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Water Quality Study and Plume Behavior Modeling for Lake Pontchartrain at the Mouth of the Tchefuncte River

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WATER QUALITY STUDY AND PLUME BEHAVIOR MODELING FOR LAKE PONTCHARTRAIN AT THE MOUTH OF THE TCHEFUNCTE RIVER

A Thesis

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To my beloved family and friends

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ABSTRACT

Over the last several decades, the Lake Pontchartrain Basin has been impacted by the presence of high levels of Fecal Coliform bacteria following periods of rainfall. This is a potential problem for recreational uses of the area. In 2003 a field sampling study was initiated in the north shore area of the Lake at the mouth of the Tchefuncte River. The objectives were to determine the water quality in the area and to simulate the plume patterns from the Tchefuncte River. Twenty eight stations at the mouth of the Tchefuncte River, and a station at the Madisonville Bridge were selected for study on the basis of proximity to the mouth of the River. Fecal coliform counts were found to be “wet” weather-dependent at the mouth of the River and unsuitable for primary contact recreation for at least two to three days following a rain event.

A 3-D finite volume hydrodynamics model (A coupled Hydrodynamical-Ecological Model for Regional and Shelf Seas – COHERENS) and the TECPLOT™ equation feature were used for the prediction of contaminant plumes from the Tchefuncte River into the Lake Pontchartrain. The field data were used to validate the model. The upper limits predicted by the model and those measured in the field were in good agreement. The model used river flow and tidal forcing without wind shear. The model verified that that the wet weather effect lasted for two to three-day after a high storm water discharges at the mouth of the river.

CHAPTER 1
INTRODUCTION

1.1. Thesis Overview

Clean water is essential to human life and to health of the environment. As a valuable natural resource, it comprises, marine estuarine, freshwater (river and lakes) and groundwater environments, across coastal and inland areas. Water has two attributes that are closely linked – quantity and quality. Water quality is commonly defined by its physical, chemical, biological and aesthetic characteristics.

The need for the use of water quality models has increased with the increasing demands on water systems with respect to efficiency, economics and public health reliability, and the increased complexity due to integration of different segments of water system. Field studies are essential part of calibrating and validating a numerical model.

Over the last several decades, the Lake Pontchartrain Basin, one of the largest estuarine ecosystems on the Gulf coast and one of the largest in the United States has been the object of a number of environmental modeling studies related to the decline in the basin water quality, shoreline erosion, loss of wetlands, diminished fisheries resource, closed beaches, and its substantial commercial and recreational values that have been impacted by the presence of high levels of bacteria and nutrients.

The Lake Pontchartrain is approximately 640 square miles (1660 square kilometers) in area and the average depth is 12 to 15 feet (3.6 to 4.6 meters). The lake drains a watershed of approximately 12,173 km^2 (4,700 mi^2) and it encompasses 16 parishes in southeast Louisiana. The Tchefuncte River one of the major contributing rivers to the lake (U.S. Army Corps of Engineering. 1975) is located near the center of the northern gulf coastal plain in the lower reaches of the Mississippi embayment. It rises in the southeast Louisiana and flows about 70 miles in a southerly direction entering to the lake on its north shore.

The Tchefuncte River furnishes excellent fishing, boating and other recreational activities to the communities of Madisonville and Covington, Louisiana, however the bacteriological quality of the waters is deficient according to the standards established by Louisiana Department of Environmental Quality (LDEQ), representing a high risk for habitants in the area. The fecal coliform concentration in the river has frequently exceeded the LDEQ limits for primary contact recreation coming mainly from septic tanks, and surface runoff; it moves until reach its mouth and finally the lake's waters.

Based on this, and as a part of a larger study for restoring the northshore water quality of the Lake Pontchartrain, the objective for this study includes: 1) field sampling data for fecal coliform and nutrients during dry and wet weather, required to identify the role of storm water runoff plumes in the rise of bacteria levels at the northshore and 2) A three dimensional hydrodynamic model (A Coupled Hydrodynamical-Ecological Model for Regional and Shelf Seas COHERENS), developed and calibrated for Lake Pontchartrain and specifically to this area, is used to predict the effect of the changing conditions on the biota and to simulate the pollutant input and dispersion of contaminants in the lake at the mouth of the Tchefuncte River. One of the purposes of this research is the development of methods to predict a possible health hazard during and following severe wet weather conditions.

1.2. Problem Statement

The Lake Pontchartrain has been exposed to pollution for decades and it has been unsuitable for swimming some time. High levels of microbial fecal pollutions indicators have been present on the north shore of the lake, specifically at the mouth of the Tchefuncte River, principally after periods of rainfall.

