MERMENTAU RIVER WATERSHED TMDL
TO ADDRESS DISSOLVED OXYGEN AND NUTRIENTS
INCLUDING WLAS FOR TWO TREATMENT FACILITIES

SUBSEGMENT 050401

SURVEYED JULY, 1982

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EXECUTIVE SUMMARY

This report presents the results of a watershed based, calibrated modeling analysis of the Mermentau River. The modeling was conducted to establish a dissolved oxygen TMDL for the Mermentau River watershed. The model extends from the river's beginning at the confluence of Bayou Nezpique and Bayou Des Cannes to the mouth of Lake Arthur near the town of Lake Arthur, La. The Mermentau River is located in south central Louisiana and its watershed includes the following tributaries: Bayou Nezpique, Bayou Des Cannes, Bayou Que de Tortue, Plaquemine Brule, Andress Cove and several unnamed tributaries. The Mermentau River is in the Mermentau River Basin and represents LA DEQ Water Quality Subsegment 050401. The entire watershed is 1765 square miles in area. The drainage area within subsegment 050401 is 67.11 square miles. The area is sparsely populated outside its small municipalities, and the land use is dominated by agriculture. One sewage treatment facility and one industrial facility were included in the modeling effort. Several other industrial facilities fall within the subsegment; these facilities were deemed either intermittent stormwater or minor discharges and were represented in the nonpoint loading via incremental flows or benthic loads.

Input data for the calibration model was developed from the LADEQ Reference Stream Study; data collected during the July, 1982 LADEQ field survey; data collected by LADEQ at several ambient monitoring stations in the watershed; DMRs, permits and permit applications for each of the point source dischargers; USGS drainage area and low flow publications; USGS daily flow stations; previous modeling studies conducted by LADEQ in the area; and data garnered from several previous LADEQ studies on nonpoint source loadings. A satisfactory calibration was achieved for the main stem. In those cases where the calibration was not as accurate (primarily due to limited data), a conservative approach was taken. For the projection models, data was taken from the current LADEQ/EPA discharge permits, current applications, and LADEQ ambient temperature records. The Louisiana Total Maximum Daily Load Technical Procedures, 1999 (LTP), have been followed in this study.

Modeling was limited to low flow scenarios for both the calibration and the projections since the constituent of concern was dissolved oxygen and the available data was limited to low flow conditions. 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 Mermentau River, Subsegment 050401, was on the 1996 and 1998 303(d) list of impaired water bodies requiring the development of TMDLs. It was ranked as a high priority (priority 1) on both lists for development of a TMDL. The suspected causes of impairment for the 1996 list were nutrients, organic enrichment/ low DO, pathogen indicators, suspended solids and turbidity. The suspected causes of impairment for the 1998 list were nutrients, organic enrichment/ low DO, suspended solids, copper, mercury and lead. This TMDL addresses the organic enrichment/low DO impairment.

The results of the summer projection model show the dissolved oxygen water quality standard in the Mermentau River (WQ Subsegment 050401) can be maintained at 3.0 mg/l during the summer critical season. This can be accomplished with the imposition of a 30% reduction from all manmade nonpoint sources as well as the imposition of a 10 mg/l $CBOD_5$ / 10 mg/l NH_3 limit on Village of Mermentau and a 10 mg/l $CBOD_5$ / 10 mg/l NH_3 limits on BCI LA/Shepherd Oil ethanol plant. This also assumes the imposition of the point and nonpoint load reductions required in the Bayou Nezpique, Bayou Des Cannes, Bayou Plaquemine Brule and Bayou Que de Tortue Summer TMDL's. The output of these waterbody's summer projections were inputs into the Mermentau River summer projection.

The results of the winter projection model show the dissolved oxygen water quality criteria in the Mermentau River can be maintained at 5.0 mg/l during the winter critical season. To achieve the criteria, the model assumed the imposition of a 30% reduction from all manmade nonpoint sources and the imposition of 10 mg/l $CBOD_5$ / 10 mg/l NH_3 limits on the Village of Mermentau and a 20 mg/l $CBOD_5$ / 10 mg/l NH_3 limit on the BCI LA/Shepherd Oil ethanol plant. This also assumes the imposition of the point and nonpoint load reductions required in the Bayou Nezpique, Bayou Des Cannes, Bayou Plaquemine Brule and Bayou Que de Tortue Winter TMDL's. The output of these waterbodies winter projections were inputs into the Mermentau River winter projection.

This 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. LADEQ'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.

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1. Introduction

The 1996 and 1998 303(d) lists cited the Mermentau River, Subsegment 050401, as being impaired due to organic enrichment/low DO and required the development of a Total Maximum Daily Load (TMDL) for dissolved oxygen (DO). It was ranked as a high priority (priority 1) on both lists for development of a TMDL. A calibrated water quality model for the Mermentau River was developed and projections were modeled, which included the output of the Bayous Nezpique, Des Cannes and Que de Tortue seasonal projections as their inputs. These projections quantified the point source and nonpoint source waste load reductions which would be necessary in order for the Mermentau River to comply with its established water quality standards and criteria. This report presents the results of that analysis.

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2 Study Area Description

2.1 General Information

Water quality subsegment 050401 is part of the Mermentau River Basin. The Basin encompasses the prairie region of the state and a section of the coastal zone. The drainage area for the Basin, excluding the gulf water segment, is 3,710 square miles. The subsegment is located in south central Louisiana in the parishes of Vermillion, Acadia and Jefferson Davis and has a drainage area of 67.11 square miles. The subsegment is prairie, characterized by large expanses of flat grassland and scattered areas of oak trees and other mixed hardwoods. Much of the area adjoining the water body is hardwood swamp with water depths of 1'-3' extending approximately 50' to 300' out from the river. The slope of the land is generally north to south. Because of its relatively low relief the region is characterized by poor drainage and annual backwater flooding of agricultural lands. The land use in the watershed is vividly depicted on the SPOT-TM map in Appendix L and summarized in Table 1.

Table 1. Land Uses in Segment 0504

LAND USE TYPE	NUMBER OF ACRES	% OF TOTAL AREA
Urban	1,994	2.60
Extractive	105	0.10
Agricultural	51,059	67.20
Forest Land	5,176	6.80
Water	5,553	7.30
Wetland	12,055	15.90
Barren Land	58	0.10
Other	224	0.04
TOTAL AREA	76,000	100.00

The model extends from the river's beginning at the confluence of Bayou Nezpique and Bayou Des Cannes to the mouth of Lake Arthur near the town of Lake Arthur, La. The Mermentau River is located in south central Louisiana and its watershed includes the following tributaries: Bayou Nezpique, Bayou Des Cannes, Bayou Que de Tortue, Andress Cove and several unnamed tributaries. The area is sparsely populated outside its small municipalities, and the land use is dominated by agriculture. One sewage treatment facility and one industrial facility were included in the modeling effort. Maps of the study area are presented in Appendix L. A vector diagram outlining this is shown in Appendix B.

