TMDLS FOR DISSOLVED OXYGEN AND NUTRIENTS FOR BOGGY BAYOU, LA

SUBSEGMENT 100602

MARCH 24, 2008

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Prepared for

USEPA Region 6
Water Quality Protection Division
Oversight and TMDL Team
1445 Ross Avenue, Suite 1200
Dallas, TX 75202-2733

Contract No. 68-C-02-108
Task Order 95

Prepared by

FTN Associates, Ltd.
3 Innwood Circle, Suite 220
Little Rock, AR 72211

FTN No. 2110-616

March 24, 2008

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 (TMDLs) for those waterbodies. A 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) and nutrients for Boggy Bayou (Subsegment 100602) in the Red River basin in northwestern Louisiana.

Boggy Bayou flows generally eastward from its headwaters near the Texas state line to its confluence with Cypress Bayou near the upper end of Wallace Lake south of Shreveport. Subsegment 100602 covers 79.4 square miles and the predominant land uses are forest (55.7%), urban/transportation (16.5%), and grassland/herbaceous (12.3%).

Subsegment 100602 was cited as being impaired on the final 2004 303(d) list for Louisiana as not fully supporting the designated use of propagation of fish and wildlife. It was ranked as priority No. 2 for TMDL development. The causes for impairment cited in the 303(d) list included organic enrichment/low DO and nutrients. The DO criterion specified in the Louisiana water quality standards for this subsegment is 5 mg/L year-round. Currently, there are no numeric water quality criteria for nutrients in Louisiana.

A water quality model (LA-QUAL) was set up to simulate DO, carbonaceous biochemical oxygen demand (CBOD), ammonia nitrogen, and organic nitrogen in Boggy Bayou. The model was set up and calibrated using data from a field survey conducted by FTN Associates, Ltd. (FTN) during August and September of 2005. The data collected during the field survey included stream flows, depths, widths, and water quality data (both in situ parameters and laboratory analyses of samples).

A water quality model (LA-QUAL) was set up to simulate DO, CBOD, ammonia nitrogen, and organic nitrogen in the subsegment. The model was set up and calibrated using observations from a synoptic survey conducted by FTN during August through

September of 2005, and other information obtained from the Louisiana Department of Environmental Quality (LDEQ) and the United States Geological Survey. Summer and winter projection simulations were run at critical flows and temperatures to address seasonality as required by the Clean Water Act. Reductions of existing nonpoint source loads were required for the projection simulations to show the DO standard of 5 mg/L being maintained. In general, the modeling in this study was consistent with guidance in the Louisiana TMDL Technical Procedures Manual.

TMDLs were calculated for dissolved oxygen, total phosphorus, and total nitrogen. The TMDL for oxygen-demanding substances (CBOD, ammonia nitrogen, organic nitrogen, and sediment oxygen demand) was calculated using the results of the projection simulations (Table ES.1). Both implicit and explicit margins of safety were included in the TMDL calculations, along with a 10% future growth component. The nutrient TMDLs were calculated using the allowable nitrogen loadings from the DO modeling and the naturally occurring ratio of total nitrogen to total phosphorus from reference streams in the South Central Plains Ecoregion. The nutrient TMDLs also included a 10% explicit margin of safety and a 10% future growth allowance (Table ES.1). Fourteen point sources were identified in Subsegment 100602, but only eight of them were included in the TMDLs; the other point sources were considered to have negligible contributions of oxygen demand and nutrients. The allowable loads and concentrations for point sources in these TMDLs are shown in Tables ES.2 and ES.3.

In order to maintain the DO standard of 5.0 mg/L throughout the subsegment, summer nonpoint source oxygen demand loads will need to be reduced by 46%. No reduction of winter loads will be required. Because the Boggy Bayou average total phosphorus and nitrogen concentrations were approximately 60% higher than the average concentrations in the reference streams, total phosphorus and total nitrogen loads also need to be reduced.

It is recommended that as a first step to implement the nutrient TMDLs, the point sources should be given nutrient monitoring requirements in their permits to determine if the point sources are causing or contributing nutrients. However, final decisions for point source nutrient limitations will be made by LDEQ on a case-by-case basis during the re-issuance of each permit.

Additional data is needed to determine if reductions in point-source nutrient discharges will be required. The nutrient TMDLs are summarized in Table ES.1.

Table ES.1. TMDLs for Subsegment 100602.

Parameter	Loads, lbs/day				
	WLA	LA	MOS	FG	TMDL
Oxygen Demand (summer)	95.08	261.95	50.88	50.88	508.66
Oxygen Demand (winter)	95.08	520.65	89.37	89.37	893.66
Total Phosphorus (summer)	2.205	0.313	0.315	0.315	3.148
Total Phosphorus (winter)	2.205	4.629	0.854	0.854	8.542
Total Nitrogen (summer)	22.05	3.13	3.15	3.15	31.48
Total Nitrogen (winter)	22.05	46.29	8.54	8.54	85.42

Table ES. 2. Flows, concentrations, and loads for point sources included in DO TMDL.

Subsegment. Number	NPDES Number	Name of discharger	Flow rate (gallons per day)	Concentrations			Loads*		
				BOD5 or CBOD5 (mg/L)	Ammonia nitrogen (mg/L)	Organic nitrogen (mg/L)	BOD5 or CBOD5 (lbs/day)	Ammonia nitrogen (lbs/day)	Organic nitrogen (lbs/day)
100602	LAG480011	LA Lift and Equip. Inc. FKA LA Clarklift Inc	1,800 (Outfall 001 only)	45	10	20	0.68	0.15	0.30
100602	LAG480284	Jack Cooper Transport Co Inc	2,600	45	10	20	0.98	0.22	0.44
100602	LAG530693	KEH Property Ltd., Fud's III Bar and Lounge	675	45	10	20	0.25	0.06	0.10
100602	LAG541012	Grawood Baptist Church	6,000	30	10	5	1.50	0.50	0.25
100602	LAG560089	Wildwood Estates	33,000	20	6.7	13.4	5.51	1.85	3.69
100602	LAG570220	Eagle Water Inc - LaLaurie Lane Oxidation Pond	60,000	10	1.7	3.3	5.01	0.85	1.65
100602	LAG750459	Norwell Equip. Co. Shreveport Facility	5,000	45	10	20	1.88	0.42	0.17
100602	LAG750449	Deep South Equip. Co. Shreveport	5,000	45	10	20	1.88	0.42	0.17
100602 Total Loads:							17.69	4.47	6.77

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

Table ES.3. Point source concentrations and loads for nutrient TMDL.

