BAYOU DES CANNES WATERSHED TMDL
FOR DISSOLVED OXYGEN AND NUTRIENTS
INCLUDING WLA FOR ONE TREATMENT FACILITY

SUBSEGMENTS 050101, 050103, 050201

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EXECUTIVE SUMMARY

This report presents the results of a watershed based, calibrated modeling analysis of Lower Bayou Des Cannes. The modeling was conducted to establish a dissolved oxygen TMDL for the Lower Bayou Des Cannes watershed. The model extends from River Kilometer 60.4 near the USGS gaging station to the confluence of Bayou Des Cannes with the Mermentau River. Upper Bayou Des Cannes was not modeled because it was determined to be permanently man altered. Bayou Des Cannes is located in south central Louisiana and the modeled portion of the watershed includes the following tributaries: Tiger Point Gully, Richard's Gully, Bayou Barwick, Bayou Mallet, Point Aux Loup, and Bayou Plaquemine Brule. The modeled portion of the watershed is 605.89 square miles in area. The Lower Bayou Des Cannes modeled area is in the Mermentau River Basin and includes Water Quality Subsegments 050101, 050103, and 050201. The area is sparsely populated outside its small municipalities, and land use is dominated by agriculture, most specifically rice crops. With the exception of the Town of Iota, all dischargers in this modeled region are too small or too far away to have a significant impact on the watershed model. Limits for these small facilities are generally set by state policy. One municipality was included in the modeling effort.

Input data for the calibration model was developed from the LDEQ Reference Stream Study; data collected during the 1999 intensive survey; data collected by LDEQ and USGS at several ambient monitoring stations in the watershed; DMRs, permits and permit applications; USGS drainage area and low flow publications; and data garnered from several previous LDEQ studies on non-point source loadings. A satisfactory calibration was achieved for the main stem and on the tributaries modeled. For the projection models, data was taken from the current municipal discharge permits, current applications, and ambient temperature records. The Louisiana Total Maximum Daily Load Technical Procedures (LTP), 1999, have been followed in this study.

The model used for this TMDL was LA-QUAL, a steady-state one-dimensional water quality model. In 1999, the Louisiana Department of Environmental Quality and Wiland Consulting, Inc. developed LA-QUAL based on QUAL-TX Version 3.4. The program was converted from a DOS-based program to a Windows-based program with a graphical interface and enhanced graphic output. Other program modifications specific to the needs of Louisiana and the Louisiana DEQ were also made. LA-QUAL is a user-oriented model and is intended to provide the basis for evaluating total maximum daily loads in the State of Louisiana.

The model used eight reaches to analyze the lower Bayou Des Cannes region. Reaches 1,3,4,5,7 and 8 modeled the mainstem of lower Bayou Des Cannes. Reach 1 included Tiger Point Gully and Richards Gully as point source tributaries. Reach 3, 5, and 7 had no point source dischargers or tributaries. Reach 4 included Bayou Mallet as a point source tributary. Reach 2 modeled Bayou Barwick with no significant dischargers. Originally, Bayou Barwick was modeled because of the discharger, Enron. Upon further investigation, it was determined that Enron did not have a significant discharge. Due to the time constraints of developing this TMDL, the tributary was modeled rather than redo the model elements and include the tributary as a point source. The input data development for the calibration model is presented in Appendix A.

Bayou Des Cannes, Subsegment 050101, was on the 1996 303(d) list of impaired water bodies requiring the development of a TMDL. The subsegment was ranked priority one on the 1996 list. The suspected causes of impairment for the 1996 list were organic enrichment/ low DO, pathogen indicators, oil and grease, and turbidity. This TMDL addresses the organic enrichment/low DO impairment. The results of the summer projection model show that the water quality standard for dissolved oxygen for Bayou Des Cannes of 3.0 mg/l can be maintained during the summer critical season. The water quality standard for dissolved oxygen for Point Aux Loup of 3.0 mg/l can also be maintained during the summer critical season. The results of the summer projection model show that a DO of 3 mg/l DO can be maintained with the imposition of an 50% reduction from all manmade nonpoint sources from reaches 1 – 6 and a 75% reduction from all manmade nonpoint sources for reaches 7-8, and the imposition of post reaeration for the City of Iota STP (maintaining their current limits of 10mg/l CBOD5/10mg/lNH3). The minimum DO on the main stem is 3.11 mg/l at RK 0.0.

The results of the winter projection model show that the water quality criteria for dissolved oxygen for Bayou Des Cannes and Bayou Point Aux Loup of 5.0 mg/l can be maintained during the winter critical season in the entire watershed. The minimum dissolved oxygen is 5.0 mg/l and is located at RK 0.0 . To achieve the criteria, the model assumed the imposition of a 50% reduction from all manmade nonpoint sources for reaches 1-6 and a 75% reduction for reaches 7-8, and the imposition of 10 mg/l $CBOD_5$/10 mg/l NH_3/2 mg/l DO limits on City of Iota STP.

The TMDL for the summer and winter critical scenarios are summarized in the table below.

Table 7. Total Maximum Daily Load (Sum of CBOD, NH3N, and SOD)

ALLOCATION	SUMMER (MAR-NOV) (lbs/day)	WINTER (DEC-FEB) (lbs/day)
Point Source WLA	228	228
Point Source Reserve MOS	57	57
Headwater/Tributary Loads	2,027	5,577
Benthic Loads	14,324	14,324
TMDL	16,636	20,186

LDEQ will work with other agencies such as local Soil Conservation Districts to implement agricultural 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, the 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.

