TOTAL MAXIMUM DAILY LOAD (TMDL) DEVELOPMENT

Escatawpa River Segment 3 (MS107M3)

Located near Moss Point, from I-10 to the mouth at the Pascagoula River

Pollutants of Concern

Organic Enrichment/Low Dissolved Oxygen

Pathogens

pH

Chlorine

and

For Toxicity due to:

Total Toxics

Nonpriority Organics

July 2, 2001

(HUC 0317008)

Pascagoula River Basin, Mississippi

EPA
United States
Environmental Protection
Agency

Region 4
serving the southeast

Summary Page

The Consent Decree between the Environmental Protection Agency (EPA) and the Sierra Club in the Mississippi Total Maximum Daily Load (TMDL) Lawsuit requires EPA to develop TMDLs for waters included on Mississippi's 1996 303(d) List of Impaired Waterbodies, according to a prescribed schedule. The 1996 Section 303(d) List includes all waters determined to be impaired based on monitored or evaluated assessments, and shows cause(s) of impairment for each listed waterbody. Mississippi's evaluated listings assume that agricultural activities in the watershed may have adversely affected water quality in this specific reach of the Escatawpa River.

These TMDLs were first proposed on December 28, 2000 in compliance with the Consent Decree to address monitored and evaluated impairments in segment MS107M3 of the Escatawpa River. In response to comments received on the December 2000 proposal, EPA re-proposed these TMDLs on June 5, 2001 and is now finalizing these TMDLs.

Because of the complexity of the estuary system and the limited data available for some of the pollutants, EPA is proposing a phased approach for TMDL development for some of the pollutants. In a phased TMDL, EPA or the state uses the best information available at the time to establish the TMDL at levels necessary to implement applicable water quality standards and to make allocations to pollution sources. The phased TMDL approach recognizes that additional data, information and modeling may be necessary to validate the assumptions of the TMDL and to provide greater certainty that the TMDL will achieve the applicable water quality standard. Thus, Phase 1 identifies levels needed to protect the waterbody at the present time based on existing data and information. In Phase 2, data and information are collected to determine the specific cause and effect relationships that exist and the appropriate levels of pollutant reduction needed to achieve water quality standards. The Phase 2 TMDL will include targeted pollution allocation strategies for specific causes of impairment and a margin of safety that addresses uncertainty about the relationship between load allocations and receiving water quality.

EPA guidance states that TMDLs under the phased approach include allocations that confirm existing limits or would lead to new limits or new controls while allowing for additional data collection to more accurately determine assimilative capacities and pollution allocations. (USEPA, 1991) Therefore, no new or additional source of pollutant representative of any of the cited classes of respective impairments shall be introduced into these segments until:

- actual impairment status is known;
- specific pollutants causing impairment are determined; and
- the Phase 2 TMDLs are developed for individual pollutants in these segments; or
- these segments are de-listed based on the biological or toxicity/water quality monitoring to be conducted.

The Organic Enrichment/Low Dissolved Oxygen TMDL was determined using a hydrodynamic and water quality model applied at the critical conditions. The TMDL for the oxygen demanding waste is calculated by adding together the point source ultimate Biochemical Oxygen Demand (BOD) in pounds per day and the nonpoint sources ultimate BOD in pounds per day. The Load Allocation (LA) (52,500 lbs/days) plus the Wasteload Allocation (WLA) (50,330 lbs/day) equals the Ultimate BOD TMDL of 102,830 lbs/day.

The Pathogens TMDL is calculated by adding together the point source fecal coliform "load" and the nonpoint sources fecal coliform "load". The LA (258,000 counts per 100 ml times million gallons per day [mgd]) plus WLA (6,080 counts per 100 ml times mgd) equals the fecal coliform TMDL "load" of 264,080 counts per 100 ml times mgd.

A watershed model estimated the watershed loading of fecal coliform. The point source loadings are based on the NPDES permit limits. Fecal coliform data collected in the 1990s as well as the watershed modeling shows no fecal coliform violations, therefore no fecal coliform reductions are necessary.

The pH TMDL is described as follows: EPA Region 4 and MDEQ collected pH data during an intensive survey in the spring of 1999. Continuous (every 30 minutes) pH data for a 4-day period were collected during the study at 3 locations in the Escatawpa River. Based on these data there is not a present problem or water quality standards violation due to pH in this Escatawpa River segment. A point source pH requirement to maintain the pH water quality target is included in

NPDES permits: "(T)he pH shall not be less than 6.5 standard units nor greater than 9.0 standard units". This permit requirement provides assurance that permitted facilities will not cause or contribute to pH impairment in the Escatawpa River.

The Toxicity TMDL due to nonpriority organics and total toxics is expressed in terms of chronic toxicity units (TU). This TMDL has been established to protect the listed segments of the Escatawpa River against chronic toxicity due to nonpriority organics and total toxics that may cause toxicity to aquatic organisms. The toxicity wasteload allocation (WLA) for any dischargers to these segments of the Escatawpa River will be determined as follows:

Toxicity from each point source = 100 / NOEC = 100 / IWC = 100 / 20 = 5.0 TU

Where NOEC is the No Effect Concentration; IWC is the Instream Water Concentration and TU is Toxicity Units. A 20 percent margin of safety is incorporated resulting in a TMDL of 4.0 TU. Since these segments of the Escatawpa River are on the State's 303(d) List of Impaired Waters, the IWC for any new or expanding sources will be established at 4.0. The existing toxicity contribution to these segments of the Escatawpa River from nonpoint sources is not known. The toxicity associated with any new nonpoint sources, therefore, cannot exceed 1.0 TU. Additionally, the TMDL finals toxicity monitoring and assessment to be conducted during Phase 2 to determine actual impairment status and to obtain data to support future

The Chlorine TMDL is calculated by adding together the allowable point source chlorine "load" and the nonpoint sources chlorine "load". The LA of zero plus the WLA of 2.03 lbs/day equals a TMDL of 2.03 lbs/day.

7/2/01

Beverly H. Banister, Director
Water Management Division

Date

Table of Contents

Summary Page ii

Table of Figures viii

Table of Figures viii

Introduction 1

Problem Definition 1

Target Identification 3

Phased Total Maximum Daily Load (TMDL) for D.O. 4

- Problem Definition 4
- Target Identification 4
- Model Development 6
- Model Calibration 9
- Existing Point Sources 9
- Total Maximum Daily Load (TMDL) 10
- Water Quality Target and TMDL Determination 11

Phased Total Maximum Daily Load (TMDL) for Fecal Coliform 13

- Target Identification 13
- TMDL Approach 13
- Nonpoint Source Wet Weather Fecal Coliform Determination 14
- Wasteload Allocation Determination: 17
- Fecal Coliform TMDL 17

Total Maximum Daily Load (TMDL) for pH 17

Nonpoint Source Load Allocation Determination 17

Wasteload Allocation Determination: 18

TMDL 18

Phased TMDL Approach For Toxicity due to Nonpriority Organics and Total Toxics 19

Total Maximum Daily Load (TMDL) Development 20

Wasteload Allocations 20

Load Allocations 21

Margin of Safety and Seasonality 21

TMDL For Toxicity due to Chlorine Toxicity 21

Total Maximum Daily Load (TMDL) Development 22

Wasteload Allocations 22

Wasteload Allocation Determination: 23

Load Allocations 23

Chlorine TMDL 23

Margin of Safety and Seasonality 23

References: 24

Appendix A – White Paper Escatawpa CE-QUAL-W2 Model 25

Introduction 25

INITIAL CONCENTRATIONS 31

Calibration 33

Table of Tables

Table 1: Model Boundaries and Point Source Locations........ 6

Table 2 Initial and Upstream Concentrations applied to Model. 8

Table 3 List of Branches and Tributaries. 26

Table 4 Upstream Flows and Distributed Tributary Flow........27

Table 5 Initial and Upstream Concentrations applied to Model. 31

Table 6: Tributary and Distributed Tributary Concentrations........32

Table of Figures

Figure 1 Escatawpa River Watershed Map 3

Figure 2 Branch 1 Downstream Elevation. 29

Figure 3 Branch 6 Downstream Elevation. 29

Figure 4 Salinity Comparison at E.R. 3; 9/11; 8:05am 36

Figure 5 DO Comparison at E.R. 3; 9/11; 8:05am 36

Figure 6 Salinity Comparison at E.R. 3; 9/11; 8:52am 36

Figure 7 Salinity Comparison at E.R. 3; 9/10; 9:40am 36

Figure 8 DO Comparison at E.R. 3; 9/10; 9:40am 36

Figure 9 DO Comparison at E.R. 3; 9/11; 8:52am 36

Figure 10 Salinity Comparison at E.R. 12; 9/10; 11:10am 37

Figure 11 Salinity Comparison at P.R. 0; 9/10; 11:00am 37

Figure 12 Salinity Comparison at P.R. 5; 9/10; 09:00am 37

Figure 13 DOComparison at E.R. 12; 9/10; 11:10am 37

Figure 14 DO Comparison at P.R. 0; 9/10; 11:00am 37

Figure 15 DO Comparison at P.R. 5; 9/10; 09:00am 37

Figure 16 Salinity Comparison at P.R. 8; 9/11; 09:44am 38

Figure 17 Salinity Comparison at P.R. 13; 9/11; 10:20am 38

Figure 18 Salinity Comparison at P.R. 7; 9/10; 9:40am 38

Figure 19 DO Comparison at P.R. 8; 9/11; 09:44am 38

Figure 20 DO Comparison at P.R. 13; 9/11; 10:20am 38

Figure 21 DOComparison at P.R. 7; 9/10; 9:40am 38

Figure 22 DO Time-series; ER 03. 39

Figure 23 DO Time-series; ER 12. 39

Figure 24 DO Time-series; PR 08. 40

Figure 25 Escatawpa Axial DO Distribution with Tributaries Active..40

Figure 26 Escatawpa Axial DO Distribution with Tributaries Inactive. 41

Introduction

Section 303(d) of the Clean Water Act (CWA) as Amended by the Water Quality Act of 1987, Public Law 100-4, and the United States Environmental Protection Agency's (USEPA/EPA) Water Quality Planning and Management Regulations [Title 40 of the Code of Federal Regulation (40 CFR), Part 130] require each State to identify those waters within its boundaries not meeting water quality standards applicable to the water's designated uses. Total maximum daily loads (TMDLs) for all pollutants violating or causing violation of applicable water quality standards are established for each identified water. Such loads are established at levels necessary to implement the applicable water quality standards with consideration given to seasonal variations and margins of safety. The TMDL process establishes the allowable loadings of pollutants or other quantifiable parameters for a water body, based on the relationship between pollution sources and in-stream water quality conditions, so that states can establish water-quality based controls to reduce pollution from both point and nonpoint sources and restore and maintain the quality of their water resources (USEPA, 1991).