2.2 Water Quality Standards

Water quality standards for the State of Louisiana have been defined (Louisiana Department of Environmental Quality, Environmental Regulatory Code, Part IX, Water Quality Regulations, Chapter 11, 1998). These include both general narrative standards and numerical criteria. General standards include prevention of objectionable color, taste and odor, solids, toxics, oil and grease, foam, and nutrient conditions as well as aesthetic degradation. The Water Quality criteria and designated uses for the Mermentau River subsegment is shown in Table 2.

Table 2. Water Quality Numerical Criteria and Designated Uses

Subsegment	050401
Stream Description	Mermentau R., Origin to Lake Arthur
Designated Uses	A B C F
Criteria:	
Cl	90
SO_4	30
DO	5 : DEC-FEB 3 : MAR-NOV
pH	6.0 – 8.5
BAC	1
EC	32
TDS	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 5 mg/L dissolved oxygen criterion to a 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 the Mermentau River and its tributaries.

2.3 Wastewater Discharges

The discharger inventory for the Mermentau River watershed was reviewed. There are approximately 40 dischargers listed in the LADEQ Permit Tracking System and the Discharger Inventory combined. These facilities and their current permitting status were evaluated and only 2 were considered to have any ability to impact the target reaches: the Village of Mermentau and BCI LA, LLC/BIOCOM/Shepherd Oil. All others were considered to be small, no longer in operation or intermittent stormwater discharges. The list of facilities and the modeling decision for each is shown in Appendix G. The permits record, permits applications, and Discharger Monitoring Reports (DMR) for these facilities were examined and appropriate input information for the calibration and projection modeling runs was derived to the maximum extent possible. The input data development for the calibration model is presented in Appendix C1.

2.4 Water Quality Conditions/Assessment

Subsegment 050401, Mermentau River from its origin to the mouth of Lake Arthur, is listed as "threatened" in supporting its designated uses according to the 1998 305(b) Water Quality assessment for Louisiana. Suspected causes of impairment are Nutrients (Phosporus and Nitrogen), Organic Enrichment/Low DO and Metals (Copper, Lead and Mercury) from irrigated and nonirrigated crop production nonpoint sources. The subsegment is on the 1998 303(d) list and is scheduled for current TMDL development. An excerpt from the 1998 303(d) list is presented in Appendix K. The subsegment was also on the 1996 303(d) list for nutrients, organic enrichment/low DO, pathogen indicators, suspended solids, and turbidity.

2.5 Prior Studies

The lower reaches of Bayou Nezpique, Bayou Des Cannes, Bayou Plaquemine Brule, Bayou Que de Tortue, the upper Mermentau River and the Jennings STP Canal were the subject of an intensive survey in 1982 and a reconnaissance survey in 1990. A surveillance survey of the upper Mermentau River and its tributaries was performed between 1986-1987. Modeling studies performed on these waterbodies resulted in recommendations for standards reevaluation and phased approach TMDLs. Use Attainability Analyses have been conducted in the watershed and revised standards have been issued as shown in Table 2.

3. Documentation of Calibration Model

3.1 Model Description and Input Data Documentation

3.1.1 Program Description

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 was hydrologically calibrated to the LADEQ July, 1982 intensive survey measurements of chlorides, to the estimated discharge values based on USGS stations(See Appendix F) and to the various cross-sectional data collected in 1990 and 1999. See a composite of the cross-sectional data in Appendix B. Water quality parameters and coefficients were then established based on available data and best professional judgement. The calibration model output was then compared to the LADEQ July, 1982 intensive survey measurements of water quality parameters including dissolved oxygen and the calibration was determined to be successful.

3.1.2 Model Schematic or Vector Diagram

A vector diagram of the modeled area is presented in Appendix B. The vector diagram shows the reach/element design, the location of Municipal/Industrial dischargers, and the locations of major tributaries contributing flow. A digitized maps of the stream showing river kilometers, locations of cross-sections and July 1982 survey sampling sites is also included in Appendix L.

3.1.3 Hydrology and Stream Geometry and Sources

The USGS has historical daily flow estimates for stations on Bayou Nezpique near Basile, on Bayou Des Cannes near Eunice and on the Mermentau River near the Village of Mermentau. LADEQ has a monthly water quality sampling station at the Mermentau River at Mermentau station. LADEQ continues to perform monthly sampling at the Mermentau River near Mermentau station as part of a statewide trend program. Data from the LADEQ historical ambient water quality station located on the Mermentua River was used to determine critical temperatures for each season, this data is presented in Appendix E. The USGS flow station historical data was used to determine the calibration flows.

Data collected during an Eularian survey conducted from July 7-8, 1982, was used to establish the input for the model calibration and is presented in Appendix D. Flow measurements were not performed during the water quality survey. On a water body of this size it is difficult to determine an accurate discharge due to the low velocities at critical seasonal flows. Using the USGS daily flow stations on Bayou Nezpique and Des Cannes, as well as the chloride data provided by the water quality survey, the estimated survey flow rates of the headwater and tributaries in the Mermentau River were determined. See Appendix F for the calculation sheets.

The reach and element design for the Mermentau River model was made using a 0.20 km element length. This allowed the total reaches and elements to be within the limitations of the model "The current version is dimensioned for a maximum of 200 reaches, 100 headwaters, 300 wasteloads and 3000 elements." (LA-QUAL User's Manual) The final design incorporated 3 reaches, 1 headwaters, 6 wasteloads, and 148 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 station, treatment plant and unmodeled tributary were fed into a related spreadsheet and the element number for each of these locations was determined. These spreadsheets are presented in Appendix B.

The flow in each reach, headwater, and unmodeled tributary was determined based on the chloride balance, the two USGS daily flow stations, the drainage area associated with each flow, and a determination of appropriate incremental nonpoint source flowrate in terms of cms/mile. Best professional judgement was used to determine where similar streams concepts could be used. Municipal/Industrial treatment plant flows were determined based on available data from permits, applications, and DMRs. Where this type of data was lacking or inconsistent, determinations were made based on best professional judgement from available information. Flow determinations are presented in Appendix F. The vector diagram and the digitized map showing the individual drainage areas are presented in Appendix B & L. Tables 3 and 4 summarize the POTW flow information used in the calibration and projection model inputs.