The LDEQ has implemented a watershed approach to surface water quality monitoring. Through this approach, the entire state is sampled over a five-year cycle with two targeted basins sampled each year. Long-term trend monitoring sites at various locations on the larger rivers and Lake Pontchartrain are sampled throughout the five-year cycle. Sampling is conducted on a monthly basis or more frequently if necessary to yield at least 12 samples per site each year. Sampling sites are located where they are considered to be representative of the waterbody. Under the current monitoring schedule, targeted basins follow the TMDL priorities. In this manner, the first TMDLs will have been implemented by the time the first priority basins will be monitored again in the second five-year cycle. This will allow the 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. The sampling schedule for the first five-year cycle is shown below.

1998 - Mermentau and Vermilion-Teche River Basins
1999 - Calcasieu and Ouachita River Basins
2000 - Barataria and Terrebonne Basins
2001 - Lake Pontchartrain Basin and Pearl River Basin
2002 - Red and Sabine River Basins

(Atchafalaya and Mississippi Rivers will be sampled continuously.)
Mermentau and Vermilion-Teche Basins will be sampled again in 2003.

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1. Introduction

The 1996 303(d) list cited Bayou Des Cannes, Subsegment 050101, as being impaired due to organic enrichment/low DO and required the development of a Total Maximum Daily Load (TMDL) for dissolved oxygen (DO). The subsegment was ranked priority one on the 1996 list. The waterbody was also listed as impaired due to nutrients. This TMDL establishes load limitations for oxygen-demanding substances and goals for reduction of those pollutants. LDEQ's position, as supported by the ruling in the lawsuit regarding water quality criteria for nutrients (Sierra Club v. Givens, 710 So.2d 249 (La. App. 1st Cir. 1997), writ denied, 705 So.2d 1106 (La. 1998), is that 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 this TMDL through wastewater discharge permits and 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. A calibrated water quality model for the lower portion of the watershed was developed and projections were modeled to quantify the point source and non-point source waste load reductions which would be necessary in order for Bayou Des Cannes to comply with its established water quality standards and criteria. This report presents the results of that analysis.

2. Study Area Description

2.1 General Information

Water quality segment 0501 is part of the Mermentau River Basin. The Basin encompasses the prairie region of the state and a section of the coastal zone. Bayou Des Cannes is located in southwestern Louisiana in the Mermentau River Basin. The Mermentau River Basin is bounded on the north and east by the Vermilion-Teche Basin, on the west by the Calcasieu Basin and southward by the Gulf of Mexico. Land resources of the Mermentau River Basin consist of low relief prairie land interspersed with trees that line stream banks and some wetland areas. Natural vegetation in this region is comprised of bluestem, broomsedge, water grass, and switch grass. Vegetation introduced to the vicinity includes Johnson grass and carpet grass. The well-developed soil profile consits of dark to grey topsoil with an impervious claypan located approximately 14 inches below the surface. This claypan is conducive to rice farming because it holds water necessary for irrigation of the crops. Soybeans and crawfish are rotated with the rice crops. The average annual rainfall in the vicinity of Bayou des Cannes is approximately 57 inches. The land use for Bayou des Cannes watershed is summarized in Table 1.

Table 1. Land Uses in Segment 0501

LAND USE TYPE	NUMBER OF ACRES	% OF TOTAL AREA
Urban	4,092	2.55
Barren Land	86	0.05
Agricultural	121,401	75.75
Forest Land	18,853	11.76
Water	3,209	2.00
Wetland	9,055	5.65
Rangeland	3,561	2.22
Other	32	.02
TOTAL AREA	160,257	100

The model extends from the headwaters near the USGS gaging station to the confluence with the Mermentau River. The modeled portion of Bayou Des Cannes watershed includes the following tributaries: Tiger Point Gully, Richard's Gully, Bayou Barwick, Bayou Mallet, Bayou Point Aux Loup, and Bayou Plaquemine Brule. The watershed includes Water Quality Subsegments 050101, 050103, and 050201. The area is sparsely populated outside its small municipalities and land use is dominated by agriculture. Maps of the study area are presented in Appendix G.

2.2 Water Quality Standards

The Water Quality criteria and designated uses for subsegments in the Bayou Des Cannes watershed are shown in Table 2.

Table 2. Water Quality Numerical Criteria and Designated Uses

Subsegment	050101	050103	050201	
Stream Description	Bayou Des Cannes –Headwaters to Mermentau R.	Bayou Mallet - Headwaters to Bayou Des Cannes	Bayou Plaquemine Brule - Headwaters to Bayou Des Cannes	
Designated Uses	A B C F	A B C F	A B C F	
Criteria:				
Cl (mg/L)	90	90	90	
SO_4 (mg/L)	30	30	30	
DO (mg/L)	5 : DEC-FEB 3 : MAR-NOV	5 : DEC – FEB 3 : MAR - NOV	5 : DEC – FEB 3 : MAR - NOV	
PH	6.0 – 8.5	6.0 – 8.5	6.0 – 8.5	
BAC	1	1	1	
EC	32	32	32	
TDS (mg/L)	260	260	260	

USES: A – primary contact recreation; B – secondary contact recreation; C – propagation of fish and wildlife; D – drinking water supply; E – oyster propagation; F – agriculture; G – outstanding natural resource water; L – limited aquatic life and wildlife use.

A Use Attainability Analysis (UAA) was recently completed for Mermentau River Basin supporting revision of the dissolved oxygen criterion of 5 mg/L to seasonal criteria of 5 mg/L December through February and 3 mg/L March through November. The seasonal criteria have been promulgated and apply to Bayou Des Cannes and its tributaries.

