FINAL

TMDLs for Dissolved Oxygen and Nutrients in Selected Subsegments in the Middle Terrebonne Basin, Louisiana

(120202, 120204, 120304, 120403, 120604)

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EXECUTIVE SUMMARY

Section 303(d) of the Clean Water Act and the U.S. Environmental Protection Agency's (EPA's) Water Quality Planning and Management Regulations (at Title 40 of the *Code of Federal Regulations* [CFR] Part 130) require states to develop Total Maximum Daily Loads (TMDLs) for impaired waterbodies. A TMDL establishes the amount of a pollutant that a waterbody can assimilate while still meeting the water quality standard for that pollutant. TMDLs provide the scientific basis for a state to establish water quality-based controls to reduce pollution from both point and nonpoint sources to restore and maintain the quality of the state's water resources (USEPA 1991).

A TMDL for a given pollutant and waterbody is composed of the sum of individual wasteload allocations (WLAs) for point sources and load allocations (LAs) for nonpoint sources and natural background levels. In addition, the TMDL must include an implicit or explicit margin of safety (MOS) to account for the uncertainty in the relationship between pollutant loads and the quality of the receiving waterbody, and it may include a future growth (FG) component. The TMDL components are illustrated using the following equation:

$$TMDL = \Sigma\ WLAs + \Sigma\ LAs + MOS + FG$$

The study area for this TMDL includes five middle Terrebonne Basin subsegments. The middle Terrebonne Basin is mainly in Terrebonne Parish; smaller portions are in Assumption, St. Mary's, and Lafourche Parishes. Land use in the middle Terrebonne Basin is dominated by wetlands, water, and cultivated crop production. There are areas of urban land in each subsegment. Heavy rainfall events typically occur in March and April as frontal weather systems pass through.

The Louisiana Department of Environmental Quality (LDEQ) has included five middle Terrebonne Basin subsegments on the state's 2004 section 303(d) list of impaired waterbodies. The subsegments are listed for dissolved oxygen and nutrient impairments. The impaired designated uses for the subsegments (Table ES-1) are primary and secondary contact recreation (PCR and SCR), fish and wildlife propagation (FWP), drinking water supply (DWS), and agriculture (AGR). The subsegments are either fully supporting (F) or not supporting (N).

Table ES-1. Section 303(d) listing for subsegments included in this report

Sub-segment	Subsegment name	Subsegment description	Designated use				
			PCR	SCR	FWP	DWS	AGR
120202	Bayou Black	ICWW to Houma	F	F	N	F	
120204	Lake Verret and Grassy Lake	Lake Verret and Grassy Lake	F	F	N		
120304	Intracoastal Waterway	Houma to Larose	F	F	F	F	F
120403	Intracoastal Waterway	Bayou Boeuf Locks to Bayou Black in Houma; includes portions of Bayous Boeuf, Black, Chene, and Cocodrie	F	F	F	F	F
120604	Bayou Blue	ICWW to Grand Bayou Canal	N	F	N		

A water quality model (LA-QUAL) was set up to simulate dissolved oxygen, carbonaceous biochemical oxygen demand (CBOD), ammonia nitrogen, and nitrate+nitrite. The model was calibrated using data from fieldwork conducted in July 2006. The projection simulation was run at critical flows and temperatures to address seasonality, as the Clean Water Act requires. Reductions of existing nonpoint source loads were required for the projection simulation to show maintenance of the dissolved oxygen standard, 5 milligrams per liter (mg/L). In general, the modeling in this study was consistent with guidance in the Louisiana TMDL technical procedures manual (LDEQ 2005). TMDLs for oxygen-demanding substances ($CBOD_u$, ammonia, and sediment oxygen demand [SOD]) were calculated using the projection simulation.

In TMDL development, allowable loads from all pollutant sources that cumulatively amount to no more than the TMDL must be established, thereby providing the basis for establishing water quality-based controls. WLAs were assigned to permitted point source discharges. The LAs include background loadings and human-induced nonpoint sources. An explicit MOS of 10 percent and an FG component of 10 percent were also included.

The dissolved oxygen TMDL establishes load limitations for oxygen-demanding substances and goals for reducing those pollutants. When oxygen-demanding substances are controlled and limited to ensure that the dissolved oxygen criterion is supported, nutrients are also controlled and limited. Implementing the dissolved oxygen TMDL through future wastewater discharge permits, if required, and implementing best management practices to control and reduce runoff of soil and oxygen-demanding pollutants from nonpoint sources in the watershed will also control and reduce the nutrient loading from those sources.

Table ES-2 presents a summary of the dissolved oxygen TMDLs for the subsegments addressed in this report. The numeric water quality criterion that applies to the impaired subsegments and used to calculate the total allowable dissolved oxygen pollutant loads is 5 mg/L.

Table ES-3 presents a summary of the reduction percentages for LAs for oxygen demand. There were no reductions to nutrients. Reduction percentages from baseline conditions for total oxygen demand ranged from 0 to 32 percent. There were no reductions for WLAs.

Table ES-2. Summary of dissolved oxygen TMDLs, WLAs, LAs, MOSs, and FGs for the middle Terrebonne Basin

Subsegment	Oxygen demand (lb/d)				
120202	SOD	$CBOD_u$	Ammonia	Organic N	Total
WLA	624	2,109	1,009	1,049	4,791
MOS for WLA	78	264	126	131	599
FG for WLA	78	264	126	131	599
LA	6,495	10,293	992	6,165	23,944
MOS for LA	812	1,287	124	771	2,993
FG for LA	812	1,287	124	771	2,993
TMDL	8,899	15,502	2,501	9,017	35,919

Table ES-2. (continued)

Subsegment	Oxygen demand (lb/d)				
120204	**SOD**	**$CBOD_u$**	**Ammonia**	**Organic N**	**Total**
WLA	4,208	14,151	164	1,389	19,911
MOS for WLA	526	1,769	20	174	2,489
FG for WLA	526	1,769	20	174	2,489
LA	313,737	1,044,751	3,468	99,166	1,461,122
MOS for LA	39,217	130,594	434	12,396	182,640
FG for LA	39,217	130,594	434	12,396	182,640
TMDL	397,431	1,323,627	4,540	125,693	1,851,291
Subsegment	**Oxygen demand (lb/d)**				
120304	**SOD**	**$CBOD_u$**	**Ammonia**	**Organic N**	**Total**
WLA	496	6,890	73	1,303	8,762
MOS for WLA	62	861	9	163	1,095
FG for WLA	62	861	9	163	1,095
LA	8,397	116,442	1,082	21,985	147,906
MOS for LA	1,050	14,555	135	2,748	18,488
FG for LA	1,050	14,555	135	2,748	18,488
TMDL	11,116	154,166	1,444	29,109	195,836
Subsegment	**Oxygen demand (lb/d)**				
120403	**SOD**	**$CBOD_u$**	**Ammonia**	**Organic N**	**Total**
WLA	850	2,366	88	1,165	4,470
MOS for WLA	106	296	11	146	559
FG for WLA	106	296	11	146	559
LA	73,374	199,703	4,822	99,162	377,060
MOS for LA	9,172	24,963	603	12,395	47,133
FG for LA	9,172	24,963	603	12,395	47,133
TMDL	92,780	252,586	6,138	125,409	476,913
Subsegment	**Oxygen demand (lb/d)**				
120604	**SOD**	**$CBOD_u$**	**Ammonia**	**Organic N**	**Total**
WLA	0	35	22	11	68
MOS for WLA	0	4	3	1	9
FG for WLA	0	4	3	1	9
LA	910	3,984	166	1,818	6,879
MOS for LA	114	498	21	227	860
FG for LA	114	498	21	227	860
TMDL	1,138	5,024	235	2,286	8,684

Table ES-3. Summary of reduction percentages for LAs in the middle Terrebonne Basin

Subsegment	Percent reduction				
	SOD	**$CBOD_u$**	**Ammonia**	**Organic N**	**Total**
120202	23.7	12.7	8.8	9.4	15.1
120204	13.2	22.6	1.3	21.9	20.6
120304	70.9	22.1	40.9	39.5	31.7
120403	11.7	7.8	1.1	3.7	7.5
120604	0.0	0.0	0.0	0.0	0.0

Table ES-4 presents a summary of the nutrient TMDLs for the subsegments addressed in this report. The state's nutrient criteria are narrative and include the following language (LDEQ 2007):

> The naturally occurring range of nitrogen-phosphorous ratios shall be maintained. This range shall not apply to designated intermittent streams. To establish the appropriate range of ratios and compensate for natural seasonal fluctuations, the administrative authority will use site-specific studies to establish limits for nutrients. Nutrient concentrations that produce aquatic growth to the extent that it creates a public nuisance or interferes with designated water uses shall not be added to any surface waters.

Table ES-4. Summary of TMDLs for nutrients in the middle Terrebonne Basin

Subsegment	MOS (10%) (lb/d)	Total allowable loading (lb/d)	Percent reduction
Total phosphorus			
120202	0.06	0.64	0.00
120204	0.08	0.76	0.00
120304	0.00	0.03	0.00
Total nitrogen			
120202	0.39	3.90	0.00
120204	0.47	4.68	0.00
120304	0.02	0.16	0.00

Hurricane Katrina made landfall on Monday, August 29, 2005, as a Category 4 hurricane. The storm brought heavy winds and rain to southeast Louisiana, breaching several levees and flooding up to 80 percent of New Orleans and large areas of coastal Louisiana. Both Hurricanes Katrina and Rita have caused a significant amount of change in sedimentation and water quality in southern Louisiana. Many wastewater treatment facilities were temporarily or permanently damaged. Some wastewater treatment facilities will be rebuilt; others will be relocated.

The proposed TMDLs in this report were developed on the basis of pre- and post-hurricane water quality conditions. Some point sources in this TMDL have been updated with post-hurricane information, where available. Post-hurricane water quality conditions and other factors could delay the implementation of these proposed TMDLs, render some proposed TMDLs obsolete, or require modifications of the TMDLs. Although hurricane effects might be valid for some TMDLs, any deviation from the TMDLs should be justified using site-specific data or information.

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1 INTRODUCTION

Section 303(d) of the Clean Water Act and the U.S. Environmental Protection Agency's (EPA's) Water Quality Planning and Management Regulations (at Title 40 of the *Code of Federal Regulations* [CFR] Part 130) require states to develop Total Maximum Daily Loads (TMDLs) for waterbodies that are not supporting their designated uses, even if pollutant sources have implemented technology-based controls. A TMDL establishes the maximum allowable load (in mass per unit time) of a pollutant that a waterbody is able to assimilate while still supporting its designated uses. The maximum allowable load is determined on the basis of the relationship between pollutant sources and in-stream water quality. A TMDL provides the scientific basis for a state to establish water quality-based controls to reduce pollution from both point and nonpoint sources to restore and maintain the quality of the state's water resources (USEPA 1991).

Monitoring data collected by the Louisiana Department of Environmental Quality (LDEQ) indicate that observed dissolved oxygen levels sometimes do not meet the state's water quality criteria in five subsegments in the middle Terrebonne Basin. The impaired designated uses for the subsegments are primary and secondary contact recreation, fish and wildlife propagation, drinking water supply, and agriculture. The subsegments are either fully supporting (F) or not supporting (N) the designated uses. Table 1-1 presents information from Louisiana's 2004 section 303(d) list of impaired waters for the five subsegments. All the subsegments have the suspected cause of *unknown sources*, which indicates that various sources might be present but not enough data are available to identify them.

Table 1-1. Subsegments and impairments addressed in this report

Sub-segment	Subsegment name	Subsegment description	Designated use				
			PCR	SCR	FWP	DWS	AGR
120202	Bayou Black	ICWW to Houma	F	F	N	F	
120204	Lake Verret and Grassy Lake	Lake Verret and Grassy Lake	F	F	N		
120304	Intracoastal Waterway	Houma to Larose	F	F	F	F	F
120403	Intracoastal Waterway	Bayou Boeuf Locks to Bayou Black in Houma; includes portions of Bayous Boeuf, Black, Chene, and Cocodrie	F	F	F	F	F
120604	Bayou Blue	ICWW to Grand Bayou Canal	N	F	N		

Oxygen concentrations in the water column fluctuate under natural conditions, but severe depletion usually results from human activities that introduce large quantities of biodegradable organic materials into surface waters. In polluted waters, bacterial degradation of organic materials can result in a net decline in oxygen concentrations in the water. Oxygen depletion can also result from chemical reactions that place a chemical oxygen demand on receiving waters. Other factors, such as temperature and salinity, influence the amount of oxygen dissolved in water. For example, prolonged hot weather decreases oxygen concentrations and can cause fish kills even in clean waters because warm water cannot hold as much oxygen as cold water (Scorecard 2005).

Other factors that affect dissolved oxygen concentrations include the following (Murphy 2005):

- Volume and velocity of water flowing in the waterbody
- Climate and season
- The type and number of organisms in the waterbody
- Altitude
- Dissolved or suspended solids
- Amount of nutrients in the water
- Organic waste
- Riparian vegetation
- Ground water inflow

Low dissolved oxygen concentrations in streams can be linked to both natural conditions and human activities. In Louisiana natural stream conditions like low flow, high temperature, and high organic content often result in dissolved oxygen levels already below current water quality criteria, making it difficult to develop standards for best management practices, or BMPs (Mason et al. 2007). Additional data for these 303(d)-listed areas are needed to determine whether the low dissolved oxygen occurs naturally or is related to human activity (i.e., is anthropogenic).

2 BACKGROUND INFORMATION

2.1 General Description

The study region consisted of five subsegments in the middle portion of the Terrebonne Basin: Bayou Black (subsegment 120202); Lake Verret and Grassy Lake (subsegment 120204); Intracoastal Waterway east of Houma (subsegment 120304); Intracoastal Waterway–Bayou Boeuf Locks to Bayou Black in Houma, which includes portions of Bayous Boeuf, Black, Chene, and Cocodrie (subsegment 120403); and Bayou Blue (subsegment 120604). The middle Terrebonne Basin is mainly in Terrebonne Parish; there are smaller portions in Assumption, St. Mary's, and Lafourche Parishes. Table 2-1 lists the parishes and approximate drainage area of each subsegment, and Figure 2-1 shows the locations of the subsegments. The watershed's U.S. Geological Survey (USGS) hydrologic unit code is 08090302.

Table 2-1. Drainage area and parish of each subsegment

Subsegment name	Subsegment	Parish	Area (mi^2)	Area (km^2)
Bayou Black	120202	Assumption, Lafourche, Terrebonne	133	345
Lake Verret and Grassy Lake	120204	Assumption	149	386
Intracoastal Waterway east of Houma	120304	Lafourche, Terrebonne	5	14
Intracoastal Waterway – Bayou Boeuf Locks	120403	Assumption, St. Mary, Terrebonne	137	355
Bayou Blue	120604	Lafourche, Terrebonne	26	69

2.2 Land Use

Land use data were obtained from the 2001 USGS National Land Cover Dataset (NLCD; Figure 2-2 and Table 2-2). The predominant land use in the impaired subsegments is wetland. The percentage of wetlands in the watersheds ranges from 36 percent to 81 percent followed by cultivated crops, water, and developed. There is very little barren, forest, or grassland/shrub land in any of the five subsegments. Subsegments 120202 and 120204 have cultivated crops as roughly a quarter of the land use. Subsegments 120403 and 120604 are over 90 percent wetlands and open water.