Table 3. Treatment Plant Flows for Projections

Treatment Plant	Design Flow, gpd	Projection (Design flow/80%) Flow, cms	Source
BCI LA, LLC/BIOCOM/ Shepherd Oil	1,400,000	0.0766	This is the design flow taken from the April, 1996 LADEQ permit.
Village of Mermentau	85,000	0.0046	This is the design flow taken from the Sept. 1997 LADEQ/EPA permit, and was verified against the Oct. 1996 permit application.
Castex Systems, Inc.	0	0	According the LADEQ files the facility is no longer in operation, thus it was not included in the projection runs.

Table 4. Treatment Plant Flows for Calibration

Treatment Plant	Calibration Flow, cms	Source
BCI LA, LLC/BIOCOM/Shepherd Oil	0.0031	Value taken from previous model input. Verified against the 1983 application's 50 gpm maximum flow rate.
Village of Mermentau	0.0025	Value taken from previous model input. Verified against the average flow rate for 1984-85.
Castex Systems, Inc.	0.0044	Value taken from 1984 permit application for Outfall 001.

Rather than directly inputting the widths and depths of the stream, the model requires that the advective hydraulic characteristics (a modification of the Leopold Coefficients and Exponents) be entered. In reviewing the stream hydrology and the current USGS daily flow station on the Mermentau River it was determined that the waterbody's width and depth are not dependant on the flow rate, but on the water level within Lake Arthur. The bottom surface in this waterbody is estimated to be lower than the bottom surface of Lake Arthur. Thus making the Mermentau River during critical flow periods a large stretch lake where its width and depth are more dependant on the direction of the winds in Lake Arthur than on the flow in the river. According to the directional velocity records at the USGS station on the Mermentau River the river actually slows and backs up depending on the sloshing effects in the Lake. The tidal effects on this area are minimized by the Catfish Control Structure. Since the depths and width are basically consistent during critical flow periods, the model's reach coefficients and exponents were set to zero and the measured widths and depths from two hydrologic surveys were input as the modified Leopold equation constants.

Seven of the major oxbows in the river have been cut through apparently to assist navigation. At first it was assumed that the majority of the flow in the river was passing through the cutoffs, thus bypassing the original oxbow. To test this assumption the Manning's equation was adapted to determine the ratio of the flows in the cutoff to the oxbows. The derived equation used the cross-sectional areas, lengths and hydrologic radiuses of the cutoff and oxbow. The cutoffs in this waterbody are narrower and shallower than the original width and depths in the oxbow. Due to the differences in cross-sectional areas the derived equation determined that the majority of the flow was passing through the oxbows. To test this theoretical equation a drogue study was performed on two of the cutoffs. Due to a flow shift, the data from one of the cutoffs was inconsistent, however the other cutoff provided a reliable estimated velocity along with measured cross-sections in the cutoff and oxbow. The cutoff and oxbow lengths were determined from GIS mapping. In a comparision, the ratio of the measured flows was within 20% of the estimated ratio from our derived equation. This difference was determined to be acceptable due to the low degree of accuracy in our flow measurements. The derived Manning's equation was then applied to all cutoffs proving the majority of the river's flow was passing through the oxbows in each case. The reach length and element counts were then adjusted for the longer stream length. See Appendix H for the calculation sheets of this analysis.

Since the entire Mermentau River is characterized by frequent flow reverses and is deep, wide and very sluggish especially at low flows, the dispersive hydraulic coefficients were used for all reaches. The fraction of the boundary tide was set to one hundred percent and the exponents were assumed to be zero. The dispersion coefficient was then given values ranging from 10 to 15, which is consistent with the values used in the Plaquemine Brule model.

3.1.4 Headwater and Waste Water Loads

Bayou Des Cannes was modeled as the headwater with Bayou Nezpique, Bayou Que de Tortue and Andress Cove as unmodeled tributaries. The water quality for Bayous Des Cannes, Nezpique and Que de Tortue was input from the average values determined in the July 1982 Eularian survey. The water quality data input for Andress Cove was assumed to be similar to Bayou Que de Tortue. Municipal/Industrial treatment plant wasteloads were derived from permit information, permit applications, and DMRs. Summaries and copies of selected data are presented in Appendix J.

3.1.5 Water Quality Input Data and Their Sources.

Water quality data collected on July 7-8, 1982, on the Mermentau River and its tributaries was entered in a spreadsheet for ease of analysis. The Louisiana GSBOD program was applied to the 20 day suppressed BOD data in the spreadsheet and the ultimate CBOD, CBOD decay rate, CBOD Lag values were computed for each sample taken. Since multiple samples were taken at each station, the average value of each parameter was computed for each station. A complete listing is presented in Appendix D. The NBOD values were derived from the July 1982 survey TKN data and the decay and settling rates were based on the Texas "Waste Load Evaluation Methodology" document for Organic Nitrogen (Org-N). This data was the primary source for the model calibration input data for initial conditions; decay rates; incremental temperature and DO; headwater temperature and DO; and, wasteload data.

3.1.5.1 Temperature Correction of Kinetics, Data Type 4

The temperature correction factors specified in the LTP were entered in the model.

3.1.5.2 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 initial condition input values were determined as the average of the July 1982 survey stations located on the Mermentau River main channel. See Appendix D for a composite of the survey water quality data.

3.1.5.3 Reaeration Rates, Data Type 12

The average river depths and low velocities for the Mermentau River do not meet any of the standard reaeration rate equation's depth and velocity ranges. The minimum K_L of 2.3 ft/day was used to simulate the reaeration rate for the three reaches in the model. This minimum KL value was then adjusted for water surface wind velocities. This waterbody is wide and susceptible to seasonable winds. The equation used to make this adjustment is Equation (3-23), page 122, in the Rates, Constants, and Kinetics Formulations in Surface Water Quality Modeling (2nd edition). The wind velocity used was derived from the historical monthly average for the month of July at the Lake Charles Municipal Airport. This historical monthly average was based on wind velocities measured at 10 meters height. The monthly value was reduced to its equivalent water surface wind velocity at a 0.1 meters height. The equivalent water surface wind velocity was used in the above equation to calculate the adjusted minimum K_L value. The data and calculations are shown in Appendix I.

3.1.5.4 Sediment Oxygen Demand, Data Type 12

Values of SOD from the LTP were used in several preliminary calibration runs. These values have been established for wasteload allocation modeling of short stream reaches directly below treatment plant outfalls and were not suitable for a watershed level model. SOD values were therefore achieved through calibration and are considerably lower than those predicted by the LTP. This was probably a result of the deeper waters of the Mermentau River. The values used were consistent with the SOD values determined in the lower reaches of the Bayou Nezpique and Bayou Plaquemine Brule models. The SOD value for each reach is shown in Appendix C1.