2.3 Wastewater Discharges

The discharger inventory for the Bayou Des Cannes watershed was reviewed. The facilities were evaluated based on the volume of their discharge, their location with respect to the listed waterbody, any water quality data which demonstrated their impact or lack of impact, whether or not the NPS contribution included any small facilities, and best professional judgement. Only one facility was considered to have any ability to impact the target reaches: the City of Iota STP. The permit record, permit application, and Discharger Monitoring Reports (DMR) for this facility was examined and appropriate input information for the calibration and projection modeling runs was derived. Although the City of Eunice is a large discharger, a previous study indicated that the dissolved oxygen sag occurred and recovered on a secondary tributary to Bayou Mallet. Therefore, it was believed to not have a significant dissolved oxygen impact on Bayou Mallet or Bayou Des Cannes. The data collected during the April 1999 survey confirmed

this assumption. Originally, Bayou Barwick was modeled because of the discharger, Enron. After further investigation, it was determined that Enron did not have a significant discharge. Due to the time constraints of developing this TMDL, the tributary was modeled rather than redo the model elements and include the tributary as a point source. The input data development for the calibration model is presented in Appendix A.

2.4 Water Quality Conditions/Assessment

Subsegment 050101, Bayou Des Cannes from the headwaters to the Mermentau River, is considered threatened in supporting its designated uses according to the 1996 305(b) Water Quality assessment for Louisiana. Suspected pollutants are Organic Enrichment/Low DO, oil and grease, and turbidity. The subsegment is on the 1996 303(d) list and is scheduled for current TMDL development. An excerpt from the 1996 303(d) list is presented in Appendix D.

2.5 Prior Studies

Several prior studies have been performed on upper portions of the Bayou Des Cannes watershed. None of the studies produced an approved TMDL for the lower portion of Bayou Des Cannes. A survey was done in 1999 to obtain data for this purpose. Use Attainability Analyses have been conducted in the watershed and revised standards have been issued as shown in Table 2.

3. Development of Models

"Simulation models are used extensively in water quality planning and pollution control. Models are applied to answer a variety of questions, support watershed planning and analysis and develop total maximum daily loads (TMDLs). . . . Receiving water models simulate the movement and transformation of pollutants through lakes, streams, rivers, estuaries, or nearshore ocean areas. . . . Receiving water models are used to examine the interactions between loadings and response, evaluate loading capacities (LCs), and test various loading scenarios. . . . A fundamental concept for the analysis of receiving waterbody response to point and nonpoint source inputs is the principle of mass balance (or continuity). Receiving water models typically develop a mass balance for one or more constituents, taking into account three factors: transport through the system, reactions within the system, and inputs into the system." (EPA841-B-97-006, pp. 1-30)

3.1 Program Description

The model used for this TMDL was LA-QUAL, a steady-state one-dimensional water quality model that has been developed by the Louisiana Department of Environmental Quality. Its history dates back to the QUAL-I model developed by the Texas Water Development Board with Frank D. Masch & Associates in 1970 to 1971. The original code was written by William A. White. In June 1972, the United States Environmental Protection Agency awarded Water Resources Engineers, Inc. (now Camp Dresser & McKee) a contract to modify QUAL-I for application to the Chattahoochee-Flint River, the Upper Mississippi River, the Iow-Cedar River, and the Santee River. The mofified version of QUAL_I was known as QUAL-II. Over the next three years, several versions of the model evolved in response to specific client needs. In March,

1976, the Southeast Michigan Council of Governments (SEMCOG) contracted with Water Resources Engineers, Inc. to make further modivications and to conbine the best features of the existing versions of QUAL-II into a single model. That became known as the QUAL-II/SEMCOG version. Between 1978 and 1984, Bruce L., Wiland with the Texas Department of Water Resources modified QUAL-II for application to the Houston Ship Channel estuarine system. Numerous modifications were made to enable modeling this very large and complex system including the addition of tidal dispersion, lower boundary conditions, nitrification inhibition, sensitivity analysis capability, branching tributaries, and various input/output changes. This model became known as QUAL-TX and was subsequently applied to streams throughout the State of Texas. In 1985, EPA's Cneter for Water Quality Modeling sponsored a National Council of the Paper Industry for Air and Stream Improvement (NCASI) review of other versions of QUAL-II and incorporated certain features of these versions into a program called QUAL2E. In 1987, further enhancements were added to QUAL2E in cooperative agreements between EPA, NCASI, and the Department of Civil Engineering at Tufts University.

In 1999, the Louisiana Department of Environmental Quality and Wiland Consulting, Inc. developed LA-QUAL based on QUAL-TX Version 3.4. The program was converted from a DOS-based program to a Windows-based program with a graphical interface and enhanced graphic output. Other program modifications specific to the needs of Louisiana and the Louisiana DEQ were also made. LA-QUAL is a user-oriented model and is intended to provide the basis for evaluating total maximum daily loads in the State of Louisiana.

The development of a TMDL for dissolved oxygen generally occurs in 3 stages. Stage 1 encompasses the data collection activities. These activities may include gathering such information as stream cross-sections, stream flow, stream water chemistry, stream temperature and dissolved oxygen and various locations on the stream, location of the stream centerline and the boundaries of the watershed which drains into the stream, and other physical and chemical factors which are associated with the stream. Additional data gathering activities include gathering all available information on each facility which discharges pollutants in to the stream, gathering all available stream water quality chemistry and flow data from other agencies and groups, gathering population statistics for the watershed to assist in developing projections of future loadings to the water body, land use and crop rotation data where available, and any other information which may have some bearing on the quality of the waters within the watershed. During Stage 1, any data available from reference or least impacted streams which can be used to gauge the relative health of the watershed is also collected.

Stage 2 involves organizing all of this data into one or more useable forms from which the input data required by the model can be obtained or derived. Water quality samples, field measurements, and historical data must be analyzed and statistically evaluated in order to determine a set of conditions which have actually been measured in the watershed. The findings are then input to the model . Best professional judgement is used to determine initial estimates for parameters which were not or could not be measured in the field. These estimated variables are adjusted in sequential runs of the model until the model reproduces the field conditions which were measured. In other words, the model produces a value of the dissolved oxygen, temperature, or other parameter which matches the measured value within an acceptable margin of error at the locations along the stream where the measurements were actually made. When this happens, the model is said to be calibrated to the actual stream conditions. At this point, the

model should confirm that there is an impairment and give some indications of the causes of the impairment. If a second set of measurements is available for slightly different conditions, the calibrated model is run with these conditions to see if the calibration holds for both sets of data. When this happens, the model is said to be verified.