The Tchefuncte Boat Launch is an important resource for recreation, including activities such as swimming, boating, fishing and sail boarding which involve body contact with the water. The major human health concern for recreational waters is microbial contamination by bacteria. Chemical pollutants may also pose health risks, but exposure to disease-causing microorganisms from sources such as untreated or poorly treated sewage, and storm water runoff are a more urgent risk.

However, the concentration of pathogens at a specific site depends on factors such as strength of the source or sources, hydrodynamic dilution and growth or decay of pathogens between the source and the location. The growth or decay is related to the salinity, water temperature, the dissolved oxygen, and total suspended solids among some others. At this point in time, there is no definitive technique of discerning between human and animal sources.

There is a need for a method of predicting the fate of pathogens associated with wet weather runoffs from areas that may impact recreational activities and or locations. This technique should account for the microbial processes as well the hydrodynamic processes including transport and dilution.

1.3. Significance of the Research

The application of the model could be used to provide the public with information related to the water quality in the vicinity of the Tchefuncte Boat Launch. Also, it can be used as a tool to simulate other areas of the Lake Pontchartrain and to obtain information which can be used as an indicator of a possible Public Health Threat.

1.4. Objectives

1.4.1. Generals

- Characterize the water quality in the Lake Pontchartrain at the mouth of the Tchefuncte River.
- Develop a predictive model to simulate the plume patterns from the Tchefuncte River.

1.4.2. Specifics

- Collect water sampling and measure parameters such as fecal coliform, nutrients ($N\text{-}NH_3$ and $N\text{-}NO_3$), water chemistry, temperature, turbidity, pH, dissolved oxygen and total suspended solids during representative rain events and dry weather.
- Simulate the runoff plume from the Tchefuncte River.
- Determine the hydrograph of the Tchefuncte River at its mouth.
- Determine fecal coliform loading at the mouth of the Tchefuncte River.

CHAPTER 2
REVIEW OF PREVIOUS STUDIES ON LAKE PONTCHARTRAIN

Many research studies and restoration programs and projects have been implemented on Lake Pontchartrain to find technical solutions for lake's environmental problems. Modeling studies of the lake system have shown a correlation between the high bacteria levels with the corresponding precipitation.

Since 1989, the Lake Pontchartrain Basin Foundation "LPBF," (a membership-citizen's organization which is the public independent voice) has been dedicated to restoring and preserving the Lake Pontchartrain Basin. To achieve this goal, LPBF has built consensus on the environmental issues facing the Basin and developed strategies to manage and solve these problems. Through research programs, LPBF has worked with area universities to better understand these environmental problems in order to find technical solutions. The University of New Orleans (UNO), Tulane University, Louisiana Department of Health and Hospitals (LDHH) and the U.S. Geological Survey (USGS) have conducted research to build a strong technical basis for formulation of sound strategies and programs for restoration

2.1. Die-off bacteria in surface waters. [Thomann, R.V, Mueller, J.A (1987)]

When organisms enter marine or estuarine environments, their fate depends on various processes, leading to either their disappearance or an alteration in their physiological state. A number of biotic and abiotic factors influence bacterial die-off, including algae toxin, bacteriophages, nutrients, pH, predation, temperature, salinity and sunlight.

These factors may be present in varying degrees depending on the specific situation. The resultant distribution of the organism concentration will then reflect the net decay (or increase) of the organism as a function of location in the body of water. (Thomann, R.V, Mueller, J.A, 1987) Table 2.1 indicates the reported decay rates (K_B) for fecal coliforms in various water bodies.

Table 2.1: Reported Overall Decay Coefficients for Fecal Coliform

Organisms	$K_B(h^{-1})$	Remarks	Reference[a]
Fecal Coliform	1.54 – 4.58	Seawater and sunlight	1
	0.52	Sewage effluent-seawater, sunlight	2

[a]References: (1) Fujioka et al. (1981); (2) Sinton et al. (1994)

2.2. Study of Microbiological Levels in the Tchefuncte River [Barbé and Francis (1992)]

The authors conducted for Urban Waste Management & Research Center and the University of New Orleans through a cooperative agreement with the U.S EPA studied the microbial levels in the lower Tchefuncte River as a function of the river discharge during the summer season (May through October) and the winter season (November trough April). Field data for a period of 15 years (1975 through 1991) at three different locations on the Tchefuncte River showed that runoff during the winter season is greater resulting in higher fecal coliform counts in the Tchefuncte River and the Lake. Runoff usually is lower in the summer season, due to the effects of evaporation and transpiration which resulted in fecal coliform counts in the river and the lake that are lower than winter levels.