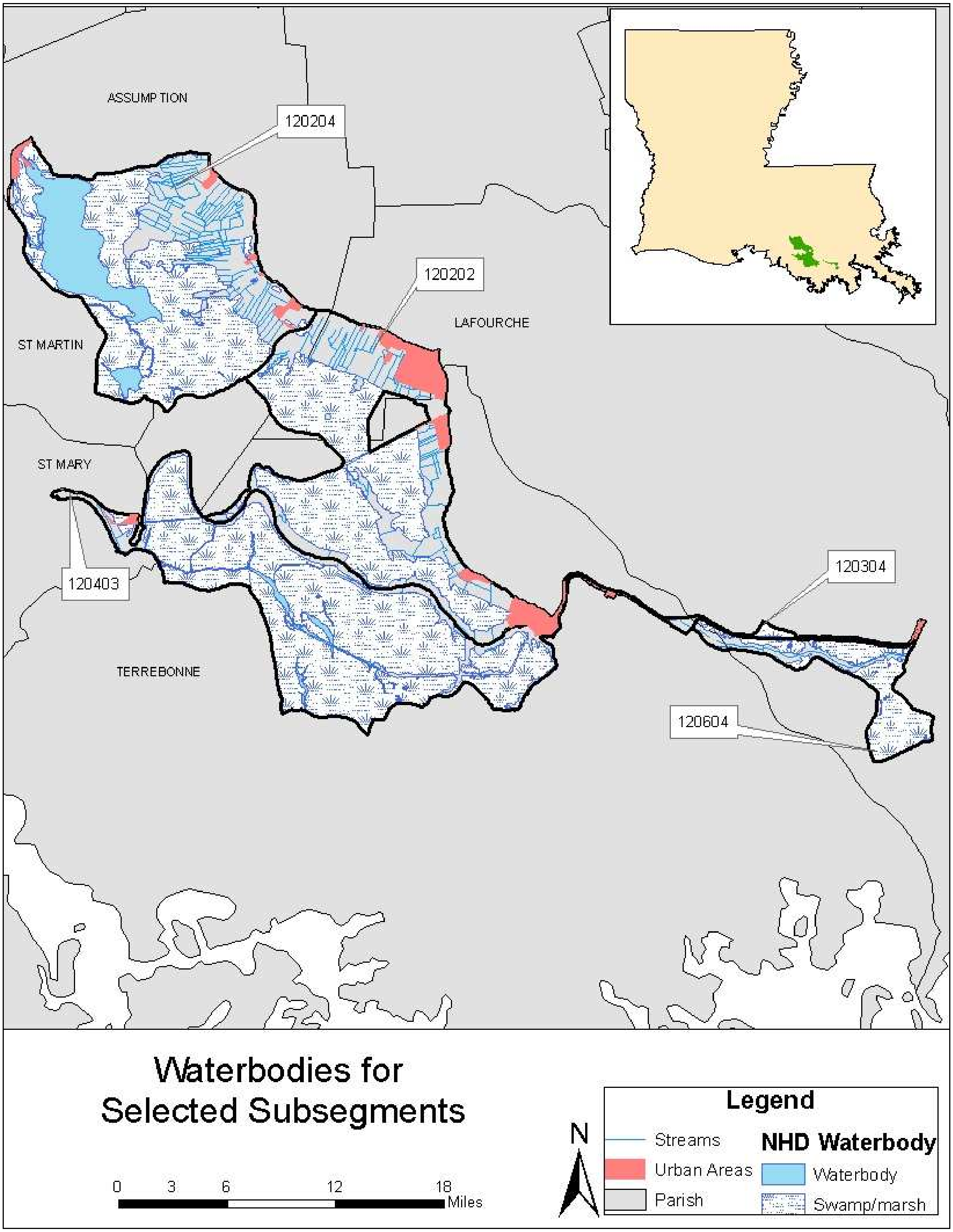

Figure 2-1. Locations of middle Terrebonne Basin subsegments.

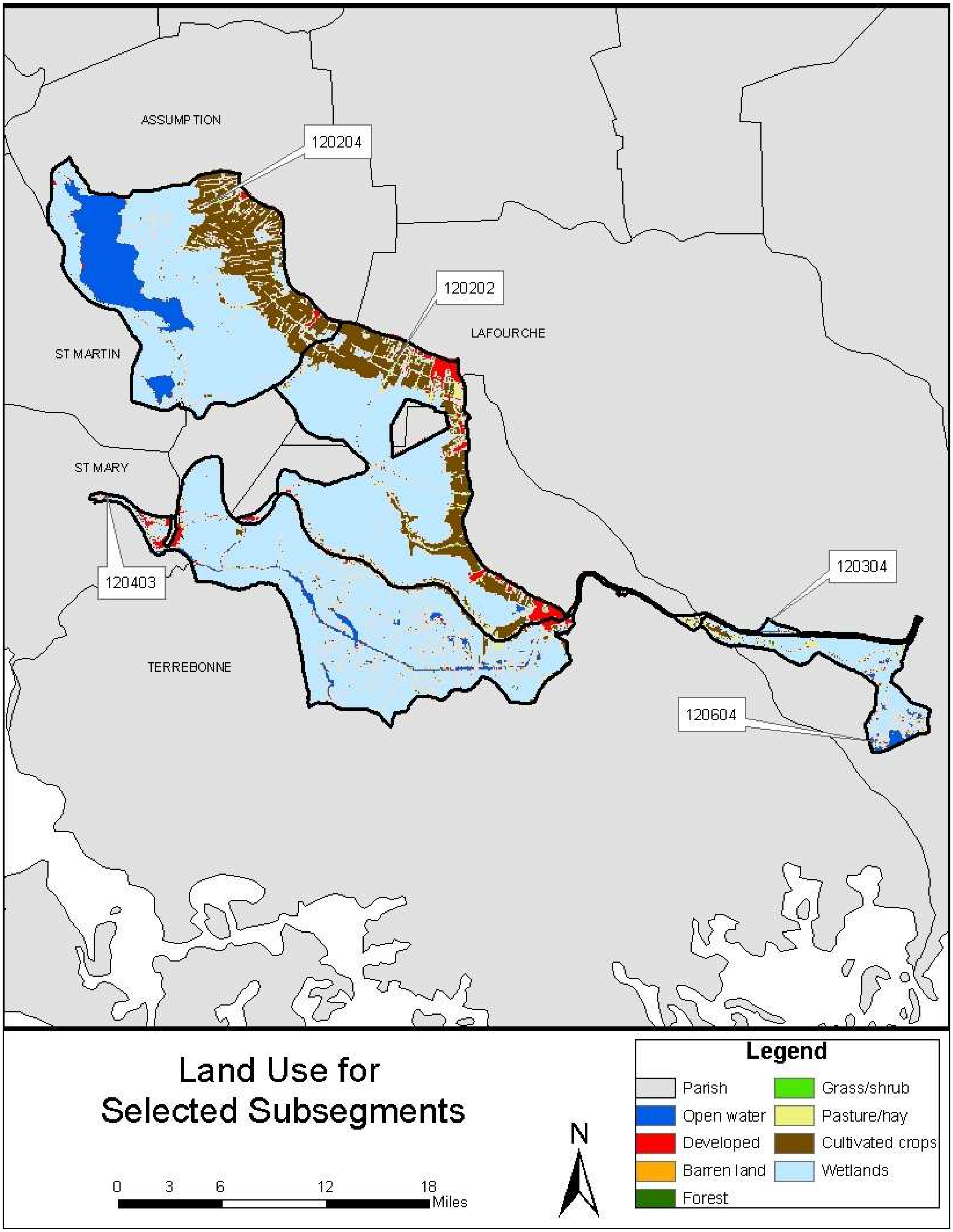

Figure 2-2. Land use in the middle Terrebonne Basin subsegments.

Table 2-2. Land use percentages for each listed subsegment in the middle Terrebonne Basin

Land use type	Percent of total area				
	Bayou Black (120202)	Lake Verret (120204)	Intracoastal Waterway (120304)	Intracoastal Waterway (120403)	Bayou Blue (120604)
Water	0.53	17.78	41.71	9.70	13.96
Developed	9.06	2.22	12.04	3.48	2.37
Barren	0.16	0.00	0.03	0.08	0.11
Forest	0.01	0.00	0.00	0.01	0.00
Grassland/shrub	0.31	0.08	0.24	0.15	0.25
Pasture/hay	1.86	0.38	3.91	1.58	3.26
Cultivated crops	25.52	22.79	6.53	3.50	3.85
Wetlands	62.55	56.75	35.53	81.49	76.20
TOTAL	100.00	100.00	100.00	100.00	100.00

2.3 Hydrologic Setting

Because reversing flows occur at times throughout the Terrebonne Basin, there are very few USGS flow gauges in the Terrebonne Basin. The USGS online hydrology database, NWISWeb, contains two stations with flow data for the listed subsegments that are impaired for dissolved oxygen and nutrients. One station, on the Intracoastal Waterway near Houma (USGS station 07381331; subsegment 120304), has only peak discharge data and was not used. The other station is on the Intracoastal Waterway near Bay Wallace (USGS 073816505; subsegment 120403). Not using negative flows, the average flow at this station is 5,737 cubic feet per second (cfs); the minimum flow is 292 cfs, and the maximum is 11,500 cfs.

2.4 Designated Uses and Water Quality Criteria

Louisiana's 2004 section 303(d) list indicates that the four listed subsegments—all assigned a use of primary or secondary contact recreation, fish and wildlife propagation, outstanding natural resource, or shellfish propagation—do not meet applicable water quality standards because of unknown sources. Primary contact recreation includes any recreational or other water contact involving full-body exposure to water and a considerable probability of ingesting water. Examples of the use are swimming and water skiing. Secondary contact recreation involves activities like fishing, wading, or boating, where water contact is accidental or incidental and there is a minimal chance of ingesting appreciable amounts of water. Fish and wildlife propagation includes the use of water for aquatic habitat, food, resting, reproduction, cover, or travel corridors for any indigenous wildlife and aquatic life species associated with the aquatic environment. Outstanding Natural Resource Waters are waterbodies designated for preservation, protection, reclamation, or enhancement of wilderness, aesthetic qualities, and ecological regimes, such as those designated under the Louisiana Natural and Scenic Rivers System or those designated by the department as waters of ecological significance. Characteristics of outstanding natural resource waters include highly diverse or unique in-stream or riparian habitat, high species diversity, balanced trophic structure, unique species, or similar qualities. Shellfish propagation involves the use of water to maintain biological systems that support economically important species of shellfish so that their productivity is preserved and the health of human consumers of these species is protected.

The assessment methodology presented in LDEQ's 305(b) report (LDEQ 2004) specifies that primary contact recreation, secondary contact recreation, and fish and wildlife propagation uses are to be fully supported. The state minimum dissolved oxygen criterion for the subsegments in this TMDL is 5 milligrams per liter (mg/L) year-round.

Louisiana does not have numeric water quality standards for nutrients, but its narrative standard for nutrients states the following:

- The naturally occurring range of nitrogen-phosphorus ratios shall be maintained (except for intermittent streams), and
- Nutrient concentrations that produce aquatic growth to the extent that it creates a public nuisance or interferes with designated water uses shall not be added to any surface waters.

The Louisiana water quality standards also include an antidegradation policy (*Louisiana Administrative Code* [LAC] Title 33, Part IX, Section 1109.A), which states that state waters exhibiting high water quality should be maintained at that high level of water quality. If that is not possible, water quality of a level that supports the designated uses of the waterbody should be maintained. The designated uses of a waterbody may be changed to allow a lower level of water quality only through a use attainability study.

2.5 Identification of Sources

2.5.1 Point Sources

LDEQ stores permit information using internal databases. LDEQ generated a list of point source discharges in the study area by using the TEMPO and PTS databases. Information on point source discharges to the listed subsegments was obtained from the Electronic Document Management System (EDMS) database at LDEQ. Data were pulled from EDMS and analyzed for the TMDLs. Each facility was evaluated on the basis of its discharges and permit limits to determine whether the facility would be used in developing the TMDLs. The evaluation yielded 48 permitted point source discharges in subsegment 120202, 15 in subsegment 120204, 12 in subsegment 120304, 5 in subsegment 120403, and 5 in subsegment 120604. Because of the large number of permits, they are listed in Appendix A.

Phase I and II stormwater systems are additional possible point source contributors in the Terrebonne Basin. Stormwater discharges are generated by runoff from urban land and impervious areas such as paved streets, parking lots, and rooftops during precipitation events. These discharges often contain high concentrations of pollutants that can eventually enter nearby waterbodies. Most stormwater discharges are considered point sources and require coverage by a National Pollutant Discharge Elimination System (NPDES) permit.

Under the NPDES stormwater program, operators of large, medium, and regulated small municipal separate storm sewer systems (MS4s) must obtain authorization to discharge pollutants. The Stormwater Phase I Rule (55 *Federal Register* 47990, November 16, 1990) requires all operators of medium and large MS4s to obtain an NPDES permit and develop a stormwater management program. Medium and large MS4s are defined by the size of the population within the MS4 area, not including the population served by combined sewer systems. A medium MS4 has a population between 100,000 and 249,999; a large MS4 has a population of 250,000 or more.

Phase II requires a select subset of small MS4s to obtain an NPDES stormwater permit. A small MS4 is any MS4 not already covered by the Phase I program as a medium or large MS4. The Phase II rule automatically covers all small MS4s in urbanized areas (UAs), as defined by the Bureau of the Census, and also includes small MS4s outside a UA that are so designated by NPDES permitting authorities, case by case (USEPA 2000).

In Louisiana, there are two ways that an MS4 can be identified as a regulated small MS4. This category includes all cities within UAs and any small MS4 area outside UAs with a population of at least 10,000 and a population density of at least 1,000 people per square mile (LDEQ 2002). In the middle Terrebonne Basin, Terrebonne Parish, the City of Morgan City, and the Assumption Parish Police Jury are regulated small MS4s. Table 2-3 presents MS4 information by subsegment for MS4 discharges to impaired subsegments in the Terrebonne Basin. Terrebonne Parish discharges to additional waterbodies that are not impaired for dissolved oxygen; these waterbodies are not part of this TMDL. Similarly, La Fourche Parish has an MS4 permit, but it does not discharge to any of the impaired subsegments in this TMDL.