Stage 3 covers the projection modeling which results in the TMDL. The critical conditions of flow and temperature are determined for the waterbody and the maximum pollutant discharge conditions from the point sources are determined. These conditions are then substituted into the model along with any related condition changes which are required to perform worst case scenario predictions. At this point, the loadings from the point and nonpoint sources (increased by an acceptable margin of safety) are run at various levels and distributions until the model output shows that dissolved oxygen criteria are achieved. It is critical that a balanced distribution of the point and nonpoint source loads be made in order to predict any success in future achievement of water quality standards. At the end of Stage 3, a TMDL is produced which shows the point source permit limits and the amount of reduction in man-made nonpoint source pollution which must be achieved to attain water quality standards. The man-made portion of the NPS pollution is estimated from the difference between the calibration loads and the loads observed on reference or least impacted streams.

3.2 Model Calibration

The model for Bayou Des Cannes was hydrologically calibrated to the 1999 survey measurements of flow and chlorides. Water quality parameters and coefficients were then established based on available data and best professional judgement.

3.2.1 Model Schematic or Vector Diagram

A schematic diagram of the modeled area is presented in Appendix G. The diagram shows the locations of survey sites, the reach/element design, the locations of modeled tributaries and POTWs, and the locations of tributaries contributing flow but not modeled. A digitized map of the streams showing river miles and survey sampling sites is also included in Appendix G.

3.2.2 Hydrology and Stream Geometry and Sources

The USGS maintains a daily flow gaging station on Bayou Des Cannes. Data collected during an intensive survey conducted from April, 1999, was used to establish the input for the model calibration and is presented in Appendix C. Using the survey sites where discharge measurements were made and the digitized mapping as guides, the reaches and elements were established. The survey had been performed in terms of river miles so a conversion was made to river kilometers. The reach and element design for Bayou des Cannes was made within the limitations of the model. "The current version is dimensioned for a maximum of 200 reaches, 100 headwaters, 300 waste loads and 3000 elements." (LA-QUAL User's Manual) The resulting design incorporated 8 reaches, 3 headwaters, 1 wasteload, and 532 elements. A simple spreadsheet was used to calculate the reach length, element length and cumulative number of elements at the bottom of each reach. The locations of each survey site, treatment plant and unmodeled tributary were fed into a related spread sheet and the element number for each of these locations was determined. These spreadsheets are presented in Appendix A.

The flow in each reach, headwater, and unmodeled tributary was determined based on the survey discharge measurements, a chloride balance, and a determination of appropriate incremental nonpoint source flowrate in terms of cubic meters per second (cms/mile). A chloride balance was needed on the mainstem to determine the flows because the measured velocities on the mainstem were below an acceptable range for the instrument used. The City of Iota STP flow was determined based on available data from the permit, the application, and daily monitoring reports (DMRs).

Rather than directly inputting the widths and depths of the stream, the model requires that the advective hydraulic characteristics (Leopold Coefficients and Exponents) be entered. The widths and depths for the mainstem of Bayou Des Cannes throughout the modeled area do not vary largely and were held constant by setting the width (a) and depth (d) coefficients to zero. The determination of the remaining coefficients and exponents for the tribs were made based on data collected for Point Aux Loup. The coefficients and exponents calculated for the tributaries are located in Appendix A.

Since the mainstem reaches are tidal in nature with frequent flow reverses and are very deep, wide and sluggish especially at low flow, the dispersive hydraulic coefficients were used. A linear regression was used to calculate the dispersion for each reach based on the output from the Bayou Plaquemine Brule TMDL (Berger, et. al. 1999). The dispersion values applied in the Bayou Plaquemine Brule model were based upon dispersions measured and model confirmation in Bayou Queue de Tortue (Mermentua Basin, Smythe 1999). The spreadsheet used to calculate the dispersion for each reach is located in Appendix A.

3.2.3 Headwater and Waste Water Loads

The Headwater and Wasteloads were obtained from survey sites from the April, 1999 survey. The detailed spreadsheets of sites and justifications are located in Appendix A.

3.2.4 Water Quality Input Data and Their Sources.

Water quality data collected in April, 1999, on Bayou Des Cannes are presented in Appendix C. The Louisiana GSBOD program was applied to the BOD data in the spreadsheet and values were computed for each sample for ultimate BOD. This data was the primary source for the model input data for initial conditions. The CBOD was then calculated using other lab data available and is located in Appendix C.

3.2.4.1 Temperature Correction of Kinetics, Data Type 4

The temperature values computed are used to correct the rate coefficients in the source/sink terms for the other water quality variables. These coefficients are input at 20 ^{o}C and are then corrected to temperature using a Streeter-Phelps type formulation:

$$X_T = X_{20} * \text{Theta}^{(T-20)}$$

Where:

X_T = the value of the coeffieicnt at the local temperatue T in degrees Celcius
X_{20} = the value of the coefficient at the standard temperature at 20 degrees Celcius
Theta = an empirical constant for each reaction coefficient
(QUAL2E Documentation and User Model. 1987)

In absence of specified values for data type 4, the model uses default values. A complete listing of these values can be found in the LA-QUAL for Windows User's Manual.(LDEQ. 1999)

The temperature correction factor specified in the LTP for Benthal of 1.065 was entered in the model. For all other temperature correction factors the default was used.

3.2.4.2 Initial Conditions, Data Type 11

The initial conditions are used to reduce the number of iterations required by the model. The values required for this model were temperature and DO by reach. The input values came from the survey sites located closest to the reach or from an average of samples taken. The input data and sources are shown in Appendix A.