2.3. Modeling microbial levels using precipitation data and seasonal analysis [Barbé, Francis and Gunta (1999)]

The Departments of Civil & Environmental Engineering and Biological Science of the University of New Orleans presented models for estimating fecal coliform concentrations in the Bogue Falaya and Tchefuncte River as a function of basin average precipitation and using seasonal analysis. The seasonal effect was successfully applied in regression modeling of fecal coliform in the Tchefuncte River (Barbé and Francis 1992). Even though a seasonal effect was found for the Tchefuncte River, no seasonal effect was evident for the Bogue Falaya River. The authors explained this by the basin lag for each watershed. Because the Bogue Falaya River has a relatively short basin lag, the evapotranspiration and bio degradation are not significant factors in the watershed. The basin transport is governed by the precipitation which is not seasonal. The basin lag of the Tchefuncte River is long enough that the evapotranspiration is a significant factor for transport in the watershed. The transport of fecal coliform will be seasonal, since the evapotranspiration is seasonal; with greater evapotranspiration in the summer and therefore less transport and the conversely in the winter. Therefore, the result of this study showed the importance of seasonal analysis, even for adjacent watersheds.

2.4. Climatic effect on water quality evaluation [Carnelos, McCorquodale and Barbé (2001)]

The authors conducted a study on the fate of storm water run-off to describe microbial die-off from drainage canals discharging into the Lake Pontchartrain and to assess water quality near beach site areas on the southern shore of the lake that is under a swimming advisory naming fecal coliform as the causative pollutant. The storm water outfall plumes typically enter the lake with low velocities and become shore-attached with reduced dilution. Bacterial contamination was correlated to significant storm events (> 0.5 inches) at recreational sites adjacent to drainage canals initiating pumped discharges. Water quality data confirmed that dilution of the effluent from the drainage canals is low. The net dilution ratios of fecal coliforms (decay and dilution) were in the range of 1.5 to 6. In general, fecal coliform concentrations were observed to meet safe recreational use criteria within three days following the pump event. Other water quality field data also indicated typically low dilution ratios in the range of 2:1 to 6:1.

2.5. Fate of Pathogen indicators in storm water runoff [Carnelos, McCorquodale, Englande, Carnelos, Georgiou, Wang (EPA Report, 2003)]

The authors developed a forecasting system for assessing the risk level associated with recreational activities in the south shore waters after the occurrence of a stormwater pump event. A 3-D hydrodynamic and mass transport model based on a modification of the Princeton Ocean Model (Blumberg and Mellor, 1987) was developed. The high-resolution nearshore model included density currents due to temperature and salinity as well as an integrated bacteria fate/transport sub-model. The model verified a 2- to 3-day impact period associated with stormwater discharges as well as highly variable wind-driven plume migration patterns often characterized by shore reattachment as was observed in the field. Overall, the sediment portion of this study illustrated that Lake Pontchartrain sediment has the potential to allow the bacteria to survive for months in an aquatic environment, rather than days as typically measured in water. It indicates a more rapid die-off in water

2.6. Pollution Source Tracking in the Bogue Falaya/Tchefuncte River Watershed [Bourgeois-Calvin, Rheams and Dufrechou (LPBF, 2003)]

In 2002 the Lake Pontchartrain Basin Foundation (LPBF) began the Sub-Basin Pollution Source Tracking Program in response to high fecal coliform bacteria counts in north shore Rivers. The Tchefuncte watershed was targeted in 2003.

The Sub-Basin Program's methodology utilizes a multi-faceted approach to track down and correct sources of human fecal pollution. Activities include intensive water quality monitoring throughout the year, inspection of an assistance to wastewater treatment plants (WWTPs), and analysis of data through the LPBF's Geographic Information Science (GIS) Program, all covered under an EPA Quality Assurance Project Plan. Part of the Sub-Basin Program begins with LPBF performing a reconnaissance survey for fecal coliform and E. Coli on the Tchefuncte since January of the year. All sites are monitored weekly to monthly for the primary parameters of fecal coliform and E.Coli on the Tchefuncte and the secondary water physiochemical parameters of temperature, dissolved oxygen, specific conductance, pH, and turbidity. All sites are monitored from February to December of the year (Figure 2.1)

