs/day.

4.3 Model Calibration Process

The first step in calibrating a water quality model is to calibrate the hydrodynamics of the model. During the calibration process, several important hydrodynamic parameters were adjusted, and output from trial model runs was analyzed. After the adjustments were completed, output from the hydrodynamic model was compared to observed data by producing temporal profiles of observed and predicted measurements of tide level and flow velocity. The profiles are available in *Water Quality and Hydrodynamic Models for Back Bay of Biloxi, Volume II – Calibration/Verification, 1994/1995 Data* (Shindala et al. 1996). The profiles show that the predicted tide levels and flow velocity reasonably match the observed data at several points within the Back Bay of Biloxi system.

Calibration of the water quality model began after completion of the hydrodynamic calibration. In order to conduct the calibration, organic material and nutrient contributions from all sources were estimated or measured, hydrologic transport processes were superimposed, and then water quality modeling was performed to allow adjustments in parameters and sources as part of the calibration process. Water quality calibration is an iterative process; the model predictions are the integrated results of all the assumptions used in developing the model input and in representing the physical and chemical processes occurring in the waterbody. Difference in model predictions and the observations require the model user to reevaluate these assumptions, in terms of both the estimated model input and model parameters, and consider the accuracy and uncertainty in the observations. Graphs which show comparisons between monitoring data and model output are shown in *Water Quality and Hydrodynamic Models for Back Bay of Biloxi, Volume II – Calibration/Verification, 1994/1995 Data* (Shindala et al. 1996). Examination of the graphs in this document shows that the model, in general, reproduces most of the observed water quality data but does not predict every data point.

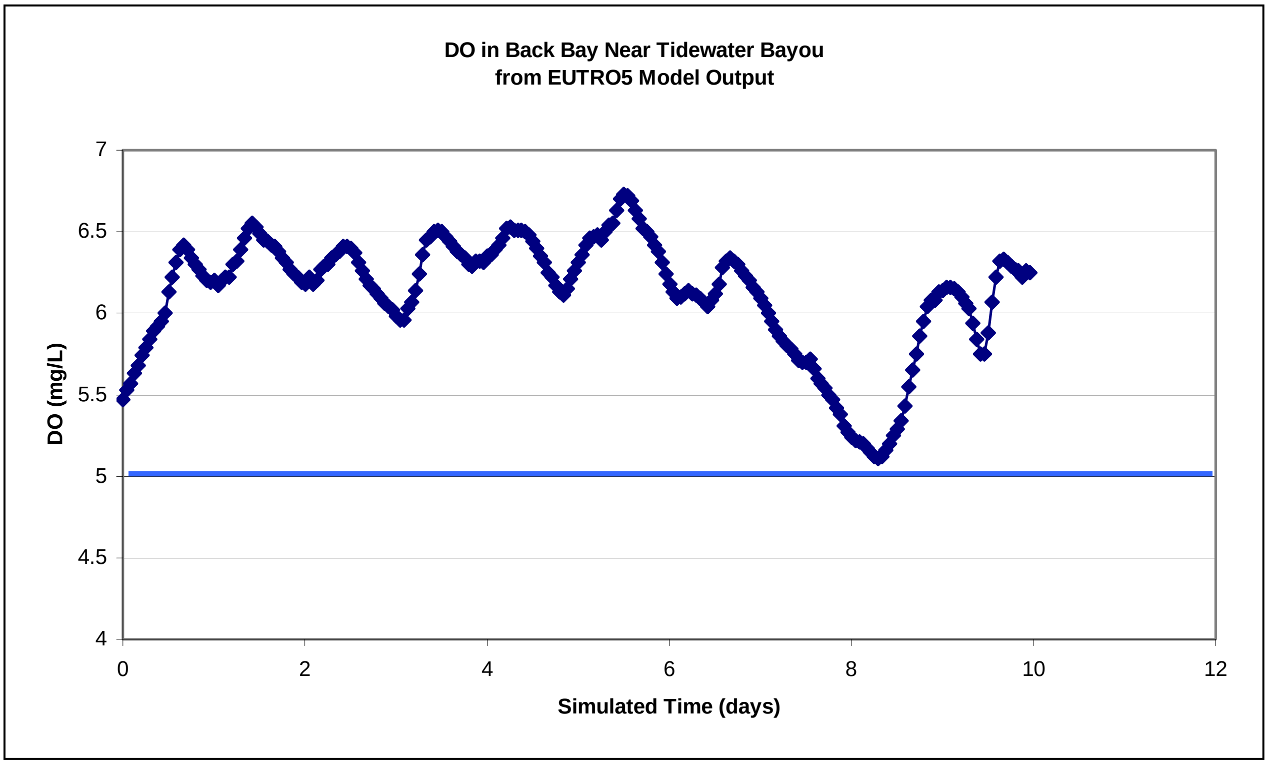
4.4 Selection of Representative Modeling Period