Problem Definition

The Consent Decree between the Environmental Protection Agency (EPA) and the Sierra Club in the Mississippi Total Maximum Daily Load (TMDL) Lawsuit requires EPA to develop TMDLs for waters included on Mississippi's 1996 303(d) List of Impaired Waterbodies, according to a prescribed schedule. The 1996 Section 303(d) List includes all waters determined to be impaired based on monitored or evaluated assessments, and shows cause(s) of impairment for each listed waterbody. Mississippi's evaluated listings assume that agricultural activities in the watershed may have adversely affected water quality in this specific reach (MS107M3) of the Escatawpa River.

These TMDLs were first final on December 28, 2000 in compliance with the Consent Decree to address monitored and evaluated impairments in segment MS107M3 of the Escatawpa River. In response to comments received on the December 2000 proposal, EPA re-proposed these TMDLs on June 5, 2001 and is now finalizing the TMDLs.

Because of the complexity of the estuary system and the limited data available for some of the pollutants, EPA is proposing a phased approach for TMDL development for some of the pollutants. In a phased

TMDL, EPA or the state uses the best information available at the time to establish the TMDL at levels necessary to implement applicable water quality standards and to make allocations to pollution sources. The phased TMDL approach recognizes that additional data, information and modeling may be necessary to validate the assumptions of the TMDL and to provide greater certainty that the TMDL will achieve the applicable water quality standard. Thus, Phase 1 identifies levels needed to protect the waterbody at the present time based on existing data and information. In Phase 2, data and information are collected to determine the specific cause and effect relationships that exist and the appropriate levels of pollutant reduction needed to achieve water quality standards. The Phase 2 TMDL will include targeted pollution allocation strategies for specific causes of impairment and a margin of safety that addresses uncertainty about the relationship between load allocations and receiving water quality.

EPA guidance states that TMDLs under the phased approach include allocations that confirm existing limits or would lead to new limits or new controls while allowing for additional data collection to more accurately determine assimilative capacities and pollution allocations. (USEPA, 1991) Therefore, no new or additional loading of pollutants from any of the cited classes of respective impairments shall be introduced into these segments until:

- Actual impairment status is known;
- Specific pollutants causing impairment are determined; and
- The Phase 2 TMDLs are developed for individual pollutants in these segments; or
- These segments are de-listed based on the biological, toxicity or water quality monitoring to be conducted.

The TMDL is the total amount of pollutant that can be assimilated by the receiving water body while maintaining water quality standards. For some pollutants, TMDLs are expressed on a mass loading basis (e.g., pounds per day). In accordance with 40 CFR Part 130.2(i), "TMDLs can be expressed in terms of ... mass per time, toxicity, or other appropriate measure." In addition, NPDES permitting regulations in 40 CFR 122.45(f) state that "All pollutants limited in permits shall have limitations...expressed in terms of mass except...pollutants which cannot appropriately be expressed by mass." For the total toxics and toxicity due to nonpriority organics and chlorine, the Total Maximum Daily Load is expressed in terms of chronic toxicity units (TU).

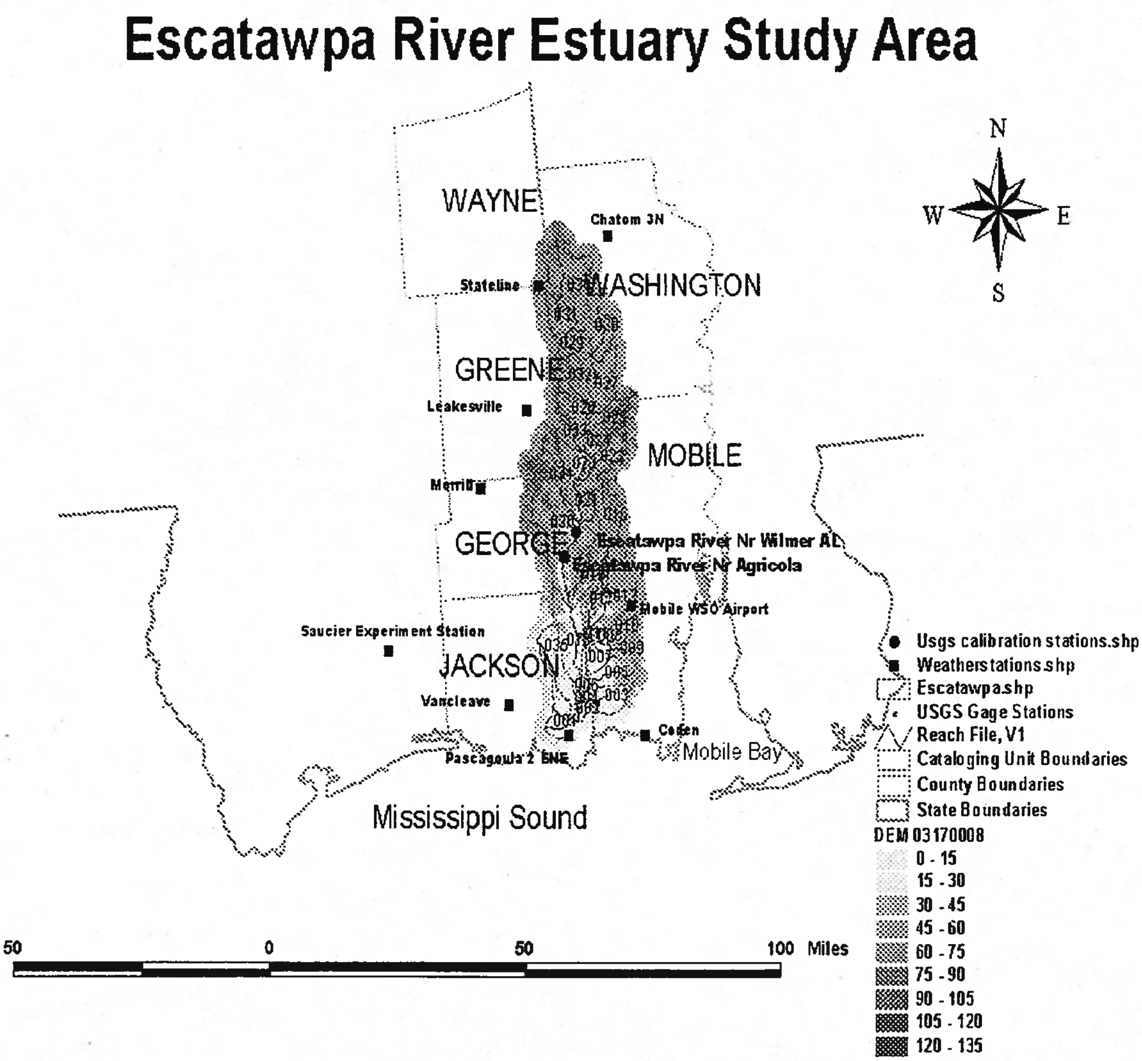

Figure 1 Escatawpa River Watershed Map

Target Identification

Escatawpa River Segment 3 (MS107M3), located near Moss Point, from I-10 to the mouth at the Pascagoula River, is listed for organic enrichment/low dissolved oxygen, pH, pathogens, nonpriority organics, chlorine and total toxics. Available data are available for D.O., fecal coliform, pH, estuarine toxicity testing and whole effluent toxicity testing of the wastewater effluents.

The Phase One TMDL for Escatawpa River Segment 3 (MS107M3) establishes:

- An initial TMDL for organic enrichment/low dissolved oxygen and fecal coliform,
- Wasteload allocation limits for pH and Chlorine, and
- A toxicity limit and a monitoring plan to: (1) perform toxicity monitoring to determine if the segment is impaired due to nonpriority organics and total toxics; and (2) if the toxicity monitoring suggests impairment, then the segment should be screened for all major regulated classes of nonpriority organics and toxic pollutants that may be discharged to the system.

Phased Total Maximum Daily Load (TMDL) for D.O.

Problem Definition

The 303(d) listed segment for low DO is Escatawpa River Segment 3 (MS107M3), located near Moss Point, from I-10 to the mouth at the Pascagoula River. Historically low DO values have been measured in the Escatawpa River and estuary system. These low DOs are due to a combination of impacts of point source discharges' past practices resulting in a large sediment oxygen demand, and naturally low estuary DO conditions due to salinity intrusion and low velocities.

Target Identification

Applicable Water Quality Standards

The applicable dissolved oxygen water quality standard for waters is as follows:

Numeric. "Dissolved oxygen concentrations shall be maintained at a daily average of not less than 5.0 mg/l with an instantaneous minimum of not less than 4.0 mg/l in streams; shall be maintained at a daily average of not less 5.0 mg/l with an instantaneous minimum of not less 4.0 mg/l in estuaries and in the tidally affected portions of streams, and shall be maintained at a daily average of not less than 5.0 mg/l with an instantaneous minimum of not less than 4.0 mg/l in the epilimnion (i.e., the surface layer of lakes and impoundments that are thermally stratified, or five feet from the water's surface (mid-depth if the lake or impoundment is less than 10 feet deep at the point of sampling)) for lakes and impoundments that are not stratified." (Variance for DO in the Escatawpa River from Mile 10 to Pascagoula River - DO shall not be less than 3.0 mg/l) State of Mississippi Water Quality Criteria for Intrastate, Interstate, and Coastal Waters - 1995.

Natural Water Quality - EPA. "Where natural conditions alone create dissolved oxygen concentrations less than 110 percent of the applicable criteria means or minima or both, the minimum acceptable concentration is 90 percent of the natural concentration." Ambient Aquatic Life Water Quality Criteria for Dissolved Oxygen (Freshwater). (EPA440/5-86-003)

Dissolved Oxygen Target

Based on the recent available water quality data and the modeling results the natural surface DO is around 4 to 5 mg/l. The DO in the bottom area goes to zero mg/l due to the deep natural channel and the salinity intrusion. These low DO areas are naturally occurring, as evidenced by the available monitoring completed in the Pascagoula and West Pascagoula River / Estuary. These estuary systems have similar physical characteristics as the Escatawpa River, but are not impacted by point source dischargers. (EPA 1997 and 1999)

For the Phase 1 DO TMDL, the target will be maintaining the DO in the water surface layer at an acceptable level. Natural surface DO is around 4 to 5 mg/l range and based on EPA criteria, the natural DO can be lowered 10% and still be acceptable. (EPA, 1986) This translates into an allowable DO deficit due to the point source dischargers of 0.4 mg/l. Including a margin of safety the target DO deficit due to point source discharges in the surface waters will be set at 0.3 mg/l. The Dissolved Oxygen target is not to be less than 3.0 mg/l or 0.3 mg/l less than natural conditions.

Phase 2 of the TMDL will examine in more detail:

- The impacts of point source dischargers on the naturally occurring low DO bottom zone; and
- The appropriate application of a site specific water quality target.