Table 2-3. MS4 information for the Terrebonne Basin

NPDES permit number	Authority	Municipalities included	Discharge subsegment	Subsegment name	Urban area (acres)
LAR041023	Terrebonne Parish	Houma, Schriever, Thibodaux	120202	Bayou Black	7,462
LAR041023	Terrebonne Parish	Houma	120304	Intracoastal Waterway east of Houma	188
LAR041023	Terrebonne Parish	Houma	120403	Intracoastal Waterway–Bayou Boeuf Locks	657
LAR041028	Morgan City	Morgan City	120403	Intracoastal Waterway–Bayou Boeuf Locks	346
LAR041039	Assumption Parish Police Jury	Labadieville, Supreme	120204	Lake Verret and Grassy Lake	1,261

2.5.2 Nonpoint Sources

Louisiana's section 303(d) list does not identify the suspected cause of the dissolved oxygen impairment in the subsegments of the middle Terrebonne Basin. The source is listed as *unknown*.

3 CHARACTERIZATION OF EXISTING WATER QUALITY

3.1 Water Quality Data

Water quality data were obtained from LDEQ's routine ambient water quality monitoring program (Figure 3-1). Appendix B includes summaries of the data for the 303(d)-listed constituents, along with additional constituents used in the TMDL development process. Dissolved oxygen data were available for each of the seven listed subsegments (see Table 3-1).

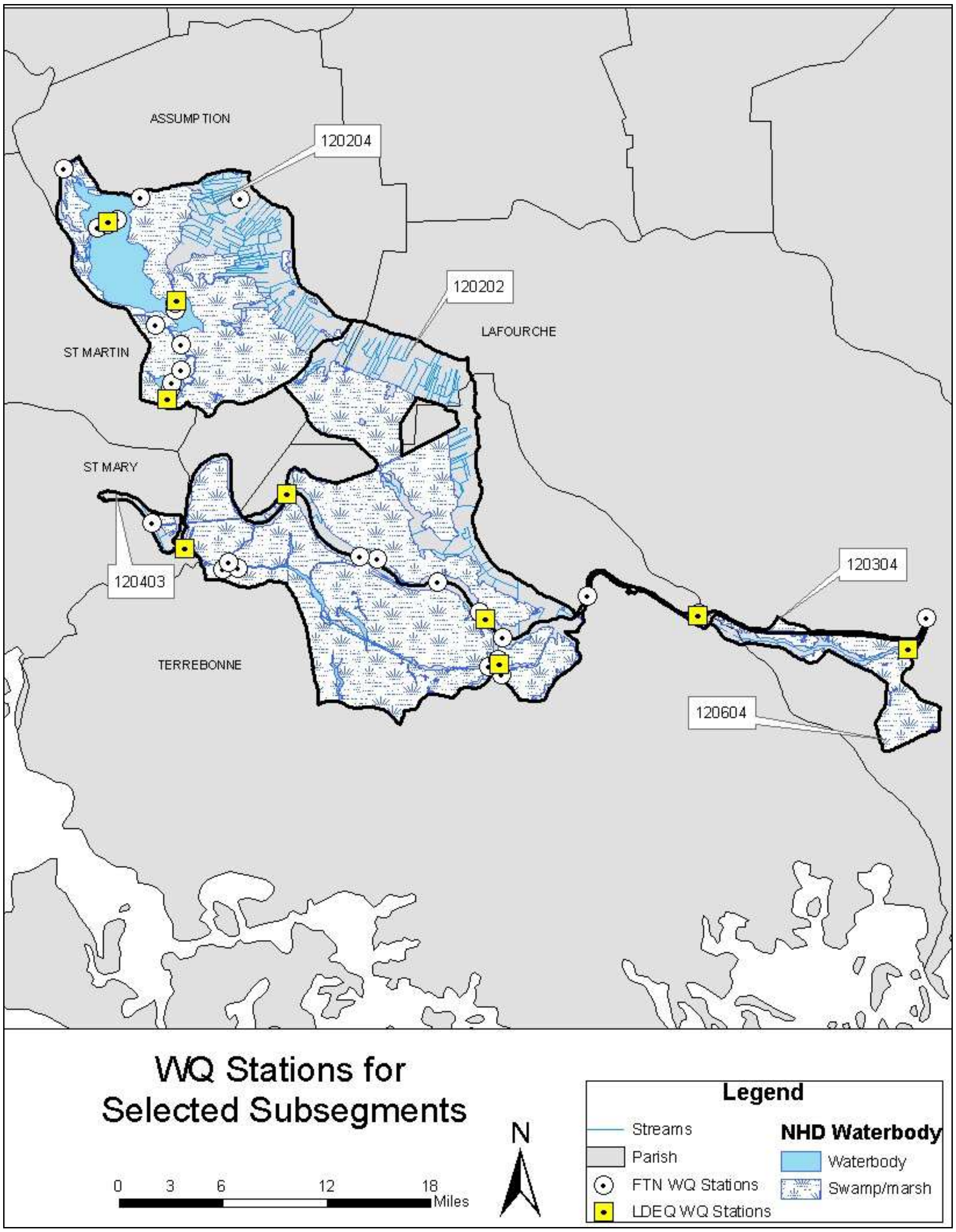

Figure 3-1. Locations of monitoring stations in the middle Terrebonne Basin.

A field survey of the four model subsegments was conducted in the Terrebonne Basin during July 2006. The hydrologic conditions during the field survey were typical for the Terrebonne Basin during summer (high temperatures and generally low flows). A list of the field survey sites and the types of data collected at each site is presented in Table 3-2. The water quality samples were analyzed for 20-day carbonaceous biochemical oxygen demand (CBOD) time series, total Kjeldahl nitrogen (TKN), ammonia nitrogen (NH_3-N), nitrate+nitrite nitrogen, total phosphorus, chlorophyll *a*, total organic carbon (TOC), and total suspended solids (TSS). The in situ measurements and water quality sampling results are summarized in Appendix B. Appendix B also contains summaries of the depth, widths, and flows measured with the acoustic Doppler current profiler (ADCP) instrument. Plots of the continuous monitoring data are presented in Appendix B. Appendix C contains the field survey notes.

Table 3-1. LDEQ water quality monitoring stations and dissolved oxygen data summaries

Sub segment	Station	Station name	Period of record	No. of obs.	DO min (mg/L)	DO max (mg/L)	DO ave. (mg/L)
120202	114	Bayou Black at Gibson, LA	6/1/58–5/12/98	389	0.1	11.0	3.6
120202	339	Bayou Black west of Houma, LA	2/4/91–4/19/04	60	1.0	8.7	4.4
120204	144	Lake Verret at Attakapas Landing near Georgia	1/13/87–11/29/00	100	2.7	12.8	8.1
120204	145	Lake Verret near Pierre Part, LA	1/13/87–12/11/90	47	5.2	14.5	8.5
120304	340	Intracoastal waterway east of Houma, LA	2/5/91–12/6/00	56	2.9	10.5	6.5
120403	934	Intracoastal Waterway at Venvirotek Dock, LA	1/5/00–4/19/04	16	4.0	10.0	6.5
120604	945	Bayou Blue SSW of Larose, LA	1/4/00–4/13/04	16	3.0	9.7	6.4

Note: DO = dissolved oxygen

Table 3-2. Data types from July 2006 monitoring

Subsegment	Site ID	Site name	Data types collected
120202	114	Bayou Black at Gibson, LA	In situ, sample, cross section, flow, contin.
120202	120202-A	Terrebonne-Lafourche Drainage Canal near Greenwood, LA	In situ, sample, flow
120202	120202-B	Bayou Black near Oak Forest, LA	In situ, cross section
120202	120202-C	Bayou Black near Humphreys, LA	In situ, cross section
120202	339	Bayou Black west of Houma, LA	In situ, sample, flow, cross section
120204	120204-A	Bayou Pierre Part near Pierre Part, LA	In situ, sample, flow
120204	145	Lake Verret near Pierre Part, LA	In situ, sample, depth
120204	120204-B	Lake Verret west of Station 145	In situ, depth
120204	120204-C	Lake Verret east of Station 145	In situ, depth
120204	120204-D	Godchaux Canal near Lake Verret	In situ, sample, flow, cross section
120204	120204-E	Godchaux Canal near Napoleonville	In situ, sample, flow, cross section
120204	144	Lake Verret at Attakapas Landing near Georgia, LA	In situ, depth
120204	120204-F	Lake Verret south of Attakapas Landing	In situ, sample, depth
120204	120204-G	Bayou Magazille	In situ, sample, flow
120204	120204-H	Fourmile Bayou near Lake Verret	In situ, flow, cross section
120204	120204-I	Fourmile Bayou near Grassy Lake	In situ, cross section
120204	120204-J	Grassy Lake northeast of middle	In situ, depth
120204	120204-K	Grassy Lake near middle	In situ, sample, depth
120304	340	Intracoastal Waterway east of Houma, LA	In situ, sample
120304	120304-A	Intracoastal Waterway at Larose, LA	In situ, sample, flow

Table 3-2. (continued)

Subsegment	Site ID	Site name	Data types collected
120403	120403-A	Intracoastal Waterway between Bayou Chene and Bayou Black	In situ, flow, cross section
120403	120403-B	Bayou Black near confluence with GIWW south of Lake Bridge, LA	In situ, flow, cross section
120403	120403-C	Intracoastal Waterway east of confluence with Bayou Black S of Lake Bridge, LA	In situ, cross section
120403	120403-D	Intracoastal Waterway west of Minors Canal	In situ, sample, flow, cross section
120403	120403-E	Minors Canal north of GIWW	In situ, flow, cross section
120403	120403-F	Minors Canal south of GIWW	In situ, flow, cross section
120403	120403-G	Bayou Boeuf at Amelia, LA	In situ, sample
120403	120403-H	Intracoastal Waterway near lock at Morgan City	In situ, sample, cross section
120403	120403-I	Bayou Chene near Intracoastal Waterway	In situ, sample
120403	120403-J	Houma Navigation Canal near Houma	In situ, sample, flow
120604	945	Bayou Blue SSW of Larose, LA	In situ, sample, flow

3.2 Comparison of Observed Data to Criteria

Water quality monitoring data were obtained from LDEQ and during the July 2006 sampling event. Table 3-3 provides a summary of the LDEQ dissolved oxygen data available for stations in the model subsegments. Each station has between 16 and 389 data points. All seven stations had dissolved oxygen observations below the water quality criterion of 5 mg/L.

Table 3-3. Summary of LDEQ dissolved oxygen data for the middle Terrebonne Basin

LDEQ station	Subsegment	Period of record	No. of samples	DO min. (mg/L)	DO max. (mg/L)	DO ave. (mg/L)	Percent <5 mg/L
114	120202	6/1/58–5/12/98	389	0.1	11.0	3.6	70
339	120202	2/4/91–4/19/04	60	1.0	8.7	4.4	58
144	120204	1/13/87–11/29/00	100	2.7	12.8	8.1	7
145	120204	1/13/87–12/11/90	47	5.2	14.5	8.5	0
340	120304	2/5/91–12/6/00	56	2.9	10.5	6.5	29
934	120403	1/5/00–4/19/04	16	4.0	10.0	6.5	19
945	120604	1/4/00–4/13/04	16	3.0	9.7	6.4	25

Table 3-4 provides a summary of the July 2006 dissolved oxygen data for stations in the model subsegments. Each station has between 2 and 18 data points. All four stations except subsegment 120406 had dissolved oxygen observations below the water quality criterion of 5 mg/L.

Table 3-4. Summary of dissolved oxygen data from July 2006 monitoring event

Subsegment	No. of locations	Range of sample depths	No. of samples	DO min. (mg/L)	DO max. (mg/L)	DO ave. (mg/L)	Percent samples < 5 mg/L
120202	5	2–9	10	1.8	10.5	4.9	50
120204	13	0.4–18	24	1.6	12.4	7.0	29
120304	3	3–15	6	3.8	4.6	4.2	100
120403	10	3–18	26	3.2	6.8	4.7	69
120604	1	3–6	2	4.8	4.9	4.8	100

4 WATER QUALITY MODEL SETUP AND CALIBRATION

4.1 Model Setup

LA-QUAL (Version 8.11) was chosen to simulate dissolved oxygen in the TMDL subsegments. LA-QUAL is a steady-state model that LDEQ developed based on the QUAL-TX (Version 3.4) model. Several modifications were made to the QUAL-TX model, including the addition of new aeration equations that better represent conditions in Louisiana.

LA-QUAL evaluates the relationships between pollutant sources and water quality. Model configuration involved setting up the model segments and setting initial conditions, boundary conditions, and hydraulic and kinetic parameters. This section describes the configuration and key components of the model.

Three models were used for the middle Terrebonne Basin: Lake Verret (120204), Bayou Blue (120604), and Bayou Black (120202)/Intracoastal Waterways (120304 and 120403). Only the main stems of the systems were explicitly simulated and thus segmented for modeling purposes. Segmentation refers to separating a waterbody into smaller computational units. Segmentation occurred around major hydrological features, such as tributaries. Tributaries were represented through boundary condition designation. Appendix D contains diagrams of the model segmentations and stream kilometers.

4.2 Calibration Period

The calibration period was selected to coincide with the intensive field monitoring that had occurred in July 2006. The data used for calibration are the averages of the samples taken during the measurement period from July 10 through July 13, 2006. These dates were selected for calibration because they were the only dates for which data were available. This period is considered the critical period because high temperatures decrease dissolved oxygen saturation values and increase rates for oxygen-demanding processes, such as biochemical oxygen demand (BOD) decay, nitrification, and sediment oxygen demand (SOD). In addition, lower flow rates do not cause strong reaeration, so the exchange of oxygen between air and water is low.

4.3 Model Options (Data Type 2)

Data type 2 is used to identify the constituents being modeled to achieve calibration—for this TMDL, dissolved oxygen, BOD, and a nitrogen series (ammonia nitrogen, and nitrate+nitrite).

4.4 Program Constants (Data Type 3)

LA-QUAL is programmed with certain default program parameters. Data type 3 is used to override the default parameters and is optional; that is, values need to be entered only if values other than the default values are desired. Default values were used for all program parameters except for the hydraulic calculation method. This parameter was changed from method 1 to method 2. For descriptions of the parameters and their default values, see the LA-QUAL user manual (Wiland Consulting, Inc. 2005). For the Bayou Black/Intracoastal Waterway and Bayou Blue models, the maximum iteration limit was changed from the default 100 to 500; the wind speed was changed from the default of 0 to 1.3; and the algae oxygen production was changed from the default of 0.05 to 0.026.