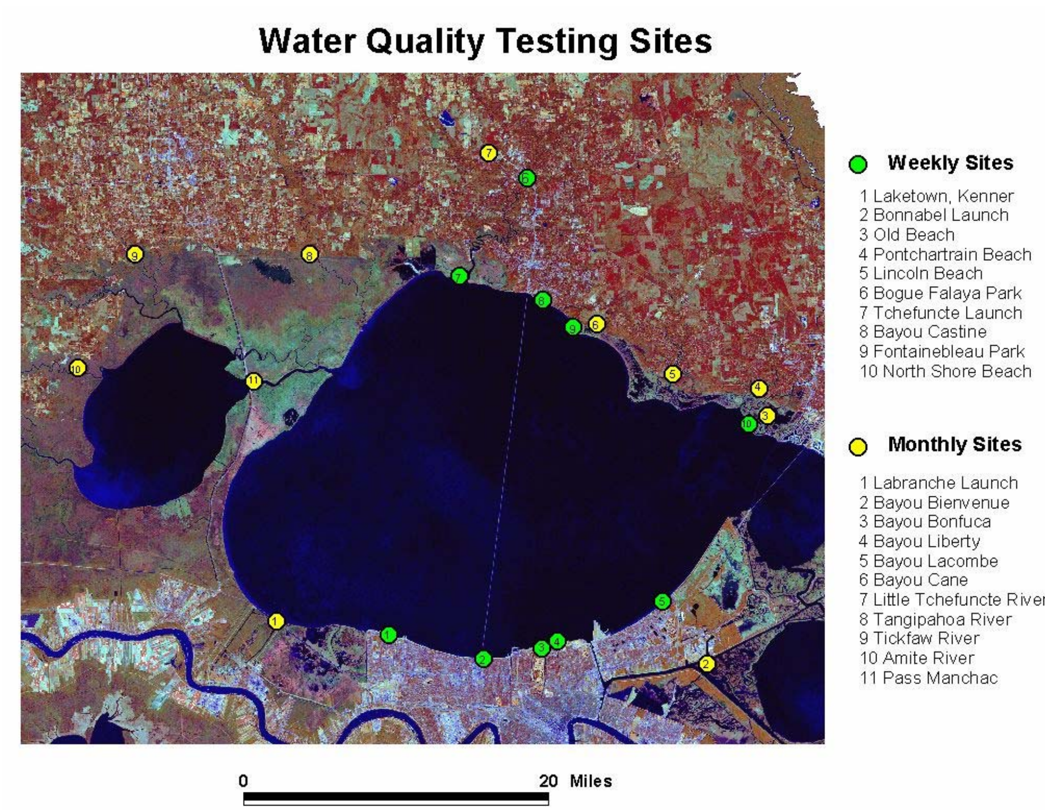

Figure 2.1: LBPF's Water Quality Testing Sites [LPBF, 2003]

On the Tchefuncte River, fecal coliform geometric means ranged from 52 (at the mouth of the river) to a high of 434 MPN, directly south of the City of Covington. Sites in the lowest portion of the river (after the confluence with the Bogue Falaya) were found to have significantly lower fecal coliform and E. Coli counts than sites higher on the river ($\alpha=0.05$, Turkey-Kramer) due to the influence of Lake Pontchartrain. Table 2.2

Table 2.2: LPBF's sampling data at the mouth of the Tchefuncte River during dates close to this survey dates.

Site	Date	Fec. Col.	Q	E.coli	Water Temp	Diss. O2	Spec. Cond.	pH	Turbidity
TFR1	6/3/2003	8	306.4725	5	30.5	8.13	1270.3	7.39	7.16
TFR1	6/16/2003	130	2814.758	78	29.9	7.23	155.2	7.02	8.17
TFR1	7/14/2003	30	1840.924	24	29.4	5.45	65.3	6.55	20.5
TFR1	7/28/2003	30	675.5132	18	30.9	5.27	189.8	6.49	19
TFR1	8/11/2003	30	380.3353	12	31.1	6.15	762	6.59	12.3
TFR1	8/25/2003	4	344.5238	4	31.7	6.38	1884.3	6.73	6.67
TFR1	9/8/2003	30	313.8863	18	30.2	5.23	2006	6.65	3.82

Water quality analyses performed on the drainages were utilized to asses input into the sub-basin. Prioritizing by fecal coliform counts, land use within the drainage basin was investigated and fecal pollution sources targeted and assisted. In 2002-2003 aided 182 WWTPs in the combined Bogue Falaya/Tchefuncte subwatershed, ranging size from 500-1.4 million gallons per day (gpd). Nearly half (48%) of the plants assisted were small, ranging 500-1000 gpd, and belonged to small business. Plants >1000 gpd accounted for 40% of plants and the last 10% of plants were septic systems, plants of unknown size, or the facilities tied in to municipal sewerage through the process. Most owners/operators suffered from a lack of education on their plant. Only a small percentage of plants, less than 10%, had to be referred to LDEQ's enforcement division due to lack of cooperation. LPBF has also partnered with the City of Covington to assist in leak detection, repair, and upgrading of the City's sewerage system.

