TMDLS FOR DISSOLVED OXYGEN FOR BLACK LAKE BAYOU (100702), BLACK LAKE AND CLEAR LAKE (100703), AND SALINE BAYOU (100803)

MARCH 25, 2008

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AND SALINE BAYOU (100803)

Prepared for

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EXECUTIVE SUMMARY

Section 303(d) of the Federal Clean Water Act requires states to identify waterbodies that are not meeting water quality standards and to develop total maximum daily pollutant loads for those waterbodies. A total maximum daily load (TMDL) is the amount of pollutant that a waterbody can assimilate without exceeding the established water quality standard for that pollutant. Through a TMDL, pollutant loads can be distributed or allocated to point sources and nonpoint sources discharging to the waterbody. This report presents TMDLs that have been developed for dissolved oxygen (DO) for Black Lake Bayou (Subsegment 100702), Black Lake and Clear Lake (Subsegment 100703), and Saline Bayou (Subsegment 100803), in the Red River basin in central Louisiana.

Black Lake Bayou begins in north central Louisiana east of Minden, Louisiana. From there it flows into Black Lake. Black Lake flows into Clear Lake. Water can exit Clear Lake at its downstream end via Chivery Dam (which is actually two dams, one built in the 1950s and another built downstream of the first in 1990) and flows into Saline Bayou. Water also exits Clear Lake at its northern end via Black Lake Bayou, which flows east and enters Saline Bayou.

Subsegments 100702, 100703, and 100803 were listed on the Modified Court Ordered 303(d) List for Louisiana as not fully supporting the designated use of propagation of fish and wildlife. Subsegment 100702 was ranked as priority No. 2 for TMDL development, and Subsegments 100703 and 100803 were ranked as priority No. 7. No known sources for impairment were cited in the 303(d) list. The water quality standard for DO in these subsegments is 5 mg/L year-round.

A water quality model (LA-QUAL) was set up to simulate DO, carbonaceous biochemical oxygen demand (CBOD), ammonia nitrogen, and organic nitrogen in these subsegments. The model was set up and calibrated using Louisiana Department of Environmental Quality historical monitoring data, observations from a synoptic survey conducted by FTN Associates, Ltd. during September 2005, and other various information obtained from LDEQ and United States Geological Survey. The projection simulation was run at critical flows and temperatures to address seasonality as required by the Clean Water Act.

Oxygen-demanding load reductions were required to meet the DO standard. Nonpoint source load reductions of approximately 22% in Subsegment 100702 and 3% in Subsegment 100703 were needed to bring the predicted DO values to at least 5.0 mg/L during the summer season. No reduction was required in Subsegment 100803. For the winter season, a nonpoint source load reduction of 7% was needed in Subsegment 100702 to bring the predicted DO concentrations to at least 5.0 mg/L. No nonpoint load reductions were needed in Subsegments 100703 and 100803 to meet the DO standard of 5.0 mg/L in the winter season. No reductions in point source loads were needed to maintain the DO standard during either the summer or winter season. Therefore, no change in permit limits is required as a result of this TMDL.

TMDLs for oxygen-demanding substances (CBOD, ammonia nitrogen, organic nitrogen, and sediment oxygen demand (SOD)) were calculated using the results of the projection simulations. Both implicit and explicit margins of safety were included in the TMDL calculations. The TMDLs for each subsegment and season are shown in Tables ES.1 and ES.2. The point source loads used in the TMDLs for Subsegments 100702 and 100703 are shown in Tables ES.3 and ES.4, respectively.

Table ES.1. Summer DO TMDLs.

Subsegment	Loads (lbs/day)				
	WLA	**LA**	**MOS**	**FG**	**TMDL**
Black Lake Bayou (100702)	918.4	4,807	715.9	715.9	7,157.1
Black Lake and Clear Lake (100703)	19.6	523,948.5	6,551.7	6,551.7	654,958.9
Saline Bayou (100803)	0	21,648.5	2,706.4	2,706.4	27,061.3

Table ES.2. Winter DO TMDLs.

Subsegment	Loads (lbs/day)				
	WLA	**LA**	**MOS**	**FG**	**TMDL**
Black Lake Bayou (100702)	918.4	6,788.5	963.2	963.2	9,613.1
Black Lake and Clear Lake (100703)	19.6	250,637	31,332.5	31,332.5	313,321.7
Saline Bayou (100803)	0	24,557.3	3,068.8	3,068.8	30,695

Table ES.3. Flows, concentrations, and loads for point sources included in DO TMDL for Subsegment 100702.

NPDES Permit Number	Name of Discharger	Outfall	Flow Rate (gpd)	Concentrations			Loads*		
				BOD_5 or $CBOD_5$ (mg/L)	Ammonia Nitrogen (mg/L)	Organic Nitrogen (mg/L)	BOD_5 or $CBOD_5$ (lbs/day)	Ammonia Nitrogen (lbs/day)	Organic Nitrogen (lbs/day)
LA0049484	Ringold STP	001	185,000	10	1.7	3.4	15.43	2.62	5.25
LA0053261	Gibsland Municipal WWTF	001	150,000	10	1.7	3.4	12.51	2.13	4.25
LA0080446	Weyerhaeuser Company – Taylor Sawmill	002	97,000	200 +	0	0	161.80	0.00	0.00
		003	8,000	45	3.3	6.6	3.00	0.22	0.44
		005	270,000	250 +	0	0	562.95	0.00	0.00
LAG480478	Tesco Services, Inc.	001	13	200 +	0	0	0.02	0.00	0.00
LAG540420	ADA Rest Area - Eastbound	001	15,000	30	3.3	6.6	3.75	0.41	0.83
LAG540421	ADA Rest Area - Westbound	001	15,000	30	3.3	6.6	3.75	0.41	0.83
LAG560094	Athens WWTF	001	40,000	20	3.3	6.6	6.67	1.10	2.20
100702 TOTAL LOADS:							769.89	6.90	13.79

+ COD Permit Limits
* Loads of organic nitrogen and ammonia nitrogen in this table represent loads of nitrogen, not oxygen demand.

Table ES.4. Flows, concentrations, and loads for point sources included in DO TMDL for Subsegment 100703.

NPDES Permit Number	Name of Discharger	Outfall	Flow Rate (gpd)	Concentrations			Loads*		
				BOD_5 or $CBOD_5$ (mg/L)	Ammonia Nitrogen (mg/L)	Organic Nitrogen (mg/L)	BOD_5 or $CBOD_5$ (lbs/day)	Ammonia Nitrogen (lbs/day)	Organic Nitrogen (lbs/day)
LAG541156	Natchitoches Parish Consolidated School District No. 7	001	9,320	30	3.3	6.6	2.33	0.26	0.51
LAG541299	Lakeview Junior & Senior High School	001	11,760	30	3.3	6.6	2.94	0.32	0.65
100703 TOTAL LOADS:							5.27	0.58	1.16

* Loads of organic nitrogen and ammonia nitrogen in this table represent loads of nitrogen, not oxygen demand.

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1.0 INTRODUCTION

This report presents total maximum daily loads (TMDLs) for dissolved oxygen (DO) for Black Lake Bayou (Subsegment 100702), Black Lake and Clear Lake (Subsegment 100703), and Saline Bayou (Subsegment 100803). These subsegments were cited as being impaired on the final 2004 303(d) list for Louisiana (United States Environmental Protection Agency (USEPA) 2005). The priority ranking and the suspected sources and suspected causes for impairment from the 303(d) list are presented in Table 1.1. The impairments for other pollutants in these subsegments are being addressed in other documents by either the Louisiana Department of Environmental Quality (LDEQ) or USEPA. The DO TMDLs in this report were developed in accordance with Section 303(d) of the Federal Clean Water Act and USEPA regulations at Title 40 Code of Federal Regulations (CFR) Part 130.7.

The purpose of a TMDL is to determine the pollutant loading that a waterbody can assimilate without exceeding the water quality standard for that pollutant and to establish the load reduction that is necessary to meet the standard in a waterbody. The TMDL is the sum of the wasteload allocation (WLA), the load allocation (LA), and a margin of safety (MOS). The WLA is the load allocated to point sources of the pollutant of concern, and the LA is the load allocated to nonpoint sources. The MOS is a percentage of the TMDL that accounts for the uncertainty associated with the model assumptions and data inadequacies, and the future growth (FG) takes into account any future increase in loads to the waterbody.