NPDES Number	Name of Discharger	Flow Rate (gpd)	Concentrations		Loads	
			Total Nitrogen (mg/L)	Total Phosphorus (mg/L)	Total Nitrogen (lbs/day)	Total Phosphorus (lbs/day)
LAG480011	LA Lift and Equipment Inc. – Clarklift Inc.	1800	44.92	4.49	0.75	0.075
LAG480284	Jack Cooper Transport Co. Inc.	2600	42.28	4.23	1.06	0.106
LAG530693	KEH Property Ltd. – Fud's III Bar and Grill	675	34.35	3.44	0.29	0.029
LAG560089	Wildwood Estates	3300	30.23	3.02	10.34	1.034
LAG750459	Norwell Equipment Co.	5000	41.40	4.14	2.07	0.207
LAG750449	Deep South Equipment Co.	5000	41.40	4.14	2.07	0.207
LAG570220	Eagle Water Inc. – LaLaurie Lane Oxidation Pond	60000	14.99	1.50	9.39	0.939
LAG541012	Grawood Baptist Church	6000	25.25	2.53	1.59	0.159
Subsegment 100602 TOTAL LOADS:					22.05	2.205

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1.0 INTRODUCTION

This report presents total maximum daily loads (TMDLs) for dissolved oxygen (DO) and nutrients for Subsegment 100602 (Boggy Bayou from the headwaters to Wallace Lake). This subsegment was cited as being impaired on the final 2004 303(d) list for Louisiana (Louisiana Department of Environmental Quality (LDEQ) 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 TMDL in this report was developed in accordance with Section 303(d) of the Federal Clean Water Act and United States Environmental Protection Agency (USEPA) regulations at 40 CFR 130.7. The impairments for sedimentation/siltation and turbidity in this subsegment have been addressed in a previous TMDL report (FTN 2007).

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), future growth (FG), and a margin of safety (MOS). The WLA is the load allocated to point sources of the pollutant of concern. The LA is the load allocated to nonpoint sources, including natural background. The FG is reserved for future increases in loads to the waterbody. The MOS is a percentage of the TMDL that accounts for any lack of knowledge concerning the relationships between pollutant loading and water quality, including uncertainty associated with model assumptions and data inadequacies.

Table 1.1. Summary of 303(d) listing for Subsegment 100602

Subsegment Number	Waterbody Description	Suspected Causes	Suspected Sources	Priority Ranking (1 = highest)
100602	Boggy Bayou – From headwaters to Wallace Lake	Organic enrichment/low DO	Unknown source	2
		Nutrients	Unknown source	2
		Sedimentation/Siltation	Unknown source	1
		Turbidity	Unknown source	1

2.0 STUDY AREA DESCRIPTION

2.1 General Information

Boggy Bayou (Subsegment 100602) is located in northwestern Louisiana in the Red River Basin (see Figure A.1 in Appendix A). Boggy Bayou flows generally eastward from its headwaters near the Texas state line to its confluence with Cypress Bayou within the upper end of Wallace Lake south of Shreveport. Subsegment 100602 covers 79.4 square miles and includes Gilmer Bayou and other small tributaries of Boggy Bayou. This subsegment lies entirely within the South Central Plains ecoregion.

2.2 Land Use

Land use characteristics for Subsegment 100602 were compiled from the United States Geological Survey (USGS) 2001 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 are shown on Figure A.2 (located in Appendix A) and land use percentages are shown in Table 2.1. These data indicate that over half of this subsegment is forest.

Table 2.1. Land use percentages for Subsegment 100602.

Land Use Type	Percent of Total Area
Water	0.6%
Urban/Transportation	16.5%
Barren	0.2%
Forest	55.7%
Grasslands/Herbaceous	12.3%
Pasture/Hay	6.8%
Cultivated Crops	0.1%
Wetlands	7.8%
TOTAL	**100.0%**

2.3 Water Quality Standards

Water quality standards for Louisiana are listed in the Title 33 Environmental Regulatory Code (LDEQ 2007). The designated uses for Subsegment 100602 are primary contact recreation,

secondary contact recreation, propagation of fish and wildlife, and agriculture. The primary numeric criteria for the DO TMDL presented in this report are the DO criterion of 5 mg/L (year round) and the temperature criterion of 32°C.

The Title 33 Environmental Regulatory Code does not include numeric criteria for nutrients, but it does include the following narrative criteria for nutrients (LAC 33: IX.1113.B.8):

> "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."

The Louisiana water quality standards also include an antidegradation 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.

2.4 Point Sources

A list of point sources in selected portions of the Red River basin 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, 14 point sources were identified within Subsegment 100602 (Table 2.2; located at the end of Section 2). Approximate locations of these point sources are shown on Figure A.3 (in Appendix A). All of the discharges that were considered to have oxygen demand above background levels were included in the TMDL. Most of the oxygen-demanding discharges are far away from Boggy Bayou such that they are not expected to affect DO concentrations in Boggy Bayou. The only two discharges that were close enough to Boggy Bayou to be included in the LA-QUAL model were Eagle Water (LaLaurie Lane) and Grawood Baptist Church.

Storm runoff from areas within the Shreveport city limits is classified as a point source for this TMDL because the City of Shreveport has a Municipal Separate Storm Sewer System (MS4) permit (permit number LAS000401). The Urbanized Area for Shreveport (USEPA 2002) extends into Subsegment 100602 and covers approximately 12.7 square miles of the subsegment (16% of the subsegment). This MS4 permit does not set numeric limits for the quality of storm runoff from urban areas, but it does require the City of Shreveport to identify and implement best management practices (BMPs) to minimize pollutants in storm runoff.

2.5 Nonpoint Sources

The 303(d) list did not cite any specific nonpoint sources as suspected sources of the DO and nutrient impairments for Subsegment 100602 (Table 1.1).

Individual nonpoint sources are not identified and quantified here because this TMDL focuses on total nonpoint source loading. Individual sources should be identified and quantified by state or local agencies if they develop an implementation plan.

2.6 Historical Water Quality Data Summary

There is one LDEQ routine water quality monitoring station in this subsegment; it is Station 1207 (Boggy Bayou southwest of Shreveport, Louisiana). Its location is shown on Figure A.1 in Appendix A. The DO and nutrient data for this station were obtained from LDEQ. The data are summarized in Table 2.3 (located at the end of Section 2) and the individual data are listed in Table B.1 (Appendix B). During 2002 through 2005, approximately 36% of the DO measurements were below the water quality criterion of 5.0 mg/L. Eight of the 12 values below 5.0 mg/L occurred during May through September 2005, which was a drier than normal period for northwestern Louisiana (Southern Regional Climate Center (SRCC) 2007).

Table 2.2. List of point source discharges in Subsegment 100602.