4.5 Temperature Correction of Kinetics (Data Type 4)

Data type 4 contains factors used for temperature correction in rate equations. The temperature correction factors used in the model were consistent with the *Standard Operating Procedure for Louisiana TMDL Technical Procedures* (LTP) when these factors were available (LDEQ 2005). The correction factors were as follows:

- Correction for BOD decay: 1.047 (LTP and model default)
- Correction for SOD: 1.065 (LTP and model default)
- Correction for ammonia N decay: 1.083 (model default)
- Correction for organic N decay: 1.020 (model default)
- Correction for reaeration: 1.024 (LTP and model default)

For the Bayou Black/Intracoastal Waterway and Bayou Blue models, the ammonia N decay rate was changed from the default to 1.07.

4.6 Hydraulics (Data Type 9)

These data types describe the hydraulic characteristics of the model reaches. The stream hydraulics were specified in the input file for the model using the following power functions:

$$width = a \times Q^b + c$$
$$depth = d \times Q^e + f$$

where:

a =	width coefficient	=	0.0
b =	width exponent	=	0.0
c =	width constant	=	average width of segment
d =	depth coefficient	=	0.0
e =	depth exponent	=	0.0
f =	depth constant	=	average depth of segment

The average width and depth for each segment were based on observed measurements in July 2006; they are shown in Table 4-1. Slight adjustments were made in some reaches to better simulate observed hydrology and water quality.

Table 4-1. Average channel widths and depths for each model segment

Model reach	120202/1200304/120403		120204		120604	
	Width (m)	Depth (m)	Width (m)	Depth (m)	Width (m)	Depth (m)
1	182.49	9.30	1,343	1.01	10.0	0.5
2	209.06	13.35	107	5.24	44.0	1.4
3	395.30	12.77	87	2.50	65.5	0.9
4	190.0	12.19	87	4.39	--	--
5	196.71	4.57	1,892	1.34	--	--
6	31.17	1.16	4,092	2.13	--	--
7	31.17	1.16	767	1.95	--	--
8	155.80	12.8	--	--	--	--

4.7 Dispersion (Data Types 10 and 27)

Dispersion was specified in the model because subsegments in these models are tidally influenced. The tidal influence creates diurnal flow reversals that provide mixing and dispersive transport. Lower boundary conditions were added to the model using results from monitoring locations near the end of the reaches from the intensive study in July 2006.

4.8 Initial Conditions (Data Type 11)

Initial conditions were set for temperature, dissolved oxygen, nitrate+nitrite, and chlorophyll *a* using observed water quality data, while ammonia data were set to a constant. Because LA-QUAL is a steady-state model, the initial conditions affect only the number of iterations needed to reach steady-state conditions. Setting initial conditions on the basis of observed data reduces the amount of iterations the model must perform to reach steady-state.

Salinity, phosphorus, phytoplankton, and macrophytes were the parameters not simulated in the model. Their initial conditions were set to zero so that the model would not assume a fixed concentration and include their effects.

4.9 Water Quality Kinetics (Data Types 12 and 13)

Several kinetic rates, including reaeration, SOD, CBOD decay, nitrification, and mineralization (organic nitrogen decay) rates, were used in the model. Data types 12 and 13 focus on different rates used by the model. Data type 12 is needed only if BOD or dissolved oxygen is being simulated, and data type 13 is needed only if nitrogen or phosphorus is being simulated. For this TMDL, both data types were included.

The model calculates the reaeration rate by using one of a standard set of equations. For this TMDL, the O'Conner-Dobbins equation was used for the stream portions of the model. This equation is applicable to moderately deep to deep channels (1 ft to 30 ft with flow between 0.5 ft/s and 12.2 ft/d). The equation is

$$K_2 = \frac{3.932 \times V^{0.969}}{D^{1.5}}$$

where:

V = stream velocity (meters per second)
D = stream depth (meters)

For the portion of the model that simulates Lake Verret, a different method was used. This equation is

$$K_2 = \frac{a}{D}$$

where:

a = oxygen transfer coefficient (meters per day)
D = stream depth (meters)

For the Bayou Black/Intracoastal Waterway model, a different method was used. This equation is

$$K_2 = \frac{0.319 \times W}{D}$$

where:

W = wind velocity (meters/second)
D = stream depth (meters)

The input files that list these values are provided in Appendix E. Table 4-2 summarizes these rates. The CBOD decay rate varied by subsegment and was based on the measured $CBOD_3$, $CBOD_5$, $CBOD_{12}$, $CBOD_{20}$, and $CBOD_{25}$ data. Slight adjustments were made in some reaches to better simulate observed water quality. The SOD was calibrated in the model and varied by subsegment reach. The SOD was calibrated after the CBOD levels were finalized. The SOD rates changed iteratively until modeled dissolved oxygen concentrations agreed well with measured water column dissolved oxygen concentrations.

Table 4-2. Water quality kinetics rates

Program constant	120202/1200304/ 120403	120204	120604
Background SOD (g/m^2/d)	0.7–2.2	0.7–3	0.5–0.7
BOD #1 decay rate (aerobic) (1/d)	0.15–0.17	0.16–0.23	0.15
Ammonia decay rate (1/d)	0.02	0.02	0.02
Ammonia nitrogen oxidation rate (1/d)	0.13–0.2	0.2	0.13
Oxygen transfer coefficient "*a*" (m/d)	--	0.75	--

4.10 Incremental Data (Data Types 16, 17, and 18)

These data types include information on inflows and outflows from the model reaches. For this TMDL, incremental information for flow, temperature, dissolved oxygen, $CBOD_u$, organic nitrogen, ammonia, and nitrate+nitrite was included. Appendix E contains the input files with these values. Incremental flow was determined from flow measurements obtained during the July 2006 monitoring. Incremental data were not used in the Lake Verret model.

4.11 Nonpoint Source Loads (Data Type 19)

This data type accounts for nonpoint source loads not associated with incremental and tributary flows. The nonpoint source loads that are specified in the model can be most easily understood as resuspended load from the bottom sediments and are modeled as SOD, $CBOD_u$ loads, and organic nitrogen loads. The SOD (from data type 12) and the mass loads of organic nitrogen and $CBOD_u$ (data type 19) were all treated as calibration parameters; their values were adjusted until the model output was similar to the calibration target values.

Typically, these three calibration parameters were adjusted in a specific order based on the interactions between state variables in the model. First, the organic nitrogen loads were adjusted until the predicted organic nitrogen concentrations were similar to the observed concentrations. Organic nitrogen was calibrated first because none of the other state variables will affect the organic nitrogen concentrations. Next, the $CBOD_u$ loads were adjusted until the predicted $CBOD_u$ concentrations were similar to the observed concentrations. Finally, the SOD rates were adjusted until the predicted dissolved oxygen concentrations were similar to the observed concentrations. The SOD rate was not adjusted below 0.5 grams per square meter per day (g/m^2/day). The dissolved oxygen was calibrated last because all the other state variables affect dissolved oxygen.

4.12 Headwater Flow, Water Quality, and Junction Data (Data Types 20, 21, 22, and 23)

These data types account for flow and water quality from upstream of the modeled subsegment. Headwater flow and water quality data were derived from monitoring data. In general, the flow measured at the most upstream station was taken as the headwater flow. Water quality data (mainly CBOD and dissolved oxygen) were estimated from the monitoring data at the most upstream stations.

4.13 Wasteload Flow and Water Quality Data (Data Types 24, 25, and 26)

These data types account for flow and water quality from point sources discharging into the listed waterbodies. The model included 13 direct permitted dischargers, plus 28 permitted dischargers that were combined because of lack of discharge pathway information and their proximity to assumed pathways. Eleven tributaries were included as input in these data types and 8 outflows to other waterbodies. The inputs and their associated flows and concentrations are provided in Table 4-3. Data from tributaries were developed from observed data. Dissolved oxygen was set to 5.0 for point sources. Permitted BOD_5 discharge limits were converted to ultimate CBOD using a conversion factor of 2.3. Organic nitrogen and nitrate+nitrite were assumed from surrounding waters. Ammonia was assumed to be 1.5 mg/L for smaller point sources; for larger point sources, ammonia was taken from permit limits or from discharge monitoring reports. When point sources were combined, flow-weighted averages were used.

Table 4-3. Summary of point sources and tributaries used in LA-QUAL

Sub-segment	Point source/ tributary name	Flow (mgd)	DO (mg/L)	$CBOD_u$ (mg/L)	Org N (mg/L)	Ammonia (mg/L)	NO_3+NO_2 (mg/L)	Comment
120202	LA0074331	0.0002	5	103.5	1.4	1.5	2	Combined point sources
120202	LA0111236	0.5	5	57.5	1.4	20	2	Point source
120202	LAG531469	0.0032	5	103.5	1.4	1.5	2	Point source
120202	LAG540726	0.0008	5	69	1.4	1.5	2	Point source
120202	LAG541223	0.0162	5	69	1.4	1.5	2	Point source
120202	LAG541317	0.0097	5	69	1.4	1.5	2	Point source
120202	Little Bayou Black	29.7	2.3	9.42	1.63	0.14	0	Tributary
120202	Minors Canal	12	10.4	7.16	1.4	0.1	0	Tributary
120202	PS Bayou Black#1	0.0341	5	56.879	1.4	1.5	2	Combined point sources
120202	PS Bayou Black#2	0.0439	5	52.67	1.4	1.5	2	Combined point sources
120202	PS Bayou Black#3	0.0042	5	103.5	1.4	1.5	2	Combined point sources
120202	PS Hanson Canal	0.0365	5	25.346	1.4	1.5	2	Combined point sources
120202	PS Lil Bayou Black	0.009	5	103.5	1.63	1.5	2	Combined point sources
120204	Bayou Magazille	687.016	7.6	16.8	2.4	0.1	0.2	Tributary
120204	LAG540112	0.01	5	69	2	1.5	2	Point source
120204	LAG560026	0.028	5	46	2	1.5	2	Point source
120204	NPDES Group1	0.036	5	69	2	1.5	2	Combined point sources
120204	NPDES Group2	0.211	5	27.14	2	5.7	2	Combined point sources

Table 4-3. (continued)

Sub-segment	Point source/ tributary name	Flow (mgd)	DO (mg/L)	$CBOD_u$ (mg/L)	Org N (mg/L)	Ammonia (mg/L)	NO3+NO2 (mg/L)	Comment
120204	NPDES Group3	0.002	5	103.5	2	1.5	2	Combined point sources
120204	Outflow to FB Oxbow	-200.855	6.8	25.5	1.7	0.1	0	Flow to another waterbody
120304	Bayou Bleu North	27.8	3.34	8.74	0.9	0.1	0	Tributary
120304	Bayou Bleu South	-9						Flow to another waterbody
120304	Bayou Terrebonne E.	-22						Flow to another waterbody
120304	Bayou Terrebonne W.	32.3	2.3	9.42	1.63	0.14	0	Tributary
120304	Company Canal North	95	3.89	9.83	1.34	0.1	0	Tributary
120304	Company Canal South	-12.3						Flow to another waterbody
120304	LA0089648	0.0785	5	103.5	1.4	1.5	2	Point source
120304	LA0104868	0.0011	5	103.5	1.4	1.5	2	Point source
120304	LA0111376	0.0003	5	103.5	1.4	1.5	2	Point source
120304	PS ICWW#2	0.0009	5	103.5	1.4	1.5	2	Combined point sources
120304	St Louis Canal	10.3	3.34	8.74	0.9	0.1	0	Tributary
120403	Bayou Boeuff	1,093.40	4.4	5	1.6	0.1	0	Tributary
120403	Bayou Chene	-832.5						Flow to another waterbody
120403	Copasaw Canal	349	6.6	6.17	1.4	0.1	0	Tributary
120403	Houma Nav. Can.	-543.5						Flow to another waterbody
120403	Minors Canal North	-12						Flow to another waterbody
120403	Minors Canal South	102.1	10.4	7.16	1.4	0.1	0	Tributary
120403	PS ICWW#1	0.0006	5	103.5	1.4	1.5	2	Combined point sources
120403	Unnamed Canal	35.5	6.6	6.17	1.4	0.1	0	Tributary
120604	ICWW	-9.04711						Flow to another waterbody
120604	LA0084077	0.003877	5	103.5	1.4	1.5	0	Point source

4.14 Calibration and Model Results

Model calibration was a multistep process using ammonia, $CBOD_u$, and SOD concentrations for each reach, starting with the most upstream reach and working down to the outflow reach. Organic nitrogen was first adjusted so that predicted concentrations matched observed data. The ammonia and nitrate loads were then adjusted so that the predicted nitrogen concentrations would match the observed concentrations. After ammonia was calibrated, the $CBOD_u$ loads were adjusted until the predicted $CBOD_u$ concentrations were similar to the observed concentrations. Finally, SOD was adjusted until the predicted dissolved oxygen concentrations were similar to the observed concentrations.

Table 4-4 lists the oxygen demand loadings for calibration conditions, which were based on existing conditions. Overall, the model did well in predicting the observed values for temperature, ammonia, $CBOD_u$, and dissolved oxygen, and the model was considered adequately calibrated on the basis of the data available. Plots of observed and calibration water quality are presented in Appendix F. Figure 4-1 is an example calibration plot.

Table 4-4. Existing oxygen demand

Subsegment	Oxygen demand (lb/d)				
	SOD	$CBOD_u$	Ammonia	Organic N	Total
120202	10,636	8,656	890	3,411	22,113
120204	457,729	1,986,216	8,309	224,615	2,676,656
120304	36,128	191,807	2,290	45,525	275,739
120403	103,827	284,252	6,069	128,309	522,421
120604	1,138	2,798	82	816	4,816

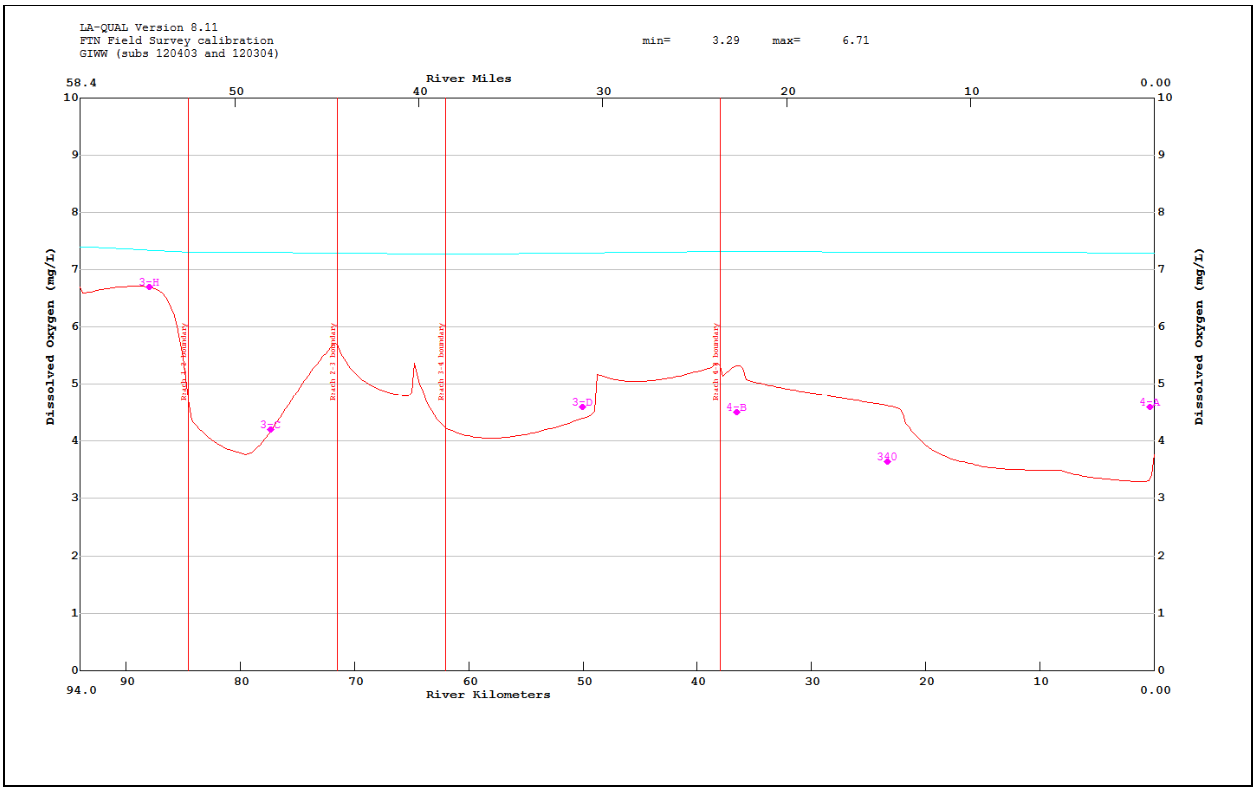

Figure 4-1. Calibration plot for dissolved oxygen in subsegments 120304 and 120403.