Table 1.1. Summary of 303(d) listings addressed in this report.

Subsegment Number	Waterbody Description	Suspected Sources	Suspected Causes	Priority Ranking (1 = highest)
100702	Black Lake Bayou-Webster-Bienville Parish Line to Black Lake (Scenic)	DO	Source unknown	2
100703	Black Lake and Clear Lake	DO	Source unknown	7
100803	Saline Bayou-from Saline Lake to Red River	DO	Source unknown	7

2.0 STUDY AREA DESCRIPTION

2.1 General Information

Black Lake Bayou begins in north central Louisiana east of Minden, Louisiana. From there it flows into Black Lake which flows into Clear Lake. Water flows from Clear Lake into Prairie Lake at the southern and into Black Lake Bayou at its southeastern end. Water exits Prairie Lake at its downstream end via Chivery Dam (which is actually two dams, one built in the 1950s and another built downstream of the first in 1990) and flows into Saline Bayou. After exiting Clear Lake, Black Lake Bayou flows east and enters Saline Bayou which is the outflow for Saline Lake. Black Lake Bayou thus allows water exchange between Saline Lake and Clear Lake (via Cheechee Dam), and the two lakes have comparable water surface elevations.

Saline Lake drains through Cheechee Dam (located at the southern end of Saline Lake) into Saline Bayou which drains through Allen Dam before it merges with Black Lake Bayou about 0.5-river mile (RM) below Allen Dam. Saline River then flows south for 10 miles where it flows into the Red River. All of the dams (Cheechee, Chivery, and Allen) in these subsegments are simple concrete weirs with a gate at the bottom to allow the lakes to be drained for maintenance purposes.

This TMDL covers Black Lake Bayou from the Webster-Bienville Parish line to Black Lake (Subsegment 100702), Black Lake and Clear Lake (Subsegment 100703), and Saline Bayou from Saline Lake to the Red River (Subsegment 100803). A map of the study area is shown in Figure A.1 in Appendix A. The total study area covers 611 square miles.

2.2 Land Use

Land use characteristics for Subsegments 100702, 100703, and 100803 were compiled from the United States Geological Survey (USGS) National Land Cover Database (USGS 2006). These data are the most recent land use data that are currently available for this area. The spatial distribution of these land uses is shown on Figure A.2 (located in Appendix A) and land use percentages are shown in Table 2.1. The majority of the land use is forest in

Subsegments 100702 and 100703 and split between agriculture and forest in Subsegment 100803.

Table 2.1. Land uses in the study area (USGS 2006).

Land Use Type	% of Total Area		
	100702	**100703**	**100803**
Water	0.7	9.2	1.2
Urban	0.6	0.1	1.3
Barren	2.2	4.8	1.4
Forest	74.7	64.8	44.8
Shrub/Grass	0.0	0.0	0.3
Pasture/Hay	6.7	2.8	6.3
Row Crops	4.7	3.3	34.4
Small Grains	0.0	0.0	1.4
Wetlands	10.4	15.0	8.9
TOTAL	**100.0**	**100.0**	**100.0**

2.3 Water Quality Standards

Water quality standards for Louisiana are included in the Title 33 Environmental Regulatory Code (LDEQ 2006). The numeric water quality standards and designated uses for these subsegments are shown in Table 2.2. The primary numeric standard for the TMDLs presented in this report is the DO criterion of 5 mg/L year-round.

The Louisiana water quality standards also include an anti-degradation policy (LAC 33:IX.1109.A). This policy states that waters exhibiting high water quality should be maintained at that high level of water quality. If this is not possible, water quality of a level that supports designated uses of the waterbody should be maintained. Changing the designated uses of a waterbody to allow a lower level of water quality can only be achieved through a use attainability study.

Table 2.2. Water quality standards and designated uses for the study area (LDEQ 2006).

	Subsegment 100702	**Subsegment 100703**	**Subsegment 100803**
Waterbody Description	Black Lake Bayou – Webster – Bienville Parish Line to Black Lake (Scenic)	Black Lake and Clear Lake	Saline Bayou - from Saline Lake to Red River
Designated Uses	ABCFG	ABCF	ABCF
WQ Criteria			
Chloride	26 mg/L	26 mg/L	110 mg/L
Sulfate	9 mg/L	9 mg/L	20 mg/L
DO	5.0 mg/L (year-round)	5.0 mg/L (year-round)	5.0 mg/L (year-round)
pH	6 - 8.5	6 - 8.5	6 - 8.5
Temperature	32°C	32°C	32°C
TDS	9 mg/L	9 mg/L	250 mg/L

Note: Designated uses are listed as follows: A – primary contact recreation; B – secondary contact recreation; C – propagation of fish and wildlife; F – agriculture; G – outstanding natural resource water.

2.4 Identification of Sources

2.4.1 Point Sources

A list of point sources in selected portions of the Red and Sabine River basins was developed using data from LDEQ's internal point source databases with additional information obtained from LDEQ’s Electronic Document Management System (EDMS). Using this information, ten point sources were identified within Subsegment 100702 and two in Subsegment 100703, for a total of 12 point sources identified within the study area. No point sources were identified discharging in Subsegment 100803. Approximate locations of these point sources are shown on Figure A.3 (in Appendix A). A summary of the permit information for these point sources, including limits for carbonaceous biochemical oxygen demand (CBOD), ammonia nitrogen (NH_3-N), and chemical oxygen demand (COD), are shown in Table 2.3. Since all of the discharges with oxygen demand permit limits discharge to tributaries at a distance from Black Lake Bayou and/or Black Lake and Clear Lake, no point sources were included in the DO models for these subsegments. However, WLAs for all point sources with oxygen demand permit limits discharging in the subsegments addressed in this report were included in the TMDLs.

2.4.2 Nonpoint Sources

No nonpoint sources were cited as the suspected source of impairment in the 303(d) list for the subsegments addressed in this TMDL report (Table 1.1).

2.5 Historical Data

There are seven LDEQ water quality monitoring stations in these three subsegments. FTN Associates, Ltd. (FTN) was able to get the LDEQ routine monitoring data for all of the stations except Station 1205 (Saline Lake Dam at end of Cheechee Dam Road, north of Crews, Louisiana). Only Station 282 (Black Lake Bayou west of Castor, Louisiana) had long-term data. The DO data from these stations are summarized in Table 2.4 and the station locations are shown on Figure A.1 (in Appendix A). Tabular listings and plots of the LDEQ DO data are found in Tables B.1 through B.6 and Figures B.1 through B.4 in Appendix B.

Table 2.3. Point sources in Subsegments 100702 and 100703.