3.1.5.5 Carbonaceous BOD Decay and Settling Rates, Data Type 12

These rates are labeled Aerobic BOD Decay and BOD Settling in LA-Qual. The reach decay rates used were based on the average of the survey site's bottle rates in or near each reach. The settling rates were taken from the Texas "Waste Load Evaluation Methodology", page D-14. The decay and settling rates used for each reach are shown in Appendix C1.

3.1.5.6 Nitrogenous Decay and Settling Rates, Data Type 13

The rates are labeled NCM decay and NCM Settling in LA-QUAL. The initial decay rates used were based on the Texas "Waste Load Evaluation Methodology" guidelines for Org-N. These values were then modified during calibration. The settling rates were based on the Texas "Waste Load Evaluation Methodology" guidelines for Org-N. These rates were not modified during calibration. The Org-N decay and settling rates were used to the simulate NBOD rates because the Org-N decay rate is the limiting rate in the Nitrogen cycle and is the part of NBOD that is settlable. The decay and settling rates used for each reach are shown in Appendix C1.

3.1.5.7 Incremental Conditions, Data Types 16, 17, and 18

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 and silvicultural areas as a result of a storm in the area just prior to the survey or that there was some input from groundwater as a result of the rain recharging the underlying water table. Due to a lack of valid nonpoint data from the survey, the incremental Temperature, DO, Chlorides, CBOD and NBOD values for each reach were based on the water quality sampling on Bayou Que de Tortue. This stream drains a similar drainage area to the land types adjacent to the Mermentau River, and its water quality should be similar to the incremental nonpoint values. These nonpoint sources could include agricultural runoff, industrial stormwater runoff, natural runoff as well as individual package sewage treatment plants. The data and its source for each reach are presented in Appendix C1.

3.1.5.8 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. The values used in the model were determined via calibration. Their load equivalents in (gm O_2/m^2-day) were comparable to values found in the other models recently performed on the Mermentau Basin. These nonpoint sources could include agricultural loading, industrial stormwater loading, and natural background benthic materials. The data and sources are presented in Appendix C1.

3.1.5.9 Headwaters, Data Types 20, 21, and 22

The headwater values were determined from the survey station 05-MR-09 on Bayou Des Cannes. The data and sources are presented in Appendix C1.

3.1.5.10 Wasteloads, Data Types 24, 25, and 26

The wasteloads entered in the model were of two different types: treatment plant effluent and unmodeled tributaries. The unmodeled tributaries consisted of Andress Cove with no known point source dischargers and Bayou's Nezpique and Que de Tortue that were previously modeled. All of the unmodeled tributaries were sampled during the survey with the exception of Andress Cove and the results of these samples were the basis for the input data. The Bayou Que de Tortue values were used for Andress Cove. The wasteloads from the treatment plants were determined from permits, applications and DMRs which have been included or summarized in Appendix G. The temperature of treated effluent has been assumed to be 30º C. The data and sources are presented in Appendix C1.

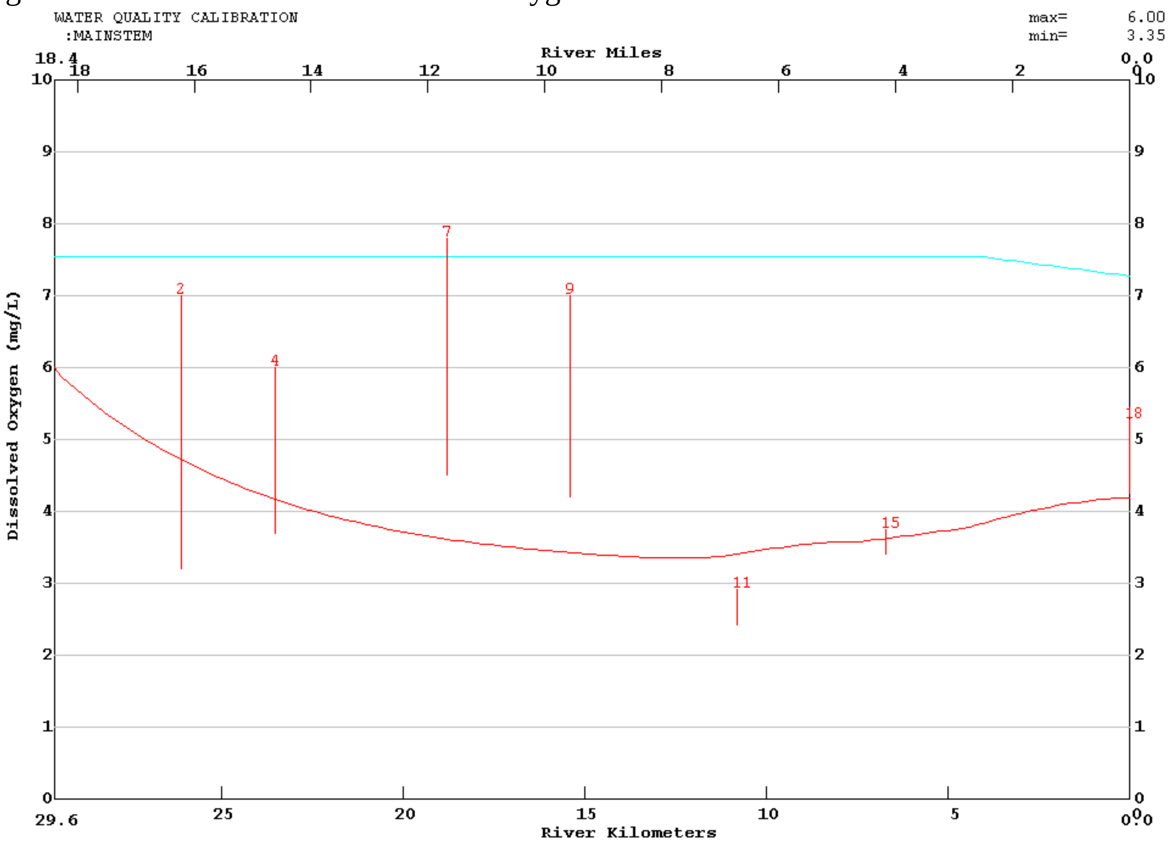
3.1.5.11 Boundary Conditions, Data Type 27

The lower boundary conditions were assumed to be equivalent to the measurements taken at July 1982 survey station 05-MR-17. This station was very near the location of the model boundary.

3.2 Model Discussion and Results

The calibration model input and output is presented in Appendix M1. The overlay plotting option was used to determine if calibration had been achieved. A plot of the dissolved oxygen concentration versus river kilometer is presented in Figure 1.