CHAPTER 3
FIELD STUDY

The research study was directed towards sample collection and data gathering. Due to drought conditions, the numbers of planned rain event samples were not completed in 2003. However, background samplings were conducted in the vicinity of the mouth of the Tchefuncte River to determine the background source contamination levels from this tributary into Lake Pontchartrain.

A background survey was performed after three consecutive days of no-rain or insignificant precipitation (less than 0.5 in). A significant isolated rain event is defined at least 0.5 inches of rain preceded by at least 3 days of dry weather

3.1. Site Area and Sampling Locations

On the North Shore, waterways leading to Lake Pontchartrain are typically contaminated through poorly maintained septic systems, non-permitted wastewater treatment plants and agricultural run-off (Bourgeouis-Calvin et al., 2004). In fact, many of the rivers on the North Shore that drain into Lake Pontchartrain are on the "Louisiana Final 2002 Section 303 (d) List of Impaired Waters Requiring a Total Maximum Daily Load (TMDL)". These include the Tchefuncte, Bogue Falaya and Tangipahoa Rivers.

One of the major contributing rivers of Lake Pontchartrain, The Tchefuncte River is on this list for violation of Total fecal coliforms from its headwaters to its mouth and was of particular concern in this study.

The Tchefuncte River is located in the "Florida Parishes" of the southeast Louisiana. It is approximately 70 miles long and has a drainage area about 390 square miles. It discharges into and is therefore part of the drainage basin of Lake Pontchartrain.

The major tributary of the Tchefuncte River is the Bogue Falaya. It begins in Washington Parish and discharges into the Tchefuncte approximately 10 miles above Lake Pontchartrain. (Figure 3.1)

Figure 3.1: Tchefuncte River System, highlighting the Bogue Falaya subwatershed [Pontchartrain Institute for Environmental Studies, the Coastal Research Lab, Department of Geology and Geophysics College of Sciences of UNO, 2002]

Both rivers are influenced by tides in Lake Pontchartrain. The tides influence the Tchefuncte River upstream from its mouth for a distance of approximately 14 miles. Other than the reach affected by the tides, the Tchefuncte River has characteristics of a hill stream flowing through a low gently sloping rural area (U.S. Army Corps of Engineers, 1991.)

Although there are no advisories against swimming at this position, twenty eight locations at the mouth and two additional samples upstream at the Madisonville Bridge (for comparison purposes) were performed in order to obtain the following water quality parameters: fecal coliform, nutrients (N-NH_3, NO_3), Total Suspended Solids, turbidity, salinity, temperature, DO and pH.

The sampling grid covered an area of approximately 2400 m (North to South) by 6000 m (West to East), South of the mouth of the Tchefuncte River. From the shore, the first row of grid points was approximately 200 to 500 meters off shore. A distance of 1000 meters separated all of the columns. The distance between the first and second row was approximately 400 m. The distances between the second, third and fourth rows were 1000 meters, as shown in Figure 3.2

The location of the grid (Table 3.1) was based on its proximity to the mouth of the river, location pertinent to recreational impact, safety, accessibility and sample representativeness.

Table 3.1: Longitude and Latitude for all stations

Station	Longitude	Latitude
1	-90.186264	30.378704
2	-90.180267	30.378704
3	-90.174263	30.378704
4	-90.168266	30.378704
5	-90.162270	30.376301
6	-90.156265	30.373896
7	-90.150269	30.373896
8	-90.186264	30.376301
9	-90.180267	30.376301
10	-90.174263	30.376301
11	-90.168266	30.376301
12	-90.162270	30.373896
13	-90.156265	30.371490
14	-90.150269	30.371490
15	-90.186264	30.370300
16	-90.180267	30.370300
17	-90.174263	30.370300
18	-90.168266	30.370300
19	-90.162270	30.370300
20	-90.156265	30.367895
21	-90.150269	30.365490
22	-90.186264	30.364300
23	-90.180267	30.364300
24	-90.174263	30.364300
25	-90.168266	30.364300
26	-90.162270	30.361895
27	-90.156265	30.359489
28	-90.150269	30.358299
Bridge	-90.155022	30.400846
Interception	-90.116119	30.415035

To investigate the die-off rates and kinetics information for sediment samples, an *in situ* laboratory experiment investigated sediment from three stations. The justification for choosing the three locations was to evaluate various organic contents, particle size distributions, and nutrient contents that may influence die-off of indicator bacteria. The three sediment locations also represent the path of bacterial pathogens as they exit the Tchefuncte River following a rain event, enter the water column, and potentially contaminate the recreational areas. A recreational beach station was used at the mouth of the Tchefuncte River, a river station was chosen at the mouth, and Station 5 within the lake was used (Englande et al., 2004). The stations are labeled and indicated by the colored dots on Figure 3.2.