5 WATER QUALITY MODEL PROJECTION

EPA's regulations at 40 CFR 130.7 require that parties determining TMDLs take into account critical conditions for stream flow, loading, and water quality parameters. The calibrated model was used to project water quality for critical conditions. Two scenarios were run for the critical conditions: baseline and TMDL. The model was run for baseline conditions, which used the same water quality and model parameters as the calibration model; however, the flow and temperature were changed to critical conditions and effluent water quality from permitted dischargers were changed to permit limits. The TMDL model run was the same as the baseline run; however, pollutant loadings were reduced so that dissolved oxygen met criteria at all locations. Identifying critical conditions and the model input data used for critical conditions are discussed in this section. Appendix G contains the baseline output files and Appendix H contains the TMDL output files. The output files include the input parameters.

5.1 Identification of Critical Conditions

The LDEQ LTP defines critical conditions in terms of flow and temperature. Critical flow conditions for tidally influenced regions are simulated using one-third the average or typical flow averaged over one tidal cycle, irrespective of flow. In addition, all point sources are assumed to be discharging at design capacity and at their permit limits. The LTP specifies that the critical temperature should be determined by calculating the 90^{th} percentile seasonal temperature for the waterbody being modeled, if data are available. Otherwise, 30 degrees Celsius (ºC) was used.

5.2 Temperature Inputs

The critical temperatures for the headwaters were based on the 90^{th} percentile temperature of LDEQ ambient monitoring in the representative subsegment. A critical temperature of 30 °C was used for incremental and wasteload inputs. Because these subsegments have a year-round standard for dissolved oxygen, a winter projection simulation was not performed. The most critical time of year for meeting a constant dissolved oxygen standard is the period of high temperatures and low flows.

5.3 Headwater and Tributary (Wasteload) Inputs

The inputs for the headwater and tributaries for the projection simulation were based on guidance in the LTP. According to the LTP, the critical flow rates for tidal systems for summer should be set to one-third the average or typical flow averaged over one tidal cycle, irrespective of flow. These flows were calculated for headwater and tributary model flows and used in the baseline and TMDL model predictions.

Dissolved oxygen from headwaters and tributaries were set to the water quality criterion of 5 mg/L or the observed concentration, whichever was greater. $CBOD_u$ levels from headwaters and tributaries were reduced until modeled dissolved oxygen met the criteria. The ammonia levels were low from both the headwaters and tributaries; therefore, the ammonia inputs were not changed from the calibration values.

5.4 Point Source Inputs

Ammonia and organic nitrogen levels were changed from observed or assumed concentrations to proposed concentrations. The nitrogen concentrations were assumed to be half the amount of the oxygen demand, with two-thirds assumed to be ammonia loading and one-third as organic nitrogen loading. These assumptions are consistent with information presented in the LTP. If necessary, input concentrations were reduced to keep the dissolved oxygen concentration above 5 mg/L.

5.5 Downstream Values

Modeling parameters for downstream boundary conditions were the same as the calibration parameters except for temperature and dissolved oxygen. The temperature was set to the critical condition. The dissolved oxygen value, if below criteria, was set to the water quality standard of 5.0 mg/L.

5.6 Baseline Model Results

Baseline line conditions were run under critical conditions for calibrated parameters and water quality values. Plots of baseline water quality are presented in Appendix I. Baseline oxygen demand is presented in Table 5-1.

Table 5-1. Baseline oxygen demand

Subsegment	Oxygen demand (lb/d)				
	SOD	$CBOD_u$	Ammonia	Organic N	Total
120202	10,636	16,139	2,501	9,075	38,350
120204	451,609	1,686,949	4,540	158,722	2,301,820
120304	36,128	186,972	2,299	45,414	270,813
120403	103,827	270,953	6,138	128,750	509,668
120604	1,138	5,024	235	2,286	8,684

5.7 Model Results for Projection

Several steps were used to develop the reduction percentages for oxygen demand. The TMDL was calculated by first iteratively reducing SOD. After meeting the dissolved oxygen criterion by reducing SOD, the CBOD reduction rate was calculated by the SOD/CBOD relationship ($SOD = a \times \sqrt{CBOD}$). Slight adjustments were made to the SOD reduction rate, and an updated CBOD reduction rate was calculated. This process was repeated until the optimal reduction rates were determined.

To meet the dissolved oxygen standard, 5.0 mg/L, total oxygen demand must be reduced between 0 and 32 percent. This percentage reduction for nonpoint source loads represents a percentage of the entire nonpoint source loading, not a percentage of the man-made nonpoint source loading. The nonpoint source loads in this report were not divided between natural and man-made because it would be difficult to estimate natural nonpoint source loads. Plots of predicted water quality are presented in Appendix J.

6 TMDL DEVELOPMENT

A TMDL is the total amount of a pollutant that a receiving waterbody can assimilate while still achieving water quality standards. In TMDL development, allowable loadings from all pollutant sources that cumulatively amount to no more than the TMDL must be established, thereby providing the basis for establishing water quality-based controls.

A TMDL for a given pollutant and waterbody is composed of the sum of individual wasteload allocations (WLAs) for point sources and load allocations (LAs) for nonpoint sources and natural background levels. In addition, the TMDL must include an implicit or explicit margin of safety (MOS) to account for the uncertainty in the relationship between pollutant loads and the quality of the receiving waterbody, and it may include a future growth (FG) component. The TMDL components are illustrated using the following equation:

$$TMDL = \Sigma\, WLAs + \Sigma\, LAs + MOS + FG$$

The LA is the portion of the TMDL assigned to nonpoint sources such as natural background loadings. For this TMDL, the LA was calculated by subtracting the WLA, MOS, and FG from the total TMDL allocation. LAs were not allocated to separate nonpoint sources because of the lack of available source characterization data.

The WLA portion of the TMDL equation is the total loading of a pollutant that is assigned to point sources. The permitted or average (expected or observed) flows were used to calculate the WLAs. If the permitted or average flow was unavailable, the permit maximum flow was used. The permit maximum flow was usually the maximum flow covered by the specific type of general permit. For example, the LPDES Class II Sanitary General Permit covers facilities with flow of up to 25,000 gallons per day. Sometimes the permit maximum flow was significantly greater than the expected flow, and therefore the permit maximum was used only when other flows were not available.

EPA’s stormwater permitting regulations require municipalities to obtain permit coverage for all stormwater discharges from MS4s. For each MS4 in the basin, a gross MS4 load was computed by multiplying the LA by the ratio of the MS4 area in each subsegment to the subsegment area. Note that these values are estimates that can be refined in the future as more information about the MS4s and land-use-specific loadings becomes available. Note also that the MS4 loads presented reflect only that portion of the MS4 in the subsegment. The computed MS4 load was subtracted from the LA and included as a WLA component of the TMDL because MS4s are permitted dischargers but function similarly to nonpoint sources (through storm-driven processes). EPA expects that the MS4 WLAs will be achieved through BMPs and adaptive management.

Section 303(d) of the Clean Water Act and the regulations at 40 CFR 130.7 require that TMDLs include an MOS to account for uncertainty in available data or in the actual effect that controls will have on the loading reductions and receiving water quality. The MOS may be expressed explicitly as unallocated assimilative capacity or implicitly using conservative assumptions in establishing the TMDL. In addition to the MOS, an FG component may be added to account specifically for FG in the TMDL area.

There are two ways to incorporate the MOS (USEPA 1991). One way is to implicitly incorporate it by using conservative model assumptions to develop allocations, including the following:

- *Using slightly higher water temperatures than the suggested water temperature.* If dissolved oxygen meets the criterion with higher water temperature, it will meet the criterion with lower water temperature when other factors remain unchanged.
- *Using the dissolved oxygen water quality criterion for model inflows.* Dissolved oxygen from headwaters and tributaries was set to the water quality criterion, which is lower than the 90 percent saturation level of dissolved oxygen at 30 ºC.

The other way is to explicitly specify a portion of the TMDL as the MOS and use the remainder for allocations. For this analysis, the MOS is explicit: 10 percent of each targeted TMDL was reserved as the MOS to account for any uncertainty in the TMDL. Using 10 percent of the TMDL load provides an additional level of protection to the designated uses of the subsegments of concern.

The MOS is an allocation for scientific uncertainly, while the FG is an allocation for growth. Ten percent of the load was allocated for FG in the area covered by the TMDL. This growth includes future urban development, including point sources, MS4 areas, agriculture, and other nonpoint sources. The FG could also be used for sources not accounted for or unknown and therefore not otherwise included in the TMDL.

6.1 Dissolved Oxygen TMDLs

The dissolved oxygen TMDLs are presented as oxygen demand from $CBOD_u$, ammonia nitrogen, and SOD, and they were derived using the LA-QUAL model. A summary of the TMDLs is presented in Table 6-1. The TMDLs were calculated from SOD, CBOD, ammonia, and organic nitrogen from nonpoint source model inputs, tributary flows, incremental flows, and background. Table 6-2 presents a summary of the reduction percentages for LAs; there were no reductions for WLAs. The reduction percentages for total oxygen demand ranged from 0 to 32 percent.

WLAs were calculated using monthly average permit limits, when applicable. If a permit did not have a monthly average permit limit, the weekly average permit limit was used. If the facility had neither a monthly nor a weekly limit, the daily maximum limit was used to calculate loads. All facilities had oxygen demand and limits; however, only a few had ammonia limits. The nitrogen loading was assumed to be half the amount of the oxygen demand, with two-thirds was assumed to be ammonia loading and one-third as organic nitrogen loading. These assumptions are consistent with information presented in the LTP. The WLAs are presented in Tables 6-4 through 6-17. Table 6-18 lists the individual WLAs for the MS4s identified in Section 2.5. Reductions from point source discharges are not required as a result of this TMDL.

Table 6-1. Summary of dissolved oxygen TMDLs, WLAs, LAs, MOSs, and FGs for the middle Terrebonne Basin

Subsegment	Oxygen demand (lb/d)				
120202	SOD	$CBOD_u$	Ammonia	Organic N	Total
WLA	624	2,109	1,009	1,049	4,791
MOS for WLA	78	264	126	131	599
FG for WLA	78	264	126	131	599
LA	6,495	10,293	992	6,165	23,944
MOS for LA	812	1,287	124	771	2,993
FG for LA	812	1,287	124	771	2,993
TMDL	8,899	15,502	2,501	9,017	35,919
Subsegment	Oxygen demand (lb/d)				
120204	SOD	$CBOD_u$	Ammonia	Organic N	Total
WLA	4,208	14,151	164	1,389	19,911
MOS for WLA	526	1,769	20	174	2,489
FG for WLA	526	1,769	20	174	2,489
LA	313,737	1,044,751	3,468	99,166	1,461,122
MOS for LA	39,217	130,594	434	12,396	182,640
FG for LA	39,217	130,594	434	12,396	182,640
TMDL	397,431	1,323,627	4,540	125,693	1,851,291
Subsegment	Oxygen demand (lb/d)				
120304	SOD	$CBOD_u$	Ammonia	Organic N	Total
WLA	496	6,890	73	1,303	8,762
MOS for WLA	62	861	9	163	1,095
FG for WLA	62	861	9	163	1,095
LA	8,397	116,442	1,082	21,985	147,906
MOS for LA	1,050	14,555	135	2,748	18,488
FG for LA	1,050	14,555	135	2,748	18,488
TMDL	11,116	154,166	1,444	29,109	195,836
Subsegment	Oxygen demand (lb/d)				
120403	SOD	$CBOD_u$	Ammonia	Organic N	Total
WLA	850	2,366	88	1,165	4,470
MOS for WLA	106	296	11	146	559
FG for WLA	106	296	11	146	559
LA	73,374	199,703	4,822	99,162	377,060
MOS for LA	9,172	24,963	603	12,395	47,133
FG for LA	9,172	24,963	603	12,395	47,133
TMDL	92,780	252,586	6,138	125,409	476,913
Subsegment	Oxygen demand (lb/d)				
120604	SOD	$CBOD_u$	Ammonia	Organic N	Total
WLA	0	35	22	11	68
MOS for WLA	0	4	3	1	9
FG for WLA	0	4	3	1	9
LA	910	3,984	166	1,818	6,879
MOS for LA	114	498	21	227	860
FG for LA	114	498	21	227	860
TMDL	1,138	5,024	235	2,286	8,684

Table 6-2. Summary of percent reductions for LAs in the middle Terrebonne Basin

Subsegment	Percent reduction				
	SOD	$CBOD_u$	Ammonia	Organic N	Total
120202	23.7	12.7	8.8	9.4	15.1
120204	13.2	22.6	1.3	21.9	20.6
120304	70.9	22.1	40.9	39.5	31.7
120403	11.7	7.8	1.1	3.7	7.5
120604	0.0	0.0	0.0	0.0	0.0