3.2.4.3 Reaeration Rates, Data Type 12

Many emperical equeations exist in scientific literature. The applicability is dependent upon stream geometry and hydrologic conditions at the time of calibration and projection. Orginally, for the mainstem O'Conner-Dobbins and Owens were the reaeration equations chosen. However, it was observed that the model was actually using the minimum K_2. The model defaults to the minimum K_2 because of the large depths and widths of the stream. In the calibration runs, the Louisiana Equation was used to determine a constant reaeration rate for the tributary reaches 2 and 6 that contained average depths less than 3.0 feet. The minimum K_2 was used for the mainstem reaches. The reaeration rate equations selected for each reach are shown in Appendix A. The LTP was used as guidance in choosing the reaeration equations.

3.2.4.4 Sediment Oxygen Demand, Data Type 12

Initially, the SOD rates were based on Texas's "Wasteload Evaluation Methodology for estuarine muds" (Texas Water Commission, 1990). The final SOD values were achieved through calibration. The SOD value for each reach is shown in Appendix A.

3.2.4.5 Carbonaceous BOD Decay and Settling Rates, Data Type 12

These rates are labeled Aerobic BOD Decay and BOD Settling in LAQUAL. The concept of similar streams was used to transfer rates between streams in the watershed. The settling rates were taken from the LTP and Texas's "Wasteload Evaluation Methodology for estuarine muds" (Texas Water Commission, 1990). The settling rates finally used were the result of calibration. The decay and settling rates used for each reach are shown in Appendix A.

3.2.4.6 Organic Nitrogen and Ammonia Nitrogen Decay and Settling Rates, Data Type 13

For the mainstem reaches which were wide and deep, the Texas "Wasteload Evaluation Methodology" (Texas Water Commission, 1990) was used for initial values and modified during calibration. For the tributaries, the LTP was used for initial conditions and modified during calibration. The decay and settling rates used for each reach are shown in Appendix A.

3.2.4.7 Incremental Conditions, Data Types 16 and 17

The incremental conditions were used in the calibration to represent nonpoint source loads associated with flows. It is likely that there were overland discharges from agricultural (primarily ricefields) and silvicultural areas. The data and its source for each reach and a summary of the reference stream findings are presented in Appendix A.

3.2.4.8 Nonpoint Sources, Data Type 19

Nonpoint source loads which are not associated with a flow are input into this part of the model. These can be most easily understood as resuspended load from the bottom sediments and are modeled as SOD, CBOD and NBOD loads. The loads were determined through calibration. The model inputs CBOD and O-N in units of kg/day and SOD in units of g O_2/m^2/day. Table 3 displays the loads and equivalent loads.

Table 3 Calibration loads and equivalent loads.

Reach	**CBOD (kg/day)**	**CBOD (gO_2/m^2/day)**	**O-N (kg/day)**	**O-N (gO_2/m^2/day)**	**SOD (gO_2/m^2/day)**
1	2000	4.78	9.0	0.022	0.01
2	100	2.084	9.0	0.188	1.0
3	100	0.418	75.0	0.314	1.5
4	200	0.445	100.0	0.222	1.5
5	200	1.183	100.0	0.591	1.5
6	125	2.316	9.0	0.167	1.5
7	4000	5.881	200.0	0.294	0.5
8	1450	6.731	100.0	0.464	0.5

The data and sources are presented in Appendix A.

3.2.4.9 Headwaters, Data Types 20 and 21

The headwater loadings were determined from site measurements. The data and sources are presented in Appendix A.

3.2.4.10 Wasteloads, Data Types 24 and 25

The wasteloads entered in the model were of two different types: treatment plant effluent and unmodeled tributaries. The unmodeled tributaries were sampled during the survey and the results of these samples were the basis for the input data. The wasteload from the City of Iota treatment plant was determined from the permit, the permit application and DMRs which have

been included or summarized in Appendix C. The data and sources are presented in Appendix A.

3.2.4.11 Boundary Conditions, Data Type 27

The only lower boundary condition set for this model was temperature. The rest of the parameters were not set because the ocean exchange ratio was set to zero. The ocean exchange ratio was set to zero to allow dispersion in the model but not force the bottom element through the boundary conditions.

3.3 Model Discussion and Results

The calibration model input and output is presented in Appendix A. The overlay plotting option was used to determine if calibration had been achieved. The graphics for each parameter is also presented in Appendix A.

Bayou Des Cannes main stem extends from river kilometer 60.4 to the Mermentau River and is represented by Reaches 1, 3, 4, 5, 7, and 8. Very good calibration was achieved for DO, CBOD, Chlorides and the nitrogen cycle on the main stem. The calibration model shows that in April

1999, the DO standard of 3 mg/l was not being met in Bayou Des Cannes. The use of the model's dispersion capability was required on the mainstem reaches to achieve calibration. These waters are known to be affected by tides, wind tides, and irrigation water withdrawals causing reverse flows. The model of Bayou Plaquemine Brule 1999 (Duerr, et. Al, 1999) also made use of dispersion. The minimum DO on the main stem was 1.2 mg/l at RK 0.0.

Point Aux Loup is a tributary to Bayou Des Cannes. This system is represented by reach 6. One discharger, The City of Iota STP, is located on this tributary. The minimum DO was 4.1 mg/l at RK 8.06.

4. Water Quality Projections

The dissolved oxygen standard of 3.0 mg/l for the summer months of March – November was used for the summer projections. The dissolved oxygen standard of 5.0 mg/l for the winter months of December – February was used for the winter projections. Additionally, a summer no man-made nonpoint loading run was done to see if the standards could be met if no man-made loading was present. The spreadsheet used to calculate the loadings is presented in Appendix B.