The NPSM model was run for a period representing a wet year, January through December 1995. A wet year was chosen for the representative modeling period, because it would predict a higher than usual amount of runoff from the watershed, which would increase the estimated nonpoint source loads. Using the higher estimates of nonpoint source loads for the TMDL ensures that water quality standards will be attained during all seasons of the year.

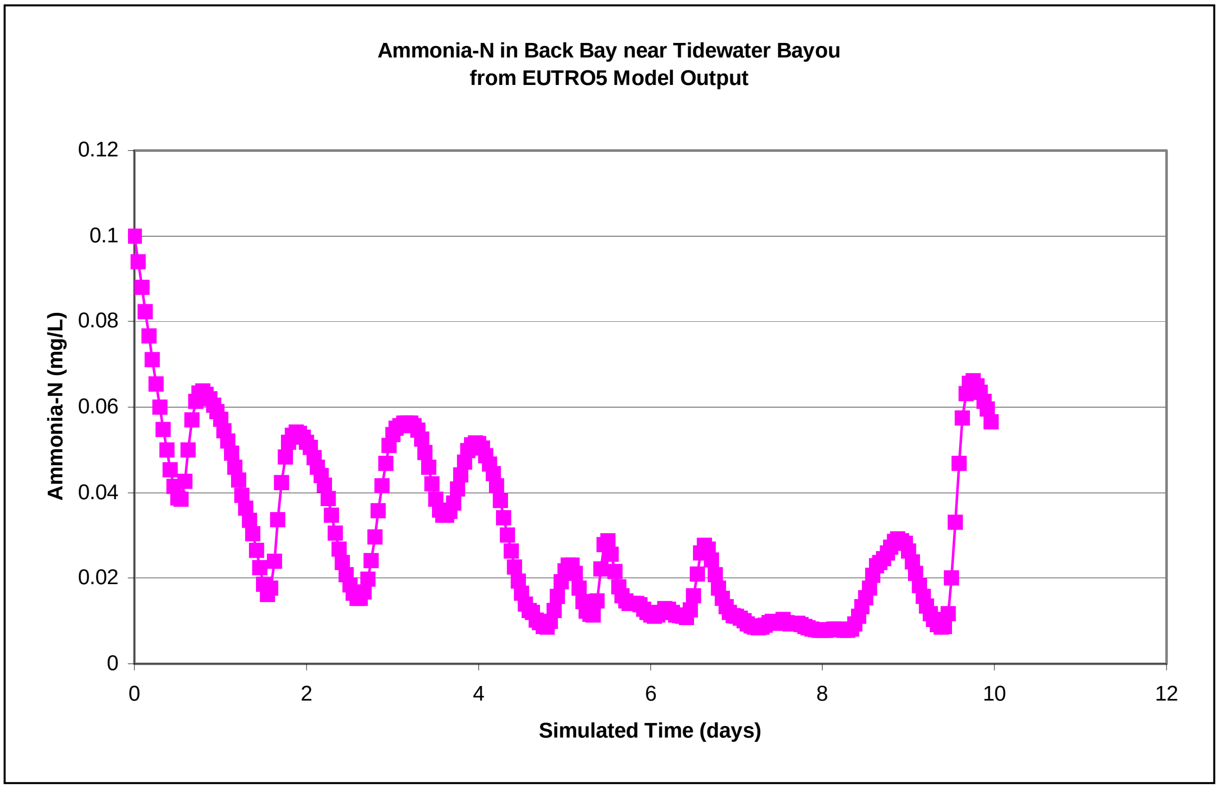
The WASP5 model was run for a 10-day period, simulating low-flow, critical conditions. The first two days of the model run allowed the model to stabilize, and output data from days three through ten were used to evaluate the water quality response to the pollutant loadings. The boundary flow condition for the modeled segment of Tidewater Bayou was set at the 7Q10 flow, .3027 cfs. The 7Q10 is the minimum flow expected for seven consecutive days during a period of ten years. The 7Q10 was calculated according to a method provided by the USGS in *Techniques for Estimating 7-Day, 10-Year Low Flow Characteristics on Ungaged Sites on Streams in MS*. Since the nonpoint source loads are based on a yearly average flow for a wet-year, they would not be expected to occur during 7Q10 flow conditions. However, placing these loads in the model at low flow conditions adds an additional margin of safety to the TMDL.