Permit Number and AI Number*	Company and Facility Name	Type of Facility	Receiving Stream	Outfall	Flow (gpd)	Relevant Permit Limits	Included in TMDLs
LAG780000 (AI=52367)	SWEPCO Dean Road Tree Trim Debris Landfill	Tree debris landfill	Gilmer Bayou to Boggy Bayou	001	30,000	50 mg/L TOC	No
LAG110024 (AI=7844)	Builders Supply Brooks Road Plant	Ready mix concrete	Ditch to drainage ditch to Boggy Bayou			none related to DO	No
LAG480011 (AI=10216)	LA Lift and Equip. Inc. FKA LA Clarklift Inc	Forklift dealer / service facility	Gilmer Bayou to Boggy Bayou	001	1,800 avg 2,520 max	45 mg/L BOD5 wk. avg	DO, N, P
				002	12,067	200 mg/L COD mo. avg 300 mg/L COD dly max	No
LAG480284 (AI=41933)	Jack Cooper Transport Co Inc	Auto transport maintenance	Ditch to Gilmer Bayou to Boggy Bayou	001	2,600	45 mg/L BOD5 wk. avg	DO, N, P
LAG530693 (AI=42032)	KEH Property Ltd., Fud's III Bar and Lounge	Restaurant / bar / lounge	Ditch to Gilmer Bayou to Boggy Bayou	001	675	45 mg/L BOD5 wk. avg	DO, N, P
LAG531200 (AI=93686)	Whitt's Barbeque	Restaurant	Socagee Creek in Texas, then to Sabine River	001	3,000	45 mg/L BOD5 wk. avg	No (flows to Texas)
LAG541012 (AI=87657)	Grawood Baptist Church	Church	Ditch to Boggy Bayou	001	6,000	30 mg/L BOD5 mo. avg 45 mg/L BOD5 wk. avg	DO, N, P
LAG560089 (AI=18900)	Wildwood Estates	Manufactured home community	Stream to Lakeland Farm Lake to Boggy Bayou	001	33,000	20 mg/L BOD5 mo. avg 30 mg/L BOD5 wk. avg	DO, N, P
LAG570220 (AI=41326)	Eagle Water Inc - LaLaurie Lane Oxidation Pond	Residential sewage treatment	Boggy Bayou	001	60,000	10 mg/L BOD5 mo. avg 15 mg/L BOD5 wk. avg	DO, N, P
LAG750459 (AI=42680)	Norwell Equip. Co. Shreveport Facility	Heavy equipment sales & service	Ditch to Boggy Bayou	002	< 5,000	45 mg/L BOD5 wk. avg	DO, N, P
LAG750449 (AI=14030)	Deep South Equip. Co. Shreveport	Forklift trucks / sales & service	Ditch to Boggy Bayou	002	< 5,000	45 mg/L BOD5 wk. avg	DO, N, P
LAR05M320 (AI=3349)	General Motors Shreveport Assembly Plant	Motor vehicle assembly plant	Bayou Gilmer to Boggy Bayou			none related to DO	No
LAR05N167 (AI=27348)	Industrial Oils Unlimited, AR Inc.	Industrial lubricant supplier	Gilmer Bayou to Boggy Bayou			none related to DO	No
LAR05N401 (AI=11454)	General Electric Shreveport					none related to DO	No

*AI Number = Agency Interest number (assigned by LDEQ and used in LDEQ point source files and databases).

Table 2.3. Summary of LDEQ routine water quality monitoring data for Boggy Bayou.

Station ID and Description	Period of Record	Parameter	Number of Values	Minimum (mg/L)	Average (mg/L)	Maximum (mg/L)	Number of Values Below Criterion	Percent of Values Below Criterion
1207 – Boggy Bayou southwest of Shreveport	1/07/02 thru 9/27/05	DO	33	1.8	6.2	12.6	12	36%
		Nitrate + Nitrite	36	< 0.05	0.11	0.42	NA	NA
		Ammonia Nitrogen	36	< 0.10	0.09	0.56	NA	NA
		Total Kjeldahl Nitrogen (TKN)	36	0.19	0.94	5.89	NA	NA
		Total Phosphorus	36	< 0.05	0.14	0.91	NA	NA

3.0 FTN FIELD DATA

FTN conducted a field survey for 14 subsegments in the Red River and Sabine River basins during 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. Field data were collected in the Boggy Bayou subsegment on August 31, 2005.

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 time series for carbonaceous biochemical oxygen demand (CBOD), total Kjeldahl nitrogen (TKN), ammonia nitrogen, nitrate+nitrite nitrogen, 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 are shown in Table C.4.

For the Boggy Bayou subsegment, field data were collected at LDEQ Station 1207 and at Station 100602-A (location shown on Figure A.1 in Appendix A). The field data collected at these two sites are listed in Table 3.1. The DO concentrations measured in Boggy Bayou were 5.2 mg/L and 4.4 mg/L.

Table 3.1. FTN field data collected for Subsegment 100602.

	Station 1207	**Station 100602-A**
Date and time of sample / measurements	8/31/05 2:40 pm	8/31/05 1:45 pm
Depth (m) of sample / measurements	mid-depth	mid-depth
Width of stream (ft)	30.0	13.6
Mean depth of stream (ft)	0.51	0.92
Stream flow rate (cfs)	3.3	too low to measure
Water temperature (°C)	31.5	27.2
DO (mg/L)	5.2	4.4
Conductivity (µmhos/cm)	156	208
pH (su)	7.1	7.1
TSS (mg/L)	19	78
TKN (mg/L)	1.5	1.8
Total phosphorus (mg/L)	0.14	0.15
TOC (mg/L)	6.1	8.1
Chlorophyll *a* (mg/L)	<0.02	<0.02
Ammonia nitrogen (mg/L)	<0.10	<0.10
Nitrate+nitrite nitrogen (mg/L)	<0.05	<0.05
CBOD on day 3 of analysis (mg/L)	< 2	2.7
CBOD on day 5 of analysis (mg/L)	< 2	3.9
CBOD on day 9 of analysis (mg/L)	2.1	5.0
CBOD on day 14 of analysis (mg/L)	3.4	7.8
CBOD on day 20 of analysis (mg/L)	6.0	9.4
Ultimate CBOD (mg/L; calculated)	13.1	12.0
CBOD decay rate (1/day; calculated)	0.04	0.07

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 version 8.11 of LA-QUAL (Wiland and LeBlanc 2007), 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, ultimate CBOD (CBODu), and DO.

Figure D.1 in Appendix D shows the model reach/element design and the location of the modeled inflows. Boggy Bayou was divided into two reaches to represent varying depths and widths upstream and downstream of the mouth of Gilmer Bayou. Aerial photos showed that Boggy Bayou is channelized downstream of Gilmer Bayou, but appears to be a natural channel upstream of Gilmer Bayou.

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 (CBOD decay, nitrification, and sediment oxygen demand (SOD)). In most systems, low flow causes low reaeration rates. 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 two data sets that were considered for model calibration were the FTN field survey (August 31, 2005) and the LDEQ routine monitoring data at Station 1207 (January 2002 – September 2005). The FTN field survey was chosen for the model calibration period because the survey was conducted during hot, dry conditions, field data were collected at multiple locations within the subsegment, and the field data included flow and cross section data that were not available for the LDEQ routine ambient monitoring data.

The calibration targets (i.e., the concentration to which the model was calibrated) for each parameter were set equal to the concentrations measured during the survey. Organic nitrogen was estimated as TKN minus ammonia nitrogen.

4.3 Temperature Correction of Kinetics (Data Type 4)

The temperature correction factors used in the model were consistent with the Louisiana Technical Procedures Manual (the "LTP," LDEQ 2006). These correction factors were:

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

4.4 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 were specified using the constants in these power functions (c and f) because the changes in widths and depths between the calibration and projection were assumed to be negligible. This assumption was made because the FTN field survey was conducted under very low flow conditions. The width and depth of Reach 1 (4.1 m and 0.28 m, respectively) were set equal to the values measured at Station 100602-A during the field survey. The width and depth of Reach 2 (9.1 m and 0.16 m, respectively) were set equal to the values measured at Station 1207 during the field survey. The values measured during the field survey are shown in Table 3.1.

4.5 Initial Conditions (Data Type 11)

Because temperature is not being simulated in the model, the temperature for each reach was specified in the initial conditions for LA-QUAL. The temperature for Reach 1 was set to 27.2°C, which was the measured temperature at Station 100602-A during the FTN field survey. The temperature for Reach 2 was set to 31.5°C, which was the measured temperature at Station 1207 during the field survey.

Initial concentrations of DO and ammonia nitrogen were also specified in the LA-QUAL input using measured values from the field survey. The initial concentrations of these two parameters do not affect the model output; the model uses them only as starting points for its iterative solution technique.