To adequately address this issue, additional analysis will need to be completed to better determine the appropriate water quality target. A three dimensional model will need to be established to better characterize the areal extent of the naturally occurring low DO and the point sources impacts. The water quality standards and modeling work being completed in the Mobile Bay Estuary and the Savannah Harbor area will assist with these analyses. With the development of the 3 dimensional models a better understanding of the relationship between the model results and data will be determined and then the MOS may be decreased.

Model Development

CE-QUAL-W2 (Cole 1995), a two dimensional model of the Escatawpa/Pascagoula system, was established for the TMDL. The modeling setup and application are described in U.S. EPA's Escatawpa River Water Quality Model using CE-QUAL-W2 (EPA 1999) and in Mississippi State University's white paper modeling report (Appendix A). The W2 model included the following branches, tributaries and point sources.

Table 1: Model Boundaries and Point Source Locations

Branch Number	Stream Name	Tributary or Point Source name
Branch 1	Pascagoula River	Black Creek
Branch 2	Escatawpa River	International Paper Wastewater Treatment Facility (WTF)
Branch 3	I-10 Cut	Zapata Haynie WTF
Branch 4	Bayou Chemise	Morton WTF
Branch 5	Industrial Cut	Escatawpa WTF
Branch 6	W. Pascagoula River	Gautier WTF
		Pascagoula River Moss Point WWTP

The primary state variable simulated was dissolved oxygen. The kinetic processes, sources, and sinks considered within the water quality simulations that impact the mass balance of dissolved oxygen were:

- Ultimate Carbonaceous Biochemical Oxygen Demand (CBODU) decay
- Reaeration
- Sediment Oxygen Demand
- Headwater and offshore boundary fluxes of CBODU, nitrogen and phosphorus series and dissolved oxygen
- Point source discharges of CBODU, nitrogen and phosphorus series and dissolved oxygen

The model simulation period extended from August 1, 1997 through September 17, 1997. This encompassed the EPA Region 4 and Mississippi Department of Environmental Quality (MDEQ) field study period of September 10, 1997 through September 15, 1997 and provided a forty-day model stabilization period. Boundary data for the model stabilization period was extrapolated from the model study period data, as appropriate.

Based upon prior modeling of the Escatawpa River, a distributed inflow was applied along the entire length of the River. The distributed tributary flow was introduced into the model to account for the flow from small creeks, streams and lateral inflows in the Escatawpa branch of the model. Initial distribution of modeled constituents and their temporal variation during the model stabilization period were extrapolated from study period field data.

Applied parameter concentrations are summarized in Table 2. The boundary concentrations, included in Appendix A, were taken directly from the field data taken during the 1997 survey period, with the exception of ultimate carbonaceous BOD (CBODU), which was applied as a background value of 4 mg/l. All CBOD concentrations were applied as CBODU. The CBODU values based on long-term BOD analyses, supplied by EPA, were used for the point source discharges.

Table 2 Initial and Upstream Concentrations applied to Model.

INITIAL CONCENTRATIONS		UPSTREAM CONCENTRATIONS		
		Branch 1	Branch 2	Branch 6
Constituent	**Conc. (mg/l)**	**Conc. (mg/l)**	**Conc. (mg/l)**	**Conc. (mg/l)**
Tracer	0.001	0	0	0
Salinity	Varies Longitudinally (interpolated from field data)	1	1	1
Labile and Refractory DOM	0.01	0.01	0.01	0.01
Algae	Varies Longitudinally (interpolated from field data)	0.8	0.09	0.7
Detritus	0.01	0.01	0.01	0.01
Phosphate	0.25	0.05	0.05	0.06
Ammonium	0.2	0.17	0.15	0.24
Nitrate-Nitrite	0.02	0.02	0.3	0.02
D.O.	Varies Longitudinally (interpolated from field data)	6	5	6.5
CBOD	4	4	4	4

The meteorological data applied in this model consists of air temperature, dew point temperature, wind speed and direction, and cloud cover. Wind data was gathered during the study period and was extrapolated in time for the model stabilization period. Air temperature data was obtained from NOAA information Buoy 42007 that is located 20 miles S/SE of Biloxi, Mississippi. Cloud cover data was obtained from the Leakesville weather station MS224966 for the entire simulation period.

Model Calibration

Model data as described earlier and as provided with the CE-QUAL-W2 application, was applied to simulate the hydrodynamics and water quality in the Escatawpa/Pascagoula study area for the study period September 10, 1997 through September 15, 1997. Model results were compared with field study data to facilitate calibration by changing key model parameters, boundary and initial data, and model geometry until adequate correlation with field data was attained. Details are available in Appendix A.

Existing Point Sources

Existing point sources in the study area with their permit limits are listed below:

WTF Name	Flow (mgd)	BOD5 (mg/l)	CBODU (mg/l)	Ammonia (mg/l)	NBDODU (mg/l)
International Paper	20	28	230	3.5	16.0
Escatawpa Municipal*	3.0	30	47.5	10	45.7
Zapata / Omega	8.4	20	74.0	4.0	18.3
Morton	1.0	12.3	55.4	1.0	4.6

* Escatawpa Municipal has received a flow expansion to 3.0 mgd. The allowable new BOD5 and Ammonia permit limits will be consistent with the ultimate BOD #/day final by this TMDL.

Total Maximum Daily Load (TMDL)

The TMDL analysis includes an evaluation of the relationship between the sources and the impact on the receiving water. Due to the many factors that dynamically influence in-stream dissolved oxygen concentrations within estuarine systems, this relationship was developed using a complex hydrodynamic and water quality model linkage – CE-QUAL-W2.

The Escatawpa River calibrated model for the critical condition period of September of 1997 was used for the TMDL development. This period was chosen based upon the availability of sufficient data and it was a critical summer low flow/high temperature period.

Critical Condition Determination

The determination of the critical conditions for application of the Escatawpa River W2 model was defined as the 1997 summer/fall, low flow and high temperature period. All inputs to the model do not change from the calibration except the point sources were input at their design NPDES permit conditions.

Seasonal Variation

The Clean Water Act and EPA regulations require that a TMDL be established with consideration of seasonal variations. Seasonal variation was considered through modeling under the most critical period during the year for impacts to dissolved oxygen as discussed above. Therefore, if the TMDL is protective and assures that water quality standards are met during the most critical period, the TMDL is protective of all other seasonal conditions.

Margin of Safety

The margin of safety (MOS) is part of the TMDL development process. There are two basic methods for incorporating the MOS (USEPA, 1991):

Implicitly incorporate the MOS using conservative model assumptions to develop allocations, Explicitly specify a portion of the total TMDL as the MOS; use the remainder for allocations.

A margin of safety was explicitly considered in the TMDL by incorporation into the DO target used in the TMDL.

Water Quality Target and TMDL Determination

Mississippi's water quality standards state the following criteria for measurements of dissolved oxygen with a use classification of fishing: *Numeric.* A daily average of 5.0 mg/l and no less than 4.0 mg/l at all times for waters supporting warm water species of fish. U.S. EPA guidelines supplement the Mississippi standards when naturally low dissolved oxygen conditions occur, as in the Escatawpa Estuary system. The EPA criterion provides numeric targets "Where natural conditions alone create dissolved oxygen concentrations less than 110 percent of the applicable criteria means or minima or both, the minimum acceptable concentration is 90 percent of the natural concentration."

A baseline dissolved oxygen level was determined for the Escatawpa Estuary system using the calibrated hydrodynamic and water quality model and a review of the available data, with the critical conditions described previously, and all anthropogenic point source loads removed. It was determined that the "natural" D.O. levels were between 4 mg/l and 5 mg/l. The anthropogenic impact on dissolved oxygen is 0.4 mg/l. Incorporating a margin of safety, the target DO deficit was set at 0.3 mg/l D.O. Also the DO was not allowed to go below the State standard of 3 mg/l.

Using the 1997 baseline critical condition model simulation, the point source loads were input at their total permitted load. The net water surface dissolved oxygen deficit (evaluated at a 24 hour averaging period) was less than 0.3 mg/l. Based upon this evaluation, the existing discharges at their permit loads meet the DO standard in the water surface layer.

Another reason for the stringent MOS is that the model also indicates that the lower naturally occurring anoxic zone is increased to some extent by the oxygen demanding waste. Further analyses need to be conducted to determine an appropriate water quality target and more extensive modeling using a 3 dimensional hydrodynamic and water quality model must be completed to better define the

Escatawpa River Estuary System. These analyses along with reevaluation of the MOS will be completed in phase 2 of the TMDL.

Because there is a yet undetermined impact of the point source dischargers on the lower layers, the wasteload allocation for point sources will be held at the existing NPDES permit limits.

Wasteload Allocation Determination:

The WLA due to point source oxygen demanding pollutant loading values is expressed as ultimate BOD (UBOD = CBODU plus NBODU). For the point sources discharging into and impacting the listed Segment 3 of the Escatawpa River, the WLA is 50,330 lbs/day. The existing point sources are International Paper, Escatawpa Municipal, Zapata / Omega, and Morton WTFs.

Load Allocation Determination:

The ultimate BOD coming from natural and nonpoint sources is equivalent to that measured in the 1997 survey. The LA equals 52,500 lbs/day UBOD.

TMDL

The TMDL is calculated by adding together the point source ultimate BOD in pounds per day and the nonpoint source ultimate BOD in pounds per day. The LA (52,500 lbs/days) plus WLA (50,330 lbs/day) equals the Ultimate BOD TMDL of 102,830 lbs/day.

Phased Total Maximum Daily Load (TMDL) for Fecal Coliform

Target Identification

The MDEQ summer season water quality standard for fecal coliform is a geometric mean of 200 counts per 100 ml. "For the months of May through October, when water contact recreation activities may be expected to occur, fecal coliform shall not exceed a geometric mean of 200 per 100 ml nor shall more than 10 percent of the samples examined during any month exceed 400 per 100 ml. For the months of November through April, when incidental recreational contact is not likely, fecal coliform shall not exceed a geometric mean of 2000/100 mg/l, nor shall more than ten percent of samples examined during any month exceed 4000/100 ml." State of Mississippi Water Quality Criteria for Intrastate, Interstate, and Coastal Waters - 1995.

There is limited water quality data available for the nonpoint source contributions, therefore, the water quality target for the summer period will be set at 150 counts per 100 ml for a 30 day geometric mean. This yields a margin of safety of 50 counts per 100 ml. The summer period water quality target for point source dischargers that have fecal coliform in their wastewater is 200 counts per 100 ml in their effluent discharge.

TMDL Approach

There are two sources of fecal coliform loading to the impaired segment of the Escatawpa River. One is the natural and nonpoint source of fecal being delivered to the segment from the upstream watershed and the second is the fecal coliform being discharged from the wastewater treatment facilities. Since this is an evaluated segment for fecal coliform, the watershed loading of fecal coliform or the LA had to be determined by a watershed model. The point source loadings are based on the NPDES permit limits. The critical period is the summer period and TMDL will be developed for this timeframe.