4.5 Model Results

These graphs of the model results show the instream water quality conditions in this TMDL. The first graph shows the daily average dissolved oxygen concentration in Tidewater Bayou on days 3 through 10 of the WASP5 model simulation. The straight line at 5.0 mg/l indicates the water quality target for this TMDL, which is a daily average dissolved oxygen concentration of 5.0 mg/l.



The second graph for the ammonia nitrogen concentrations in Tidewater Bayou shows the daily average ammonia nitrogen concentrations compared to the ammonia nitrogen standard for toxicity. As shown, the ammonia nitrogen concentrations do not exceed the chronic criteria of a 4-day average of 1.2 mg/l ammonia nitrogen.



5.0 ALLOCATION

The allocation for this TMDL involves a load allocation (LA) for nonpoint sources and an implicit margin of safety (MOS), which will result in continued attainment of water quality standards in Tidewater Bayou. The wasteload allocation specified in this TMDL is zero because this waterbody is not an appropriate discharge point for NPDES Permits. There is a current regional sewer system available for any potential discharger in this watershed.

At the current loads, water quality standards are attained and no reductions are necessary. However, it is recognized that the models used in this TMDL are limited, because collection of additional data and refinement of the models are necessary in order to better represent the physical and chemical processes occurring in the waterbody. Due to the limitations of the model, it is also recognized that the actual assimilative capacity of the waterbody may be greater than the loads specified in this TMDL.

5.1 Wasteload Allocations

The contribution of load from point sources was included in the Back Bay model used for this study based on the facilities' current NPDES permit limits and available discharge monitoring data. No reduction in the current wasteload allocation was necessary to establish this TMDL. None of the facilities had a direct impact on this waterbody.

This waterbody is not an appropriate discharge location for future development. The regional sewer system serves this area. The original city POTW was removed from this bayou to enhance the use of the marina. Future discharges into the bayou will not be allowed.

5.2 Load Allocations

The load allocation developed for this TMDL is an estimation of the contribution of all nonpoint sources in the watershed. Measurements of the relative contribution of actual sources in the watershed were not considered due to the difficulty of obtaining such data. Estimates of nonpoint sources were estimated based on data collected at Simmons Bayou and Davis Bayou during the intensive studies of Back Bay. Because land uses are similar, the assumption was made that the concentrations of organic substances and nutrients found in runoff in the headwater watershed of Simmons Bayou and Davis Bayou would be the same as the concentrations resulting from runoff in the Tidewater Bayou watershed.

5.3 Incorporation of a Margin of Safety (MOS)

The two types of MOS development are to implicitly incorporate the MOS using conservative model assumptions or to explicitly specify a portion of the total TMDL as the MOS. The MOS selected for this model is implicit. Running the model simulations with no violations of the water standard throughout the critical condition period provides the primary component of the MOS. Another component of the MOS is the conservative assumption that the yearly average runoff and nonpoint source loads reach the stream during the 7Q10 flow.