Figure 1. Calibration Model Dissolved Oxygen versus River Kilometer



The Mermentau River main stem extends from the confluence of Bayou Des Cannes and Bayou Nezpique to the mouth of Lake Arthur and is represented by Reaches 1, 2 and 3. A good calibration was achieved for CBOD, NBOD and Chlorides on the main stem. The DO values during the survey varied tremendously depending on the time sampled. This was probably due to water surface wind aeration and/or algal production. Both wind and algal oxygen production effects were taken into consideration in the calibration. The model simulates the measured values of DO adequately at the one meter depth. The survey data shows that in the summer of 1982, the DO standard of 3 mg/l was not being met in the Mermentau River at RK 10.8. This survey site's DO low value was 2.68 mg/l. The model could not go through the minimal value using reasonable model input values, but it was on the conservative side of four of the samples and was determined to be a reasonable calibration. Reach 1 includes three dischargers, the Village of Mermentau, BCI LA/Shepherd Oil and Castex Systems, Inc. All three discharge into small streams/swamps and ditches thence into the Mermentau River.

4. Water Quality Projections

Three traditional summer and winter projections loading scenarios were performed. These scenarios were:

a. No Load Projection Scenario - No point source loads and no nonpoint source loads above reference stream background at Summer season critical conditions.
b. Summer Projection Scenario – Reduced point source loads and man-made nonpoint loads at Summer season critical conditions.
c. Winter Projection Scenario – Reduced point source loads and man-made nonpoint loads at Winter season critical conditions.

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 Mermentau River TMDL, LADEQ 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 LADEQ 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 (and nonpoint 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.

LADEQ simulated critical summer conditions in the Mermentau River dissolved oxygen TMDL projection modeling by using the output flows and loading from the Bayous Des Cannes, Nezpique and Que de Tortue critical summer projection models. The temperature used was the 90th percentile temperature for the summer critical season at the LADEQ Water Quality ambient site# 0003 on the Mermentau River. Incremental flow was assumed to be zero; model loading was from point sources, perennial tributaries, sediment oxygen demand, and resuspension of sediment loads. In addition, LADEQ assumes that all point sources are discharging at maximum capacity plus a 20% MOS.

LADEQ simulated critical summer no-load conditions in the Mermentau River dissolved oxygen TMDL projection modeling by using the output flows and loading from the Bayous Des Cannes, Nezpique and Que de Tortue critical summer no-load projection models. The temperature used was the 90th percentile temperature for the summer critical season at the LADEQ Water Quality ambient site# 0003 on the Mermentau River. Incremental flow was assumed to be zero; model loading was from perennial tributaries, natural background sediment oxygen demand, and resuspension of background natural sediment loads. The point source loads were negated for this projection scenario.

LADEQ simulated critical winter conditions in the Mermentau River dissolved oxygen TMDL projection modeling by using the output flows and loading from the Bayous Des Cannes, Nezpique and Que de Tortue critical winter projection models. The temperature used was the 90th percentile temperature for the winter critical season at the LADEQ Water Quality ambient site# 0003 on the Mermentau River. Incremental flow was assumed to be zero; model loading was from point sources, perennial tributaries, sediment oxygen demand, and resuspension of sediment loads. In addition, LDEQ assumes that all point sources are discharging at maximum capacity plus a 20% MOS.

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 the point source loads.

4.1.2 Hydrology and Stream Geometry and Sources

The flows used in all the projection scenarios were taken from the outputs of the corresponding projection scenario models on Bayou Des Cannes, Bayou Nezpique and Bayou Que de Tortue. All incremental flows and the flow in Andress Cove were assumed to be zero during critical flow periods.

In reviewing the stream hydrology and the current USGS daily flow station on the Mermentau River it was determined that the waterbody's width and depth are not dependant on the flow rate, but on the water level within Lake Arthur. The bottom surface in this waterbody is estimated to be lower than the bottom surface of Lake Arthur. Thus making the Mermentau River during critical flow periods a large stretch lake where its width and depth are more dependant on the direction of the winds in Lake Arthur than on the flow in the river. According to the directional velocity records at the USGS station on the Mermentau River the river actually slows and backs up depending on the sloshing effects in the Lake. The tidal effects on this area are minimized by the Catfish Control Structure. Since the depths and width as basically consistent during critical flow periods, the model's reach coefficients and exponents were set to zero and the measured widths and depths from two hydrologic surveys were input as the modified Leopold equation constants for the projection runs. Since the river's cross-sections do not change substantially the ratios of the amount of flow going through the oxbow in comparison to the amount of flow passing through the cutoffs should be consistent with the calibration model. Thus it is determined that the majority of the flow is passing through the oxbows and no modifications had to be made to the model's reach lengths.

Treatment plant flows were determined based on available data from current permits and applications and then increased by 25% in order to explicitly incorporate a 20% margin of safety in the effluent loads. Treatment plant projected flows are summarized in Table 3. The Castex System, Inc. facility according to the LADEQ files is no longer in operation, thus it was not included in the projections.

4.1.3 Water Quality Input Data and Their Sources.

The initial conditions temperatures were set to the 90th percentile critical season temperature in accordance with the LTP. Critical temperatures for each season were determined from the temperature data collected by LADEQ as part of its historical and current ambient monitoring strategy. The 90th percentile temperature for each season was computed for LADEQ water quality ambient station #0003 on the Mermentau River near the Village of Mermentau from August 1989 to the present. This represents the last ten years of record. The temperature analysis spreadsheet is shown in Appendix E. The dissolved oxygen values for the initial conditions were set at the stream DO criteria.

The CBOD decay and settling rates as well as the NBOD decay and settling rates, were held constant in the calibration. The average river depths and low velocities for the Mermentau River do not meet any of the standard reaeration rate equation's depth and velocity ranges. The minimum K_L of 2.3 ft/day was used to simulate the reaeration rate for the three reaches in the model. This minimum K_L value was then adjusted for water surface wind velocities. This waterbody is wide and susceptible to seasonable winds. The equation used to make this adjustment is Equation (3-23), page 122, in the Rates, Constants, and Kinetics Formulations in Surface Water Quality Modeling (2nd edition). The wind velocity used was derived from the historical critical seasonal monthly average at the Lake Charles Municipal Airport. This historical seasonal monthly average was based on wind velocities measured at 10 meters height. The historical value was reduced to its equivalent water surface wind velocity at a 0.1 meters height. The equivalent water surface wind velocity was used in the above equation to calculate the adjusted minimum K_L value. The data and calculations are shown in Appendix I.

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. Any small flows, such as individual sewage package plants are assumed to be susceptible to evaporation or groundwater recharge.

The headwater and unmodeled tributary's water quality parameters used in all the projection scenarios were taken from the outputs of the corresponding projection scenario models on Bayou Des Cannes, Bayou Nezpique and Bayou Que de Tortue. These water qualtity parameters included UCBOD, UNBOD, temperature and DO.