Table 6-3. WLAs for BOD_5 for subsegment 120202 in the middle Terrebonne Basin

NPDES permit number	Outfall	Facility name	Flow (mgd)	BOD_5 (mg/L)	BOD_5 (lb/d)
LA0042510	002	Lafourche Sugars, LLC FKA A Corp	1.5	10	125.18
LA0066486	001	Tesi-Magnolia Park Service	0.22	10	18.36
LA0074331	101	Universal Compression, Inc.	0.000282	45	0.11
LA0074331	002	Universal Compression, Inc.	0.00016	45	0.06
LA0081809	001	Tesi-Plantation/Leighton	0.12	10	10.01
LAG480528	002	Hydraulic Well Control, Inc.	0.001	45	0.38
LAG480528	003	Hydraulic Well Control, Inc.	0.001	45	0.38
LA0095257	001	Service Sanitary Corporation	0.1307	10	10.91
LA0111236	001	Daneco, Inc.	0.5	25	104.32
LAG750496	002	Redfish Rental of Houma, Inc.	0.005	45	1.88
LAG480103	003	Crosstex Lig Liquids, LLC	0.00144	45	0.54
LAG480103	004	Crosstex Lig Liquids, LLC	0.00144	45	0.54
LAG480134	001	Tetra Technologies, Inc.	0.005	45	1.88
LAG480272	002	Smith Int'l Inc.	0.00015	45	0.06
LAG480317	002	WFS-Liquids Co	0.0015	45	0.56
LAG480563	001	Marine Systems, Inc.	0.0017	45	0.64
LAG530072	001	Bellsouth Telecommunications	0.005	45	1.88
LAG530268	001	J B Levert Land Company	0.00036	45	0.14
LAG530887	001	Sita, Inc.	0.005	45	1.88
LAG531154	001	Terrebonne Parish Recreation	0.005	45	1.88
LAG531233	001	Williams Field Services Co	0.0025	45	0.94
LAG531388	001	Williams Field Svcs Co	0.005	45	1.88
LAG531451	001	Earl Cato Apartments	0.0008	45	0.30
LAG531469	001	Kiva Construction	0.005	45	1.88
LAG531620	001	Circle K #664	0.0009	45	0.34
LAG531981	001	Enviro-Lab, Inc.	0.0002	45	0.08
LAG532058	001	Terrebonne Parish Communications District	0.0015	45	0.56
LAG540525	001	Crestview Mobile Home Park	0.005	45	1.88
LAG540726	001	Terrebonne Ph School-Gibson Elem.	0.0013	30	0.33
LAG540737	001	Tesi-Midway Sub	0.059923	30	15.00
LAG540846	001	C&J Mobile Home Estates	0.025	30	6.26
LAG540934	001	McDonald Sanitation Svc, Inc.	0.00144	30	0.36
LAG541104	001	McDonald & Robichaux, Inc.	0.00831	30	2.08
LAG541158	001	L&B Enterprises of Assumption	0.00126	30	0.32
LAG541223	001	Circle G Mobile Home Park	0.025	30	6.26
LAG541317	001	Mandalay Manor Trailer Park	0.015	30	3.76
LAG560080	001	Harvest Cathedral Ministries	0.02782	20	4.64
LAG560135	001	Terrebonne Par Consolidated Govt	0.024960	20	4.17
LAG560174	001	Schexnayder Properties, LLC	0.03	20	5.01
LAG560175	001	Tesi-Acadian Villa	0.04625	20	7.72
LAG560197	001	Terrebonne Par Cons-Gibson Jar	0.03	20	5.01
LAG560224	001	Tesi-Country Hollow	0.584	20	97.47
LAG570035	001	Lafourche Ph Sewer Dist #4	0.078	10	6.51
LAG570091	001	Thoroughbred Park Subdivision	0.0504	10	4.21

Table 6-3. (continued)

NPDES permit number	Outfall	Facility name	Flow (mgd)	BOD_5 (mg/L)	BOD_5 (lb/d)
LAG570155	001	Lakes of Terrebonne, LLC, The	0.0548	10	4.57
LAG570198	001	Tesi- Twelve Cedars Subdivision	0.0384	20	6.41
LAG750372	002	Hill City Oil Co, Inc.	0.005	45	1.88
LAG750372	003	Hill City Oil Co, Inc.	0.025	30	6.26
LAG750372	004	Hill City Oil Co, Inc.	0.025	45	9.39

Table 6-4. WLAs for ammonia for subsegment 120202 in the middle Terrebonne Basin

NPDES permit number	Outfall	Facility name	Flow (mgd)	NH_3 (mg/l)	NH_3 (lb/d)
LA0042510	002	Lafourche Sugars, LLC FKA A Corp	1.5	3.3	41.73
LA0066486	001	Tesi-Magnolia Park Service	0.22	3.3	6.12
LA0074331	101	Universal Compression, Inc.	0.000282	15.0	0.04
LA0074331	002	Universal Compression, Inc.	0.00016	15.0	0.02
LA0081809	001	Tesi-Plantation/Leighton	0.12	3.3	3.34
LAG480528	002	Hydraulic Well Control, Inc.	0.001	15.0	0.13
LAG480528	003	Hydraulic Well Control, Inc.	0.001	15.0	0.13
LA0095257	001	Service Sanitary Corporation	0.1307	3.3	3.64
LA0111236	001	Daneco, Inc.	0.5	20	83.45
LAG750496	002	Redfish Rental of Houma, Inc.	0.005	15.0	0.63
LAG480103	003	Crosstex Lig Liquids, LLC	0.00144	15.0	0.18
LAG480103	004	Crosstex Lig Liquids, LLC	0.00144	15.0	0.18
LAG480134	001	Tetra Technologies, Inc.	0.005	15.0	0.63
LAG480272	002	Smith Int'l Inc.	0.00015	15.0	0.02
LAG480317	002	WFS-Liquids Co	0.0015	15.0	0.19
LAG480563	001	Marine Systems, Inc.	0.0017	15.0	0.21
LAG530072	001	Bellsouth Telecommunications	0.005	15.0	0.63
LAG530268	001	J B Levert Land Company	0.00036	15.0	0.05
LAG530887	001	Sita, Inc.	0.005	15.0	0.63
LAG531154	001	Terrebonne Parish Recreation	0.005	15.0	0.63
LAG531233	001	Williams Field Services Co	0.0025	15.0	0.31
LAG531388	001	Williams Field Svcs Co	0.005	15.0	0.63
LAG531451	001	Earl Cato Apartments	0.0008	15.0	0.10
LAG531469	001	Kiva Construction	0.005	15.0	0.63
LAG531620	001	Circle K #664	0.0009	15.0	0.11
LAG531981	001	Enviro-Lab, Inc.	0.0002	15.0	0.03
LAG532058	001	Terrebonne Parish Communications District	0.0015	15.0	0.19
LAG540525	001	Crestview Mobile Home Park	0.005	15.0	0.63
LAG540726	001	Terrebonne Ph School-Gibson Elem.	0.0013	10.0	0.11
LAG540737	001	Tesi-Midway Sub	0.059923	10.0	5.00
LAG540846	001	C&J Mobile Home Estates	0.025	10.0	2.09
LAG540934	001	McDonald Sanitation Svc, Inc.	0.00144	10.0	0.12
LAG541104	001	McDonald & Robichaux, Inc.	0.00831	10.0	0.69
LAG541158	001	L&B Enterprises of Assumption	0.00126	10.0	0.11
LAG541223	001	Circle G Mobile Home Park	0.025	10.0	2.09
LAG541317	001	Mandalay Manor Trailer Park	0.015	10.0	1.25
LAG560080	001	Harvest Cathedral Ministries	0.02782	6.7	1.55
LAG560135	001	Terrebonne Par Consolidated Govt	0.024960	6.7	1.39
LAG560174	001	Schexnayder Properties, LLC	0.03	6.7	1.67
LAG560175	001	Tesi-Acadian Villa	0.04625	6.7	2.57
LAG560197	001	Terrebonne Par Cons-Gibson Jar	0.03	6.7	1.67
LAG560224	001	Tesi-Country Hollow	0.584	6.7	32.49
LAG570035	001	Lafourche Ph Sewer Dist #4	0.078	3.3	2.17

Table 6-4. (continued)

NPDES permit number	Outfall	Facility name	Flow (mgd)	NH_3 (mg/l)	NH_3 (lb/d)
LAG570091	001	Thoroughbred Park Subdivision	0.0504	3.3	1.40
LAG570155	001	Lakes of Terrebone, LLC, The	0.0548	3.3	1.52
LAG570198	001	Tesi- Twelve Cedars Subdivision	0.0384	6.7	2.14
LAG750372	002	Hill City Oil Co, Inc.	0.005	15.0	0.63
LAG750372	003	Hill City Oil Co, Inc.	0.025	10.0	2.09
LAG750372	004	Hill City Oil Co, Inc.	0.025	15.0	3.13

Table 6-5. WLAs for organic nitrogen for subsegment 120202 in the middle Terrebonne Basin

NPDES permit number	Outfall	Facility name	Flow (mgd)	Org N (mg/l)	Org N (lb/d)
LA0042510	002	Lafourche Sugars, LLC FKA A Corp	1.5	1.7	20.86
LA0066486	001	Tesi-Magnolia Park Service	0.22	1.7	3.06
LA0074331	101	Universal Compression, Inc.	0.000282	7.5	0.02
LA0074331	002	Universal Compression, Inc.	0.00016	7.5	0.01
LA0081809	001	Tesi-Plantation/Leighton	0.12	1.7	1.67
LAG480528	002	Hydraulic Well Control, Inc.	0.001	7.5	0.06
LAG480528	003	Hydraulic Well Control, Inc.	0.001	7.5	0.06
LA0095257	001	Service Sanitary Corporation	0.1307	1.7	1.82
LA0111236	001	Daneco, Inc.	0.5	10.0	41.73
LAG750496	002	Redfish Rental of Houma, Inc.	0.005	7.5	0.31
LAG480103	003	Crosstex Lig Liquids, LLC	0.00144	7.5	0.09
LAG480103	004	Crosstex Lig Liquids, LLC	0.00144	7.5	0.09
LAG480134	001	Tetra Technologies, Inc.	0.005	7.5	0.31
LAG480272	002	Smith Int'l Inc.	0.00015	7.5	0.01
LAG480317	002	WFS-Liquids Co	0.0015	7.5	0.09
LAG480563	001	Marine Systems, Inc.	0.0017	7.5	0.11
LAG530072	001	Bellsouth Telecommunications	0.005	7.5	0.31
LAG530268	001	J B Levert Land Company	0.00036	7.5	0.02
LAG530887	001	Sita, Inc.	0.005	7.5	0.31
LAG531154	001	Terrebonne Parish Recreation	0.005	7.5	0.31
LAG531233	001	Williams Field Services Co	0.0025	7.5	0.16
LAG531388	001	Williams Field Svcs Co	0.005	7.5	0.31
LAG531451	001	Earl Cato Apartments	0.0008	7.5	0.05
LAG531469	001	Kiva Construction	0.005	7.5	0.31
LAG531620	001	Circle K #664	0.0009	7.5	0.06
LAG531981	001	Enviro-Lab, Inc.	0.0002	7.5	0.01
LAG532058	001	Terrebonne Parish Communications District	0.0015	7.5	0.09
LAG540525	001	Crestview Mobile Home Park	0.005	7.5	0.31
LAG540726	001	Terrebonne Ph School-Gibson Elem.	0.0013	5.0	0.05
LAG540737	001	Tesi-Midway Sub	0.059923	5.0	2.50
LAG540846	001	C&J Mobile Home Estates	0.025	5.0	1.04
LAG540934	001	McDonald Sanitation Svc, Inc.	0.00144	5.0	0.06
LAG541104	001	McDonald & Robichaux, Inc.	0.00831	5.0	0.35
LAG541158	001	L&B Enterprises of Assumption	0.00126	5.0	0.05
LAG541223	001	Circle G Mobile Home Park	0.025	5.0	1.04
LAG541317	001	Mandalay Manor Trailer Park	0.015	5.0	0.63
LAG560080	001	Harvest Cathedral Ministries	0.02782	3.3	0.77
LAG560135	001	Terrebonne Par Consolidated Govt	0.024960	3.3	0.69
LAG560174	001	Schexnayder Properties, LLC	0.03	3.3	0.83
LAG560175	001	Tesi-Acadian Villa	0.04625	3.3	1.29
LAG560197	001	Terrebonne Par Cons-Gibson Jar	0.03	3.3	0.83

Table 6-5. (continued)

NPDES permit number	Outfall	Facility name	Flow (mgd)	Org N (mg/l)	Org N (lb/d)
LAG560224	001	Tesi-Country Hollow	0.584	3.3	16.25
LAG570035	001	Lafourche Ph Sewer Dist #4	0.078	1.7	1.08
LAG570091	001	Thoroughbred Park Subdivision	0.0504	1.7	0.70
LAG570155	001	Lakes of Terrebonne, LLC, The	0.0548	1.7	0.76
LAG570198	001	Tesi- Twelve Cedars Subdivision	0.0384	3.3	1.07
LAG750372	002	Hill City Oil Co, Inc.	0.005	7.5	0.31
LAG750372	003	Hill City Oil Co, Inc.	0.025	5.0	1.04
LAG750372	004	Hill City Oil Co, Inc.	0.025	7.5	1.56

Table 6-6. WLAs for BOD_5 for subsegment 120204 in the middle Terrebonne Basin

NPDES permit number	Outfall	Facility name	Flow (mgd)	BOD_5 (mg/L)	BOD_5 (lb/d)
LA0043966	001	Village of Napoleonville	0.3	10	25.04
LA0118818	005	Browning Oil Company, Inc.	0.00155	45	0.58
LAG530071	001	Bellsouth Pierre Port-Switching Station	0.0001	45	0.04
LAG531350	001	Pierre Part Store, Inc.	0.00166	45	0.62
LAG531365	001	Ladotd-Pierre Part Bridge	0.00002	45	0.01
LAG531584	001	Assumption Parish Police Jury	0.004	45	1.50
LAG540112	001	Tesi-Seraphim Estates	0.0156	30	3.91
LAG540140	001	Assumption Ph Polic-Violet Str	0.02	30	5.01
LAG540154	001	Worldwide Environmental Solutions-Kingston's	0.018	30	4.51
LAG540155	001	Worldwide Environmental Solutions-Labadie ES	0.0176	30	4.41
LAG541048	001	Heritage Manor of Napoleonvill	0.0202	30	5.06
LAG560026	001	Aucoin's Sewer Util-Bayou Tran	0.044	20	7.34
LAG570240	001	Assumption Parish Police	0.03	10	2.50