Subseg. No.	Permit No.	Facility Name	Receiving Water	Type Of Discharge	Outfall	Flow (gpd)	Permit Parameter	Permit Limit	Included in Model?	Included in TMDL?
100702	LA0049484	Ringold STP	Tucker Branch – 4 Mile Bayou – Black Lake Bayou	5 Acre 2 Cell Stabilization Op	1	Design 185,000	BOD_5 (Monthly avg) BOD_5 (Weekly avg)	10 mg/L 15 mg/L	No	Yes
100702	LA0053261	Gibsland Municipal Wastewater Treatment Facility	Black Lake Creek-Leatherman Creek	3 Cell Oxidation Pond	1	150,000	BOD_5 (Monthly avg) BOD_5 (Weekly avg)	10 mg/L 15 mg/L	No	Yes
100702	LA0080446	Weyerhaeuser Co - Taylor Sawmill		Sawmill	2	Intermittent 97,000	COD (Daily max.)	200 mg/L	No	No
					3	7,500	BOD_5 (Daily max.)	45 mg/L	No	Yes
					4	Intermittent 155,400	COD (Daily max.)	250 mg/L	No	No
					5	Intermittent 269,800			No	No
100702	LAG119019	Li Portable Ready Mix	Unnamed Ditch – Black Lake Creek	Ready Mix Concrete	1				No	No
					2				No	No
					3				No	No
					4				No	No
					5	<5,000	BOD_5 (Daily max.)	45 mg/L	No	Yes
					6				No	No
100702	LAG480478	Tesco Services Inc.		Oil Field Services		12.5	COD (Monthly avg) COD (Weekly avg)	200 mg/L 300 mg/L	No	Yes
100702	LAG490016	PKA Bienville Sand and Gravel Inc.	Ditch – Red Branch	Sand & Gravel Extraction Operations	1	Avg. 1,000 Max. 1,200			No	No
100702	LAG540420	ADA Rest Area - Eastbound	Caney Creek	Rest Area	1	Avg. 15,115	BOD_5 (Monthly avg) BOD_5 (Weekly avg)	30 mg/L 45 mg/L	No	Yes
100702	LAG540421	ADA Rest Area Westbound	Caney Creek – Black Lake Bayou	Rest Area	1	Avg. 15,115	BOD_5 (Monthly avg) BOD_5 (Weekly avg)	30 mg/L 45 mg/L	No	Yes
100702	LAG560094	Athens Wastewater Trmt Fac	Leatherman Creek – Black Lake Bayou	Municipal STP		40,000	BOD_5 (Monthly avg) BOD_5 (Weekly avg)	20 mg/L 30 mg/L	No	Yes
100702	LAG830214	Simmon's Stop & Shop								
100703	LAG541156	Natchitoches Parish Consolidated School District No 7	Coullee Branch – Black Lake	Elementary School	1	9,320	BOD_5 (Monthly avg) BOD_5 (Weekly avg)	30 mg/L 45 mg/L	No	Yes
100703	LAG541299	Lakeview Junior & Senior High School	Black Lake	Middle and High School	1	11,760	BOD_5 (Monthly avg) BOD_5 (Weekly avg)	30 mg/L 45 mg/L	No	Yes

Table 2.4 Data analysis of LDEQ routine monitoring stations.

Station No.	1186	282	1189	1187	366	1214
Station Location Description	Black Lake Bayou southeast of Dubberly, Louisiana	Black Lake Bayou west of Castor, Louisiana	Castor Creek at Highway 507, southwest of Castor, Louisiana	Black Lake Bayou at Highway 155, east of Martin, Louisiana	Black Lake north of Natchitoches, Louisiana	Saline Bayou southwest of Clarence, Louisiana
Begin Date	1/14/02	2/13/90	1/14/02	1/14/02	1/8/02	1/28/02
End Date	12/4/06	4/13/98	11/12/02	11/15/06	11/14/06	2/13/06
No. Values	21	49	11	22	23	14
Min	0.76	3	6.09	3.66	4.2	3.71
Median	4.76	6.4	7.43	6.22	6.4	7.66
Average	4.76	6.81	8.53	6.25	6.6	7.29
Max	9.58	10.2	20.78	9.55	10.7	10.52
No. < 5 mg/L	11	12	0	5	2	2
% < 5 mg/L	52.38%	24.49%	0%	22.73%	8.7%	14.29%

2.6 Previous Studies

Previous studies and memos were studied to see if there were any that would be useful for this TMDL. Two studies were found to be useful:

1. A memo from the Town of Gibsland to the Louisiana Stream Control Commission dated July 19, 1978, discussing the Gibsland Wastewater Treatment Plant (although at the time of the memo, it was a proposed facility). This memo described the proposed facility, its design flow, and the stream it discharges to, and gave descriptions of all the streams the discharge flows through until it reaches Black Lake Bayou. The memo also describes the designated uses of the receiving streams and ends by concluding that the discharge will "not have an adverse effect on Black Lake Bayou." As far as can be determined, the memo is consistent with the current facility.
2. "Black Lake Bayou Survey Report" prepared by the Center For Louisiana Inland Water Studies Civil Engineering Department at the University of Southern Louisiana, dated November 1990. This was an extensive survey and included fish collection at two sites, continuous monitoring at four sites, water quality sampling at three sites, and two USGS time-of-travel studies. These sampling activities took place in October of 1989 and August through September of 1990; both sampling times were periods of low flow (i.e., critical conditions). The in situ and continuous monitoring data showed several DO violations and wide DO swings, and included information concerning widths and depths of Black Lake Bayou. Although not all the sites were within Subsegment 100702 (some were in

Subsegment 100701), this report had a lot of useful data. Of particular interest was the fact that the area where most of the cross section data was taken (the 1.3 river miles between Highways 20 and 80) showed significant variation in the depths and widths. The widths varied from 6 ft to 24 ft and the depths varied between 0.2 ft and 2.7 ft.

3.0 FTN FIELD DATA

FTN conducted a field survey for 14 subsegments in the Red River and Sabine River basins August 31 through September 9, 2005. Low flow conditions existed throughout the survey area during this time. The survey was conducted after Hurricane Katrina and before Hurricane Rita. Hurricane Katrina did not cause any noticeable impacts on water quality in the survey area.

The field survey included water quality sampling and corresponding in situ measurements at various locations; measurements of flow, depth, and width at several locations; and continuous in situ monitoring at several locations. The water quality samples were analyzed for 20-day CBOD time series, total Kjeldahl nitrogen (TKN), ammonia nitrogen (NH_3-N), nitrate+nitrite nitrogen (NO_2+NO_3-N), total phosphorus, chlorophyll *a*, total organic carbon (TOC), and total suspended solids (TSS). A list of the survey sites and the type of data collected at each site is presented in Table C.1 (in Appendix C). The in situ measurements and water quality sampling results are summarized in Tables C.2 and C.3, respectively. The calculations of CBOD decay rates and ultimate CBOD (CBODu) concentrations from the time series data using the water samples taken at the given location are shown in Table C.4. A summary of the continuous in situ DO data are plotted on Figure C.1 and listed in Table C.5 in Appendix C.

FTN collected data at a total of nine sites in the study area for this report. In situ and laboratory data were gathered at Stations 100702-B (Leatherman Creek), 282 (Black Lake Bayou west of Castor), 1178 (Black Lake Bayou at Highway 155), 100703-A (Black Lake northeast of Campti), 100703-B (Clear Lake outlet), 1214 (Saline Bayou southeast of Clarence), and 100803-B (Saline Bayou northeast of Clarence). Only in situ data were collected at Stations 100702-A (Black Lake Bayou at Highway 793) and 100803-A (Saline Bayou at Allen Dam). The data for these stations are summarized in Tables 3.1 through 3.3. It should be noted that three of the four DO values are greater than 5 mg/L. The DO value less than 5 mg/L (3.2 mg/L) was taken at 2:35 pm when DO values tend to be highest (DO concentrations peak in the late afternoon).

Table 3.1. FTN field data collected in Subsegment 100702.

	Station 100702-A	**Station 100702-B**	**Station 0282**	**Station 1187**
Date and time of sample / measurements	9/7/05 7:20 am	9/7/05 8:05 am	9/7/05 9:20 am	9/7/05 10:25 am
Depth (m) of sample / measurements	--	--	--	--
Water temperature (°C)	23.4	23.3	24.7	24.9
DO (mg/L)	2.9	3.4	5.3	5.3
Conductivity (µmhos/cm)	167	54	35	40
pH (su)	6.3	6.3	6.1	6.3
TSS (mg/L)	--	18	4.8	5.2
TKN (mg/L)	--	2.4	1.6	1.7
Total phosphorus (mg/L)	--	0.11	0.048	0.064
TOC (mg/L)	--	7.5	5.9	6
Chlorophyll *a* (µg/L)	--	0.076	<0.02	<0.02
NH_3 nitrogen (mg/L)	--	0.32	0.22	0.17
Nitrate+nitrite nitrogen (mg/L)	--	<0.05	0.064	0.096
CBOD on Day 2 of analysis (mg/L)	--	<2	<2	<2
CBOD on Day 5 of analysis (mg/L)	--	2.1	<2	<2
CBOD on Day 9 of analysis (mg/L)	--	3.7	<2	<2
CBOD on Day 14 of analysis (mg/L)	--	4.6	<2	<2
CBOD on Day 20 of analysis (mg/L)	--	6.2	2.2	<2
CBODu (mg/L; calculated)	--	9.62	--	--
CBOD decay rate (1/day; calculated)	--	0.05	--	--
Flow (cfs)	--	--	13.43	9.30

Notes:

A. The in situ data were taken at 1.5 ft (0.4572 m) while the sampling data were taken at 0.5 ft (0.152 m).

B. This is the depth of just the in situ measurements.

C. Although flow was observed, the flow was too small to measure with the drogue the survey crew used.

Table 3.2. FTN field data collected in Subsegment 100703.