Nonpoint Source Wet Weather Fecal Coliform Determination

Watershed Nonpoint Source Model Development

The calibration of the watershed model was accomplished using BASINS 2.0 coupled with the Nonpoint Source Model (NPSM). (Huddleston 2000). The USGS flow station near Agricola, Mississippi was used for the watershed hydrodynamic model calibration. The station is located on the Escatawpa River, approximately in the center of the watershed area. Stream flow data is available from the USGS for calibration at Agricola from October 1, 1973 to the present date. The reported stream hydrograph for a representative year during the calibration period (1983). This is representative of a typical precipitation year in this study area. The wet season can be seen as being from late fall to early spring with the dry season being the summer and early autumn months. Major rainfall events are readily noted from the hydrograph, along with the extended dry period throughout the summer. Based on this calibration, flow modeling parameters were extrapolated throughout the remaining portion of the watershed for subsequent application simulations.

The weather station data used are from the Leakesville Station, Mobile WSO Airport, and the Saucier Experiment Station. There are no meteorological stations located within the upstream portion of the watershed; therefore, the data was extrapolated from the Leakesville station because of its proximity to the drainage area. Consequently, there is some variability in the results due to the spatial difference in the weather station and the drainage area.

The default landuse data was obtained from the USGS Geographic Information Retrieval and Analysis System (GIRAS) and uses the Anderson Level I and II classification systems. The GIRAS landuse data is based upon data collected by the USGS in the 1970's. MARIS land use data was imported into the BASINS system for simulation periods beyond 1990.

The stream hydrograph calculated with the calibrated NPSM model is compared with observed data. The meteorological data from the Leakesville Station was applied to all sub-watersheds in the study area.

Fecal Analysis on Escatawpa River

The watershed model calibrated for hydrologic and hydrodynamic simulation was applied to the study area to simulate fecal coliform loading in the Escatawpa River watershed. The selected simulation period extended from January 1,1990 through May 28, 1999. Simulation output was analyzed and reported on the Escatawpa River at the confluence with Black Creek, in the impaired segment. There are no reported point sources in the study area, consequently, the primary sources of fecal loads within the model are (1) cattle stream access and (2) failing septic tanks, along with wet weather runoff due to normal landuse activities. Most wet weather sources included wildlife and other farm and domestic animals but their contribution was found to be minor.

Data Assessment

The data necessary for the model input for each sub-watershed included estimates of human population, animal populations (domestic and wildlife), meteorological conditions, and land use. Data estimates were compared with other appropriate sources such as the U.S. census and similar studies along the Mississippi Gulf coast. Details of the data assessment are in Appendix A.

The data regarding human and animal population and the associated fecal production rates were converted into fecal coliform loading rates that were applied at the sub-watershed level. The calculated loading rates for the baseline scenario corresponding to the noted fifty percent septic failure rate and two per cent direct stream access for cattle

No data on fecal coliform was available for calibration (this was an evaluated listing and no monitoring data were available) within this study area. However, a similar study has recently been completed for the Wolf and Jourdan Rivers in the St. Louis Bay watershed. Consequently, significant model parameters obtained during calibration in the St. Louis Bay watershed were applied to the Escatawpa Estuary. Other important factors include the percentage of failing septic tanks, the percentage of cattle having direct stream/tributary access, the number of people served per septic tank, and the amount of cattle waste produced per day.

Values applied were:

Failing Septic Tanks	= 50%
% Cattle in Stream	= 2%
# People per septic tank	= 3
Cattle waste produced	= 46 lbs/animal/day

The septic tank failure rate was based upon personal communication with personnel from the Mississippi Department of Health pertaining to a prior similar project in south Mississippi. The cattle stream access percentage is based upon calibration values from the previously noted St. Louis Bay study and personal communication with personnel from the Mississippi Department of Agriculture and Commerce. The per capita rates and cattle fecal production rates were obtained from standard references.

Fecal Coliform Modeling Results

The calculated 30-day geometric mean of fecal coliform concentration during the ten-year modeling scenario results are presented for the previously described baseline simulation and various parametric sensitivity simulations. Calculated results indicate no violations of this standard during the ten-year modeling period for the baseline parameters of 2 % cattle stream access and 50% failing septic tanks. This calculation represents conservative modeling assumptions in that the first order decay rate is relatively low, the septic failure rate is somewhat high and the maximum computed value is approximately half the relevant standard. The resultant LA is 1720 mgd flow times a maximum of 150 mg/l counts per 100 ml or 258,000 counts per 100 ml times mgd.

Wasteload Allocation Determination:

The point source fecal coliform pollutant loading values are as follows:

WTF Name	Flow (mgd)	Fecal Coliform (Counts per 100 ml)
International Paper	20	200
Escatawpa Municipal	3.0	200
Zapata / Omega	8.4	200
Morton	1.0	200

The WLA is 32.4 mgd times 200 counts per 100 ml or 6,480 counts per 100 ml times mgd.

Fecal Coliform TMDL

The TMDL is calculated by adding together the point source fecal coliform "load" and the nonpoint sources fecal coliform "load". The LA (258,000 counts per 100 ml times mgd) plus WLA (6,480 counts per 100 ml times mgd) equals the TMDL "load" of 264,480 counts per 100 ml times mgd.

Total Maximum Daily Load (TMDL) for pH

Nonpoint Source Load Allocation Determination

EPA Region 4 and MDEQ collected pH data during an intensive survey in the spring of 1999. Continuous (every 30 minutes) pH data for a 4-day period were collected during the study at 3 locations in the Escatawpa. A summary of that pH data is provided below:

Escatawpa River Mile 7.7	Max. pH: 6.73	Ave. pH: 6.25	Min. pH: 5.98
Escatawpa River Mile 3.2	Max. pH: 7.31	Ave. pH: 6.90	Min. pH: 6.65

Escatawpa River Mile 0.5	Max. pH: 7.91	Ave. pH: 7.35	Min. pH: 6.75

Based on these data there is not a present problem or water quality standards violation due to pH in the Escatawpa River segment.

Wasteload Allocation Determination:

The point source pH requirements included in NPDES permits is "The pH shall not be less than 6.5 standard units nor greater than 9.0 standard units and shall be monitored continuously with a pH record". This permit requirement provides assurance that permitted facilities will not cause or contribute to pH impairment in the Escatawpa River.

TMDL

The TMDL is the total amount of pollutant that can be assimilated by the receiving water body while maintaining water quality standards. For some pollutants, TMDLs are expressed on a mass loading basis (e.g., pounds per day). In accordance with 40 CFR Part 130.2(i), "TMDLs can be expressed in terms of ... mass per time, toxicity, or other appropriate measure." In addition, NPDES permitting regulations in 40 CFR 122.45(f) state that "All pollutants limited in permits shall have limitations...expressed in terms of mass except...pollutants which cannot appropriately be expressed by mass." For the pH TMDL for Escatawpa River, the Total Maximum Daily Load is expressed in terms of pH units that meet the water quality standard. "The pH shall not be less than 6.5 standard units nor greater than 9.0 standard units". The margin of safety is that the TMDL is equal to the standard and seasonality is addressed in that the TMDL is effective all year long.

Phased TMDL Approach For Toxicity due to Nonpriority Organics and Total Toxics

Since there is limited data (instream toxicity testing and effluent whole effluent toxicity testing) to determine impairment status for these segments and there are no specific pollutants identified for certain key "evaluated" causes, specific pollutant TMDL development is not possible at this time. For this reason, EPA is proposing a phased approach for the toxicity TMDL development for these "evaluated" listings.

The phased TMDL approach recognizes that additional data and information may be necessary to validate the assumptions of the TMDL and to provide greater certainty that the TMDL will achieve the applicable water quality standard. Thus, Phase 1 identifies the toxicity level needed to protect the waterbody. Phase 2 identifies the data and information that needs to be collected to determine the specific toxicity causes and to develop the appropriate level of pollutant reduction. The Phase 2 TMDL will include targeted pollution allocation strategies for specific causes of impairment and a margin of safety that addresses uncertainty about the relationship between load allocations and receiving water quality.

EPA guidance states that TMDLs under the phased approach include allocations that confirm existing limits or would lead to new limits or new controls while allowing for additional data collection to more accurately determine assimilative capacities and pollution allocations. (USEPA, 1991) Therefore, no new or additional source of pollutant representative of any of the cited classes of respective impairments shall be introduced into these segments until:

- Actual impairment status is known;
- Specific pollutants causing impairment are determined; and
- The Phase 2 TMDLs are developed for individual pollutants in these segments; or
- These segments are de-listed based on the biological or toxicity/water quality monitoring to

be conducted.

Target Identification:

Waters shall be free from substances attributable to municipal, industrial, agricultural or other discharges in concentrations, which are toxic or harmful to humans, animals or aquatic life. Specific requirements for toxicity are found in Section II.9. State of Mississippi Water Quality Criteria for Intrastate, Interstate, and Coastal Waters - 1995.

Total Maximum Daily Load (TMDL) Development

The TMDL is the total amount of pollutant that can be assimilated by the receiving water body while maintaining water quality standards. For some pollutants, TMDLs are expressed on a mass loading basis (e.g., pounds per day). In accordance with 40 CFR Part 130.2(i), "TMDLs can be expressed in terms of ... mass per time, toxicity, or other appropriate measure." In addition, NPDES permitting regulations in 40 CFR 122.45(f) state that "All pollutants limited in permits shall have limitations...expressed in terms of mass except...pollutants which cannot appropriately be expressed by mass." For the toxicity TMDL for the Escatawpa River, the Total Maximum Daily Load is expressed in terms of chronic toxicity units (TU_cs).

Wasteload Allocations

This TMDL has been established to protect against chronic toxicity. Through its National Pollutant Discharge Elimination System (NPDES) permitting process, the MDEQ will determine whether any permitted dischargers to these segments of the Escatawpa River have a reasonable potential of discharging chronically toxic effluent. An allocation to an individual point source discharger does not automatically result in a permit limit or a monitoring requirement. The MDEQ NPDES permitting group will use its best professional judgment to determine whether a reasonable potential exists for these facilities to discharge chronically toxic effluent. If the NPDES permitting group determines that such a reasonable potential exists, effluent monitoring requirements or limitations will be established as appropriate.

Based on tracer modeling conducted using the CE-QUAL-W2 model the dilution in the system has been determined to be at a ratio of 100 to 20. The toxicity wasteload allocation (WLA) for any dischargers to this segment of the Escatawpa River will be determined as follows:

Toxicity from each point source = 100 / NOEC = 100 / IWC = 100 /20 = 5.0 TU

Where NOEC is the No Effect Concentration; IWC is the Instream Water Concentration and TU is Toxicity Units. Because of the uncertainty involved a margin of safety will be established and the allowable toxicity from each point source is 4.0 TU.