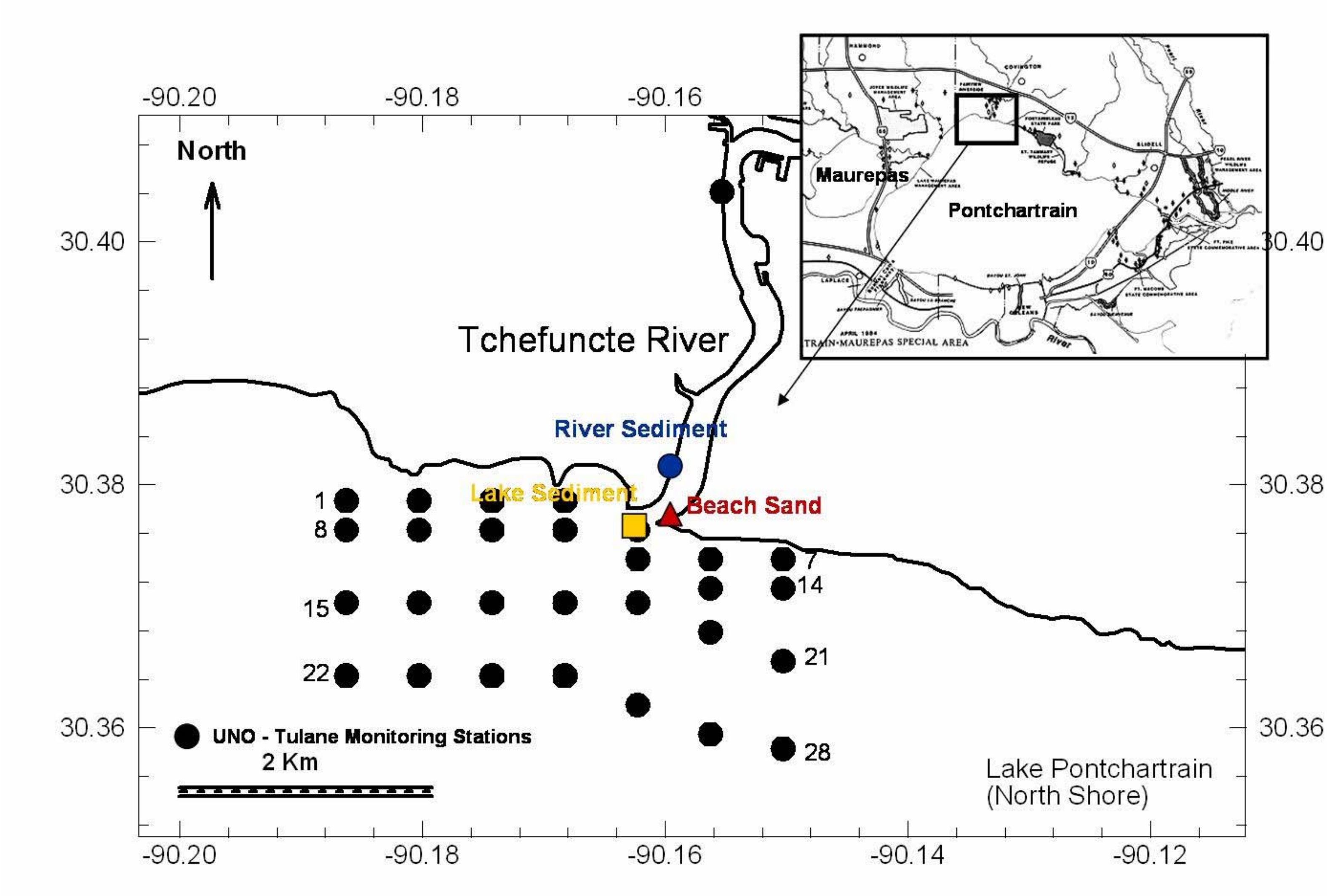

Figure 3.2: Quality Monitoring Stations and Location of Study Area

3.2. Water Quality Criteria

The Louisiana DEQ 2000 surface water quality standards (LDEQ, 2000) set target levels in two sections; general and numerical. General criteria are more qualitative and numerical more quantitative. There are numerical criteria for many compounds and material that are not being investigated in this study so they will not be stated here. The original document can be sourced for those values. All of these standards come into effect only when violations are caused by human activities; they do no apply when violations are "natural" state of the reach.