	Station 100703-A	**Station 100703-A**	**Station 100703-B**
Date and time of sample / measurements	9/7/05 11:20 am	9/7/05 11:20 am	9/7/05 12:40 pm
Depth (m) of sample / measurements	--	--	--
Water temperature (°C)	27.6	--	29.8
DO (mg/L)	5.3	--	6.9
Conductivity (µmhos/cm)	71	--	96
pH (su)	6.4	--	6.9
TSS (mg/L)	73	4.4	16
TKN (mg/L)	1.7	1.9	1.9
Total phosphorus (mg/L)	0.048	0.05	0.12
TOC (mg/L)	7.7	7.8	9.2
Chlorophyll *a* (µg/L)	<0.02	<0.02	0.1
NH_3 nitrogen (mg/L)	0.17	0.17	0.25
Nitrate+nitrite nitrogen (mg/L)	<0.05	<0.05	<0.05
CBOD on day 2 of analysis (mg/L)	<2	<2	2.4
CBOD on day 5 of analysis (mg/L)	<2	<2	5.9
CBOD on day 9 of analysis (mg/L)	<2	<2	8.9
CBOD on day 14 of analysis (mg/L)	2.5	2.3	9.6
CBOD on day 20 of analysis (mg/L)	4	3.1	14
CBODu (mg/L; calculated)	8.69	5.60	16.99
CBOD decay rate (1/day; calculated)	0.05	0.05	0.08
Flow (cfs)	--	--	--

Table 3.3. FTN field data collected in Subsegment 100803.

	Station 100803-A	**Station 1214**
Date and time of sample / measurements	9/7/05 1:40 pm	9/7/05 2:40 pm
Depth (m) of sample / measurements	--	--
Water temperature (°C)	30.6	30.2
DO (mg/L)	8.3	5.4
Conductivity (µmhos/cm)	82	105
pH (su)	7.8	6.8
TSS (mg/L)	16	22
TKN (mg/L)	3	1.9
Total phosphorus (mg/L)	0.098	0.08
TOC (mg/L)	8.7	8.6
Chlorophyll *a* (µg/L)	0.05	0.034
NH_3 nitrogen (mg/L)	0.21	0.23
Nitrate+nitrite nitrogen (mg/L)	<0.05	<0.05
CBOD on day 2 of analysis (mg/L)	<2	<2
CBOD on day 5 of analysis (mg/L)	<2	2.7
CBOD on day 9 of analysis (mg/L)	3.9	7.1
CBOD on day 14 of analysis (mg/L)	4.8	7.3
CBOD on day 20 of analysis (mg/L)	6.6	8.9
CBODu (mg/L; calculated)	10.75	8.42
CBOD decay rate (1/day; calculated)	0.05	0.31
Flow (cfs)	--	--

4.0 CALIBRATION OF WATER QUALITY MODEL

4.1 Model Setup

In order to evaluate the linkage between pollutant sources and water quality, a computer simulation model was used. The model used for these TMDLs was LA-QUAL (Version 8.11), which was selected because it includes the relevant physical, chemical, and biological processes and it has been used successfully in the past for other TMDLs in Louisiana. The LA-QUAL model was set up to simulate organic nitrogen, ammonia nitrogen, CBODu, and DO.

Figure D.1 in Appendix D shows the model reach/element design and the location of the modeled inflows. Black Lake Bayou was modeled as four reaches. Black Lake and Clear Lake were each modeled as single reaches. Prairie Lake and its outlet were modeled as a branch with two reaches. Saline Bayou was modeled as three reaches. All reaches were divided into smaller elements to take into account variation in water quality along their length.

4.2 Calibration Period and Calibration Targets

The two conditions that usually characterize critical periods for DO are high temperatures and low flows. High temperatures decrease DO saturation values and increase rates for oxygen demanding processes (BOD decay, nitrification, and SOD). In most systems, low flows cause reaeration rates to be lower. The purpose of selecting a critical period for calibration is so that the model will be calibrated as accurately as possible for making projection simulations for critical conditions.

The model was calibrated to the FTN intensive survey. This period represented the most critical period for DO. The calibration target (i.e., the concentration to which the model was calibrated) for each parameter was set equal to the concentrations measured during the survey with the exception of DO. The calibration targets for DO were set equal to estimated daily minimum DO plus 1 mg/L. For stations without continuous data, the minimum daily DO was estimated by calculating the ratio of the minimum DO to the instantaneous DO at a continuous monitoring station and then dividing the instantaneous DO measured at another in situ station by this ratio. These calculations are shown Table C.5 in Appendix C. Organic nitrogen was estimated as TKN minus the ammonia nitrogen value.

4.3 Program Constants (Data Type 3)

A value was input to replace the LA-QUAL default value for net oxygen production per unit of chlorophyll *a*. The default value (0.05 mg oxygen / µg chlorophyll *a* / day) was replaced because the chlorophyll specified in the initial conditions was contributing an unreasonably large amount of oxygen to the model reaches in the preliminary simulations. Calculations of oxygen production from photosynthesis and oxygen consumption from respiration were developed in a spreadsheet for a 24-hour period during the calibration period (shown in Appendix E). The calculations assumed a steady state concentration of algae; the increases in algal biomass due to growth were equal to the decreases in algal biomass due to respiration and settling over a 24-hour period. The net rate of oxygen added to the system from the combination of photosynthesis and respiration over a 24-hour period was calculated to be 0.026 mg oxygen / µg chlorophyll *a* / day. This value was input to the model in Data Type 3.

4.4 Temperature Correction of Kinetics (Data Type 4)

The temperature correction factors used in the model were consistent with the Louisiana Technical Procedures Manual (LTP; Aguillard and Duerr 2006). These correction factors were:

Correction for BOD decay:	1.047 (value in LTP is same as model default)
Correction for SOD:	1.065 (value in LTP is same as model default)
Correction for ammonia N decay:	1.070 (specified in Data Group 4)
Correction for organic N decay:	1.020 (not specified in LTP; model default used)
Correction for reaeration:	automatically calculated by the model

4.5 Hydraulics (Data Type 9)

The hydraulics were specified in the input for the LA-QUAL model using the power functions (width = $a * Q^b + c$ and depth = $d * Q^e + f$). The widths and depths for the streams were assumed to be fairly constant and not vary significantly with flow. The exponents and coefficients were set to zero, and the constants were set to the observed or estimated widths and depths. The widths for Black Lake, Clear Lake, and Prairie Lake were calculated by dividing the water surface area by the reach length. The depths used for Black Lake and Prairie Lake were based on personal communication with a local fisherman. The depth used for Clear Lake was calculated by subtracting the Black Lake and Prairie Lake volumes from the total volume for the Black Lake – Clear Lake – Prairie Lake complex and dividing by the surface area. These calculations are shown in Appendix E.

The widths and depths used for lower Black Lake Bayou and Saline Bayou were based on the observed widths and depths from the FTN field survey, from digital orthophoto quarter-quadrangles (DOQQs), and from personal communication with a local fisherman.

4.6 Initial Conditions (Data Type 11)

Because temperature is not being simulated in the model, the temperatures for the reaches were specified in the initial conditions for LA-QUAL. Since the FTN field survey indicated the presence of algae, and since algae was need to calibrate the model, it was added to the initial conditions. The temperatures and chlorophyll concentrations for each reach were based on temperatures and chlorophyll *a* measured during the FTN field survey. Initial DO concentrations were set based on the daily minimum DO values estimated for the FTN field survey sampling sites (Section 4.2).

For constituents not being simulated, the initial concentrations were set to zero (with the exception of the algae described in the paragraph above). Otherwise the model would have assumed a fixed concentration of those constituents and the model would have included effects of the unmodeled constituents on the modeled constituents.