Load Allocations

The existing toxicity contribution to these segments of the Escatawpa River from nonpoint sources is not known. In the event that nonpoint sources are causing or contributing to the toxicity impairment of these segments of the Escatawpa River, the allocation to the point sources would remain unchanged. The toxicity associated with either the nonpoint or point sources cannot exceed 4.0 TU_c.

Margin of Safety and Seasonality

The margin of safety in this TMDL is based on a 20 percent reduction being imposed on the allowable TU for any current or new discharges. Seasonality is addressed in that these limits are applicable for the entire year.

TMDL For Toxicity due to Chlorine Toxicity

Target Identification:

Waters shall be free from substances attributable to municipal, industrial, agricultural or other discharges in concentrations, which are toxic or harmful to humans, animals or aquatic life. For chlorine the chronic criterion is 0.0075 mg/l. Specific requirements for toxicity are found in Section II.9. State of Mississippi Water Quality Criteria for Intrastate, Interstate, and Coastal

Waters - 1995.

Total Maximum Daily Load (TMDL) Development

The TMDL is the total amount of pollutant that can be assimilated by the receiving water body while maintaining water quality standards. For some pollutants, TMDLs are expressed on a mass loading basis (e.g., pounds per day). In accordance with 40 CFR Part 130.2(i), "TMDLs can be expressed in terms of ... mass per time, toxicity, or other appropriate measure." In addition, NPDES permitting regulations in 40 CFR 122.45(f) state that "All pollutants limited in permits shall have limitations...expressed in terms of mass except...pollutants which cannot appropriately be expressed by mass." Chlorine can be expressed as mass but the permit limit should be expressed in concentration.

Wasteload Allocations

This TMDL has been established to protect against chronic chlorine toxicity. Through its National Pollutant Discharge Elimination System (NPDES) permitting process, the MDEQ will determine whether any permitted dischargers to these segments of the Escatawpa River have a reasonable potential of discharging chronically toxic effluent. An allocation to an individual point source discharger does not automatically result in a permit limit or a monitoring requirement. The MDEQ NPDES permitting group will use its best professional judgment to determine whether a reasonable potential exists for these facilities to discharge chronically toxic chlorine in their effluents. If the NPDES permitting group determines that such a reasonable potential exists, effluent monitoring requirements or limitations will be established as appropriate.

Based on tracer modeling conducted using the CE-QUAL-W2 model the dilution in the system has been determined to be at 20 percent. Because of the uncertainty involved a margin of safety will be established and the allowable toxicity from each point source will use a dilution ratio of 25 percent.

Wasteload Allocation Determination:

The point source chronic chlorine pollutant loading values are as follows:

WTF Name	Flow (mgd)	Chlorine (mg/l)
International Paper	20	0.0075
Escatawpa Municipal	3.0	0.0075
Zapata / Omega	8.4	0.0075
Morton	1.0	0.0075

The chronic chlorine WLA is 2.03 lbs/day for the existing discharge permit flows.

Load Allocations

There are no known nonpoint sources of chlorine, therefore the LA will be set at zero.

Chlorine TMDL

The TMDL is calculated by adding together the point source chlorine "load" and the nonpoint sources chlorine "load". The LA of zero plus WLA (2.03 lbs/day) equals the TMDL "load" of 2.03 lbs/day for the existing discharge permit flows.

Margin of Safety and Seasonality

The margin of safety in this TMDL is setting the criteria at end of pipe assuming no mixing zone dilution. Seasonality is addressed in that these limits are applicable for the entire year.

References:

MDEQ. 1995. State of Mississippi Water Quality Criteria for Intrastate, Interstate, and Coastal Waters. Office of Pollution Control.

Sierra Club v. EPA & Hankinson USDC-ND-GA Atlanta Div. #1: 97-CV-3683

USEPA. Guidance for Water Quality-based Decisions: The TMDL Process. U.S. Environmental Protection Agency, Office of Water, Washington, D.C. EPA/440/4-91-001, April 1991.

Ambient Aquatic Life Water Quality Criteria for Dissolved Oxygen (Freshwater), EPA440/5-86-003, April 1986.

One Dimensional Model of Escatawpa River. Shindala, Zitta 1970

Huddleston, Shindala, Hashim. Department of Civil Engineering, Mississippi State University. Escatawpa Watershed Fecal Coliform Modeling White Paper. December 2000.

U.S.EPA – SESD. "Escaptawpa Riveer Water Quality Model using CE-QUAL-W2", Model Setup Notes, March 1999.

"Escatawpa River MS STORET DATA"- Excel spreadsheet created from WRDB query of STORET database. 12/27/00. Electronically stored. L:\Mississippi\Escatawpa\Leake County MS STORET DATA.xls

Lytle, Thomas F. and Julia S. "Pollutant Transport in Mississippi Sound". Gulf Coast Research Laboratory- Mississippi-Alabama Sea Grant Consortium Publication No. MASGP-82-038. July 1985.

Appendix A – White Paper Escatawpa CE-QUAL-W2 Model

Huddleston, Shindala, Kilpatrick. Department of Civil Engineering, Mississippi State University

Introduction

The purpose of this "white paper" is to serve as an interim description of the developed CEQUAL-W2 model of the Escatawpa/Pascagoula estuary enabling EPA to begin the TMDL assessment of impaired reaches of the Escatawpa system. Since EPA personnel are already familiar with the model, we will not attempt to document any of the project or model development background in this "white paper". Rather our specific objectives are to (1) describe the CEQUAL-W2 application boundary conditions, (2) document model calibration for the September 1997 field survey (3) document a set of simulations that compare model simulations of the 1997 survey period with and without active point source loadings, and (4) transfer the current CEQUAL-W2 model to EPA for further application. A comprehensive project completion report will follow prior to the June 30, 2001 extended project deadline.

CEQUAL-W2 Boundary Conditions

EPA (Deatrick) developed an initial CEQUAL-W2 model of the Escatawpa/Pascagoula system. The model described herein is fundamentally the same as that model with modifications made (1) to correct some of the segment orientations (2) to smooth the bottom bathymetry, and (3) to incorporate the Black Creek and other lateral inflows into the Escatawpa River. This facilitated more acceptable model performance by reducing model run time and improving correlation with field data. The resulting model included 6 Branches, and 7 Tributaries (point source discharges) as described in Table 1.

The Black Creek tributary is the only tributary that is not an NPDES permitted discharge. It was included in the model to improve hydrodynamic calibration. Constituent concentrations from the Escatawpa River were extrapolated to the Black Creek for modeling purposes. The Black Creek flow rate during the study period was assumed to be approximately half of the Escatawpa River base flow rate. This estimate was based upon assessment of prior field studies and was applied herein as a first approximation. All other tributary concentrations and flows that were applied to the model were taken from the 1997 survey data supplied by the USEPA.

Table 3 List of Branches and Tributaries.

Branch 1	Pascagoula River		Tributary 1	Black Creek
Branch 2	Escatawpa River		Tributary 2	I.P./Jackson County
Branch 3	I-10 Cut		Tributary 3	Zapata Haynie
Branch 4	Bayou Chemise		Tributary 4	Morton
Branch 5	Industrial Cut		Tributary 5	Escatawpa POTW
Branch 6	W. Pascagoula River		Tributary 6	Gautier WWTP
			Tributary 7	Pasc./Moss Point WWTP

Hydrodynamic Boundary Conditions

Accurate temporal and spatial boundary conditions are required for any simulation. Hydrodynamic boundary conditions imposed herein included temporal variation of downstream tidal elevation and temporal variation of inflow rates for the Escatawpa and Pascagoula branches, and each tributary. The model simulation period extended from August 1, 1997 through September 17, 1997. This encompassed the field study period of September 10, 1997 through September 15, 1997 and provided a forty-day model stabilization period. Boundary data for the model stabilization period was extrapolated from the model study period data, as appropriate.

Based upon prior modeling of the Escatawpa River (Shindala, Zitta 1980), a distributed inflow was applied along the entire length of the River. The distributed tributary flow was introduced into the model to account for the flow from small creeks, streams and lateral inflows that were neglected in the Escatawpa branch of the model. As an initial approximation, this flow rate was estimated to be equal to the base flow in the Escatawpa based upon this prior experience.

The flow rate upstream boundary conditions for the branches and the inflow rates for the distributed tributary are summarized in Table 2. The imposed inflow rates for point source discharges are summarized in Table 3. The flow introduced in Branch 2 was determined by using a flow coefficient for the Escatawpa River @ Agricola. Splitting the flow at Graham Ferry, respectively, 35% and 65% for the two branches determined the flow in the Pascagoula and West Pascagoula. The imposed downstream tidal elevation is illustrated in Figure 1 for Branch 1 (East Pascagoula) and Figure 2 for Branch 6 (West Pascagoula). Tables 2-3 and Figures 1-2 summarize the data prescribed in the relevant boundary condition files supplied as part of the application model.

Table 4 Upstream Flows and Distributed Tributary Flow.

Time	Branch 1 Flow (cms)	Branch 2 Flow (cms)	Branch 3 Flow (cms)	Distributed Tributary Br2 Flow (cms)
213	26.9	13.1	49.9	

246	26.9	13.1	49.9	10.5
247	27.4	11.5	50.8	10.5
248	26.6	10.8	49.3	10.5
249	24.9	10.5	46.2	10.5
250	24.9	10.1	46.2	10.5
251	24.3	9.8	45.1	10.5
252	24	9.5	44.5	10.5
253	24.1	9.7	44.7	10.5
254	23.3	9.5	43.3	10.5
255	23	9.1	42.7	10.5
256	23	8.9	42.7	10.5
257	23.4	8.7	43.4	10.5
258	22.7	8.6	42.1	10.5
259	22.7	8.4	42.1	10.5
260	21.5	8.3	39.9	10.5
261	21.1	8.1	39.2	10.5

Table 3 Tributary Flows input into model.