For constituents not being simulated, the initial concentrations were set to zero. 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. Chlorophyll was not specified in the model because the chlorophyll concentrations at both stations (100602-A and 1207) were below the laboratory detection limit.

4.6 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 it has been used successfully in the past for other TMDLs in Louisiana.

The CBOD decay rate for both reaches was set to 0.055/day, which was the average of the two laboratory decay rates for Stations 100602-A and 1207 shown in Table 3.1. The nitrification rate for both reaches was initially set to 0.08/day, which was the average of 36 nitrogenous BOD (NBOD) decay rates measured by LDEQ in forested subsegments in the Ouachita River and Calcasieu River basins (shown in Table B.2 in Appendix B). During the calibration process, the nitrification rate for Reach 1 was increased to 0.18/day, which was the maximum of the 36 NBOD decay rates. This change was made because lower nitrification rates resulted in predicted ammonia concentrations that were significantly higher than the observed concentrations.

The mineralization (organic nitrogen decay) rate was set to 0.02/day for both reaches. This value was similar to the values shown in the “Rates, Constants, and Kinetics” publication (USEPA 1985) for dissolved organic nitrogen being transformed to ammonia nitrogen.

4.7 Nonpoint Source Loads (Data Types 12, 13, and 19)

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, 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. The values used as model input are shown in Table 4.1.

Table 4.1. Nonpoint source loads for model calibration.

Reach	SOD ($g/m^2/day$)	Benthic Ammonia Source ($g/m^2/day$)	CBODu Load (kg/day)	Organic Nitrogen Load (kg/day)
1	1.50	0	20.0	0.80
2	1.90	0	0.0	0.00

4.8 Headwater, Tributary, and Point Source Flows (Data Types 20 and 24)

A flow balance was developed for the Boggy Bayou LA-QUAL model based on the stream flow rates measured at Stations 1207 and 100602-A during the FTN field survey and flow rates from discharge monitoring reports (DMRs) for the two point source discharges that were included in the model (Eagle Water LaLaurie Lane oxidation pond and Grawood Baptist Church). The calculations and the resulting flow rates used in the model are summarized in Table 4.2.

Table 4.2. Inflow rates for model calibration.

Name of Inflow	Flow Rate (cfs)	Flow Rate (m^3/sec)	Explanation
Headwater	0.01	0.00028	Flow at 100602-A was too low to measure during FTN field survey. Flow of 0.01 cfs was assumed.
Eagle Water LaLaurie Lane	0	0	"No measurable flow" reported on August 2005 DMR.
Grawood Baptist Church	0.0093	0.00026	Equivalent to 6,000 gpd. Quarterly DMR for July – September 2005 reported daily maximum flow of 11,000 gpd; monthly average flow was not reported but was assumed to be similar to flow of 6,000 gallons per day in permit application.
Gilmer Bayou	1.94	0.0550	Combined flow for Gilmer Bayou and two unnamed tributaries was calculated as measured flow at station 1207 (3.3 cfs) minus the assumed headwater flow (0.01 cfs) minus the point source flows (0.0093 cfs) = 3.28 cfs. This was divided between the three inflows in proportion to their drainage areas (Gilmer Bayou = 26 mi^2, Unnamed tributary 1 = 13 mi^2, and Unnamed tributary 2 = 5 mi^2).
Unnamed tributary 1	0.97	0.0275	
Unnamed tributary 2	0.37	0.0106	

4.9 Headwater, Tributary, and Point Source Water Quality (Data Types 21 and 25)

Concentrations of DO, CBODu, ammonia nitrogen, and organic nitrogen were specified in the model for the headwater, tributary, and point source flows. Table 4.3 lists the values used in the model and provides explanations of how the input values were developed.

Table 4.3. Inflow quality for model calibration.

Name of Inflow	Parameter	Value used in model	Data source / comment
Boggy Bayou headwater and unnamed tributaries	DO	4.4 mg/L	Observed values at Station 100602-A, which was considered representative of unnamed tributaries
	CBODu	12.0 mg/L	
	Ammonia N	0.05 mg/L	Observed value at Station 100602-A (estimated as half of detection limit)
	Organic N	1.75 mg/L	Observed TKN value at 100602-A (1.8 mg/L) minus estimated ammonia (0.05 mg/L)
Eagle Water LaLaurie Lane	DO	0 mg/L	No flow during field survey
	CBODu	0 mg/L	
	Ammonia N	0 mg/L	
	Organic N	0 mg/L	
Grawood Baptist Church	DO	5.0 mg/L	Assumed to be discharging at instream criterion (DO not reported on DMRs)
	CBODu	8.56 mg/L	BOD5 on DMR for Jul. – Sep. 2005 (3.72 mg/L) times assumed CBODu:BOD5 ratio of 2.3
	Ammonia N	6 mg/L	TKN was assumed to be similar magnitude as CBODu (round up to 9 mg/L). Based on LTP, the TKN for a non-lagoon system was assumed to be 2/3 ammonia and 1/3 organic nitrogen.
	Organic N	3 mg/L	
Gilmer Bayou	DO	5.2 mg/L	Observed values at Station 1207, which was considered representative of Gilmer Bayou inflow due to proximity and degree of channelization
	CBODu	13.5 mg/L	
	Ammonia N	0.05 mg/L	Observed value at Station 1207 (estimated as half of detection limit)
	Organic N	1.45 mg/L	Observed TKN value at Station 1207 (1.5 mg/L) minus estimated ammonia (0.05 mg/L)

4.10 Model Results for Calibration

Plots of predicted and observed water quality for the calibration are presented in Appendix E and a printout of the LA-QUAL output file is included as Appendix F. 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 Critical Conditions and Seasonality

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 a MOS in the development of a TMDL. For the DO TMDL in this report, analyses of LDEQ long-term ambient data were used to determine critical seasonal conditions. Both an explicit MOS and an implicit MOS were used in developing the projection simulations.

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 water 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, of course, 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 DO 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 resuspended 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 (LDEQ 2006), critical summer conditions in DO TMDL projection modeling are simulated by using the annual 7Q10 flow or 0.1 cfs, whichever is higher, for all headwaters, and 90th percentile temperature for the summer season. Critical winter conditions are simulated. Model loading is from perennial tributaries, point sources, SOD, and resuspension of sediments.

In reality, the highest temperatures occur in July and August and the lowest stream flows occur slightly later in the year. The combination of these conditions plus the impact of other conservative assumptions regarding rates and loadings yields an implicit MOS that is not quantified. Over and above this implicit MOS, an explicit MOS of 10% was incorporated into the DO TMDL in this report to account for model uncertainty.

5.2 Temperature Inputs

The LTP specifies that the critical temperature should be determined by calculating the 90th percentile seasonal temperature for the waterbody being modeled. Water temperature data were collected in Boggy Bayou (Station 1207) for only one year, which is not enough data to calculate 90th percentile temperatures. Therefore, long-term data from an LDEQ monitoring station on a similar stream (Black Bayou near Rodessa, Station 11) were used to estimate 90th percentile temperatures for Boggy Bayou. First, 90th percentile temperatures for Black Bayou were calculated to be 30.1°C for summer and 21.0°C for winter (see Table G.1 in Appendix G). These 90th percentile temperatures were then adjusted based on differences between seasonal average temperatures in Boggy Bayou (Station 1207) and Black Bayou (Station 11) during their overlapping period of record (see Table G.2). These calculations yielded a value of 32.9°C for the adjusted 90th percentile temperature during summer, but the temperature used in LA-QUAL for the summer projection was 32.0°C because LDEQ does not consider the temperature correction algorithms in LA-QUAL to be valid for temperatures above 32.0°C. The 90th percentile winter temperature was calculated to be 22.9°C, which was used in the LA-QUAL winter projection.