The lower boundary conditions were set to the 90th percentile critical season temperature in accordance with the LTP. Critical temperatures for each season were determined from the temperature data collected by LADEQ as part of its historical and current ambient monitoring strategy. The 90th percentile temperature for each critical season was computed for LADEQ water quality ambient station #0003 on the Mermentau River near the Village of Mermentau from August 1989 to the present. This represents the last ten years of record. The temperature spreadsheets are shown in Appendix E

4.1.3.1 Sediment Oxygen Demand, Data Type 12

In both the summer and winter projection scenarios the man-made SOD was reduced by 30%. In the no-load projection scenario the SOD loading was calculated using a 100% man-made load reduction. These reductions were determined using the calibrated values for SOD, Nonpoint CBOD & NBOD and the total benthic natural loading of 2.0 gm O2/m2/day. A percentage of each loading component was calculated by a comparison 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 70% (Summer & Winter Projections) / 0% (No-load Projection) of man-made loading value, and the SOD loading portion of the reduced man-made benthic loading was determined by adding the SOD portion of the man-made benthic loading to the SOD portion of the background benthic loading. These calculations are shown in Appendix A. The value and sources for SOD for each projection run are presented in Appendices C2-C4.

4.1.3.2 Nonpoint Sources, Data Type 19

The resuspended man-made CBOD and NBOD loading was reduced by 30% in both the summer and winter projection scenarios. In the no-load projection scenario the resuspended man-made CBOD and NBOD loading was calculated using a 100% man-made load reduction. These reductions were determined using the calibrated values for SOD, Nonpoint CBOD & NBOD and the total benthic natural loading of 2.0 gm O2/m2/day. A percentage of each loading component was calculated by comparison 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 70% (Summer & Winter Projections) / 0% (No-load Projection) of man-made loading value, and the CBOD and NBOD loading portions of the reduced man-made benthic loading were determined by adding the CBOD and NBOD portions of the man-made benthic loading to the CBOD and NBOD portions, respectfully, of the background benthic loading. These calculations are shown in Appendix A. The value and sources of CBOD and NBOD for each projection run are presented in Appendices C2-C4.

4.1.3.3 Wasteloads, Data Types 24, 25, and 26

Except in the “no-load scenario” (no point source loads and no nonpoint source loads above reference stream background), the wasteloads entered in the projection models for the treatment plants were taken from the current LADEQ/EPA permit or determined by the projection. In the summer, winter and no-load projection runs, the wasteloads entered for the unmodeled tributaries were taken from the output of the Bayou Nezpique and Bayou Que de Tortue projection models. The values and sources of the data are presented in Appendices C2-C4.

4.2 Projection Model Discussion and Results

The projection model inputs are presented in Appendix C2-C4 and output data sets are presented in Appendices N1-N3.

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 loads were also reduced to the reference stream background benthic loads. As shown in the output graph in Appendix N3, the river meets the existing dissolved oxygen summer season criteria of 3.0 mg/l.

4.2.2 Summer Projection

Under this scenario, the wasteloads entered in the projection models for the treatment plants were taken from the current LADEQ/EPA permit or determined by the projection, the SOD and resuspended CBOD and NBOD loading was reduced to 30% of manmade values. The BCI LA / Shepherd Oil ethanol plant’s limits were reduced to 10 mg/l CBOD5 and its NH3-N limit to 10 mg/l. As shown in the output graphs, the river meets the existing dissolved oxygen summer season criteria of 3.0 mg/l. The minimum DO on the main stem is 3.00 mg/l from RK 28.2 to 27.0. A graph of the dissolved oxygen concentration versus river kilometer for the summer projection is presented in Figure 2.

4.2.3 Winter Projection

Under this scenario, the wasteloads entered in the projection models for the treatment plants were taken from the current LADEQ/EPA permit or determined by the projection, the SOD and resuspended CBOD and NBOD loading was reduced to 30% of manmade values. The BCI LA / Shepherd Oil ethanol plants limit was set at 20 mg/l CBOD5 and its NH3-N limit to 10 mg/l. As shown in the output graphs, the river meets the existing dissolved oxygen summer season criteria of 5.0 mg/l. The minimum DO on the main stem is 5.16 mg/l from RK 27.4 to 26.6. A graph of the dissolved oxygen concentration versus river kilometer for the summer projection is presented in Figure 3.