5.4 Calculation of the TMDL

The wasteload allocation has been set to zero. The load allocation includes the contributions from surface runoff. The margin of safety for this TMDL is implicit and derived from the conservative loading assumptions used in setting up the model. This TMDL was calculated based on the following equation:

$$\boxed{\textbf{TMDL = WLA + LA + MOS}} \qquad \text{Equation 2}$$

WLA= Set to 0

LA = 7.6 mg/l * 8.34 conversion factor * 10.36 cfs / 1.547 conversion factor = 424 lbs / day

MOS = Implicit

Table 5.1 Calculation of the TMDL

Parameter	WLA	LA	MOS	TMDL
$TBOD_U$ (lbs/day)	0	424	Implicit	**424**

5.5 Seasonality

The NPSM model was run for a representative wet year, and took into account all of the seasons within the calendar year. This time period allowed the simulation of many different atmospheric conditions such as rainy and dry periods and high and low temperatures. It also allowed seasonal critical conditions to be simulated. In order to ensure that water quality conditions will be met during all atmospheric conditions, the WASP5 model was run during the critical condition period.

6.0 TOTAL TOXICITY TMDL

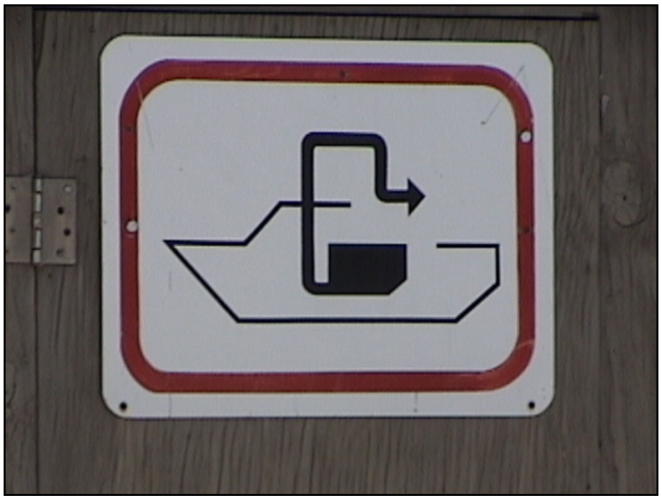
The target for the Total Toxicity TMDL is that waters shall be free from substances attributable to municipal, industrial, agricultural or other discharges in concentrations, which are toxic or harmful to humans, animals, or aquatic life. Specific requirements for toxicity are found in Section II.9. *State of Mississippi Water Quality Criteria for Intrastate, Interstate, and Coastal Waters* – 1995.

For some pollutants, TMDLs are expressed on a mass-loading basis (e.g., pounds per day). In accordance with 40CFR Part 130.2(i), "TMDLs can be expressed in terms of …mass per time, toxicity, or other appropriate measure." In addition, NPDES permitting regulations in 40CFR 122.45(f) state that, "All pollutants limited in permits shall have limitations…expressed in terms of mass except…pollutants which cannot appropriately be expressed by mass." For the toxicity TMDL for waters in the Coastal Basin, the TMDL is expressed in terms of toxicity units (TUs).

To evaluate other potential sources, such as nonpoint source runoff impacts on Tidewater Bayou, EPA Region 4 and MDEQ conducted toxicity tests on surface water samples from two points in the waterbody. Due to the wide range of salinities, two different fish were used for the toxicity tests. The freshwater fathead minnow were used on samples with less than 2 parts salinity and the estuarine silverside minnow for 2 to 22 parts salinity. Sampling occurred in May 2001. This is a representative time of springtime nonpoint source runoff and fairly high water temperature (25 to 27 degrees C). The results of the samples in Tidewater Bayou showed no mortality in the 40 organisms tested, therefore no toxicity is believed present from nonpoint sources.

This TMDL has been established to protect against toxicity. Due to the inappropriateness of this waterbody to accept a discharge from a NPDES Permitted facility, the wasteload allocation for toxicity is zero TUs. Based on the previously described surface water toxicity testing, nonpoint toxicity is believed to be absent and therefore the load allocation for total toxicity is zero. The seasonality and MOS are addressed by establishing the limits at zero dilution tidal mixing. Therefore, the TMDL for toxicity in Tidewater Bayou is zero TUs.