5.3 Headwater, Tributary, and Point Source Inputs

The inputs for the headwaters, tributaries, and point sources for the projection simulations were based on guidance in the LTP (LDEQ 2006), published 7Q10 flows, observed data from the FTN field survey, and information from the point source permits and applications. The inputs for the headwaters, tributaries, and point sources are listed in Tables 5.1 and 5.2.

The flow rate for the headwater and each tributary was set to 0.1 cfs (0.00283 m^3/sec) for summer and 1.0 cfs (0.0283 m^3/sec) for winter because the LTP recommends using these default flows when they are higher than the 7Q10 flows. The annual 7Q10 flow for Boggy Bayou near Keithville (07351000; same location as LDEQ Station 1207) is 0 cfs and the seasonal 7Q10 flows are 0 cfs for September – November, 0.11 cfs for December – February, and 1.0 cfs for March – May (USGS 2003).

Flow rates for the two point source discharges being modeled were set to 125% of design flow so that 20% of the simulated point source loading could be set aside for MOS and FG during the TMDL calculations (see Section 6.0). CBODu concentrations for the point sources were set to monthly average permit limits for BOD5 multiplied times an assumed CBODu:BOD5 ratio of 2.3. Organic nitrogen and ammonia nitrogen concentrations were based on guidance in the LTP concerning: a) typical ratios of BOD5 to the sum of organic nitrogen plus ammonia nitrogen, and b) assumed ratios of organic nitrogen to ammonia nitrogen for lagoon treatment systems (2:1) and mechanical treatment systems (1:2).

It was assumed that the quality of the headwater and tributaries would improve with reductions of nonpoint sources in the watershed. For the projection simulations, the headwater and tributary 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 and tributary 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 and tributaries. The calculations for headwater and tributary DO for the projection simulations are shown in Appendix H.

Table 5.1. Headwater, tributary, and point source inputs for summer projection.

Name of Inflow	Parameter	Value used in model	Data source / comment
Boggy Bayou headwater and unnamed tributaries	Flow	0.00283 m^3/sec	Equivalent to 0.1 cfs (see Section 5.3)
	DO	5.54 mg/L	Equivalent to 75.9% saturation at 32.0°C. Percent saturation is based on 46% reduction of nonpoint sources in watershed (Appendix H).
	CBODu	6.48 mg/L	Calibration value (12.0 mg/L) reduced by 46%
	Ammonia N	0.027 mg/L	Calibration value (0.05 mg/L) reduced by 46%
	Organic N	0.95 mg/L	Calibration value (1.75 mg/L) reduced by 46%
Eagle Water LaLaurie Lane	Flow	0.00329 m^3/sec	Equivalent to 75,000 gallons per day (design flow of 60,000 gallons per day × 1.25 to incorporate a 20% MOS + FG)
	DO	5.0 mg/L	Assumed to be discharging at instream criterion (DO not included in permit limits)
	CBODu	23 mg/L	Monthly average BOD_5 limit (10 mg/L) times assumed CBODu:BOD_5 ratio of 2.3
	Ammonia N	1.7 mg/L	Per LTP, typical TKN of 5 mg/L corresponds to 10 mg/L BOD5. For lagoon system, TKN is assumed to be 1/3 ammonia nitrogen and 2/3 organic nitrogen (per LTP).
	Organic N	3.3 mg/L	
Grawood Baptist Church	Flow	0.00033 m^3/sec	Equivalent to 7,500 gallons per day (design flow of 6,000 gallons per day × 1.25 to incorporate a 20% MOS + FG)
	DO	5.0 mg/L	Assumed to be discharging at instream criterion (DO not included in permit limits)
	CBODu	69 mg/L	Monthly average BOD_5 limit (30 mg/L) times assumed CBODu:BOD_5 ratio of 2.3
	Ammonia N	10 mg/L	Per LTP, typical TKN of 15 mg/L corresponds to 30 mg/L BOD_5. For mechanical system, TKN is assumed to be 2/3 ammonia nitrogen and 1/3 organic nitrogen (per LTP).
	Organic N	5 mg/L	
Gilmer Bayou	Flow	0.00283 m^3/sec	Equivalent to 0.1 cfs (see Section 5.3)
	DO	6.14 mg/L	Equivalent to 84.1% saturation at 32.0°C. Percent saturation is based on 46% reduction of nonpoint sources in watershed (Appendix H).
	CBODu	7.29 mg/L	Calibration value (13.5 mg/L) reduced by 46%
	Ammonia N	0.027 mg/L	Calibration value (0.05 mg/L) reduced by 46%
	Organic N	0.78 mg/L	Calibration value (1.45 mg/L) reduced by 46%

Table 5.2. Headwater, tributary, and point source inputs for winter projection.

Name of Inflow	Parameter	Value used in model	Data source / comment
Boggy Bayou headwater and unnamed tributaries	Flow	0.0283 m^3/sec	Equivalent to 1.0 cfs (see Section 5.3)
	DO	4.76 mg/L	Equivalent to 55.4% saturation at 22.9°C. Percent saturation is based on 0% reduction of nonpoint sources in watershed (Appendix H).
	CBODu	12.0 mg/L	Calibration value (12.0 mg/L) reduced by 0%
	Ammonia N	0.05 mg/L	Calibration value (0.05 mg/L) reduced by 0%
	Organic N	1.75 mg/L	Calibration value (1.75 mg/L) reduced by 0%
Eagle Water LaLaurie Lane	Flow	0.00329 m^3/sec	Equivalent to 75,000 gallons per day (design flow of 60,000 gallons per day × 1.25 to incorporate a 20% MOS + FG)
	DO	5.0 mg/L	Assumed to be discharging at instream criterion (DO not included in permit limits)
	CBODu	23 mg/L	Monthly average BOD_5 limit (10 mg/L) times assumed CBODu:BOD_5 ratio of 2.3
	Ammonia N	1.7 mg/L	Per LTP, typical TKN of 5 mg/L corresponds to 10 mg/L BOD_5. For lagoon system, TKN is assumed to be 1/3 ammonia nitrogen and 2/3 organic nitrogen (per LTP).
	Organic N	3.3 mg/L	
Grawood Baptist Church	Flow	0.00033 m^3/sec	Equivalent to 7,500 gallons per day (design flow of 6,000 gallons per day × 1.25 to incorporate a 20% MOS + FG)
	DO	5.0 mg/L	Assumed to be discharging at instream criterion (DO not included in permit limits)
	CBODu	69 mg/L	Monthly average BOD_5 limit (30 mg/L) times assumed CBODu:BOD_5 ratio of 2.3
	Ammonia N	10 mg/L	Per LTP, typical TKN of 15 mg/L corresponds to 30 mg/L BOD_5. For mechanical system, TKN is assumed to be 2/3 ammonia nitrogen and 1/3 organic nitrogen (per LTP).
	Organic N	5 mg/L	
Gilmer Bayou	Flow	0.0283 m^3/sec	Equivalent to 1.0 cfs (see Section 5.3)
	DO	6.07 mg/L	Equivalent to 70.6% saturation at 22.9°C. Percent saturation is based on 0% reduction of nonpoint sources in watershed (Appendix H).
	CBODu	13.5 mg/L	Calibration value (13.5 mg/L) reduced by 0%
	Ammonia N	0.05 mg/L	Calibration value (0.05 mg/L) reduced by 0%
	Organic N	1.45 mg/L	Calibration value (1.45 mg/L) reduced by 0%