Table 6-7. WLAs for ammonia for subsegment 120204 in the middle Terrebonne Basin

NPDES permit number	Outfall	Facility name	Flow (mgd)	NH_3 (mg/l)	NH_3 (lb/d)
LA0043966	001	Village of Napoleonville	0.3	6.08	15.222
LA0118818	005	Browning Oil Company, Inc.	0.00155	15.0	0.194
LAG530071	001	Bellsouth Pierre Port-Switching Station	0.0001	15.0	0.013
LAG531350	001	Pierre Part Store, Inc.	0.00166	15.0	0.208
LAG531365	001	Ladotd-Pierre Part Bridge	0.00002	15.0	0.003
LAG531584	001	Assumption Parish Police Jury	0.004	15.0	0.501
LAG540112	001	Tesi-Seraphim Estates	0.0156	10.0	1.302
LAG540140	001	Assumption Ph Polic-Violet Str	0.02	10.0	1.669
LAG540154	001	Worldwide Environmental Solutions-Kingston's	0.018	10.0	1.502
LAG540155	001	Worldwide Environmental Solutions-Labadie ES	0.0176	10.0	1.469
LAG541048	001	Heritage Manor of Napoleonvill	0.0202	10.0	1.686
LAG560026	001	Aucoin's Sewer Util-Bayou Tran	0.044	6.7	2.448
LAG570240	001	Assumption Parish Police	0.03	3.3	0.835

Table 6-8. WLAs for organic nitrogen for subsegment 120204 in the middle Terrebonne Basin

NPDES permit number	Outfall	Facility name	Flow (mgd)	Org N (mg/L)	Org N (lb/d)
LA0043966	001	Village of Napoleonville	0.3	3.0	7.6110
LA0118818	005	Browning Oil Company, Inc.	0.00155	7.5	0.0970
LAG530071	001	Bellsouth Pierre Port-Switching Station	0.0001	7.5	0.0063
LAG531350	001	Pierre Part Store, Inc.	0.00166	7.5	0.1039
LAG531365	001	Ladotd-Pierre Part Bridge	0.00002	7.5	0.0013
LAG531584	001	Assumption Parish Police Jury	0.004	7.5	0.2504
LAG540112	001	Tesi-Seraphim Estates	0.0156	5.0	0.6509
LAG540140	001	Assumption Ph Polic-Violet Str	0.02	5.0	0.8345
LAG540154	001	Worldwide Environmental Solutions-Kingston's	0.018	5.0	0.7511
LAG540155	001	Worldwide Environmental Solutions-Labadie ES	0.0176	5.0	0.7344
LAG541048	001	Heritage Manor of Napoleonvill	0.0202	5.0	0.8429
LAG560026	001	Aucoin's Sewer Util-Bayou Tran	0.044	3.3	1.2240
LAG570240	001	Assumption Parish Police	0.03	1.7	0.4173

Table 6-9. WLAs for BOD_5 for subsegment 120304 in the middle Terrebonne Basin

NPDES permit number	Outfall	Facility name	Flow (mgd)	BOD_5 (mg/L)	BOD_5 (lb/d)
LAG480081	001	Baker Atlas	0.0002	45	0.08
LA0089648	008	Bourg Dry Dock & Service Company	0.0005	45	0.19
LA0089648	009	Bourg Dry Dock & Service Company	0.0005	45	0.19
LA0089648	010	Bourg Dry Dock & Service Company	0.0005	45	0.19
LA0096253	001	Bourg Dry Dock & Service Company	0.0002	45	0.08
LA0097195	001	Bourg Dry Dock & Service Company	0.00025	45	0.09
LA0104868	001	Main Iron Works, LLC	0.0003	45	0.11
LA0104868	002A	Main Iron Works, LLC	0.00045	45	0.17
LA0104868	002B	Main Iron Works, LLC	0.00045	45	0.17
LA0104868	003	Main Iron Works, LLC	0.00045	45	0.17
LA0110299	001	PFG Caro	0.01	30	2.50
LA0112267	002	Neff Rental, Inc.	0.00035	45	0.13
LA0112267	003	Neff Rental, Inc.	0.00035	45	0.13
LA0118702	001	Allied Shipyard, Inc.-Larose Facility	0.0002	45	0.08
LA0118702	002	Allied Shipyard, Inc.-Larose Facility	0.0002	45	0.08
LAG110090	002	Huey Stockstill, Inc.-Houma Asphalt Plant Sn 31888	0.005	45	1.88
LAG480216	101	Southern Scrap Recycling-Morgan City, LLC	0.0005	45	0.19
LAG480216	103	Southern Scrap Recycling-Morgan City, LLC	0.0005	45	0.19

Table 6-10. WLAs for ammonia for subsegment 120304 in the middle Terrebonne Basin

NPDES permit number	Outfall	Facility name	Flow (mgd)	NH_3 (mg/l)	NH_3 (lb/d)
LAG480081	001	Baker Atlas	0.0002	15.0	0.025
LA0089648	008	Bourg Dry Dock & Service Company	0.0005	15.0	0.063
LA0089648	009	Bourg Dry Dock & Service Company	0.0005	15.0	0.063
LA0089648	010	Bourg Dry Dock & Service Company	0.0005	15.0	0.063
LA0096253	001	Bourg Dry Dock & Service Company	0.0002	15.0	0.025
LA0097195	001	Bourg Dry Dock & Service Company	0.00025	15.0	0.031
LA0104868	001	Main Iron Works, LLC	0.0003	15.0	0.038
LA0104868	002A	Main Iron Works, LLC	0.00045	15.0	0.056
LA0104868	002B	Main Iron Works, LLC	0.00045	15.0	0.056
LA0104868	003	Main Iron Works, LLC	0.00045	15.0	0.056
LA0110299	001	PFG Caro	0.01	10.0	0.835

Table 6-10. (continued)

NPDES permit number	Outfall	Facility name	Flow (mgd)	NH_3 (mg/l)	NH_3 (lb/d)
LA0112267	002	Neff Rental, Inc.	0.00035	15.0	0.044
LA0112267	003	Neff Rental, Inc.	0.00035	15.0	0.044
LA0118702	001	Allied Shipyard, Inc.-Larose Facility	0.0002	15.0	0.025
LA0118702	002	Allied Shipyard, Inc.-Larose Facility	0.0002	15.0	0.025
LAG110090	002	Huey Stockstill, Inc.-Houma Asphalt Plant Sn 31888	0.005	15.0	0.626
LAG480216	101	Southern Scrap Recycling-Morgan City, LLC	0.0005	15.0	0.063
LAG480216	103	Southern Scrap Recycling-Morgan City, LLC	0.0005	15.0	0.063

Table 6-11. WLAs for organic nitrogen for subsegment 120304 in the middle Terrebonne Basin

NPDES permit number	Outfall	Facility name	Flow (mgd)	Org N (mg/L)	Org N (lb/d)
LAG480081	001	Baker Atlas	0.0002	7.5	0.013
LA0089648	008	Bourg Dry Dock & Service Company	0.0005	7.5	0.031
LA0089648	009	Bourg Dry Dock & Service Company	0.0005	7.5	0.031
LA0089648	010	Bourg Dry Dock & Service Company	0.0005	7.5	0.031
LA0096253	001	Bourg Dry Dock & Service Company	0.0002	7.5	0.013
LA0097195	001	Bourg Dry Dock & Service Company	0.00025	7.5	0.016
LA0104868	001	Main Iron Works, LLC	0.0003	7.5	0.019
LA0104868	002A	Main Iron Works, LLC	0.00045	7.5	0.028
LA0104868	002B	Main Iron Works, LLC	0.00045	7.5	0.028
LA0104868	003	Main Iron Works, LLC	0.00045	7.5	0.028
LA0110299	001	PFG Caro	0.01	5.0	0.417
LA0112267	002	Neff Rental, Inc.	0.00035	7.5	0.022
LA0112267	003	Neff Rental, Inc.	0.00035	7.5	0.022
LA0118702	001	Allied Shipyard, Inc.-Larose Facility	0.0002	7.5	0.013
LA0118702	002	Allied Shipyard, Inc.-Larose Facility	0.0002	7.5	0.013
LAG110090	002	Huey Stockstill, Inc.-Houma Asphalt Plant Sn 31888	0.005	7.5	0.313
LAG480216	101	Southern Scrap Recycling-Morgan City, LLC	0.0005	7.5	0.031
LAG480216	103	Southern Scrap Recycling-Morgan City, LLC	0.0005	7.5	0.031

Table 6-12. WLAs for BOD_5 for subsegment 120403 in the middle Terrebonne Basin

NPDES permit number	Outfall	Facility name	Flow (mgd)	BOD_5 (mg/L)	BOD_5 (lb/d)
LA0107247	001	Global X-ray & Testing Corp	0.00012	45	0.05
LA0107247	002	Global X-ray & Testing Corp	0.00006	45	0.02
LAG480218	002	Southern Scrap Recycling Morgan City LLC	0.0015	45	0.56
LAG480218	101	Southern Scrap Recycling Morgan City LLC	0.05	45	18.78
LAG480257	002	PHI Inc	0.005	45	1.88
LAG480270	002	Chet Morrison General Contractor Inc-Houma Facility	0.0005	45	0.19
LAG480270	003	Chet Morrison General Contractor Inc-Houma Facility	0.0005	45	0.19
LAG480270	004	Chet Morrison General Contractor Inc-Houma Facility	0.0005	45	0.19
LAG480317	002	WFA Liquids Company-Bayou Black Treatment Plant	0.0015	45	0.56

Table 6-13. WLAs for ammonia for subsegment 120403 in the middle Terrebonne Basin

NPDES permit number	Outfall	Facility name	Flow (mgd)	NH_3 (mg/l)	NH_3 (lb/d)
LA0107247	001	Global X-ray & Testing Corp	0.00012	15.0	0.015
LA0107247	002	Global X-ray & Testing Corp	0.00006	15.0	0.008
LAG480218	002	Southern Scrap Recycling Morgan City LLC	0.0015	15.0	0.188
LAG480218	101	Southern Scrap Recycling Morgan City LLC	0.05	15.0	6.259
LAG480257	002	PHI Inc	0.005	15.0	0.626
LAG480270	002	Chet Morrison General Contractor Inc-Houma Facility	0.0005	15.0	0.063
LAG480270	003	Chet Morrison General Contractor Inc-Houma Facility	0.0005	15.0	0.063
LAG480270	004	Chet Morrison General Contractor Inc-Houma Facility	0.0005	15.0	0.063
LAG480317	002	WFA Liquids Company-Bayou Black Treatment Plant	0.0015	15.0	0.188

Table 6-14. WLAs for organic nitrogen for subsegment 120403 in the middle Terrebonne Basin

NPDES permit number	Outfall	Facility name	Flow (mgd)	Org N (mg/L)	Org N (lb/d)
LA0107247	001	Global X-ray & Testing Corp	0.00012	7.5	0.008
LA0107247	002	Global X-ray & Testing Corp	0.00006	7.5	0.004
LAG480218	002	Southern Scrap Recycling Morgan City LLC	0.0015	7.5	0.094
LAG480218	101	Southern Scrap Recycling Morgan City LLC	0.05	7.5	3.130
LAG480257	002	PHI Inc	0.005	7.5	0.313
LAG480270	002	Chet Morrison General Contractor Inc-Houma Facility	0.0005	7.5	0.031
LAG480270	003	Chet Morrison General Contractor Inc-Houma Facility	0.0005	7.5	0.031
LAG480270	004	Chet Morrison General Contractor Inc-Houma Facility	0.0005	7.5	0.031
LAG480317	002	WFA Liquids Company-Bayou Black Treatment Plant	0.0015	7.5	0.094

Table 6-15. WLAs for BOD_5 for subsegment 120604 in the middle Terrebonne Basin

NPDES permit number	Outfall	Facility name	Flow (mgd)	BOD_5 (mg/L)	BOD_5 (lb/d)
LA0084077	001	Bollinger Larose, LLC	0.0005	45	0.19
LA0084077	002	Bollinger Larose, LLC	0.0005	45	0.19
LA0084077	004	Bollinger Larose, LLC	0.005	45	1.88
LAG541539	008	Bollinger Larose, LLC	0.007	45	2.63
LAG530324	001	Lafourche Telephone Co	0.005	45	1.88
LAG531493	001	Lebouef Trailer Park	0.005	45	1.88
LAG532034	001	Chiasson Welding Service	0.001	45	0.38
LAG540624	001	Rousse Land Development-Bon Service Shopping Center	0.025	30	6.26

Table 6-16. WLAs for ammonia for subsegment 120604 in the middle Terrebonne Basin

NPDES permit number	Outfall	Facility name	Flow (mgd)	NH_3 (mg/l)	NH_3 (lb/d)
LA0084077	001	Bollinger Larose, LLC	0.0005	15.0	0.06
LA0084077	002	Bollinger Larose, LLC	0.0005	15.0	0.06
LA0084077	004	Bollinger Larose, LLC	0.005	15.0	0.63
LAG541539	008	Bollinger Larose, LLC	0.007	15.0	0.88
LAG530324	001	Lafourche Telephone Co	0.005	15.0	0.63
LAG531493	001	Lebouef Trailer Park	0.005	15.0	0.63
LAG532034	001	Chiasson Welding Service	0.001	15.0	0.13
LAG540624	001	Rousse Land Development-Bon Service Shopping Center	0.025	10.0	2.09

Table 6-17. WLAs for organic nitrogen for subsegment 120604 in the middle Terrebonne Basin

NPDES permit number	Outfall	Facility name	Flow (mgd)	Org N (mg/L)	Org N (lb/d)
LA0084077	001	Bollinger Larose, LLC	0.0005	7.5	0.03
LA0084077	002	Bollinger Larose, LLC	0.0005	7.5	0.03
LA0084077	004	Bollinger Larose, LLC	0.005	7.5	0.31
LAG541539	008	Bollinger Larose, LLC	0.007	7.5	0.44
LAG530324	001	Lafourche Telephone Co	0.005	7.5	0.31
LAG531493	001	Lebouef Trailer Park	0.005	7.5	0.31
LAG532034	001	Chiasson Welding Service	0.001	7.5	0.06
LAG540624	001	Rousse Land Development-Bon Service Shopping Center	0.025	5.0	1.04

Table 6-18. Summary of WLAs for MS4s the middle Terrebonne Basin

Subsegment	Urban Area	NPDES permit number	MS4 area (acres)	Pollutant	MS4 (lb/d)
120202	Terrebonne Parish	LAR041023	7,461.88	BOD_u	1,236.1
120202	Terrebonne Parish	LAR041023	7,461.88	Organic nitrogen	171.0
120202	Terrebonne Parish	LAR041023	7,461.88	Ammonia	27.5
120202	Terrebonne Parish	LAR041023	7,461.88	SOD	780.1
120304	Terrebonne Parish	LAR041023	188.35	BOD_u	8,594.1
120304	Terrebonne Parish	LAR041023	188.35	Organic nitrogen	374.7
120304	Terrebonne Parish	LAR041023	188.35	Ammonia	18.4
120304	Terrebonne Parish	LAR041023	188.35	SOD	619.8
120403	Terrebonne Parish	LAR041023	657.49	BOD_u	1,895.1
120403	Terrebonne Parish	LAR041023	657.49	Organic nitrogen	217.3
120403	Terrebonne Parish	LAR041023	657.49	Ammonia	10.6
120403	Terrebonne Parish	LAR041023	657.49	SOD	696.3
120403	Morgan City	LAR041028	346.22	BOD_u	997.9
120403	Morgan City	LAR041028	346.22	Organic nitrogen	114.4
120403	Morgan City	LAR041028	346.22	Ammonia	5.6
120403	Morgan City	LAR041028	346.22	SOD	366.7
120204	Assumption Parish Police Jury	LAR041039	1,261.17	BOD_u	17,514.5
120204	Assumption Parish Police Jury	LAR041039	1,261.17	Organic nitrogen	383.9
120204	Assumption Parish Police Jury	LAR041039	1,261.17	Ammonia	13.4
120204	Assumption Parish Police Jury	LAR041039	1,261.17	SOD	5,259.6

6.1.1 Seasonal Variation

Critical conditions for dissolved oxygen in Louisiana waterbodies have been determined to be the following: negligible nonpoint runoff and low stream flow combined with high water temperatures. Oxygen-demanding substances can enter a water system during high flows and settle to the bottom, where they exert a large oxygen demand during the high-temperature/low-flow seasons. Water temperature is one of the leading factors that affect dissolved oxygen in the three segments. High water temperatures lower the dissolved oxygen saturation concentration, decreasing the amount of dissolved oxygen that the stream can contain. In addition, high temperature increases CBOD decay and SOD. Therefore, it is most important to develop a TMDL to address the high-water-temperature conditions.