4.7 Water Quality Kinetics (Data Types 12 and 13)

Kinetic rates used in LA-QUAL include reaeration rates, CBOD decay rates, nitrification rates, and mineralization rates (organic nitrogen decay).

For reaeration, the Louisiana Equation (option 15) was specified in the model because it was developed specifically for streams in Louisiana and has been used successfully in the past for other TMDLs in Louisiana.

The rates for CBOD decay used in the model were based on analytical results from the FTN field survey. For the main-stem reaches, the average of the observed CBOD decay rates from all stations sampled, with the exception of Station 1214, was used. Station 1214 had an observed CBOD decay (0.31/day) that was significantly higher than the other stations. The CBOD decay rate used for the main-stem reaches was 0.06/day. For the Prairie Outlet branch, a CBOD decay rate of 0.08/day was used corresponding to the observed value at Station 100703-B.

The nitrification rates used in the model were based on analyzing NBOD decay rates measured by LDEQ for forested subsegments in the Ouachita and Calcesiu river basins. A subsegment was classified as forested if more than 70% land cover was forest. A total of 36 samples were averaged to calculate a decay rate of 0.08/day (shown in Appendix F).

The mineralization rates (organic nitrogen decay) in the model were set to 0.02/day for all reaches. This value was similar to the values shown in Table 5.3 of the “Rates, Constants, and Kinetics” publication (USEPA 1985) for dissolved organic nitrogen being transformed to ammonia nitrogen. The literature values for mineralization rates are shown in Appendix G.

4.8 Nonpoint Source Loads (Data Type 19)

The nonpoint source loads that are specified in the model can be most easily understood as re-suspended load from the bottom sediments and are modeled as SOD, benthic ammonia source rates, CBOD loads, and organic nitrogen loads. The SOD (specified in Data Type 12), the benthic ammonia source rates (specified in Data Type 13), and the mass loads of organic nitrogen and CBODu (specified in 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 four 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 benthic ammonia source rates were adjusted until the predicted ammonia nitrogen concentrations were similar to the observed concentrations. In this system the benthic ammonia was set equal to zero since all the ammonia came from the organic loads in the steam. Then the CBODu loads were adjusted until the predicted CBODu concentrations were similar to the observed concentrations. Finally, the SOD rates were adjusted until the predicted DO concentrations were similar to the observed concentrations. The DO was calibrated last because all of the other state variables affect DO.

4.9 Flow Rates (Data Types 16, 20 and 24)

Flow rates were specified for incremental inflows along reaches 1 through 5 (Black Lake Bayou, Black Lake, and Clear Lake), headwaters of Black Lake Bayou and Prairie Lake, six tributaries, and one withdrawal. The headwater flow rate for Black Lake Bayou was calculated by multiplying the average flow per unit area estimated at two stations from the FTN survey times the drainage area of the headwater of Black Lake Bayou. The flow rates for the tributaries were estimated the same way. Then any additional flow needed for the flow balance were added as incremental flow. The inflow for Saline Bayou (a tributary) was based on the flow measured at the USGS Gage at Saline Bayou near Lucky, Louisiana (07352000) on the day of the FTN sampling for the study area, and the drainage area of Saline Bayou upstream of Black Lake Bayou. These calculations are shown in Appendix H.

The headwater inflow for the Prairie was set equal to the withdrawal for Prairie Lake. The Prairie Lake withdrawal was set equal to half of the inflow into Clear Lake (the other half of the inflow entered Black Lake Bayou at the western end of Clear Lake).

4.10 Inflow Water Quality (Data Types 16, 20, 24, and 25)

Concentrations of DO, CBODu, organic nitrogen, and ammonia nitrogen were specified in the model for the incremental, headwater, and tributary inflows. Water quality for the incremental inflows was set to values measured during the FTN survey at Station 100702-B (Leatherman Creek). Water quality for the Black Lake Bayou headwater was set to the concentrations measured during the FTN survey at LDEQ Station 0282 (Black Lake Bayou west of Castor, Louisiana). Water quality for Prairie Lake headwater was set to the concentrations calculated by the LA-QUAL model. Water quality for the tributaries was set to values measured during the FTN survey at Station 100702-B. Organic nitrogen was estimated as TKN minus the estimated ammonia nitrogen value.

4.11 Model Results for Calibration

Plots of predicted and observed water quality for the calibration are presented in Appendix I and a printout of the LA-QUAL output file is included as Appendix J. The calibration was considered to be acceptable based on the amount of data that were available.

5.0 WATER QUALITY MODEL PROJECTION

USEPA's regulations at 40 CFR 130.7 require the determination of TMDLs to take into account critical conditions for stream flow, loading, and water quality parameters. Therefore, the calibrated model was used to project water quality for critical conditions. The identification of critical conditions and the model input data used for critical conditions are discussed below.

5.1 Identification of Critical Conditions

Section 303(d) of the Federal Clean Water Act and USEPA's regulations at 40 CFR 130.7 both require the consideration of seasonal variation of conditions affecting the constituent of concern and the inclusion of an MOS in the development of a TMDL. For the TMDLs in this report, analyses of LDEQ long-term ambient data were used to determine critical seasonal conditions. A combination of implicit and explicit MOS was used in developing the projection model.

Critical conditions for DO have been determined for Louisiana waterbodies in previous TMDL studies. The analyses concluded that the critical conditions for stream DO concentrations occur during periods with negligible nonpoint runoff, low stream flow, and high stream temperature.

When the rainfall runoff (and nonpoint loading) and stream flow are high, turbulence is higher due to the higher flow, and the stream temperature is lowered by the cooler precipitation and runoff. In addition, runoff coefficients are higher in cooler weather due to reduced evaporation and evapotranspiration, so that the high flow periods of the year tend to be the cooler periods. DO saturation values are much higher when water temperatures are cooler, but BOD decay rates are much lower. For these reasons, periods of high loading are periods of higher reaeration and higher DO concentrations, but not necessarily periods of high BOD decay.

LDEQ interprets this phenomenon in its TMDL modeling by assuming that the annual nonpoint loading, rather than loading for any particular day, is responsible for the accumulated benthic blanket of the stream, which is, in turn, expressed as SOD and/or re-suspended BOD in the model. This accumulated loading has its greatest impact on the stream during periods of higher temperature and lower flow.

According to the LTP, critical summer conditions in DO TMDL projection modeling are simulated by using the annual 7Q10 flow or 0.1 cubic ft per second (cfs), whichever is higher, for all headwaters, and 90th percentile temperature for the summer season. Critical winter conditions in DO TMDL projection modeling are simulated using the winter 7Q10 flow or 1.0 cfs, whichever is higher, for all headwaters, and the 90th percentile temperature for the winter season. Model loading is from perennial tributaries, point sources, SOD, and re-suspension of sediments.

In reality, the highest temperatures occur in July and August and the lowest stream flows occur in October and November. The combination of these conditions plus the impact of other conservative assumptions regarding rates and loadings yields an implicit MOS that is not quantified. In addition, an explicit MOS of 10% for nonpoint sources and an explicit MOS of 20% for point sources were incorporated into the TMDLs in this report to account for model uncertainty.

5.2 Temperature Inputs

The LTP (Aguillard and Duerr 2006) specifies that the critical temperature should be determined by calculating the 90th percentile seasonal temperature for the waterbody being modeled. LDEQ Station 0282 on Black Lake Bayou has a long-term temperature record. These data were used to calculate seasonal 90th percentile temperatures for Black Lake Bayou (27.7ºC for summer, and 20.1ºC for winter). These data and calculations are shown in Table K.1 in Appendix K. These 90th percentile temperatures were also used for initial conditions (Data Type 11) and the incremental inflows in the model.