3.2.1. General Criteria

Aesthetically, there can be no deposits, floating matter, bad odor, bad taste, turbidity, toxicity or anything added to the water to encourage pest species to become established.

3.2.2. Numerical Criteria

Specific numerical limits are set to the following parameters, and differ from standards for other rivers due to the scenic status of the area:

- Bacterial (such as fecal coliforms) criteria are assigned according to the primary contact recreation designated use of the river. Measured in most probable number (MPN), the criteria differ for May 1 through October 31, and from November 1 through April 30.
    - May-Oct: MPN shall not exceed a log mean of 200/100mL (using at least 5 samples within 30 days) or 400/100mL for 10% or monthly or 25% of total annual samples.
    - Nov-April: follow secondary contact criteria of 1000/100mL and 2000/100ML respectively as above.
- Allowable pH range is from 6 to 8.5 unless it is natural.
- Turbidity cannot exceed 50 when measured as nephelometric turbidity unit (NTU)
- Dissolved oxygen must measure at least 4 mg/L.

- Temperature must not exceed 30ºC, except during unseasonably high temperatures. In fresh water, an increase of 2.8ºC over ambient allowable for rivers and streams, and an increase of 1.7ºC for lakes.
- Total dissolved solids 2 – 20 mg/L for lakes or streams
- NH_3 and NO_3 must not exceed 1 mg/L for lakes or streams.

3.3. Field Sampling Schedule

June 7th 2003 was the beginning of the field sampling. During the field work, readings such as Temperature, Dissolved Oxygen, Salinity and Secchi Disk and sediment samples were collected at the different locations.

The rainfall information was measured in real-time and reported on the following United States Geologic Survey website: http://waterdata.usgs.gov/nwis/rt. The USGS 07375050 site used is located at the Hwy 190 Bridge over the Tchefuncte River near Covington, LA. Four background surveys and two rain events were performed on the following dates:

Table 3.2: Water Quality Monitoring dates during the survey period

DATE	EVENT
6/7/2003	Background 1
7/12/2003	Background 2
8/4/2003	Background 3
9/5/2003	Background 4 & Day 1 Rain Event 1
9/7/2003	Day 2 Rain Event 1
9/7/2003	Day 3 Rain Event 1
4/27/2004	Day 1 Rain Event 2
4/28/2004	Day 2 Rain Event 2

3.4. Sample Collections and Analysis Methods

Equipped with GPS tools, secchi disk transparency, conductivity, salinity, dissolved oxygen and temperature were measured in-situ. Samples for pH, salinity and turbidity measurements were put on ice, transported, and analyzed at the Tulane laboratories. All measurements and samples were taken approximately one to two feet from the water surface. Sample containers consisted 500 ml Nalgene® bottles, which were properly labeled and in compliance with chain-of-custody requirements. A summary of wet chemistry methods employed is presented in Table 3.3.

Table 3.3: Summary on Wet Chemistry Analysis

Parameter	**Method**	**Equipment**
Dissolved Oxygen	Standard Methods for Examination of Water and Wastewater, 18th edition, Method 4500-OG	YSI 55 Dissolved Oxygen Meter, 0-20 mg/l ±0.3 mg/l accuracy
pH	Standard Methods for Examination of Water and Wastewater, 18th edition, Method 4500-H^+	Orion combination pH electrode BNC model H-05711-41 and Orion EA 940 ion analyzer, ±0.2 pH units accuracy
Secchi Disk Transparency	Preisendorfer 1986	LaMotte Secchi Disc, sounding lead and Calibrated line
Turbidity	Standard Methods for Examination of Water and Wastewater, 18th edition, Method 2130B	LaMotte Digital Turbidity Meter Model 2008, 0.2% accuracy or ±0.05 NTU's
Salinity	Standard Methods for Examination of Water and Wastewater, 18th edition, Method 2520B	YSI 30 Portable Conductivity Meter, 0 – 80 ppt with 1.0% accuracy (full scale)
Conductivity	Standard Methods for Examination of Water and Wastewater, 18th edition, Method 2510B	YSI 30 Portable Conductivity Meter, 0–4,999μS/cm, ±0.5% accuracy (full scale)
Rain intensity	NA	U.S Geological Survey site
Rain quantity	NA	U.S Geological Survey site

Figure 3.3: Sampling Collection and Field readings such as Secchi disk, DO, temperature and salinity

Samples for nutrients as NH_3-N, NO_3-N and total suspended solids (TSS) were put on ice, transported, and analyzed at the Environmental Chemistry Laboratory at UNO.