4.1 Critical Conditions

4.1.1 Seasonality and Margin of Safety

The Clean Water Act requires the consideration of seasonal variation of conditions affecting the constituent of concern, and the inclusion of a margin of safety (MOS) in the development of a TMDL. For the Bayou Des Cannes TMDL, LDEQ has employed an analysis of its long-term ambient data to determine critical seasonal conditions and used a combination of implied and explicit margins of safety.

Critical conditions for dissolved oxygen were determined for the Mermentau Basin using long term water quality data from six stations on the LDEQ Ambient Monitoring Network and the Louisiana Office of State Climatology water budget. Graphical and regression techniques were used to evaluate the temperature and dissolved oxygen data from the Ambient Monitoring Network and the run-off determined from the water budget. Since nonpoint loading is conveyed by run-off, this seemed a reasonable correlation to use. Temperature is strongly inversely proportional to dissolved oxygen and moderately inversely proportional to run-off. Dissolved oxygen and run-off are also moderately directly proportional. The analysis concluded that the critical conditions for stream dissolved oxygen concentrations were those of negligible nonpoint run-off and low stream flow combined with high stream temperature.

When the rainfall run-off (with subsequent non-point loading) and stream flow are high, turbulence is higher due to the higher flow and the temperature is lowered by the run-off. In addition, run-off 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. Reaeration rates 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 dissolved oxygen 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. The manmade portion of the NPS loading is the difference between the calibration load and the reference stream load where the calibration load is higher.

LDEQ simulated critical summer conditions in the Bayou Des Cannes dissolved oxygen TMDL projection by using the annual 7Q10 flow or 0.1 cfs, whichever is higher, for all headwaters, and 90th percentile temperature for the summer season (March-November). Incremental flow was assumed to be zero; model loading was from point sources, perennial tributaries, sediment oxygen demand, and resuspension of sediments. Additionally, LDEQ assumes that all point sources are discharging at maximum capacity. The projection model inputs and outputs for summer and winter are provided in Appendix B.

LDEQ simulated critical winter conditions by using the lowest of the monthly 7Q10 flow published for the winter months or 1 cfs, whichever was higher, for all headwaters, and 90th percentile temperature for the season (December – February). Again, incremental flow was assumed to be zero; model loading was from point sources, perennial tributaries, sediment oxygen demand, and resuspension of sediments. In addition, LDEQ assumes that all point sources are discharging at maximum capacity.

In reality, the highest temperatures occur in July-August, the lowest stream flows occur in October-November, and the maximum point source discharge occurs following a significant rainfall, i.e., high-flow conditions. The combination of these conditions plus the impact of other conservative assumptions regarding rates and loadings yields an implied margin of safety which is estimated to be in excess of 10%. Over and above this implied margin of safety, LDEQ used

an explicit MOS of 20% for point loads.

4.1.2 Hydrology and Stream Geometry and Sources

Critical temperatures for each season were determined from the temperature data collected by LDEQ as part of its historical and current ambient monitoring strategy. The 90^{th} percentile temperature for each season was computed for LDEQ ambient station at the Village of Mermentau on the Mermentau River for the last ten years. The temperature spreadsheet is shown in Appendix D.

The stream cross-section was automatically adjusted for the projection flows by the model through the use of the Leopold coefficients and exponents. For reaches 2 and 6, the Leopold coefficients and exponents used for calibration were not changed for the projection runs. For the mainstem reaches however, the widths and depths were held constant. The flow in each headwater and unmodeled tributary was set at 0.1 cfs = 0.00283 cms for summer critical conditions in accordance with the LTP.

The flow in Tiger Point Gully and Richards Gully, and the headwater for Bayou Barwick and Bayou Point Aux Loup was set at 1.0 cfs = 0.0283 cms for winter critical conditions in accordance with the LTP. The Headwater for Bayou Des Cannes was set to the 7Q10 value for December, which was the lowest 7Q10 value for December, January, and February. The flow of Bayou Barwick as a point source was assumed to be zero because it was included as a headwater. The flow for Bayou Mallet was determined from survey site 11 and was included because of the discharger located on a tributary to Bayou Mallet. The flow for Bayou Plaquemine Brule was obtained from the TMDL model output of Bayou Plaquemine Brule at the confluence with Bayou Des Cannes.

The City of Iota Treatment plant flow was determined based on available data from the current permit and application and then increased by 25% in order to explicitly incorporate a 20% margin of safety in the effluent loads.

4.1.3 Water Quality Input Data and Their Sources.

The initial conditions were set to the 90th percentile critical season temperature in accordance with the LTP. The dissolved oxygen values for the initial conditions were set at the stream criteria.

The reaeration rate equations, CBOD decay and settling rates, NBOD decay and settling rates, and the fractions converting settled CBOD and settled NBOD to SOD were not changed from the calibration.

The incremental conditions were used in the calibration to represent nonpoint source loads associated with flows. For the projection and scenario runs, the incremental flows were set to zero to emulate the critical conditions for dissolved oxygen.

The values and sources for all of these conditions are located in Appendix B.

4.1.3.1 Sediment Oxygen Demand, Data Type 12

The SOD values were changed from calibration. The value and sources for SOD for each projection run are presented in Appendix B. They are based on the reduction of non-point loading used in meeting the DO standard for each season.

4.1.3.2 Carbonaceous BOD Decay and Settling Rates, Data Type 12

The BOD decay and settling rates were not changed from calibration.

4.1.3.3 Organic Nitrogen and Ammonia Nitrogen Decay and Settling Rates, Data Type 13

The organic nitrogen and ammonia nitrogen decay and settling rates were not changed from calibration.

4.1.3.4 Incremental Conditions, Data Types 16 and 17

The incremental flow was assumed to be zero for both the summer and winter projections.