7.0 CONCLUSION



Sign at Tidewater Marina Pump Out House

MDEQ's current assessment methodology indicates that Tidewater Bayou is fully supporting for the designated use. The TMDL for dissolved oxygen reinforces the fact that earlier improvements in the waterbody were created by the removal of the city POTW from this bayou. Additionally, the regional sewer system brought better pump stations and maintenance for the sewer to eliminate the chronic bypass. This waterbody is used for a marina. There is no recreational access and swimming is not allowed in the waterbody. The marina has installed a pump out station available for boaters that use the marina. The marina also dredges the bayou annually to maintain the needed water depth in the marina for the boats. MDEQ believes this waterbody is not impaired and will remove it from the next Section 303(d) list of waterbodies.

7.1 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 yearlong cycle, MDEQ resources for water quality monitoring will be focused on one of the basin groups. During the next monitoring phase in the Coastal Streams Basin, the Biloxi Bay Watershed will receive additional monitoring to identify any changes or improvements in water quality. Any request for modification of this TMDL will require additional monitoring to validate the modeling results.

7.2 Public Participation

This TMDL will be published for a 30-day public notice. During this time, the public will be notified by publication in the statewide newspaper and a newspaper in the area of the watershed. The public will be given an opportunity to review the TMDL and submit comments. At the end of the 30-day period, MDEQ will determine the level of interest in the TMDL and make a decision on the necessity of holding a public meeting.

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 ultimate completion of this TMDL for submission of this TMDL to EPA Region 4 for final approval.

DEFINITIONS

Aerobic: Environmental conditions characterized by the presence of dissolved oxygen; used to describe biological or chemical processes that occur in the presence of oxygen.

Algal growth: Algal growth is related to temperature, available light, and the available abundance of inorganic nutrients (N, P, Si). Algal species groups (e.g., diatoms, greens, etc.) are typically characterized by different maximum growth rates.

Algal respiration: Process of endogenous respiration of algae in which organic carbon biomass is oxidized to carbon dioxide.

Algae: Any organisms of a group of chiefly aquatic microscopic nonvascular plants; most algae have chlorophyll as the primary pigment for carbon fixation. As primary producers, algae serve as the base of the aquatic food web, providing food for zooplankton and fish resources. An overabundance of algae in natural waters is known as eutrophication.

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.

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

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

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.

Biochemical oxygen demand (BOD): The amount of oxygen per unit volume of water required to bacterially or chemically oxidize (stabilize) the oxidizable matter in water. Biochemical oxygen demand measurements are usually conducted over specific time intervals (5, 10, 20, 30 days). The term BOD generally refers to a standard 5-day BOD test. BOD = CBOD + NBOD.

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

Calibration: The process of adjusting model parameters within physically defensible ranges until the resulting predictions give a best possible good fit to observed data.

Carbonaceous Biological Oxygen Demand (CBOD): Refers to the oxygen demand associated with the oxidation of organic carbon

Chlorophyll: A group of green photosynthetic pigments that occur primarily in the chloroplast of plant cells. The amount of chlorophyll *a*, a specific pigment, is frequently used as a measure of algal biomass in natural waters.

Chronic toxicity: Toxicity impact that lingers or continues for a relatively long period of time, often one-tenth of an organism's life span or longer. Chronic effects could include mortality, reduced growth, or reduced reproduction.

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.

Decay: The gradual decrease in the amount of a given substance in a given system due to various sink processes including chemical and biological transformation, dissipation to other environmental media, or deposition into storage areas.

Decomposition: Metabolic breakdown of organic materials; the formation of by-products of decomposition releases energy and simple organic and inorganic compounds.

Denitrification: The process of decomposition of nitrites and nitrates (by bacteria) that results in the eventual release of nitrogen gas into the atmosphere.

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.

Diurnal: Actions or processes that have a period or a cycle of approximately one tidal-day or are completed within a 24-hour period and that recur every 24 hours.

Dynamic model: A mathematical formulation describing and simulating the physical behavior of a system or a process and its temporal variability.

Effluent: Treated wastewater flowing out of the treatment facilities.

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.

Eutrophication: The natural aging process during which a lake, estuary, or bay evolves into a bog or marsh and eventually disappears. During the later stages of eutrophication the waterbody is choked by abundant plant life as the result of increased amounts of nutritive compounds such as nitrogen and phosphorus. Human activities can accelerate the process of nutrient enrichment in waterbodies, resulting in accelerated biological productivity (growth of algae and weeds) and an undesirable accumulation of algal biomass.