Time	Tributary 1 Flow (cms)	Tributary 2 Flow (cms)	Tributary 3 Flow (cms)	Tributary 4 Flow (cms)	Tributary 5 Flow (cms)	Tributary 6 Flow (cms)	Tributary 7 Flow (cms)
213	5.04	0.72	0.42	0.049	0.03	0.057	0.19
261	5.04	0.72	0.42	0.049	0.03	0.057	0.19

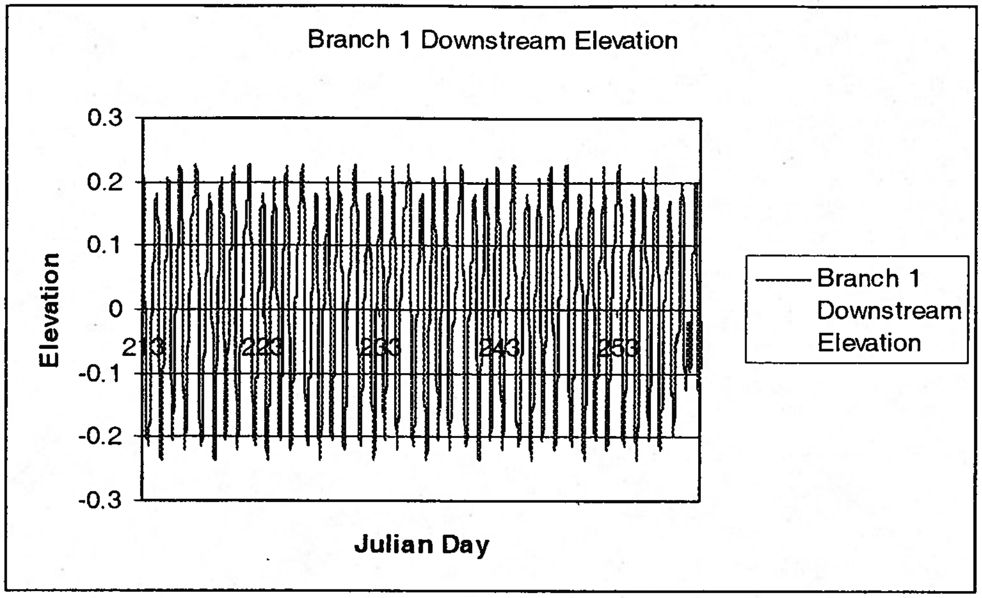

Figure 2 Branch 1 Downstream Elevation.

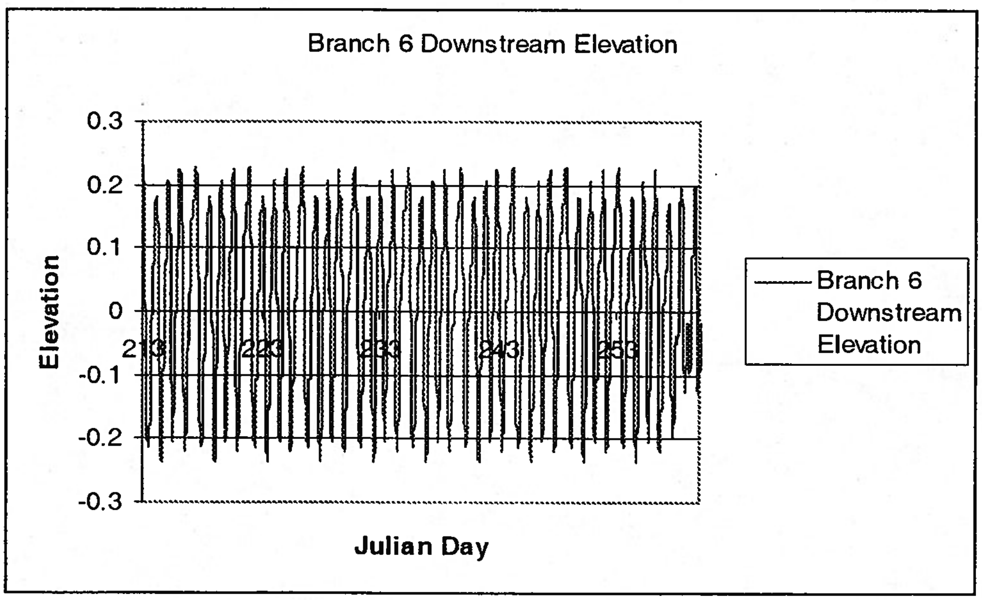

Figure 3 Branch 6 Downstream Elevation.

Initial and Boundary Concentrations

Model water quality is driven by the boundary conditions at the upstream and downstream locations, initial conditions imposed throughout the model domain, and external loads. Initial distribution of modeled constituents and their temporal variation during the model stabilization period were extrapolated from study period field data.

Applied concentrations are summarized in Table 4. The concentrations were taken directly from the field data taken during the 1997 Survey period, with the exception of CBODU, which was applied as a background value of 4 mg/l. All CBOD concentrations were applied as CBODU with the ratio of CBODU/CBOD5 set to 1 in the model. The CBODU values supplied by EPA for the point source discharges were used as input into the model. These values could not be determined directly from the long term BOD test because of the inaccuracy of the data. CBOD at the International Paper and Morton Int. discharge was determined directly from the field data, and corresponded to EPA values. The organic matter compartments (Labile DOM, Refractory DOM, and Detritus) were turned on in the model but concentrations were set to 0.01 and decay rates were set to 0.001. Per personal communication (Cole, 2000), this would enable the computation of algae. The concentration of labile DOM, refractory DOM and detritus were set to minimal values since CBOD was utilized to account for the oxygen demand of the organic matter.

Table 5 Initial and Upstream Concentrations applied to Model.

INITIAL CONCENTRATIONS		**UPSTREAM CONCENTRATIONS**		
		Branch 1	Branch 2	Branch 6
Constituent	**Conc. (mg/l)**	**Conc. (mg/l)**	**Conc. (mg/l)**	**Conc. (mg/l)**
Tracer	0.001	0	0	0
Salinity	Varies Longitudinally (interpolated from field data)	1	1	1
Labile DOM	0.01	0.01	0.01	0.01
Refractory DOM	0.01	0.01	0.01	0.01
Algae	Varies Longitudinally (interpolated from field data)	0.8	0.09	0.7
Detritus	0.01	0.01	0.01	0.01
Phosphate	0.25	0.05	0.05	0.06
Ammonium	0.2	0.17	0.15	0.24
Nitrate-Nitrite	0.02	0.02	0.3	0.02
D.O.	Varies Longitudinally (interpolated from field data)	6	5	6.5
CBOD	4	4	4	4

Table 6: Tributary and Distributed Tributary Concentrations

INFLOW TRIBUTARY CONCENTRATIONS								Distributed Tributary
	Trib 1	Trib 2	Trib 3	Trib 4	Trib 5	Trib 6	Trib 7	Branch 2
Constituent	**Conc. (mg/l)**	**Conc. (mg/l)**	**Conc. (mg/l)**	**Conc. (mg/l)**	**Conc. (mg/l)**	**Conc. (mg/l)**	**Conc. (mg/l)**	**Conc. (mg/l)**
Tracer	0	100	0	0	0	0	0	0
Salinity	0	0	0	0	0	0	0	0
Labile DOM	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Refractory DOM	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Algae	0	0	0	0	0	0	0	0
Detritus	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Phosphate	0.05	0.95	0.35	0.5	3.06	3.66	2.81	0.05
Ammonium	0.15	1.96	3.3	0.57	0.67	0.56	5.12	0.15
Nitrate-Nitrite	0.3	0.01	0.1	0.03	14	11	1.81	0.3
D.O.	5	6	6	6	6	6	6	5
CBOD	2	90	50	9	6	5.6	15.6	4

Meteorological Data

The meteorological data applied in this model consist of air temperature, dew point temperature, wind speed and direction, and cloud cover. Wind data was gathered during the study period and was extrapolated in time for the model stabilization period. Air temperature data was obtained from NOAA information Buoy 42007 that is located 20 miles S/SE of Biloxi, Mississippi. Cloud cover data was obtained from the Leakesville weather station MS224966 for the entire simulation period.

Calibration

Model data as described earlier and as provided with the CEQUAL-W2 application, was applied to simulate the hydrodynamics and water quality in the Escatawpa/Pascagoula study area for the study period September 10, 1997 through September 15, 1997. Model results were compared with field study data to facilitate calibration by changing key model parameters, boundary and initial data, and model geometry until adequate correlation with field data was attained. The maximum algae growth rate (AG), the CBOD decay rate (KBOD), and the ammonium decay rate (NH4DK) were determined to have the greatest influence on DO distribution by parametric assessment. The best data correlation was obtained with AG=1.0, KBOD=0.06 and NH4DK=0.06. All of the CEQUAL-W2 model parameters, boundary data and model geometry are defined in the associated input files.

For reasons previously discussed with the EPA, model correlation with field data was degraded for simulation of the 1999 springtime event. Hence, subsequent application of this model is expected to be limited to comparative studies for periods similar to the 1997 modeling period. Some of the figures presented compare results from the baseline model of the estuary with a modified scenario that simulates the study area with the permitted discharge facilities removed. This is done to illustrate the combined impact of these discharge facilities upon the estuary system. Alternative scenarios can easily be made by appropriate boundary condition modifications.

A series of graphs comparing computations with field data will be presented in this section to illustrate that the model is providing a reasonable simulation of the study area. Graphs of key spatial locations and snapshots in time will be presented to compare the field data with the model predictions. Time Series plots are presented to show that the model is behaving satisfactory. The field data for the time series plots is measured at a certain depth (approximately 5 ft); whereas, the model results are presented as a value averaged over the entire layer.

Longitudinal plots are presented to illustrate the change in D.O. and CBOD concentrations at the inflow of the major point sources on the Escatawpa River, which is located near Escatawpa river mile 3 and includes the following dischargers: International Paper, Zapata Haynie, and Morton International.

Figures 3-20 compare simulation results with field data throughout the modeled system at selected times where survey data was available. As can be seen the salinity profiles in the primary area of interest and water surface elevation correlates reasonably well with field data. This provides an initial level of confidence in the computational model. Note that correlation on the West Pascagoula is degraded. This is consistent with observations from the spring 1999 simulation although less pronounced.

Included in these plots are comparisons of dissolved oxygen profiles for the comparative scenarios with field data. The correlation between model results and field data in the area of interest along the Escatawpa are reasonable, in view of noted hydrodynamic deficiencies. This correlation certainly provides an adequate confidence level for drawing comparative conclusions from the model results. The improvement in the level of dissolved oxygen in the impacted area as a result of removing the discharge facilities is evident from the figures.

The time series comparisons provided at three selected locations in Figures 21-23 provide further confidence in the model results. Data at these locations was made at a specified depth of five feet. Rather than artificially smoothing computed results, these figures compare the field data with computations at model cells that bound the depth location. This provides a sense of how the model compares with data in a temporal sense as well as temporal variation of constituent with depth.

Variation of D.O. longitudinally in the Escatawpa is presented in Figures 24-25. The D.O. level in each of the four upper-most active model layers is depicted in each figure. Comparison of the two figures illustrates the D.O. deficit resulting from the discharge facilities and provides an indication of the D.O. variation with depth by comparing individual profiles on each plot. This can be shown more effectively through temporal color contours that will be included in the final report. This provides further illustration of the impact of the discharge facilities.

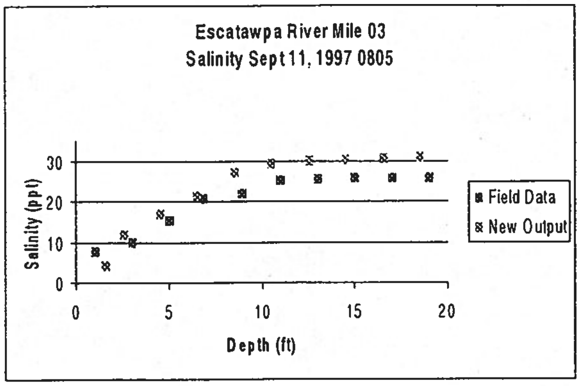

Figure 4 Salinity Comparison at E.R. 3; 9/11; 8:05am.