6.1.2 Sensitivity Analysis

A sensitivity analysis was performed on the model parameters using the sensitivity function built into LA-QUAL. LA-QUAL automatically changed the requested parameters by a set amount while keeping all other parameters constant. The calibration scenario was used as the baseline for the sensitivity analysis. For the analysis, all parameters were varied by ±30 percent. The results for dissolved oxygen and BOD are shown in Table 6-19. Result plots are shown in Appendix K. Changes to the stream reaeration, stream velocity, and background SOD had the largest influence on dissolved oxygen levels. Stream dispersion had no effect on dissolved oxygen.

Table 6-19. Results of sensitivity analysis

		BOD (mg/L)						DO (mg/L)					
		BOD aerobic decay rate	BOD settling rate	Stream dispersion	Stream reaeration	Background SOD	Stream velocity	BOD aerobic decay rate	BOD settling rate	Stream dispersion	Stream reaeration	Background SOD	Stream velocity
120202	-30%	0.51	0.36	0.36	0.36	0.36	0.25	1.49	1.49	1.49	1.49	1.49	1.49
	base	0.36	0.36	0.36	0.36	0.36	0.36	1.49	1.49	1.49	1.49	1.49	1.49
	30%	0.28	0.36	0.36	0.36	0.36	0.47	1.49	1.49	1.49	1.49	1.49	1.49
120204	-30%	20.31	13.61	13.74	13.61	13.61	9.20	3.87	3.55	3.55	2.69	4.00	3.69
	base	13.61	13.61	13.61	13.61	13.61	13.61	3.55	3.55	3.55	3.55	3.55	3.55
	30%	10.20	13.61	13.49	13.61	13.61	18.69	1.87	3.55	3.55	3.69	2.66	1.59
120304 and 120403	-30%	3.17	2.24	2.24	2.24	2.24	1.58	3.41	3.05	3.05	1.69	3.84	3.97
	base	2.24	2.24	2.24	2.24	2.24	2.24	3.05	3.05	3.05	3.05	3.05	3.05
	30%	1.73	2.24	2.24	2.24	2.24	2.89	2.83	3.05	3.05	3.76	2.26	1.44
120604	-30%	4.69	4.69	4.69	4.69	4.69	4.69	1.68	1.68	1.68	1.68	1.68	1.68
	base	4.69	4.69	4.69	4.69	4.69	4.69	1.68	1.68	1.68	1.68	1.68	1.68
	30%	4.69	4.69	4.69	4.69	4.69	4.69	1.68	1.68	1.68	1.68	1.68	1.68

6.1.3 Ammonia Toxicity Analysis

An analysis was performed on the model input and modeled results to determine whether the modeled ammonia concentrations exceeded EPA chronic criteria for ammonia toxicity (USEPA 1999). The EPA criteria are dependent on temperature and pH. Temperature was taken from the model output. Because pH is not included in the model, it was obtained from levels observed during the July 2006 monitoring event. The resulting criteria and the model-predicted ammonia concentrations are presented in Table 6-20. These concentrations were below the EPA ammonia toxicity criteria and show that the criteria will not be exceeded during critical conditions. These results do not require ammonia or organic nitrogen permit limits for the permits included in this document. If LDEQ determines there is no reasonable potential for a discharger to exceed the ammonia or organic nitrogen WLAs, then a permit may omit these parameters and still comply with this TMDL. The ammonia toxicity calculations are included in Appendix L.

Table 6-20. Predicted ammonia concentration and calculated chronic criteria

Subsegment	Predicted ammonia (mg/L)		Calculated criteria (mg/L)	
	Minimum	Maximum	Minimum	Maximum
120202	0.06	0.25	0.58	1.79
120204	0.06	0.12	0.12	1.59
120304	0.03	0.13	1.63	1.66
120403	0.07	0.12	0.47	1.93
120604	0.04	0.11	1.53	1.61

6.2 Nutrient TMDLs

Nutrients can enter a water system through surface runoff. Once they are in the environment, the most recognizable effect is algae blooms. The buildup of nutrients that leads to the blooms can occur over time even if the effects are not noticed in the short term. When algae die, the result is increased oxygen demand, which is detrimental to aquatic life.

The state's nutrient criteria are narrative and include the following language (LDEQ 2007):

> The naturally occurring range of nitrogen-phosphorous ratios shall be maintained. This range shall not apply to designated intermittent streams. To establish the appropriate range of ratios and compensate for natural seasonal fluctuations, the administrative authority will use site-specific studies to establish limits for nutrients. Nutrient concentrations that produce aquatic growth to the extent that it creates a public nuisance or interferes with designated water uses shall not be added to any surface waters.

To accomplish this, water quality data were collected from non-nutrient impaired subsegments in the Terrebonne Basin. The data included total phosphorus, nitrate+nitrite, and TKN. The nitrate+nitrite and TKN were summed to obtain the total nitrogen concentration. Table 6-12 presents the average concentrations by monitoring location for the non-impaired subsegments. The minimum, mean, and maximum are presented for total phosphorus and total nitrogen.

Table 6-12. Nutrient concentrations in non-impaired subsegments

Subsegment	Subsegment name	Site ID	Total P (mg/L)	NO_2+NO_3 (mg/L)	TKN (mg/L)	Total N (mg/L)	Total N/ total P ratio
120205	Lake Palourde	338	0.15	0.16	1.17	1.33	8.87
120206	Grand Bayou and Little Grand Bayou	82	0.52	0.37	1.39	1.76	3.38
120509	Houma Navigation Canal	343	0.14	0.47	0.79	1.26	9.00
		942	0.15	0.43	0.84	1.27	8.47
120601	Bayou Terrebonne	943	0.16	0.27	0.88	1.15	7.19
		Minimum	0.14	0.16	0.79	1.15	8.21
		Mean	0.22	0.34	1.01	1.35	6.14
		Maximum	0.52	0.47	1.39	1.76	3.38

The data in Table 6-12 were compared with the observed data for the nutrient-impaired subsegments in Table 6-13. The total nitrogen to total phosphorus ratio and mean concentrations in the nutrient listed subsegments are within the ratio and concentration ranges for the non-impaired subsegments. Because of this, no nutrient reductions were necessary for the subsegments listed in Table 6-13.

Table 6-13. Nutrient concentrations in the impaired subsegments in the middle Terrebonne Basin

Subsegment	Subsegment name	Total P (mg/L)	NO_2+NO_3 (mg/L)	TKN (mg/L)	Total N (mg/L)	Total N/ total P ratio
120202	Bayou Black	0.17	0.20	0.89	1.05	6.18
120204	Lake Verret and Grassy Lake	0.22	0.09	1.36	1.32	6.00

Because of the lack of flow data for the Terrebonne Basin, the monthly water yield (runoff in millimeters) was used to obtain TMDL loadings. The monthly water yields for the Southeast and South-central Climate Divisions were obtained from the Louisiana Office of State Climatology. The monthly water yield was divided by the number of days in the month to obtain runoff intensity (Table 6-14).

Table 6-14. Average water yields for climate divisions in the Terrebonne Basin

Climate division	Yearly average monthly water yield (millimeters)	Subsegments represented
Southeast	2.402	120202, 120304
South-central	2.378	120204

The nutrient TMDLs are presented in Table 6-15. The water yield was used with the mean reference stream concentration to determine the TMDL. The TMDL represents the loadings from local land area. Because no reductions to nutrients were required, it is assumed that the point sources may continue to discharge at their current concentration level of nutrients and not make any deleterious effect on water quality. Any increase in nutrient effluent concentrations could require additional monitoring and modeling and a revision to this TMDL.

Table 6-15. Summary of TMDLs for nutrients in the middle Terrebonne Basin

Subsegment	MOS (10%) (lb/d)	Total allowable loading (lb/d)	Percent reduction
Total phosphorus			
120202	0.06	0.64	0.00
120204	0.08	0.76	0.00
120304	0.00	0.03	0.00
Total nitrogen			
120202	0.39	3.90	0.00
120204	0.47	4.68	0.00
120304	0.02	0.16	0.00

7 FUTURE ACTIVITIES

7.1 TMDL Implementation Strategies

EPA Region 6 has funded a use attainability assessment (UAA) study for the *Development of Site-Specific Dissolved Oxygen Criteria for the Terrebonne Basin, Louisiana*. On January 31, 2008, the contractor (Tetra Tech, Inc.) submitted a draft report for EPA's review. In addition, the state is involved in analyzing available data for the Barataria and Terrebonne basin waters to evaluate and possibly revise the existing dissolved oxygen criterion.

Once LDEQ adopts and EPA approves the revised dissolved oxygen criteria, LDEQ will reassess the 303(d) listed subsegments for dissolved oxygen and nutrients in the Terrebonne Basin. If the reassessment of a subsegment indicates a subsegment is not impaired on the basis of revised criteria, if appropriate, the dissolved oxygen and nutrients TMDLs may be withdrawn, and EPA will publish a public notice. If the reassessment of a subsegment indicates that the subsegment is impaired on the basis of the revised criteria, if appropriate, the dissolved oxygen and nutrients TMDLs may be revised, and EPA will publish a public notice.

Reasonable assurance is needed that the water quality criterion will be attained. As a first step to implement these dissolved oxygen and nutrients TMDLs, it is recommended that LDEQ complete a reassessment of the 303(d)-listed subsegments in the Terrebonne Basin using the new adopted dissolved oxygen criteria to verify if the subsegment is not impaired or still considered impaired. WLAs will be implemented through Louisiana Pollutant Discharge Elimination System (LPDES) permit procedures. Part of the LAs might be implemented through the LDEQ 305(b) program and set priorities for the Clean Water Act section 319 program. BMPs from the implementation plan will be implemented throughout the subsegment. This approach will reduce the loadings and improve dissolved oxygen levels in the subsegment and subsequent downstream subsegments.

Hurricane Katrina made landfall on Monday, August 29, 2005, as a Category 4 hurricane. The storm brought heavy winds and rain to southeast Louisiana, breaching several levees and flooding up to 80 percent of New Orleans and large areas of coastal Louisiana. Both Hurricanes Katrina and Rita have caused a significant amount of change in sedimentation and water quality in southern Louisiana. Many wastewater treatment facilities were temporarily or permanently damaged. Some wastewater treatment facilities will be rebuilt; others will be relocated. Several federal and state agencies, including EPA and LDEQ, are engaged in collecting environmental data and assessing the recovery of the Gulf of Mexico waters.

The proposed TMDLs in this report were developed on the basis of pre- and post-hurricane water quality conditions. Some point sources in this TMDL have been updated with post-hurricane information, where available. Post-hurricane water quality conditions and other factors could delay the implementation of these proposed TMDLs, render some proposed TMDLs obsolete, or require modifications of the TMDLs. Although hurricane effects may be valid for some TMDLs, any deviation from the TMDLs should be justified using site-specific data or information.

7.2 Environmental Monitoring Activities

LDEQ uses funds provided under section 106 of the Clean Water Act and under the authority of the Louisiana Environmental Quality Act to run a program for monitoring the quality of Louisiana's surface waters. The LDEQ Surveillance Section collects surface water samples at various locations using appropriate sampling methods and procedures to ensure the quality of the data collected. The objectives of the surface water monitoring program are to determine the quality of the state's surface waters, to develop a long-term database for water quality trend analysis, and to monitor the effectiveness of pollution controls. The data obtained through the surface water monitoring program are used to develop the state's biennial section 305(b) report (*Water Quality Inventory*) and section 303(d) list of impaired waters.

LDEQ has implemented a watershed approach to surface water quality monitoring. Through the approach, the entire state is sampled on a 4-year cycle. Long-term trend monitoring sites at various locations on the large rivers and Lake Pontchartrain are sampled throughout the 4-year cycle. Sampling is conducted monthly to yield approximately 12 samples per site during each year the site is monitored. Sampling sites are located where they are considered representative of the waterbody. Under the current monitoring schedule, approximately one-half of the state's waters are newly assessed for section 305(b) and section 303(d) listing purposes during each biennial cycle; sampling occurs statewide each year. The 4-year cycle follows an initial 5-year rotation that covered all basins in the state according to the TMDL priorities.

Monitoring will allow LDEQ to determine whether there has been any improvement in water quality following TMDL implementation. As the monitoring results are evaluated at the end of each year, waterbodies might be added to or removed from the section 303(d) list of impaired waterbodies.

8 PUBLIC PARTICIPATION

Federal regulations require EPA to notify the public and seek comments concerning TMDLs that the Agency prepares. These TMDLs were developed under contract to EPA, and EPA held a public review period seeking comments, information, and data from the public and any other interested parties. The notice for the public review period was published in the *Federal Register* on October 25, 2007, and the review period closed on November 26, 2007.

LDEQ submitted the only comments received during the public comment period. These comments were incorporated into the final TMDLs. Public comments and EPA responses to these TMDLs, along with comments on similar TMDLs with the same public review period, have been will be included in the document: *EPA Responses to Comments for Dissolved Oxygen, Nutrients, pH, and Mercury TMDLs in the Red River, Sabine River, and Terrebonne Basins, Louisiana.*

These TMDLs were published in the *Federal Register* on April 2, 2008 as final. The TMDLs were modified in June 2008 and a notice for a second public review period was published in the *Federal Register* on August 27, 2008 and the review period closed on September 26, 2008. Comments were received from the Gulf Restoration Network. These comments and EPA responses are included in Appendix M of this document.

EPA will transmit the final modified TMDLs to LDEQ for implementation and incorporation into LDEQ's current water quality management plan.

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