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

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

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

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

Macrophytes: The larger aquatic plants of all types. They are sometimes attached to the waterbody bottom, sometimes free-floating, sometimes totally submersed, and sometimes partially emergent. Complex types usually have true roots, stems, and leaves; the macroalgae are simpler but may have stem- and leaf-like structures.

Nitrate (NO_3) and Nitrite (NO_2): Oxidized nitrogen species. Nitrate is the form of nitrogen preferred by aquatic plants.

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

Nitrifier organisms: Bacterial organisms that mediate the biochemical oxidative processes of nitrification.

Nitrogen: A nutrient assimilated by plants which promotes growth. The most bioavailable forms of nitrogen are nitrate (NO_3), nitrite (NO_2), and ammonia (NH_3).

Nitrogenous biochemical oxygen demand (NBOD): The oxygen demand associated with the oxidation of ammonia.

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

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

Nutrient: A primary element necessary for the growth of living organisms. Carbon dioxide, nitrogen, and phosphorus, for example, are required nutrients for phytoplankton growth

Organic matter: The organic fraction that includes plant and animal residue at various stages of decomposition, cells and tissues of soil organisms, and substances synthesized by the soil population. Commonly determined as the amount of organic material contained in a soil or water sample.

Organic nitrogen: Nitrogen in a form that is bound to an organic compound.

Organic phosphorous: Phosphorus in a form that is bound to an organic compound.

Orthophosphate: Phosphorus in a form that is most readily available to plants. It consists of the species $H_2PO_4^{2-}$, HPO_4^{2-}, and PO_4^{3-}. (Also known as soluble reactive phosphorus (SRP).)

Oxygen depletion: A deficit of dissolved oxygen in a water system due to oxidation of organic matter.

Phased approach: Under the phased approach to TMDL development, load allocations and wasteload allocations are calculated using the best available data and information recognizing the need for additional monitoring data to accurately characterize sources and loadings. The phased approach is typically employed when nonpoint sources dominate. It provides for the implementation of load reduction strategies while collecting additional data.

Phosphorus: A nutrient assimilated by plants which promotes growth. The most bioavailable form of phosphorus is soluble reactive phosphorus (SRP), also known as orthophosphate.

Photosynthesis: The biochemical synthesis of carbohydrate-based organic compounds from water and carbon dioxide using light energy in the presence of chlorophyll. Photosynthesis occurs in all plants, including aquatic organisms such as algae and macrophytes. Photosynthesis also occurs in primitive bacteria such as blue-green algae.

Plankton. Group of generally microscopic plants and animals passively floating, drifting, or swimming weakly. Plankton include the phytoplankton (plants) and zooplankton (animals).

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

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

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

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

Soluble reactive phosphorus: Form of phosphorus that is most readily available to plants. It consists of the species $H_2PO_4^{2-}$, HPO_4^{2-}, and PO_4^{3-}. (Also known as orthophosphate.)

Total Kjeldahl nitrogen (TKN): The total of organic and ammonia nitrogen in a sample, determined by the Kjeldahl method

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

Total nitrogen (TN): The total amount of nitrogen in a sample, including organic nitrogen, nitrate (NO_3), nitrite (NO_2), and ammonia (NH_4).

Total phosphorus (TP): The total amount of phosphorus in a sample, including both organic and inorganic forms. In most lakes, the organic forms of phosphorus make up a large majority of the total phosphorus.

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

CWA .... Clean Water Act

DMR .... Discharge Monitoring Report

DYNHYD5 .... Hydrodynamic Model - 5

EPA .... Environmental Protection Agency

GIS .... Geographic Information System

HUC .... Hydrologic Unit Code

LA .... Load Allocation

MARIS .... State of Mississippi Automated Information System

MDEQ .... Mississippi Department of Environmental Quality

MOS .... Margin of Safety

NPDES .... National Pollution Discharge Elimination System

NPSM .... Nonpoint Source Model

RF3 .... Reach File 3

USGS .... United States Geological Survey

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

WLA .... Waste Load Allocation

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