Figure 2. Summer Projection Model Dissolved Oxygen versus River Kilometer

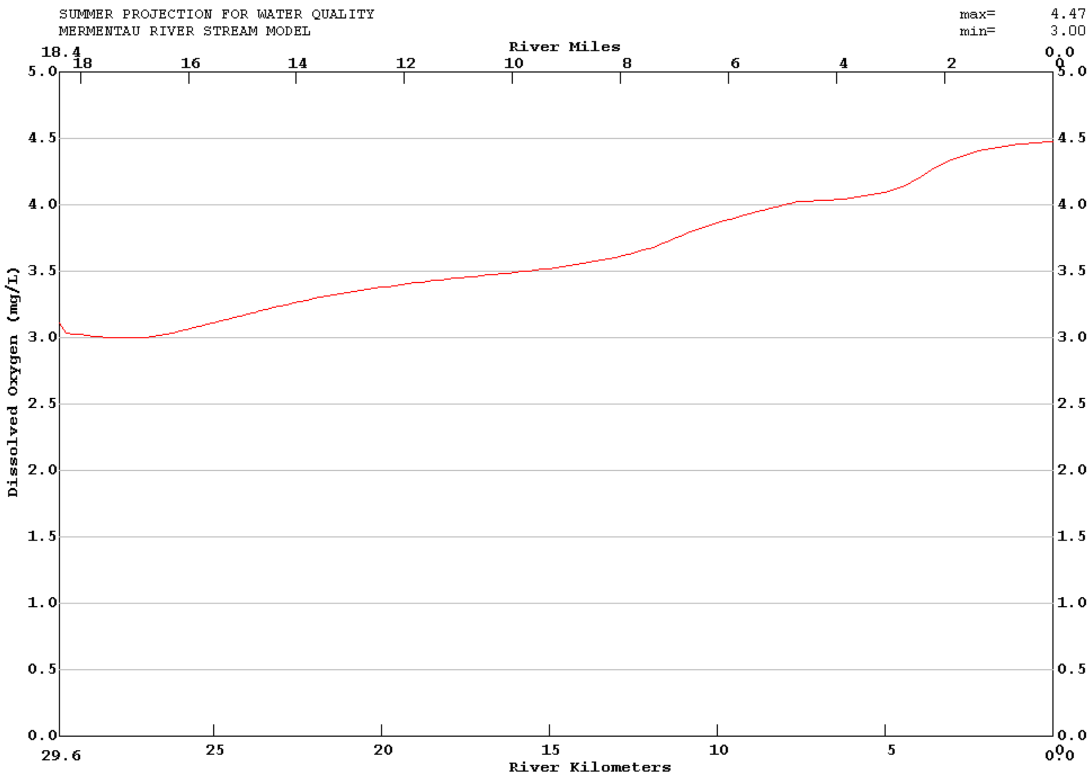
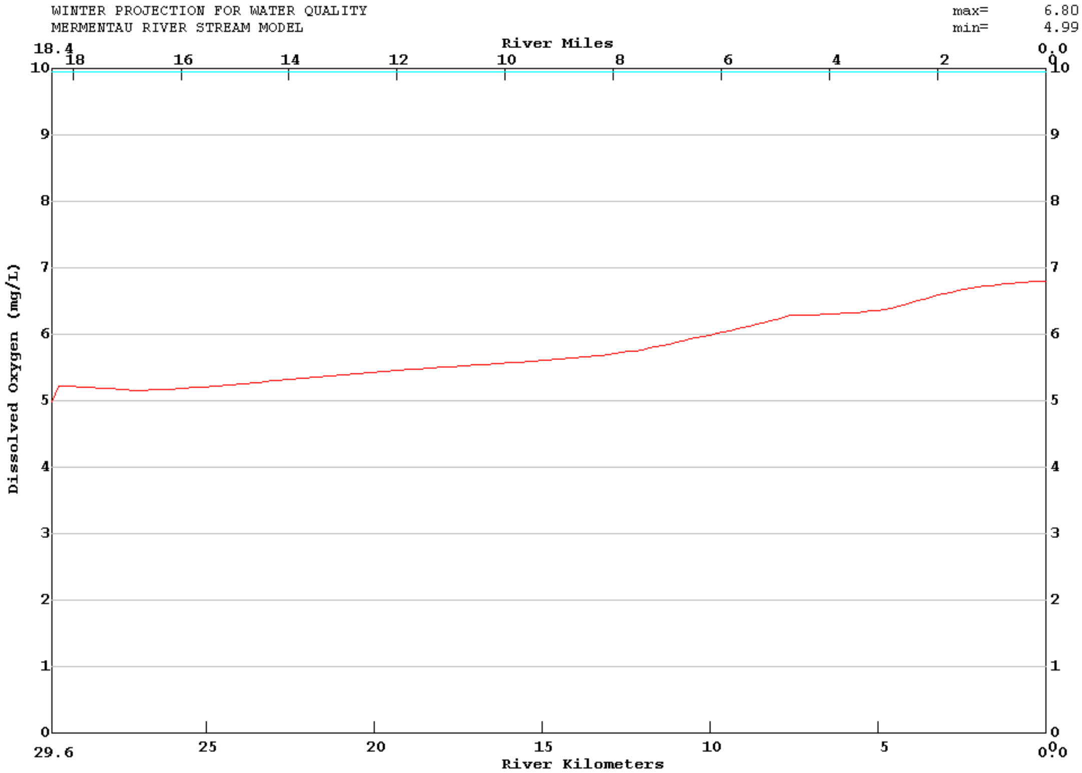


Figure 3. Winter Projection Model Dissolved Oxygen versus River Kilometer



4.3 Calculated TMDL, WLAs and LAs

TMDLs have been calculated for the summer and winter projection runs. They are presented in Appendix A by point source and reach. The winter TMDL is in this case greater than the summer TMDL because of the higher flow rate of the headwater and unmodeled tributaries. A summary of the loads is presented in Table 8.

Table 5. Seasonal Total Maximum Daily Load Summaries.

ALLOCATION	SUMMER (MAR-NOV) (lbs/day)	WINTER (DEC-FEB) (lbs/day)
Point Source WLA	817	1085
Point Source Reserve MOS	204	271
Natural/Manmade Nonpoint Source LA	37,702	35,981
Headwater/Tributary Source LA	2188	5412
TMDL = WLA + LA + MOS	40,910	42,749

4.3.1 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 nonpoint CBOD and NBOD (resuspension), and SOD were summed for each reach as gm O_2/m^2-day 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(summer)/1.0(winter) cfs, whichever was greater.
  - Headwater concentrations of CBOD, NBOD, and DO at calibration levels.
- For each reach, the nonpoint 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 nonpoint loading. The loading capacity and percent reduction of nonpoint were calculated as follows:
  - The total projection benthic loading at 20^oC was calculated as the sum of projection SOD, CBOD, and SOD expressed as gm O_2/m^2-day.
  - 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 nonpoint 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^oC 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 Mermentau River watershed was set equal to the total 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 LA-QUAL 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 water quality calibration. The sensitivity of the model's minimum DO projections to these parameters is presented in Table 6. Parameters were varied by +/- 30%, except temperature, which was adjusted +/- 2 degrees Centigrade. The calibration minimum DO was 3.42 mg/l.

Table 6, Summary of Calibration Model Sensitivity Analysis

	Positive Changes in parameter			**Negative Changes in parameter**		
Parameter	% change	Minimum DO (mg/l)	Percentage Difference	% change	Minimum DO (mg/l)	Percentage Difference
Velocity	30.0%	2.59	**-24.3%**	-30.0%	4.46	**30.4%**
CBOD Decay Rate	30.0%	3.06	**-10.5%**	-30.0%	3.99	**16.7%**
NCM (NBOD) Decay rate	30.0%	3.16	**-7.6%**	-30.0%	3.63	**6.1%**
SOD, Benthal	30.0%	3.21	**-6.1%**	-30.0%	3.62	**5.8%**
Initial Temperature	2 deg C	3.26	**-4.7%**	-2 deg C	3.59	**5.0%**
Headwater CBOD	30.0%	3.29	**-3.8%**	-30.0%	3.53	**3.2%**
Headwater NCM (NBOD)	30.0%	3.30	**-3.5%**	-30.0%	3.53	**3.2%**
Wasteload NCM (NBOD)	30.0%	3.33	**-2.6%**	-30.0%	3.50	**2.3%**
Wasteload CBOD	30.0%	3.34	**-2.3%**	-30.0%	3.49	**2.0%**
Dispersion	30.0%	3.42	**0.0%**	-30.0%	3.42	**0.0%**
Tidal Range	30.0%	3.42	**0.0%**	-30.0%	3.42	**0.0%**
Baseflow	30.0%	3.46	**1.2%**	-30.0%	3.38	**-1.2%**
NCM (NBOD) Settling Rate	30.0%	3.46	**1.2%**	-30.0%	3.36	**-1.8%**
Headwater Flow	30.0%	3.46	**1.2%**	-30.0%	3.38	**-1.2%**
CBOD Settling rate	30.0%	3.48	**1.8%**	-30.0%	3.35	**-2.0%**
Wasteload DO	30.0%	3.50	**2.3%**	-30.0%	3.33	**-2.6%**
Headwater DO	30.0%	3.52	**2.9%**	-30.0%	3.30	**-3.5%**
Depth	30.0%	3.92	**14.6%**	-30.0%	2.91	**-14.9%**
Chlorophyll A	30.0%	3.85	**12.6%**	-30.0%	2.84	**-17.0%**
Reaeration	30.0%	4.24	**24.0%**	-30.0%	2.13	**-37.7%**