4.1.3.5 Nonpoint Sources, Data Type 19

The man-made CBOD and NBOD were reduced by 50% for reaches 1-6 and 75% for reaches 7-8. An analysis was made of the projected NPS and SOD loads in terms of gm-O_2/m^2/day and compared to the reference stream loads in the same terms. This was determined using the calibrated values for SOD, nonpoint CBOD, and NBOD along with the total benthic natural loading of 2.0 gm-O_2/m^2/day . A percentage of each loading component was calculated and compared to the total calibration benthic value. The natural benthic value was subtracted from the total calibration benthic load to determine the man-made benthic loading value. These percentages were then applied to the man-made benthic loading value and the CBOD and NBOD loading portions of the reduced man-made benthic loadings was determined. The values and sources of the nonpoint input and the load analyses are presented in Appendix B for each of the projection runs. Table 4 displays the loads and load equivalents for the summer and winter projections

Table 4 Summer and Winter Projection loads and equivalent loads

Reach	**CBOD (kg/day)**	**CBOD (gO_2/m^2/day)**	**O-N (kg/day)**	**O-N (gO_2/m^2/day)**	**SOD** (gO_2/m^2/day)
1	1415.7	3.38	6.37	0.02	0.01
2	80.6	1.68	7.25	0.15	0.81
3	94.8	0.40	71.1	0.30	1.42
4	192.3	0.43	96.15	0.21	1.44
5	161.1	0.95	80.55	0.48	1.21
6	93.9	1.74	6.76	0.13	1.13
7	1898.8	2.79	94.94	0.14	0.24
8	645.2	2.99	44.49	0.21	0.22

4.1.3.5 Headwaters, Data Types 20 and 21

A .1 cfs was used for the three headwaters in the summer projections. A 1 cfs was used for the three headwaters in the winter projections. The basis for this was the LTP. For further documentation see Appendix B.

4.1.3.3 Wasteloads, Data Types 24 and 25

For the "No Load Scenario" (no point source loads and no nonpoint source loads above reference stream background), the wasteload entered in the projection models for the treatment plant was taken from the current permit or application or determined by the projection. The unmodeled tributary wasteloads were set at reference stream values for the "No Load Scenario". For the summer and winter projection runs, the values and sources of the data are presented in Appendix B.

4.2 Model Discussion and Results

The projection model input and output data sets are presented in Appendix B. The summer and winter projections, and the "No Load" are presented as complete printouts.

4.2.1 No Load Scenario

Under this Scenario, the treatment plant discharges were eliminated and the SOD was reduced to reference stream values. The NPS load was also reduced to reference stream values, which included no man-made contributions to nonpoint loads or SOD. As shown in the output graphs, the main stem and all tributaries meet the existing dissolved oxygen criteria. The DO minimum was 4.5 mg/l at RKM 0.0.

4.2.2 Summer Projection

Bayou Des Cannes main stem was modeled from the river kilometer 60.4 to the Mermentau River. The results of the model show that the water quality standard for dissolved oxygen for Bayou Des Cannes of 3.0 mg/l can be maintained during the summer critical season in the Bayou Des Cannes watershed. To meet a DO criterion of 3.0 mg/l throughout the entire watershed requires the imposition of an 50% reduction from all manmade nonpoint sources for reaches 1-6, 75% reduction for reaches 7-8.and the imposition of 10 mg/l $CBOD_5$/10 mg/l NH_3/5 mg/l DO limits on the City of Iota STP. The minimum DO on the main stem is 3.11 mg/l at RK 0.0. The minimum DO and its location for each reach is shown in the following Table 5.

Table 5. Summer Projections Minimum Dissolved Oxygen for Each Reach.

Reach Number	DO Criteria @ Minimum DO Location, mg/l	Minimum DO in Reach, mg/l	Location of Minimum DO, River Kilometers
1	3	4.77	46.4
2	3	5.47	7.6
3	3	3.90	39.0
4	3	3.59	36.6 – 36.2
5	3	3.66	16.4 - 16.2
6	3	4.31	7.6-7.524
7	3	3.50	2.4
8	3	3.11	0.2 – 0.0

4.2.3 Winter Projection

The results of the model show that the water quality criterion for dissolved oxygen for Bayou Des Cannes of 5.0 mg/l can be maintained during the winter critical season in the entire watershed. The minimum dissolved oxygen is 4.99 mg/l and located at RK 0.0. To achieve the criterion, the model assumed the imposition of a 50% reduction from all manmade nonpoint sources for reaches 1-6, 75% reduction for reaches 7-8, and the imposition of 10 mg/l $CBOD_5$/10 mg/l NH_3/2 mg/l DO limits for the City of Iota STP. The minimum DO and its location for each reach is shown in the following Table 6.

Table 6. Winter Projections Minimum Dissolved Oxygen for Each Reach.

Reach Number	DO Criteria @ Minimum DO Location, mg/l	Minimum DO in Reach, mg/l	Location of Minimum DO, River Kilometers
1	5	6.95	51.4 – 51.0
2	5	8.86	6.6 - 5.1
3	5	6.68	45.2 - 45.0
4	5	6.25	30.0-28.4
5	5	6.42	14.4
6	5	6.55	8.056
7	5	5.44	2.4
8	5	4.99	0.0

4.3 Calculated TMDL, WLAs and LAs

TMDLs for the oxygen demanding constituents (CBOD, NH3N, and SOD), have been calculated for the summer and winter projection runs. They are presented in Appendix E. The winter TMDL is greater than the summer TMDL. A summary of the loads is presented in Table 7.

Table 7. Total Maximum Daily Load (Sum of CBOD, NH3N, and SOD)

ALLOCATION	SUMMER (MAR-NOV) (lbs/day)	WINTER (DEC-FEB) (lbs/day)
Point Source WLA	228	228
Point Source Reserve MOS	57	57
Headwater/Tributary Loads	2,027	5,577
Benthic Loads	14,324	14,324
TMDL	16,636	20,186

An outline of the TMDL calculations is provided to assist in understanding the calculations in the Appendices.