Water temperature data were collected in Black Lake (Station 366) and Saline Bayou (Station 1214) for only 2 years, which is not enough data to calculate 90th percentile temperatures. Therefore, data from a nearby stream (Kepler Creek) were used to estimate 90th percentile temperatures for these water bodies. Long term water temperature data were collected by LDEQ at one station in Kepler Creek (Station 283). These data are summarized in Table K.2

in Appendix K. Summer and winter 90th percentile temperatures were developed for this station. These calculations resulted in 90th percentile temperatures of 27.1°C for summer and 19.5°C for winter (see Table K.2 in Appendix K). These temperatures were adjusted based on differences between seasonal average temperatures taken at Black Lake (Station 366) and Kepler Creek (Station 283), and between temperatures taken at Saline Bayou (Station 1214) and Kepler Creek (Station 283) during their overlapping periods of record. The 90th percentile temperatures specified in Data Type 11 in the model for Black Lake in the projection simulations were 30.7°C for summer and 21.1°C for winter (calculated in Table K.3 in Appendix K). The 90th percentile temperatures specified in Data Type 11 in the model for Saline Bayou in the projection simulations were 31.5°C for summer and 21.7°C for winter (calculated in Table K.4 in Appendix K).

5.3 Headwater and Tributary Inputs

The inputs for the headwaters and tributaries for the projection simulations were based on guidance in the LTP. 7Q10 flows were estimated for the headwaters and tributaries. Basin seasonal 7Q10 flows per square mile were used to estimate most of the 7Q10 inflows. The basin 7Q10 flows per square mile were estimated as the historical (summer) and December through February (winter) 7Q10 flows reported for the USGS gage on Black Lake Bayou near Castor, Louisiana (07352500) (USGS 2003), divided by the gage drainage area (Appendix L). The summer basin 7Q10 flow per square mile was 0.016 cfs/sq mi, and the winter basin 7Q10 flow per square mile was 0.066 cfs/sq mi. These values were used to estimate 7Q10 inflows for Leatherman Creek, Kepler Creek, Fourmile Bayou, and Castor Creek. All of these estimated 7Q10 inflows were greater than the minimum values specified in the LTP (0.1 cfs for summer and 1.0 cfs for winter), so the estimated values were used in the projection models.

The 7Q10 inflows used for Grand Bayou in the projection models were calculated by multiplying the historical (summer) and December through February (winter) 7Q10 flows reported for the USGS gage on Grand Bayou near Coushatta, Louisiana (07352800) by the ratio of the drainage area at the mouth of Grand Bayou and the drainage area of the gage. The estimated seasonal 7Q10 inflows for Grand Bayou were less than the minimum values specified in the LTP, therefore, Grand Bayou inflow was set to 0.1 cfs for the summer projection, and 1.0 cfs for the winter projection. These calculations are included in Appendix L.

Seasonal 7Q10 inflows for Saline Bayou (from Saline Lake/Cheechee Bay) were estimated using 7Q10 values reported for the USGS gage on Saline Bayou near Lucky, Louisiana (Gage 07352000). The reported historical 7Q10 was used to estimate the summer 7Q10 flow, and the reported 7Q10 for December through February was used to estimate the winter 7Q10 flow. The seasonal estimated 7Q10 flows for Saline Bayou were calculated by multiplying the 7Q10 flows reported for the USGS gage by the ratio of the drainage area of Saline Bayou at Saline Lake to the drainage area of the gage. These estimated 7Q10 flows were greater than the minimum values specified in the LTP (0.1 cfs for summer and 1.0 cfs for winter). These calculations are included in Appendix L.

It was assumed that the headwater quality would improve with reductions of nonpoint sources in the watershed. For the projection simulations, the headwater concentrations of CBODu, organic nitrogen, and ammonia nitrogen were reduced from the calibration simulation by the same percentages as the reductions of nonpoint source loads (see Section 5.4 for reductions applied to nonpoint source loads). The headwater DO concentrations for the projection simulations were estimated assuming that 0% reduction of nonpoint sources in the watershed would correspond to the same DO percent saturation as in the calibration, and 100% reduction of nonpoint sources in the watershed would correspond to 100% DO saturation in the headwater. The calculations for headwater concentrations of CBODu, organic nitrogen, and ammonia nitrogen for the projection simulations are shown in Appendix M.

5.4 Nonpoint Source Loads

Because the initial projection simulation was showing low DO values, the nonpoint source loadings were reduced until all of the predicted DO values were equal to or greater than the water quality standard of 5.0 mg/L. The same percent reduction was applied to the SOD and nonpoint source mass loads of CBODu and organic nitrogen. The calculations for the nonpoint source loads are shown in Appendix M.

5.5 Other Inputs

The only model inputs that were changed from the calibration to the projection simulation were the inputs discussed above in Sections 5.2 through 5.4. Other model inputs (e.g., hydraulic coefficients, decay rates, reaeration equations, etc.) were unchanged from the calibration simulation.

5.6 Model Results for Projection

Plots of predicted water quality for the projection are presented in Appendix N and a printout of the LA-QUAL output file is included as Appendix O.

Oxygen-demanding load reductions were required to meet the DO standard. Nonpoint source load reductions of approximately 22% in Subsegment 100702 and 3% in Subsegment 100703 were required to bring the predicted DO values to at least 5.0 mg/L during the summer season (and no reduction was needed in Subsegment 100803). For the winter season, a nonpoint source load reduction of 7% in Subsegment 100702 was required to bring the predicted DO concentrations to at least 5.0 mg/L. No reductions were needed in Subsegments 100703 and 100803 for the winter season. These reductions for nonpoint source loads represent a percentage of the entire nonpoint source loading, not a percentage of the manmade nonpoint source loading. The nonpoint source loads in this report were not divided between natural and manmade because it would be difficult to estimate natural nonpoint source loads for the study area.

6.0 TMDL CALCULATIONS

6.1 DO TMDL

TMDLs for DO have been calculated for the three subsegments addressed in this report, based on the results of the projection simulations. The DO TMDLs are presented as oxygen demand from CBODu, organic nitrogen, ammonia nitrogen, and SOD. Summaries of the seasonal loads for Subsegment 100702 are presented in Tables 6.1 and 6.2, for Subsegment 100703 are presented in Tables 6.3 and 6.4, and for Subsegment 100803 are presented in Tables 6.5 and 6.6.

The TMDL calculations were performed using a FORTRAN program that was written by FTN personnel. This program reads two files; one is the LA-QUAL output file from the projection simulation and the other is a small file with miscellaneous information needed for the TMDL calculations (shown in Appendix P). In this program, the oxygen demand from organic nitrogen and ammonia nitrogen was calculated as 4.33 times the nitrogen loads (assuming that all organic nitrogen is eventually converted to ammonia). The value of 4.33 is the same ratio of oxygen demand to nitrogen that is used by the LA-QUAL model. For the SOD loads, a temperature correction factor was included in the calculations (in order to be consistent with LDEQ procedures). The output from the program is shown in Appendix Q and the source code for the program is shown in Appendix R.

Table 6.1. Black Lake Bayou (Subsegment 100702) summer TMDL.

	Oxygen Demand (kg/day) from:					Oxygen Demand (lbs/day) from:					
	SOD	CBODu	Organic Nitrogen	Ammonia Nitrogen	Total	SOD	CBODu	Organic Nitrogen	Ammonia Nitrogen	Total	Percent Reduction Needed
Point Sources											
WLA	NA	376	27.1	13.5	416.6	NA	828.9	59.7	29.8	918.4	0%
MOS	NA	47	3.4	1.7	52.1	NA	103.6	7.5	3.7	114.9	NA
FG	NA	47	3.4	1.7	52.1	NA	103.6	7.5	3.7	114.9	NA
Nonpoint Sources											
LA	1827	150.5	178.5	24.4	2180.4	4027.8	331.8	393.5	53.8	4807	22%
MOS	228.4	18.8	22.3	3.1	272.6	503.5	41.4	49.2	6.8	601	NA
FG	228.4	18.8	22.3	3.1	272.6	503.5	41.4	49.2	6.8	601	NA
TMDL	2283.8	658.1	257	47.5	3246.4	5034.9	1450.9	566.6	104.7	7157.1	NA

Table 6.2. Black Lake Bayou (Subsegment 100702) winter TMDL.