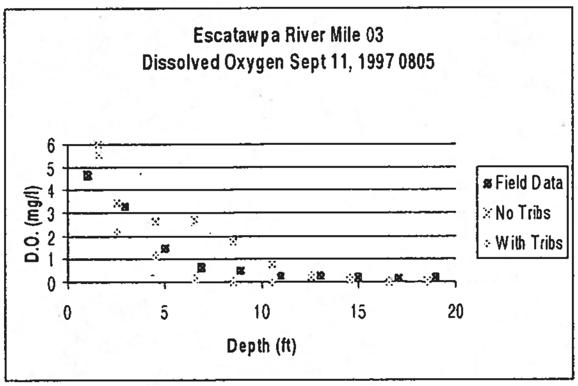

Figure 5 DO Comparison at E.R. 3; 9/11; 8:05am.

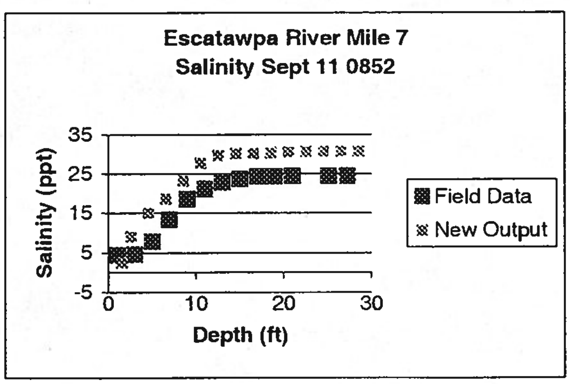

Figure 6 Salinity Comparison at E.R. 3; 9/11; 8:52am.

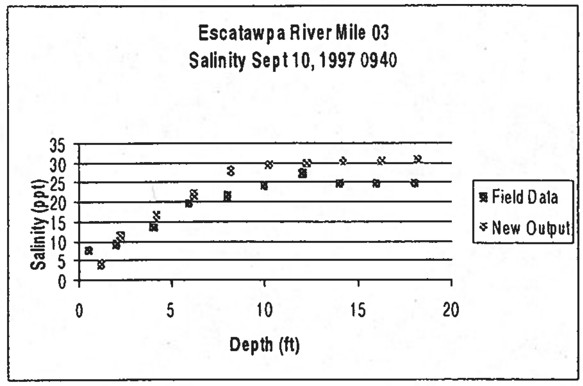

Figure 7 Salinity Comparison at E.R. 3; 9/10; 9:40am.

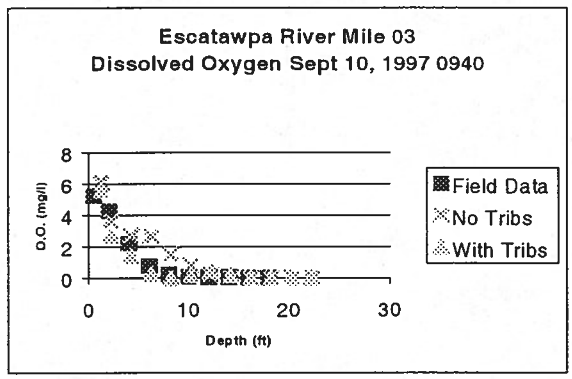

Figure 8 DO Comparison at E.R. 3; 9/10; 9:40am.

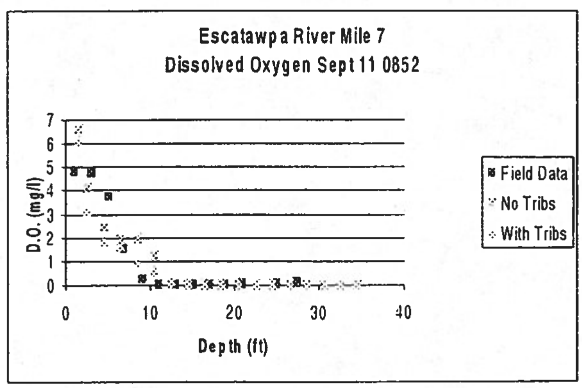

Figure 9 DO Comparison at E.R. 3; 9/11; 8:52am.

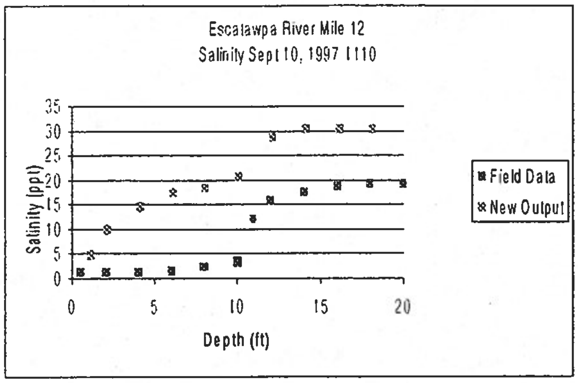

Figure 10 Salinity Comparison at E.R. 12; 9/10; 11:10am.

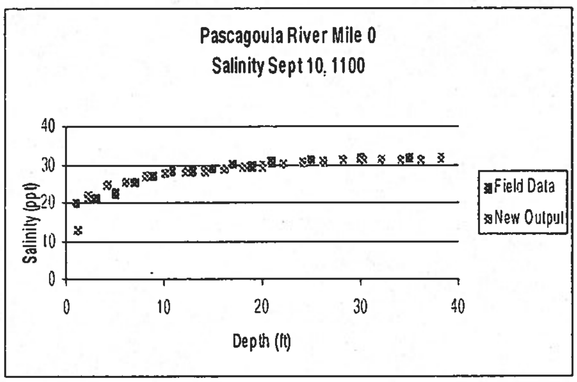

Figure 11 Salinity Comparison at P.R. 0; 9/10; 11:00am.

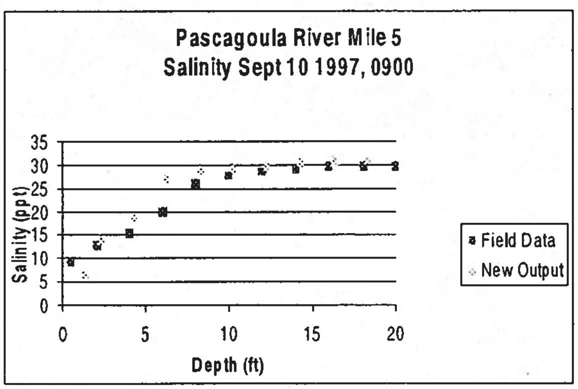

Figure 12 Salinity Comparison at P.R. 5; 9/10; 09:00am.

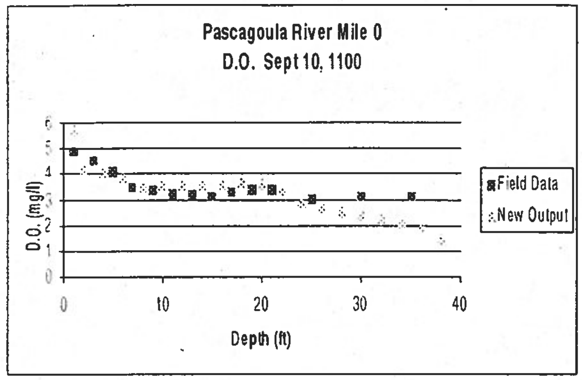

Figure 13 DOComparison at E.R. 12; 9/10; 11:10am.

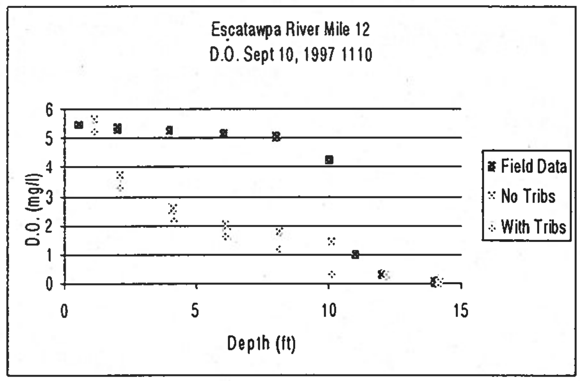

Figure 14 DO Comparison at P.R. 0; 9/10; 11:00am.

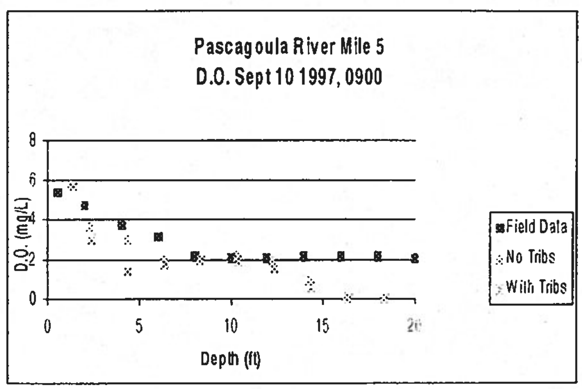

Figure 15 DO Comparison at P.R. 5; 9/10; 09:00am.

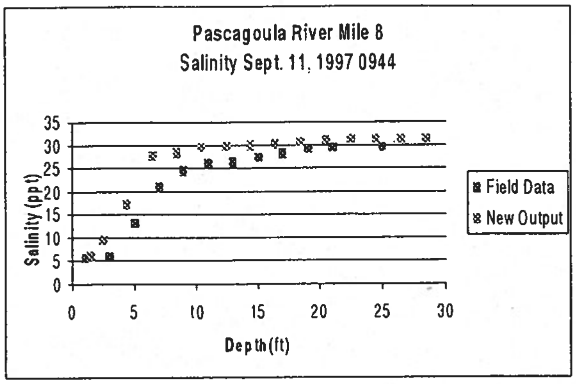

Figure 16 Salinity Comparison at P.R. 8; 9/11; 09:44am.

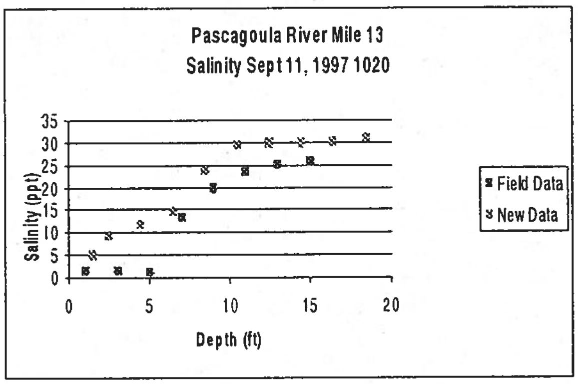

Figure 17 Salinity Comparison at P.R. 13; 9/11; 10:20am.