- The natural background benthic loading was estimated from reference stream NBOD, CBOD, and SOD data.
- The calibration anthropogenic (man-made) benthic loading was determined as follows:
  - Calibration non-point CBOD and NBOD (resuspension), and SOD were summed for each reach as gm/m^2 d to get the total calibration benthic loading.
  - The natural background benthic loading was subtracted from the total calibration benthic loading to get the total anthropogenic (man-made) calibration benthic loading.
- Projection runs were made with:
  - Point sources represented at 125% of design flow (based on Department of Health design criteria) to provide an explicit 20% margin of safety for point source loading.
  - Headwater flows at seasonal 7Q10 or 0.1 cfs (summer) / 1.0 cfs (winter), whichever was greater.
  - Headwater concentrations of CBOD, NBOD, and DO at calibration levels.

- For each reach, the non-point CBOD and NBOD (resuspension), SOD, and point source limitations were adjusted to bring the projected in-stream dissolved oxygen in compliance with criteria. No additional explicit margin of safety was employed for non-point loading. The loading capacity and percent reduction of non-point were calculated as follows:
  - The total projection benthic loading at 20^{o}C was calculated as the sum of projection NBOD, CBOD, and SOD expressed as gm/m^{2}d.
  - The natural background benthic loading was subtracted from the total projection benthic loading to get the total anthropogenic (man-made) projection benthic loading.
  - The total anthropogenic projection benthic loading was subtracted from the total calibration anthropogenic benthic loading and that number divided by the total calibration anthropogenic benthic loading to obtain the percent reduction of non-point loading needed to achieve the in-stream dissolved oxygen criteria.
  - The total projection benthic loading for each reach was calculated as follows:
    - The projection SOD at 20^{o}C was adjusted to stream critical temperature.
    - The projection CBOD, NBOD, and SOD were summed to get the total benthic loading at stream temperature critical in lb/d for each reach.
- The total stream loading capacity at stream critical temperature was calculated as the sum of:
  - Headwater CBOD and NBOD loading in lb/d.
  - Projection benthic loading for all reaches of the stream in lb/d.
  - Total point source CBOD and NBOD loading in lb/d.
  - The facility margin of safety.

The TMDL for the Bayou Des Cannes watershed was set equal to the total allocated stream loading capacity.

5. Sensitivity Analyses

All modeling studies necessarily involve uncertainty and some degree of approximation. It is 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 LAQUAL model allows multiple parameters to be varied with a single run. The model adjusts each parameter up or down by the percentage given in the input set. The rest of the parameters listed in the sensitivity section are held at their original projection value. Thus the sensitivity of each parameter is reviewed separately. A sensitivity analysis was performed on the calibration run. The value used for the minimum DO was 1.2 mg/L. The sensitivity of the model's minimum DO projections to these parameters is presented in Appendix F. Parameters were varied by +/- 30%, except temperature, which was adjusted +/- 2 degrees Centigrade.

Values reported in Appendix F are sorted by percentage variation of minimum DO in the main stem Bayou Des Cannes. A complete summary is presented in Appendix F. Stream reaeration is the parameter to which DO is most sensitive. The other parameters creating variations in the minimum DO values are stream velocity, BOD decay rate, stream baseflow, BOD settling rate, organic nitrogen decay rate, background SOD, initial temperature, incremental BOD, wasteload flow, wasteload DO, and wasteload BOD. Table 8 is a summary of the sensitivity analysis, listing only those parameters that indicated a variance from the calibrated minimum DO value of 1.2 mg/L.

Table 8 Sensitivity Analysis Summary

Parameter	**-30% min DO (mg/L)**	**% Min DO Change**	**+30% min DO (mg/L)**	**% Min DO Change**
Stream Reaeration	0.7	41.67	1.6	33.33
Stream Velocity	1.6	33.33	1	16.67
BOD Decay Rate	1.4	16.67	1	16.67
Stream Baseflow	1.1	8.33	1.2	0.00
BOD Settling Rate	1.1	8.33	1.2	0
Organic Nitrogen Decay Rate	1.2	0.0	1.1	8.33
Background SOD	1.2	0.0	1.1	8.33
Initial Temperature	1.3	8.33	1.1	8.33
Incremental BOD	1.2	0.0	1.1	8.33
Wasteload Flow	1.1	8.33	1.2	0.0
Wasteload DO	1.1	8.33	1.2	0.0
Wasteload BOD	1.2	0.0	1.1	8.33

6. Conclusions

The TMDL requires a watershed wide 50% - 75% decrease in manmade nonpoint source loads. Effluent treatment levels are required to be upgraded to effluent reaeration for the City of Iota STP in the summer months.

LDEQ will work with other agencies such as local Soil Conservation Districts to implement agricultural 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, the 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.

The LDEQ has implemented a watershed approach to surface water quality monitoring. Through this approach, the entire state is sampled over a five-year cycle with two targeted basins sampled each year. Long-term trend monitoring sites at various locations on the larger rivers and Lake Pontchartrain are sampled throughout the five-year cycle. Sampling is conducted on a monthly basis or more frequently if necessary to yield at least 12 samples per site each year. Sampling sites are located where they are considered to be representative of the waterbody. Under the current monitoring schedule, targeted basins follow the TMDL priorities. In this manner, the first TMDLs will have been implemented by the time the first priority basins will be monitored again in the second five-year cycle. This will allow the 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. The sampling schedule for the first five-year cycle is shown below.

1998 - Mermentau and Vermilion-Teche River Basins
1999 - Calcasieu and Ouachita River Basins
2000 - Barataria and Terrebonne Basins
2001 - Lake Pontchartrain Basin and Pearl River Basin
2002 - Red and Sabine River Basins

(Atchafalaya and Mississippi Rivers will be sampled continuously.)
Mermentau and Vermilion-Teche Basins will be sampled again in 2003.

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