5.4 Nonpoint Source Loads

Initial projection simulations were run with no reductions of nonpoint source loads and no improvements in headwater and tributary quality, but the summer simulation predicted DO values below the 5.0 mg/L criterion in the water quality standards. For the summer simulation, the nonpoint source loads (SOD and mass loads of CBODu and organic nitrogen) were reduced and the headwater and tributary quality was improved until all of the predicted DO values were equal to or greater than 5.0 mg/L. The point source loads in the model were not reduced because neither discharge appears to have a significant impact on DO in Boggy Bayou. Nonpoint source load reductions of 46% for summer and 0% for winter were needed for all the predicted DO values to be at least 5.0 mg/L. The values used as model inputs for nonpoint source loads are shown in Table 5.3. The benthic ammonia source loads are not shown in Table 5.3 because they were set to zero in the calibration and the projections.

Table 5.3. Nonpoint source loads for projection simulations.

Parameter	Reach	Calibration	Summer Projection (46% reduction)	Winter Projection (0% reduction)
SOD	1	1.50 $g/m^2/day$	0.81 $g/m^2/day$	1.50 $g/m^2/day$
	2	1.90 $g/m^2/day$	1.03 $g/m^2/day$	1.90 $g/m^2/day$
CBODu mass loads	1	20.0 kg/day	10.8 kg/day	20.0 kg/day
	2	0.0 kg/day	0.0 kg/day	0.0 kg/day
Organic nitrogen mass loads	1	0.80 kg/day	0.43 kg/day	0.80 kg/day
	2	0.0 kg/day	0.0 kg/day	0.0 kg/day

5.5 Other Inputs

The only model inputs that were changed from the calibration to the projection simulations 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. The depths and widths were not changed from the calibration to the projections because the calibration values were based on field measurements under low flow conditions.

5.6 Model Results for Projections

Plots of predicted DO and printouts of the LA-QUAL tabular output are presented in Appendix I for the summer projection and Appendix J for the winter projection.

The minimum predicted DO in the summer projection was 5.02 mg/L, which occurred at the downstream end of the model. The minimum predicted DO in the winter projection was 5.06 mg/L, which occurred at the upstream end of the model (in the first element) because the headwater DO concentration was lower than any of the predicted DO values in the stream.

Nonpoint source load reductions of 46% for summer and 0% for winter were needed for all the predicted DO values in the projections to be at least 5.0 mg/L. These percent reductions for nonpoint source loads represent percentages of the entire nonpoint source loading, not percentages 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 accurately estimate natural nonpoint source loads for the study area.

6.0 DO TMDL DEVELOPMENT

6.1 TMDL Calculations

A TMDL for DO was calculated for the Boggy Bayou subsegment using the results of the summer and winter projection simulations. The DO TMDL is presented as oxygen demand from CBODu, organic nitrogen, ammonia nitrogen, and SOD. Summaries of the TMDL for Boggy Bayou are presented in Tables 6.1 and 6.2.

A one-page summary of the methodology for the TMDL calculations is shown in Appendix K. 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 input file with miscellaneous information needed for the TMDL calculations (shown in Appendix K). The output files from the program are also shown in Appendix K for the summer and winter projections. The source code for the program is shown in Appendix L.

6.2 Point Source Loads

The WLA for point sources for each season was calculated by: 1) summing the loads from point sources in the projection simulation and from oxygen-demanding point sources that were too small and remote to be simulated, and 2) then subtracting 20% of the total load to account for the MOS and FG. The design flows from small, remote point sources were multiplied by 1.25 before the loads were calculated so that 20% of the resulting loads could be reserved for the MOS and FG. Loads from small, remote point sources were calculated using the FORTRAN program described above. Table 6.3 lists the flows, concentrations, and loads for point sources that were included in the DO TMDL. The point sources that were not included in the DO TMDL were shown in the complete listing of all point sources (Table 2.2).

Table 6.1. Summer DO TMDL for Subsegment 100602

	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	18.45	15.93	8.75	43.14	NA	40.67	35.12	19.29	95.08	0%
MS4	19.85	2.03	0.72	0.02	22.62	43.76	4.48	1.59	0.04	49.87	46%
MOS	NA	2.31	1.99	1.09	5.39	NA	5.09	4.39	2.40	11.88	NA
FG	NA	2.31	1.99	1.09	5.39	NA	5.09	4.39	2.40	11.88	NA
Nonpoint Sources											
LA	104.24	10.66	3.81	0.11	118.82	229.81	23.50	8.40	0.24	261.95	46%
MOS	15.51	1.59	0.57	0.02	17.68	34.19	3.51	1.26	0.04	39.00	NA
FG	15.51	1.59	0.57	0.02	17.68	34.19	3.51	1.26	0.04	39.00	NA
TMDL	155.11	38.94	25.58	11.10	230.72	341.95	85.85	56.41	24.45	508.66	NA

Table 6.2. Winter DO TMDL for Subsegment 100602.

	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	18.45	15.93	8.75	43.14	NA	40.67	35.12	19.29	95.08	0%
MS4	20.77	14.42	9.53	0.27	44.99	45.79	31.79	21.01	0.60	99.19	0%
MOS	NA	2.31	1.99	1.09	5.39	NA	5.09	4.39	2.40	11.88	NA
FG	NA	2.31	1.99	1.09	5.39	NA	5.09	4.39	2.40	11.88	NA
Nonpoint Sources											
LA	109.03	75.73	50.02	1.39	236.17	240.37	166.95	110.27	3.06	520.65	0%
MOS	16.23	11.77	7.44	0.21	35.15	35.78	24.85	16.40	0.46	77.49	NA
FG	16.23	11.77	7.44	0.21	35.15	35.78	24.85	16.40	0.46	77.49	NA
TMDL	162.26	136.76	94.34	13.01	405.38	357.72	299.29	207.98	28.67	893.66	NA

Table 6.3. Flows, concentrations, and loads for point sources included in DO TMDL.

Subsegment. Number	NPDES Number	Name of discharger	Flow rate (gallons per day)	Concentrations			Loads*		
				BOD5 or CBOD5 (mg/L)	Ammonia nitrogen (mg/L)	Organic nitrogen (mg/L)	BOD5 or CBOD5 (lbs/day)	Ammonia nitrogen (lbs/day)	Organic nitrogen (lbs/day)
100602	LAG480011	LA Lift and Equip. Inc. FKA LA Clarklift Inc	1,800 (Outfall 001 only)	45	10	20	0.68	0.15	0.30
100602	LAG480284	Jack Cooper Transport Co Inc	2,600	45	10	20	0.98	0.22	0.44
100602	LAG530693	KEH Property Ltd., Fud's III Bar and Lounge	675	45	10	20	0.25	0.06	0.10
100602	LAG541012	Grawood Baptist Church	6,000	30	10	5	1.50	0.50	0.25
100602	LAG560089	Wildwood Estates	33,000	20	6.7	13.4	5.51	1.85	3.69
100602	LAG570220	Eagle Water Inc - LaLaurie Lane Oxidation Pond	60,000	10	1.7	3.3	5.01	0.85	1.65
100602	LAG750459	Norwell Equip. Co. Shreveport Facility	5,000	45	10	20	1.88	0.42	0.17
100602	LAG750449	Deep South Equip. Co. Shreveport	5,000	45	10	20	1.88	0.42	0.17
100602 Total Loads:							17.69	4.47	6.77

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

The nonconservative behavior of DO allows many small, remote point source discharges to be assimilated by the receiving waterbodies before they reach the modeled waterbody. These discharges are said to have little to no impact on the modeled waterbody and therefore, they are not included in the model and are not subject to any reductions based on this TMDL. These facilities are permitted in accordance with state regulation and policies that provide adequate protective controls. New similarly insignificant point sources will continue to be issued permits in this manner. Significant existing point source discharges are either included in the model or are determined to be insignificant by other modeling. New significant point source discharges would have to be evaluated individually to determine what impact they have on the impaired waterbody and the appropriate controls.