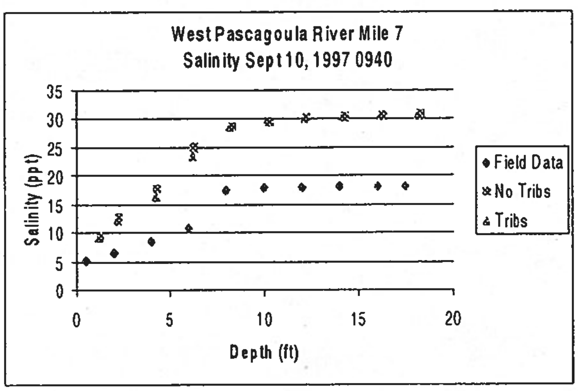

Figure 18 Salinity Comparison at P.R. 7; 9/10; 9:40am.

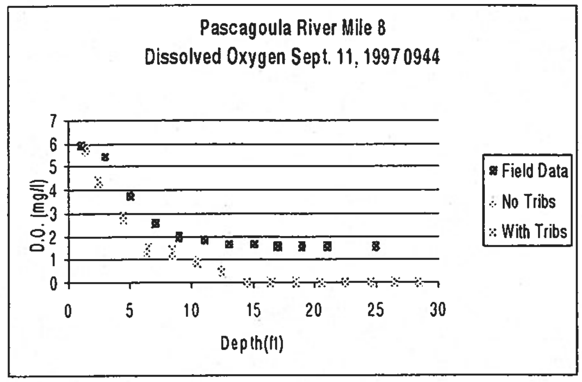

Figure 19 DO Comparison at P.R. 8; 9/11; 09:44am.

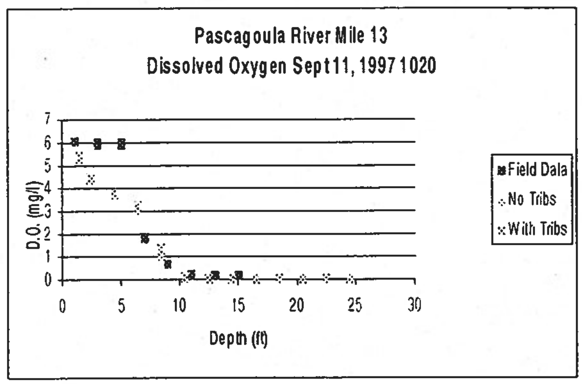

Figure 20 DO Comparison at P.R. 13; 9/11; 10:20am.

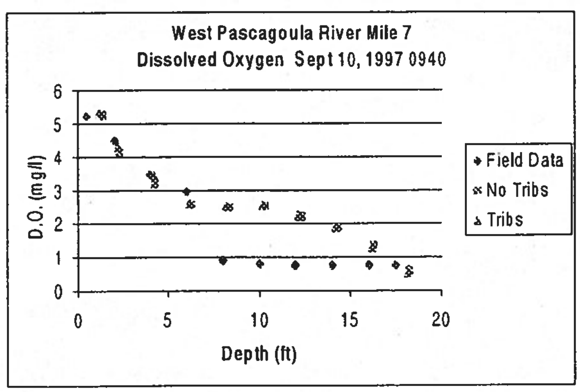

Figure 21 DOComparison at P.R. 7; 9/10; 9:40am.

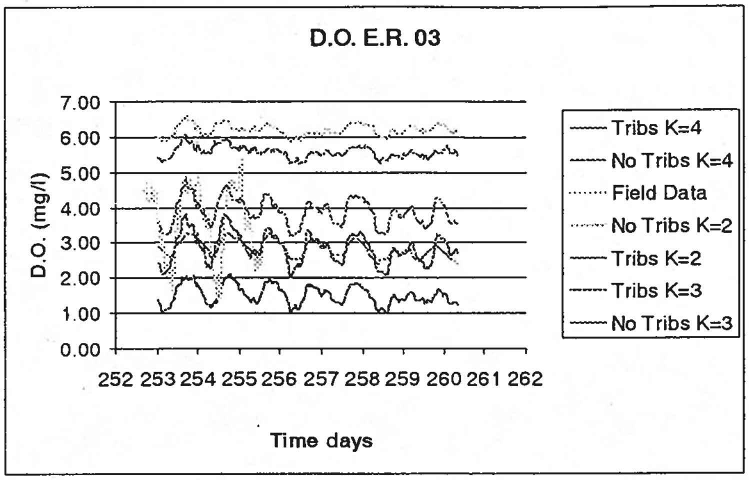

Figure 22 DO Time-series; ER 03.

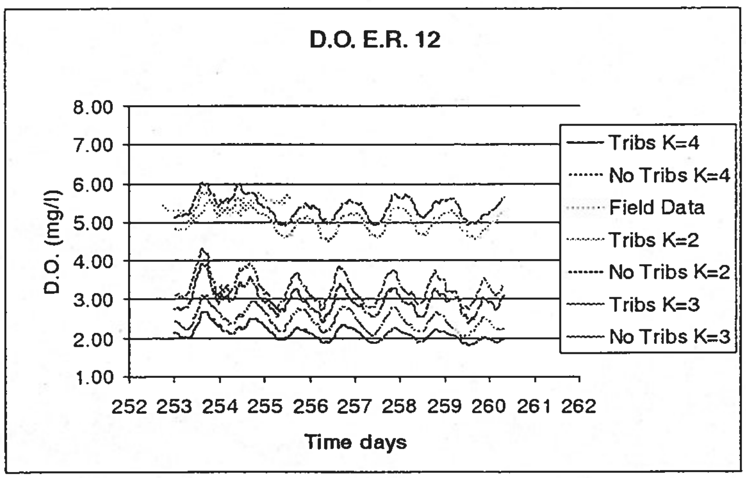

Figure 23 DO Time-series; ER 12.

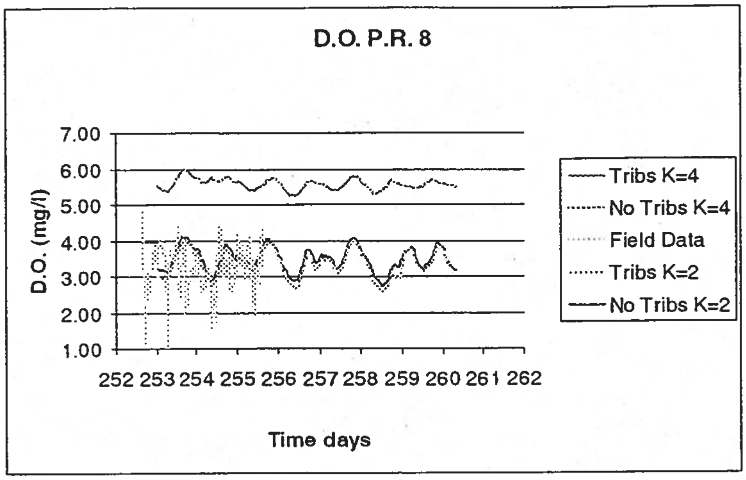

Figure 24 DO Time-series; PR 08.

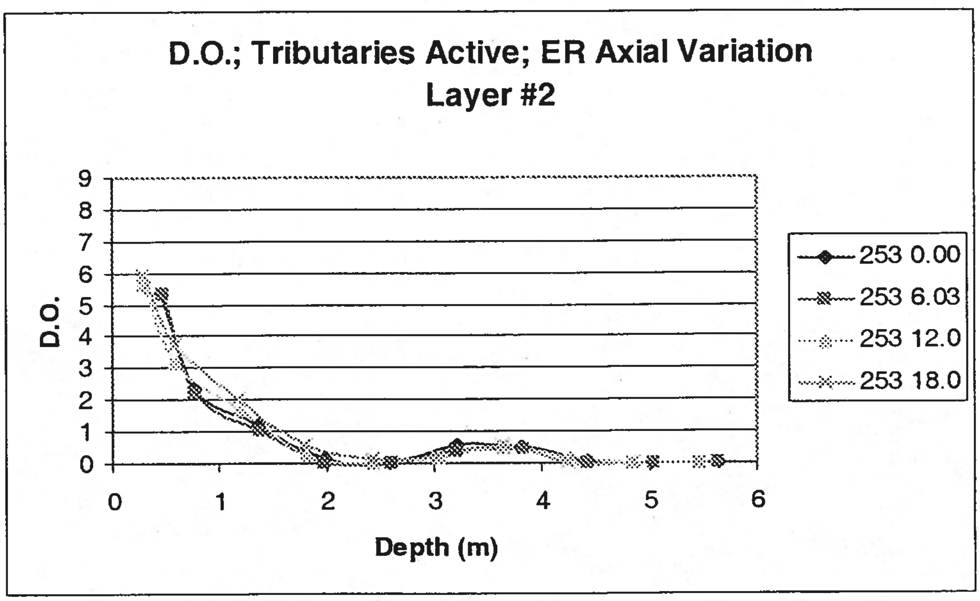

Figure 25 Escatawpa Axial DO Distribution with Tributaries Active.

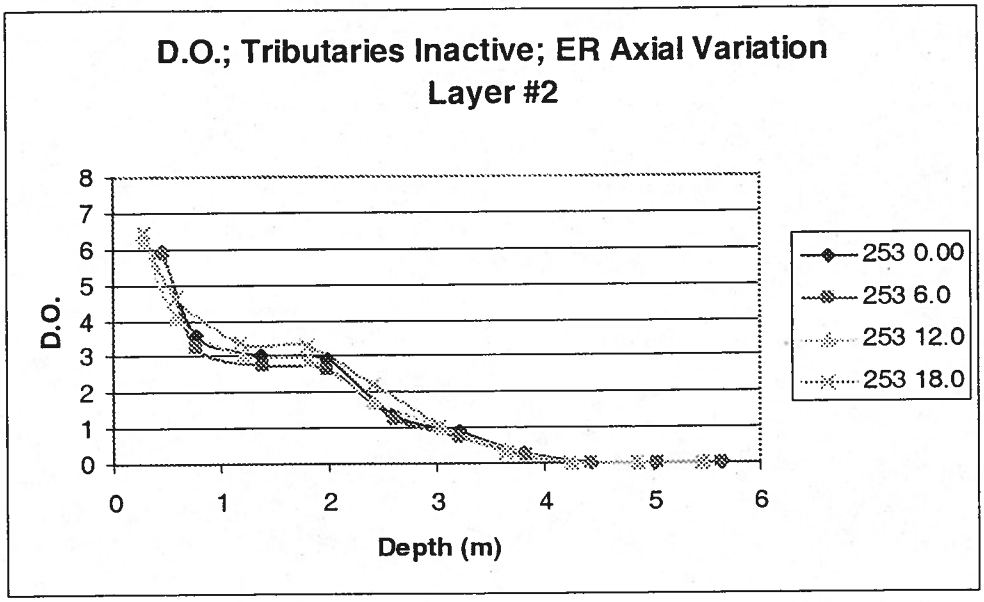

Figure 26 Escatawpa Axial DO Distribution with Tributaries Inactive.