	Oxygen Demand (kg/day) from:					Oxygen Demand (lbs/day) from:					Percent Reduction Needed
	SOD	CBODu	Organic Nitrogen	Ammonia Nitrogen	Total	SOD	CBODu	Organic Nitrogen	Ammonia Nitrogen	Total	
Point Sources											
WLA	NA	376.0	27.1	13.5	416.6	NA	828.9	59.7	29.8	918.4	0%
MOS	NA	47.0	3.4	1.7	52.1	NA	103.6	7.5	3.7	114.9	NA
FG	NA	47.0	3.4	1.7	52.1	NA	103.6	7.5	3.7	114.9	NA
Nonpoint Sources											
LA	1316.9	770	868.7	123.6	3079.2	2903.3	1697.6	1915.2	272.5	6788.5	7%
MOS	164.6	96.3	108.5	15.4	384.8	362.9	212.3	239.2	34	848.3	NA
FG	164.6	96.3	108.5	15.4	384.8	362.9	212.3	239.2	34	848.3	NA
TMDL	1646.1	1432.6	1119.6	171.3	4369.6	3629	3151.7	2463.1	376.9	9613.1	NA

Table 6.3. Black Lake and Clear Lake (Subsegment 100703) summer TMDL.

	Oxygen Demand (kg/day) from:					Oxygen Demand (lbs/day) from:					Percent Reduction Needed
	SOD	**CBODu**	**Organic Nitrogen**	**Ammonia Nitrogen**	**Total**	**SOD**	**CBODu**	**Organic Nitrogen**	**Ammonia Nitrogen**	**Total**	
Point Sources											
WLA	NA	5.5	2.3	1.1	8.91	NA	12.1	5.1	2.4	19.6	0%
MOS	NA	0.7	0.3	0.1	1.1	NA	1.5	0.7	0.2	2.4	NA
FG	NA	0.7	0.3	0.1	1.1	NA	1.5	0.7	0.2	2.4	NA
Nonpoint Sources											
LA	143617	75833	18168	41	237659	316621.3	167183.2	40053.6	90.4	523948.5	3%
MOS	17952	9479	2271	5.1	29707.1	39577.4	20897.6	5006.7	11.2	65493	NA
FG	17952	9479	2271	5.1	29707.1	39577.4	20897.6	5006.7	11.2	65493	NA
TMDL	179521	94797.9	22712.9	52.5	297084.3	395776.1	208993.7	50073.4	115.7	654958.9	NA

Table 6.4. Black Lake and Clear Lake (Subsegment 100703) winter TMDL.

	Oxygen Demand (kg/day) from:					Oxygen Demand (lbs/day) from:					Percent Reduction Needed
	SOD	**CBODu**	**Organic Nitrogen**	**Ammonia Nitrogen**	**Total**	**SOD**	**CBODu**	**Organic Nitrogen**	**Ammonia Nitrogen**	**Total**	
Point Sources											
WLA	NA	5.5	2.3	1.1	8.9	NA	12.1	5.1	2.4	19.6	0%
MOS	NA	0.7	0.3	0.1	1.1	NA	1.5	0.7	0.2	2.4	NA
FG	NA	0.7	0.3	0.1	1.1	NA	1.5	0.7	0.2	2.4	NA
Nonpoint Sources											
LA	15281	78308	19809	289	113687	33688.8	172639.6	43671.4	637.1	250637	0%
MOS	1910.1	9789	2476	36	14211.1	4211.1	21581.1	5458.6	79.4	31330.1	NA
FG	1910.1	9789	2476	36	14211.1	4211.1	21581.1	5458.6	79.4	31330.1	NA
TMDL	19101.2	97892.9	24763.9	362.3	142120.3	42110.9	215816.9	54595.1	798.7	313321.7	NA

Table 6.5. Saline Bayou (Subsegment 100803) summer TMDL.

	Oxygen Demand (kg/day) from:					Oxygen Demand (lbs/day) from:					Percent Reduction Needed
	SOD	**CBODu**	**Organic Nitrogen**	**Ammonia Nitrogen**	**Total**	**SOD**	**CBODu**	**Organic Nitrogen**	**Ammonia Nitrogen**	**Total**	
Point Sources											
WLA	NA	0	0	0	0	NA	0	0	0	0	0%
MOS	NA	0	0	0	0	NA	0	0	0	0	NA
FG	NA	0	0	0	0	NA	0	0	0	0	NA
Nonpoint Sources											
LA	5663	3143	977	36.6	9819.6	12484.8	6929.1	2153.9	80.7	21648.5	0%
MOS	708	393	122	4.6	1227.6	1560.9	866.4	269	10.1	2706.4	NA
FG	708	393	122	4.6	1227.6	1560.9	866.4	269	10.1	2706.4	NA
TMDL	7079	3929	1221	45.8	12274.8	15606.5	8662	2691.8	101	27061.3	NA

Table 6.6. Saline Bayou (Subsegment 100803) winter TMDL.

	Oxygen Demand (kg/day) from:					Oxygen Demand (lbs/day) from:					Percent Reduction Needed
	SOD	**CBODu**	**Organic Nitrogen**	**Ammonia Nitrogen**	**Total**	**SOD**	**CBODu**	**Organic Nitrogen**	**Ammonia Nitrogen**	**Total**	
Point Sources											
WLA	NA	0	0	0	0	NA	0	0	0	0	0%
MOS	NA	0	0	0	0	NA	0	0	0	0	NA
FG	NA	0	0	0	0	NA	0	0	0	0	NA
Nonpoint Sources											
LA	3066	5335	2432	306	11139	6759.4	11761.7	5361.6	674.6	24557.3	0%
MOS	383	667	304	38	1392	844.4	1470.5	670.2	83.8	3068.8	NA
FG	383	667	304	38	1392	844.4	1470.5	670.2	83.8	3068.8	NA
TMDL	3832	6669	3040	382	13923	8448.1	14702.6	6702.1	842.2	30695	NA

Table 6.7. Flows, concentrations, and loads for point sources included in DO TMDL for Subsegment 100702.

NPDES Permit Number	Name of Discharger	Outfall	Flow Rate (gpd)	Concentrations			Loads*		
				BOD_5 or $CBOD_5$ (mg/L)	Ammonia Nitrogen (mg/L)	Organic Nitrogen (mg/L)	BOD_5 or $CBOD_5$ (lbs/day)	Ammonia Nitrogen (lbs/day)	Organic Nitrogen (lbs/day)
LA0049484	Ringold STP	001	185,000	10	1.7	3.4	15.43	2.62	5.25
LA0053261	Gibsland Municipal WWTF	001	150,000	10	1.7	3.4	12.51	2.13	4.25
LA0080446	Weyerhaeuser Company – Taylor Sawmill	002	97,000	200 +	0	0	161.80	0.00	0.00
		003	8,000	45	3.3	6.6	3.00	0.22	0.44
		005	270,000	250 +	0	0	562.95	0.00	0.00
LAG480478	Tesco Services, Inc.	001	13	200 +	0	0	0.02	0.00	0.00
LAG540420	ADA Rest Area - Eastbound	001	15,000	30	3.3	6.6	3.75	0.41	0.83
LAG540421	ADA Rest Area - Westbound	001	15,000	30	3.3	6.6	3.75	0.41	0.83
LAG560094	Athens WWTF	001	40,000	20	3.3	6.6	6.67	1.10	2.20
100702 TOTAL LOADS:							769.89	6.90	13.79

+ COD Permit Limits

* Loads of organic nitrogen and ammonia nitrogen in this table represent loads of nitrogen, not oxygen demand.

Table 6.8. Flows, concentrations, and loads for point sources included in DO TMDL for Subsegment 100703.

NPDES Permit Number	Name of Discharger	Outfall	Flow Rate (gpd)	Concentrations			Loads*		
				BOD_5 or $CBOD_5$ (mg/L)	Ammonia Nitrogen (mg/L)	Organic Nitrogen (mg/L)	BOD_5 or $CBOD_5$ (lbs/day)	Ammonia Nitrogen (lbs/day)	Organic Nitrogen (lbs/day)
LAG541156	Natchitoches Parish Consolidated School District No. 7	001	9,320	30	3.3	6.6	2.33	0.26	0.51
LAG541299	Lakeview Junior & Senior High School	001	11,760	30	3.3	6.6	2.94	0.32	0.65
100703 TOTAL LOADS:							5.27	0.58	1.16

* Loads of organic nitrogen and ammonia nitrogen in this table represent loads of nitrogen, not oxygen demand.