As shown in the summary table in Appendix I, reaeration is the parameter to which DO is most sensitive (24.0%-37.7%). The other parameters creating major variations in the minimum DO values are Velocity (24.3%-30.4%), CBOD Decay Rate (10.3%-16.7%) Depth (14.6%-14.9%) and chlorophyll a (12.6%-17.0%). Temperature, Benthal SOD and NBOD decay rates are moderately sensitive with variations ranging from 4.7% to 7.6%. The model is not overly sensitive to tidal range and dispersion. The Depth sensitivity could be affected by it's relationship to the Velocity.

Table 7, Facility Discharge Limits to meet the DO Criteria in the Critical Season Projections.

PERMIT NO.	FACILITY	CURRENT FLOW, MGD	CURRENT LIMITS, mg/l	MODELED FLOW, MGD	SUMMER PROJECTION LIMITS, mg/l	WINTER PROJECTION LIMITS, mg/l
	Village of Mermentau	0.085	10BOD5/15TSS	0.106	10BOD5/10NH3	10BOD5/10NH3
	BCI LA / Shepherd Oil ethanol plant	1.4	20BOD5/30TSS	1.75	10BOD5/10NH3	20BOD5/10NH3

6. Conclusions

The results of the summer projection model show that the water quality standard for dissolved oxygen for the Mermentau River (WQ Subsegment 050401) of 3.0 mg/l can be maintained during the summer critical season. This can be accomplished with the imposition of an 30% reduction from all manmade nonpoint sources and the imposition of a 10 mg/l $CBOD_5$ / 10 mg/l NH_3 limit on Village of Mermentau; 10 mg/l $CBOD_5$ / 10 mg/l NH_3 limits on BCI LA/Shepherd Oil ethanol plant. This also assumes the imposition of the point and nonpoint load reductions required in the Bayou Nezpique, Bayou Des Cannes, Bayou Plaquemine Brule and Bayou Que de Tortue Summer TMDLs. The output of these waterbodies summer projections were inputs into the Mermentau River summer projection.

The results of the winter projection model show that the water quality criteria for dissolved oxygen for the Mermentau River of 5.0 mg/l can be maintained during the winter critical season. To achieve the criteria, the model assumed the imposition of a 30% reduction from all manmade nonpoint sources and the imposition of 10 mg/l $CBOD_5$ / 10 mg/l NH_3 limits on the Village of Mermentau and a 20 mg/l $CBOD_5$ / 10 mg/l NH_3 limit on the BCI LA/Shepherd Oil ethanol plant. This also assumes the imposition of the point and nonpoint load reductions required in the Bayou Nezpique, Bayou Des Cannes, Bayou Plaquemine Brule and Bayou Que de Tortue Winter TMDLs. The output of these waterbodies winter projections were inputs into the Mermentau River winter projection. The TMDL is based on the output of several other models and their corresponding reductions in manmade nonpoint loading and point source loading. If these practices are not implemented the Mermentau River TMDL will not accomplish its goal of meeting the DO criteria.

The modeling which has been conducted for this TMDL is very conservative and based on limited, somewhat dated information. One of the major factors this model was sensitive to was velocity, which is directly related to the flows in the model. Since no flows were measured during the July 1982 survey, the flows had to be determined using the best data available. Due to this and other uncertainties in the modeling several assumptions had to be made. The attempt was made to simulate reality as close as possible, erring on the conservative side when in doubt.

Many of the treatment plants in the watershed have been at advanced levels of treatment for many years and many nonpoint BMPs have been implemented in the Mermentau Basin. It is possible that the watershed has not yet begun to exhibit the improvements in water quality which can be expected from these control measures. Continued monitoring is recommended to see how well the TMDL and the point and nonpoint reductions improve the dissolved oxygen values. Additional modeling may be required if the improvements don't meet expectations.

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

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8.0 Appendices

See Attached Appendices A-O.

APPENDIX A

TMDL CALCULATIONS AND PERCENTAGE REDUCTION DETERMINATIONS

APPENDIX B

VECTOR DIAGRAMS AND REACH INFORMATION

APPENDIX C

MODEL INPUTS AND SOURCES

APPENDIX C1

CALIBRATION MODEL INPUTS AND SOURCES

APPENDIX C2

SUMMER PROJECTION MODEL INPUTS AND SOURCES

APPENDIX C3

WINTER PROJECTION MODEL INPUTS AND SOURCES

APPENDIX C4

SUMMER NO-LOAD PROJECTION MODEL INPUTS AND SOURCES

APPENDIX D

WATER QUALITY SURVEY DATA

APPENDIX D1

FIELD SURVEY REPORT

APPENDIX D2

SURVEY SITE DATA COMPILATIONS

APPENDIX D3

MERMENTAU RIVER MAINSTEM AVERAGES

APPENDIX E

TEMPERATURE CALCULATIONS FOR THE CALIBRATION AND PROJECTIONS

APPENDIX E1

LADEQ SITE# 0003, 90TH PERCENTILE CALCULATIONS

APPENDIX E2

MERMENTAU RIVER MAINSTEM SURVEY AVERAGES

APPENDIX F

CALIBRATION FLOW DETERMINATIONS AND SUPPORTING DATA

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DROGUE STUDY REVIEW AND RESULTS

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WIND AIDED AEREATIONS DATA REVIEW AND DETERMINATIONS

APPENDIX J

FACILITY PERMIT AND APPLICATION DATA

APPENDIX K

1998 303D LIST FOR THE MERMENTAU RIVER BASIN

APPENDIX L

MAPPING

APPENDIX M

CALIBRATION INPUT AND OUTPUT REPORT WITH CHARTS

APPENDIX N

PROJECTIONS INPUT AND OUTPUT REPORTS WITH CHARTS

APPENDIX N1

Summer Projections Input and Output Reports with Chart

APPENDIX N2

Winter Projections Input and Output Reports with Chart

APPENDIX N3

No Load Summer Projections Input and Output Reports with Chart

APPENDIX O

UNMODEL TRIBUTARY PROJECTION OUTPUT SUMMARIES