The point source loading in the TMDL also included the estimated loads originating from urban stormwater regulated by the City of Shreveport MS4 permit. These MS4 loads are simulated in the model as nonpoint source loads due to their nature, but they are included in the TMDL as point source loads. These MS4 loads were estimated as 16% of the LA for Boggy Bayou that was calculated by the FORTRAN program described in Section 6.1. The value of 16% was used because the area within the Shreveport city limits covers 16% of the subsegment (see Section 2.4). The MS4 loads are shown in Tables 6.1 and 6.2.

6.3 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 SOD. 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.

6.4 MOS and FG

The MOS accounts for any lack of knowledge or uncertainty concerning the relationship between pollutant loading and water quality. This DO TMDL includes an implicit MOS through

the use of conservative assumptions. The projection simulations assume that the highest temperatures and lowest flows occur at the same time. This is conservative because the highest temperatures typically occur in July through August and the lowest stream flows typically occur slightly later in the year (as discussed in Section 5.1). 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 DO TMDL in this report includes an explicit MOS equal to 10% of the TMDL and an explicit allowance for FG that is also equal to 10% of the TMDL. This combined allowance for the explicit MOS and FG is consistent with LDEQ's typical procedure of setting aside 20% of the TMDL to account for "modeling uncertainty, data inadequacies, and FG and safety" (LDEQ 2006; p. 7).

6.5 Ammonia Toxicity Calculations

Although Subsegment 100602 is not on a 303(d) list for ammonia, the ammonia concentrations predicted in the projection simulations 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 criteria for summer and winter for Boggy Bayou were the same as the critical temperatures used in the projection simulations (32.0°C for summer and 22.9°C for winter). The pH values used to calculate the ammonia criteria were 7.01 su for summer and 6.83 su for winter; these were seasonal averages of LDEQ ambient monitoring data at Station 1207 (Boggy Bayou southwest of Shreveport). The resulting criteria for ammonia nitrogen were 1.91 mg/L for summer and 3.64 mg/L for winter. The highest ammonia nitrogen concentrations predicted by the model (0.49 mg/L for summer and 0.19 mg/L for winter) were well below these criteria. This indicates that the ammonia nitrogen loadings that will maintain the DO standard in Boggy Bayou are low enough that the USEPA ammonia toxicity criteria will not be exceeded under critical conditions. The ammonia toxicity calculations are shown in Appendix M.

7.0 NUTRIENT TMDL DEVELOPMENT

7.1 Seasonality and Critical Conditions

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. Also, both Section 303(d) of the Clean Water Act and regulations at 40 CFR 130.7 require TMDLs to consider seasonal variations for meeting water quality standards. Aquatic life impairments typically occur as a result of long-term exposure to elevated nutrient concentrations rather than short-term fluctuations in nutrient concentrations. This nutrient TMDL was developed for average annual conditions. The most obvious result of nutrients is algal blooms. When the algae die, the resultant biological oxygen demand consumes oxygen, which adversely affects aquatic life. The effect occurs in a short time but the build-up of nutrients and the conditions to start the algal bloom may occur over an extended time.

7.2 Reference Stream Data

Since there are no numeric nutrient criteria for Louisiana, the need for nutrient reductions in Boggy Bayou was evaluated by comparing total nitrogen ($TKN+NO_2+NO_3$) and total phosphorus concentrations in Boggy Bayou with values from LDEQ reference streams in the South Central Plains Ecoregion (the ecoregion in which Boggy Bayou is located). The reference stream data consisted of samples collected from eight streams during low flow conditions in the mid-1990s (Smythe 1999). These data are shown in Table 7.1.

Table 7.1. Data from LDEQ reference streams in the South Central Plains Ecoregion.

Waterbody	NO_2+NO_3 (mg/L)	TKN (mg/L)	Total N (mg/L)	Total P (mg/L)
Meridian Creek near Conway in Union Parish [A]	0.24	0.91	1.15	0.21
Saline Bayou near Saline in Beinville Parish	0.08	0.53	0.61	0.04
Middle Fork Bayou D'Arbonne near Bernice in Claiborne Parish	< 0.01	0.94	0.95	< 0.02
Beaucoup Creek near Chester in Winn Parish	0.02	0.76	0.78	0.08
Kisatchie Bayou in Natchitoches Parish [B]	0.23	0.60	0.83	0.06
Six Mile Creek near Grant in Allen Parish	0.10	0.19	0.29	0.09
Pearl Creek near Burr Ferry in Vernon Parish	0.08	0.46	0.54	0.05
Calcasieu River near Oberlin in Allen Parish	0.08	0.48	0.56	0.11
		Minimum	0.29	< 0.02
		Median	0.70	0.07
		Mean	0.71	0.08
		Maximum	1.15	0.21

Note: A = averages of two samples, B = averages of three samples.

7.3 Nutrient Analysis

The data for Boggy Bayou that was used in the comparison to the reference streams consisted of summer (May through September) LDEQ ambient monitoring data for Station 1207 (Boggy Bayou southwest of Shreveport, LA). Summary statistics of these data are shown in Table 7.2 (the data are included in Appendix B).

Table 7.2. Boggy Bayou summer data.

Statistic	Total P (mg/L)	Total N (mg/L)
Minimum	0.03	0.40
Mean	0.14	1.08
Maximum	0.91	5.94

Concentrations of total nitrogen and total phosphorus in the reference streams and Boggy Bayou were compared by calculating selected statistics (minimum, mean, and maximum) for each data set. These statistics are shown in Tables 7.1 and 7.2. Comparison of the statistics for these data sets show that the summer concentrations of total nitrogen and total phosphorus in Boggy Bayou are greater than the reference stream concentrations. As a result, reduction of the Boggy Bayou nutrient loads is recommended.

7.4 Nutrient TMDL

The TMDL for total phosphorus and total nitrogen for Subsegment 100602 was calculated based on allowable loads of nitrogen from the DO modeling and a naturally occurring ratio of total nitrogen to total phosphorus. The naturally occurring ratio of total nitrogen to total phosphorus was used because the Louisiana Water Quality Standards require that ratio to be maintained in streams and lakes (see Section 2.3). The naturally occurring ratio of total nitrogen to total phosphorus was calculated to be 10 using the median values of total nitrogen and total phosphorus from the reference streams in Table 7.1 (0.70 mg/L and 0.07 mg/L). The allowable loads of total nitrogen were calculated as the simulated loads of organic nitrogen and ammonia nitrogen in the projection simulations plus assumed values of nitrate+nitrite nitrogen. The allowable loads of total phosphorus were then calculated as simply the allowable loads of total nitrogen divided by 10 (the naturally occurring ratio of total nitrogen to total phosphorus). The MOS and FG components for this nutrient TMDL were calculated as 10% each (or 20% combined) of the total loading after including the MOS and FG. The details of these calculations are shown in Appendix N and the results are summarized in Table 7.3.