6.2 Ammonia Toxicity Calculations

Although Subsegments 100702, 100703, and 100803 are not on the 303(d) list for ammonia, the ammonia concentrations predicted by the projection models were checked to make sure that they did not exceed USEPA criteria for ammonia toxicity (USEPA 1999). The USEPA criteria are dependent on temperature and pH. The water temperatures used to calculate the ammonia toxicity criterion were the same as the critical temperatures used in the projection simulations. For pH, an average of the values measured during the FTN field survey was used. The resulting criterion range was 2.2 mg/L to 2.8 mg/L of ammonia nitrogen for summer and 4.1 mg/L to 4.6 mg/L for winter. In neither the summer nor the winter model were the ammonia criteria exceeded. This indicates that the ammonia nitrogen loadings that will maintain the DO standard are low enough that the USEPA ammonia toxicity criteria will not be exceeded under critical conditions. The ammonia toxicity calculations are shown in Appendix S.

6.3 Summary of Nonpoint Source Reductions

In summary, the projection modeling used to develop the TMDLs above showed that nonpoint source loads need to be reduced by approximately 22% in Subsegment 100702, 3% in Subsegment 100703, and 0% in Subsegment 100803 to meet the DO standard of 5.0 mg/L during the summer season. During the winter season, nonpoint source loads need to be reduced approximately 7% in Subsegment 100702. No reductions are needed in Subsegments 100703 and 100803.

6.4 Seasonal Variation

As discussed in Section 5.1, critical conditions for DO in Louisiana waterbodies have been determined to be when there is negligible nonpoint runoff and low stream flow combined with high water temperatures. In addition, the model accounts for loadings that occur at higher flows by modeling sediment oxygen demand. Oxygen demanding pollutants that enter the waterbodies during higher flows settle to the bottom and then exert the greatest oxygen demand during the high temperature seasons.

6.5 Margin of Safety and Future Growth

The MOS accounts for any lack of knowledge or uncertainty concerning the relationship between load allocations and water quality. As discussed in Section 5.1, the highest temperatures occur in July through August, and the lowest stream flows occur in October through November. The combination of these conditions, in addition to other conservative assumptions regarding rates and loadings, yields an implicit MOS, which is not quantified. In addition to the implicit MOS, the TMDLs in this report includes an explicit MOS of 10% for nonpoint source loads and an explicit MOS of 20% for point source loads. All the TMDLs had an explicit FG of 10% of the TMDL (in addition to the MOS).

7.0 SENSITIVITY ANALYSES

All modeling studies necessarily involve uncertainty and some degree of approximation. Therefore of value to consider the sensitivity of the model output to changes in model coefficients, and in the hypothesized relationships among the parameters of the model. The sensitivity analyses were performed by allowing the LA-QUAL model to vary one input parameter at a time while holding all other parameters to their original value. The calibration simulation was used as the baseline for the sensitivity analysis. The percent change of the model's minimum DO projections to each parameter is presented in Table 7.1. Each parameter was varied by ±30%, except for temperature, which were varied ±2ºC.

Values reported in Table 7.1 are sorted by percentage variation of minimum DO from largest percentage variation to smallest. Stream reaeration, SOD (benthal demand), stream depth, and nonpoint source CBOD were the parameters to which DO was most sensitive.

Table 7.1. Summary of results of sensitivity analyses.

Parameter	Change in Parameter	Min DO (mg/L)	Change in DO
Baseline	--	2.6	--
Stream Reaeration	30%	3.9	50.0%
Benthal Demand	-30%	3.9	50.0%
Stream Depth	30%	3.7	41.9%
Benthal Demand	30%	1.8	-31.9%
Stream Depth	-30%	1.8	-31.2%
Non-Point Source CBOD	-30%	3.3	27.7%
Non-Point Source CBOD	30%	1.9	-25.8%
Initial Temperature	2°C	2.1	-18.5%
Initial Temperature	-2°C	3.1	17.3%
Non-Point Source Organic N	-30%	2.8	7.7%
Non-Point Source Organic N	30%	2.4	-7.3%
Stream Reaeration	-30%	2.5	-4.6%
Headwater Flow	30%	2.7	1.9%
Headwater Flow	-30%	2.6	-1.5%
Wasteload Flow	-30%	2.6	1.2%
Wasteload Flow	30%	2.6	-0.8%
CBOD Aerobic Decay Rate	-30%	2.6	0.4%
Wasteload Organic Nitrogen	-30%	2.6	0.0%
Wasteload Organic Nitrogen	30%	2.6	0.0%
Wasteload DO	-30%	2.6	0.0%
Wasteload DO	30%	2.6	0.0%
Wasteload CBOD	-30%	2.6	0.0%
Wasteload CBOD	30%	2.6	0.0%
Wasteload Ammonia Nitrogen	-30%	2.6	0.0%
Wasteload Ammonia Nitrogen	30%	2.6	0.0%
Organic Nitrogen Decay Rate	-30%	2.6	0.0%
Organic Nitrogen Decay Rate	30%	2.6	0.0%
Headwater Organic Nitrogen	-30%	2.6	0.0%
Headwater Organic Nitrogen	30%	2.6	0.0%
Headwater DO	-30%	2.6	0.0%
Headwater DO	30%	2.6	0.0%
Headwater CBOD	-30%	2.6	0.0%
Headwater CBOD	30%	2.6	0.0%
Headwater Ammonia	-30%	2.6	0.0%
Headwater Ammonia	30%	2.6	0.0%
CBOD Aerobic Decay Rate	30%	2.6	0.0%
Ammonia Decay Rate	-30%	2.6	0.0%
Ammonia Decay Rate	30%	2.6	0.0%

8.0 OTHER RELEVANT INFORMATION

These TMDLs have been developed to be consistent with the state anti-degradation policy (LAC 33:IX.1109.A).

This TMDL report does not include an implementation plan. Implementation plans are not required for TMDLs under current federal regulations. Implementation plans can be developed most effectively and efficiently on the state and local level.

LDEQ will work with other agencies such as local Soil Conservation Districts to implement nonpoint source best management practices (BMPs) in the watershed through the Section 319 programs. LDEQ will also continue to monitor the waters to determine whether standards are being attained.

In accordance with Section 106 of the Federal Clean Water Act, and under the authority of the Louisiana Environmental Quality Act, LDEQ has established a comprehensive program for monitoring the quality of the state's surface waters. The LDEQ Surveillance Section collects surface water samples at various locations, utilizing appropriate sampling methods and procedures for ensuring 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 data base for water quality trend analysis, and to monitor the effectiveness of pollution controls. The data obtained through the surface water monitoring program is used to develop the state's biennial 305(b) report (Water Quality Inventory) and the 303(d) list of impaired waters. This information is also utilized in establishing priorities for the LDEQ nonpoint source program.

LDEQ has implemented a watershed approach to surface water quality monitoring. Through this approach, the entire state is sampled over a 4-year cycle. Long-term trend monitoring sites at various locations on the larger rivers and Lake Pontchartrain are sampled throughout the 4-year cycle. Sampling is conducted on a monthly basis to yield approximately 12 samples per site each year the site is monitored. Sampling sites are located where they are considered to be representative of the waterbody. Under the current monitoring schedule, approximately one half of the state's waters are newly assessed for each 305(b) and 303(d) listing biennial cycle, with sampling occurring 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. This will allow LDEQ to determine whether there has been any improvement in water quality following implementation of the TMDLs. As the monitoring results are evaluated at the end of each year, waterbodies may be added to or removed from the 303(d) list.

9.0 PUBLIC PARTICIPATION

Federal regulations require USEPA to notify the public and seek comment concerning TMDLs it prepares. The TMDLs in this report were developed under contract to USEPA, and USEPA 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.

Comments were received from LDEQ. These comments were used to revise this TMDL report. The comments and responses to these TMDLs are included in a separate document that includes comments on similar TMDLs with the same public review period.

USEPA will submit the final version of these TMDLs to LDEQ for implementation and incorporation into LDEQ's current water quality management plan.

10.0 REFERENCES

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