Table 7.3. Nutrient TMDL for Subsegment 100602.

Season	Component	Loads in kg/day		Loads in lbs/day	
		Total Nitrogen	Total Phosphorus	Total Nitrogen	Total Phosphorus
Summer	LA	1.42	0.142	3.13	0.313
	WLA	10	1	22.05	2.205
	MOS	1.43	0.143	3.15	0.315
	FG	1.43	0.143	3.15	0.315
	TMDL	14.28	1.428	31.48	3.148
Winter	LA	21.00	2.100	46.29	4.629
	WLA	10	1	22.05	2.205
	MOS	3.88	0.388	8.54	0.854
	FG	3.88	0.388	8.54	0.854
	TMDL	38.76	3.876	85.42	8.542

None of the point source discharges in Subsegment 100602 had permit limits for phosphorus or nitrogen. However, a number of the point sources in the subsegment were permitted to discharge sanitary wastewater and would be expected to contribute nitrogen and

phosphorus loads to the subsegment. Those eight permits were included in the nutrient TMDL. The allowable loads and concentrations for those permits are shown in Table 7.4.

Table 7.4. Point source concentrations and loads for nutrient TMDL.

NPDES Number	Name of Discharger	Flow Rate (gpd)	Concentrations		Loads	
			Total Nitrogen (mg/L)	Total Phosphorus (mg/L)	Total Nitrogen (lbs/day)	Total Phosphorus (lbs/day)
LAG480011	LA Lift and Equipment Inc. – Clarklift Inc.	1800	44.92	4.49	0.75	0.075
LAG480284	Jack Cooper Transport Co. Inc.	2600	42.28	4.23	1.06	0.106
LAG530693	KEH Property Ltd. – Fud's III Bar and Grill	675	34.35	3.44	0.29	0.029
LAG560089	Wildwood Estates	3300	30.23	3.02	10.34	1.034
LAG750459	Norwell Equipment Co.	5000	41.40	4.14	2.07	0.207
LAG750449	Deep South Equipment Co.	5000	41.40	4.14	2.07	0.207
LAG570220	Eagle Water Inc. – LaLaurie Lane Oxidation Pond	60000	14.99	1.50	9.39	0.939
LAG541012	Grawood Baptist Church	6000	25.25	2.53	1.59	0.159
Subsegment 100602 TOTAL LOADS:					22.05	2.205

Although this TMDL specifies a WLA for nutrients, it is recommended that as a first step to implement this TMDL, the point sources should be given nutrient monitoring requirements in their permits to determine if the point sources are causing or contributing nutrients. However, final decisions for point source nutrient limitations will be made by LDEQ on a case-by-case basis during the re-issuance of each permit.

7.5 Summary of Reductions

The analysis outlined in Section 7.3 above, indicates that reduction of total nitrogen and total phosphorus loads would be needed for Boggy Bayou average total phosphorus concentration (Table 7.2) to be similar to the reference stream average concentration (Table 7.1).

The difference between the reference and Boggy Bayou average total nitrogen concentrations is 64%, so over a 60% reduction in total nitrogen would be needed. The difference between reference and Boggy Bayou average total phosphorus concentrations is 61%, so over a 60% reduction in total phosphorus would also be needed.

The DO TMDL establishes load limitations for oxygen-demanding substances and goals for reduction of those pollutants (Chapter 6). When oxygen-demanding substances are controlled and limited in order to ensure that the dissolved oxygen criterion is supported, nutrients are also controlled and limited. The implementation of the DO TMDL through implementation of 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.

Although this TMDL requires WLAs for nutrients, it is recommended that as a first step to implement this TMDL, the point sources should be given nutrients (nitrogen and phosphorus) monitoring requirements in their permits to determine if the point sources are causing or contributing nutrients to the subsegment. Because the estimated WLA for total nitrogen accounts for only 10% of the TMDL, reductions in point source total nitrogen discharges are not expected to be required as a result of this TMDL. The estimated WLA for total phosphorus accounts for a larger proportion of the TMDL, so it is possible that reductions in point source total phosphorus discharges could be necessary to meet the TMDL target. Final decision for the point sources nutrients limitations will be made by LDEQ during the re-issuance of the permit on a case-by-case basis.

8.0 SENSITIVITY ANALYSES

All modeling studies necessarily involve uncertainty and some degree of approximation. Therefore it is 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 8.1. Each parameter was varied by ±30%, except for temperature, which was varied ±2ºC.

Values reported in Table 8.1 are sorted by percentage variation of minimum DO from largest percentage variation to smallest. The model output was most sensitive to reaeration, SOD, wasteload DO (decrease only), and temperature. The model output was least sensitive to headwater parameters, wasteload parameters (excluding a decrease in DO), and the decay rates.

Table 8.1. Summary of results of sensitivity analysis.

Input Parameter	Change in Parameter	Predicted Minimum DO (mg/L)	Percent Change in Predicted DO (%)
Baseline	--	4.37	N/A
Reaeration	-30%	2.90	-33.6%
SOD	+30%	3.44	-21.3%
Wasteload DO	-30%	3.48	-20.4%
Temperature	+2ºC	3.82	-12.6%
Reaeration	+30%	4.73	+8.2%
SOD	-30%	4.68	+7.1%
Temperature	-2ºC	4.65	+6.4%
Stream Velocity	+30%	4.26	-2.5%
Stream Velocity	-30%	4.47	+2.3%
Wasteload DO	+30%	4.37	0%
Stream Depth	-30%	4.37	0%
Stream Depth	+30%	4.37	0%
BOD Decay Rate	-30%	4.37	0%
BOD Decay Rate	+30%	4.37	0%
Ammonia Nitrogen Decay Rate	-30%	4.37	0%
Ammonia Nitrogen Decay Rate	+30%	4.37	0%
Organic Nitrogen Decay Rate	-30%	4.37	0%
Organic Nitrogen Decay Rate	+30%	4.37	0%
Headwater Flow	-30%	4.37	0%
Headwater Flow	+30%	4.37	0%
Headwater DO	-30%	4.37	0%
Headwater DO	+30%	4.37	0%
Headwater BOD	-30%	4.37	0%
Headwater BOD	+30%	4.37	0%
Headwater Ammonia Nitrogen	-30%	4.37	0%
Headwater Ammonia Nitrogen	+30%	4.37	0%
Headwater Organic Nitrogen	-30%	4.37	0%
Headwater Organic Nitrogen	+30%	4.37	0%
Wasteload Flow	-30%	4.37	0%
Wasteload Flow	+30%	4.37	0%
Wasteload BOD	-30%	4.37	0%
Wasteload BOD	+30%	4.37	0%
Wasteload Ammonia Nitrogen	-30%	4.37	0%
Wasteload Ammonia Nitrogen	+30%	4.37	0%
Wasteload Organic Nitrogen	-30%	4.37	0%
Wasteload Organic Nitrogen	+30%	4.37	0%

9.0 OTHER RELEVANT INFORMATION

This TMDL has 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 in the watershed through the 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.

10.0 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.

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