Nutrients and Total Suspended Solids analysis were performed according to Standard Methods for the Examination of Water and Wastewater, 20th Edition (APHA, 1998) and are listed as follows:

- Nitrogen as Nitrate (NO_3) was measured using the method 8192 from the Hach DR/2000 Direct Reading Spectrophotometer Manual, which is adapted from the standard Method for the Examination of Water and Wastewater (Method 4500-NO_3^- E) Cadmium Reduction Method;
- Nitrogen as Ammonia (NH_3 was measured using the method 8038 from the Hach DR/2000 Direct Reading Spectrophotometer Manual, which is adapted from the standard Method for the Examination of Water and Wastewater (Method 4500-NH_3 E) Phenate Method;

Figure 3.4: Total N as NO_3 Cadmium Reduction Method

- TSS, Filtration-Evaporation-Drying-Gravimetric Method (Method 2540 B)

Microbiological sample volumes of slightly over 100ml were placed immediately in a rubber-coated rack located within ice chest containing ice. Care was taken no to allow samples to come in direct contact with ice.

The Tulane University School of Public Health and Tropical Medicine in New Orleans provided the Microbiology Laboratory for this study; the methods used are showed in Appendix A.

The rainfall data was collected through the United States Geological Survey website (www.usgs.gov). The USGS station is located in St. Tammany Parish on the Highway 190 Bridge over the Tchefuncte River at Latitude 30°29'40" and Longitude 90°10'10". The station is northwest of the town of Covington, Louisiana. Precipitation, discharge and gage height data are collected in real-time and can be viewed on the USGS website.

Table 3.4: Rainfall Data during the survey

Date	Event Day	Day of Sample Collection	Rainfall (inches)
6/7/2003	Background 1		1.24 *
7/12/2003	Background 2		0
8/4/2003	Background 3		0
9/4/03	Day 0		0.9
9/5/2003	Day 1	1 (Background #4)	NO RAIN (0)
9/6/2003	Day 2		NO RAIN (0)
9/7/2003	Day 3	2 RAIN EVENT 1 SAMPLING	NO RAIN (0)
9/8/2003	Day 4		NO RAIN (0)
9/9/2003	Day 5	3 RAIN EVENT 1 SAMPLING	NO RAIN (0)
4/25/2004	Day 0		1.1
4/26/2004	Day 1		NO RAIN (0)
4/27/2004	Day 2	1 RAIN EVENT 2 SAMPLING	NO RAIN (0)
4/28/2004	Day 3	2 RAIN EVENT 2 SAMPLING	NO RAIN (0)

* Rain Event occurred after the sampling

CHAPTER 4
ANALYSIS OF FIELD DATA

4.1. Hydrologic Study

4.1.1. Precipitation

The average annual precipitation in the area of study is approximately 50.63 inches, compared to the normal value of 55.8 in [St. Tammany Parish Health Profile, 1996]. An accumulated precipitation of 33.58 inches was reached during the 2003 period of study (June 7th to September 9th). The precipitation reading during the events performed during this study are displayed in the Table 4.1. All raw data are located in Appendix A

Table 4.1: Summary of Rainfall and Flow during the sampling events

Date	Event Day	Day of Sample Collection	Rainfall (inches)**	Tchefuncte Discharge (cfs) **
6/7/2003	Background 1		1.24 *	295
7/12/2003	Background 2		0	1457
8/4/2003	Background 3		0	713
9/4/03	Day 0		0.9	393
9/5/2003	Day 1	1 (Background 4)	NO RAIN (0)	426
9/6/2003	Day 2		NO RAIN (0)	345
9/7/2003	Day 3	2 RAIN EVENT 1	NO RAIN (0)	330
9/8/2003	Day 4		NO RAIN (0)	314
9/9/2003	Day 5	3 RAIN EVENT 1	NO RAIN (0)	307
4/25/2004	Day 0		1.1	
4/26/2004	Day 1		NO RAIN (0)	NA
4/27/2004	Day 2	1 RAIN EVENT 2	NO RAIN (0)	NA
4/28/2004	Day 3	2 RAIN EVENT 2	NO RAIN (0)	NA

* Rain Event occurred after the sampling

** Data provided by USGS

NA= Flow at the Station 07375050 not available any more by USGS, during 2004

4.1.2 Stream Gage Stations

There are three gage stations in the Watershed which were relevant in the study, all of them maintained by the USGS. They are presented by Table 4.2 and illustrated by Figure 4.1.

Table 4.2: United States Geological Survey Stations

Gage #	Gage Name
USGS 07375050	**Tchefuncte River near Covington, LA**
USGS 07375000	**Tchefuncte River near Folsom, LA**
USGS 07375500	**Tangipahoa River at Robert, LA**

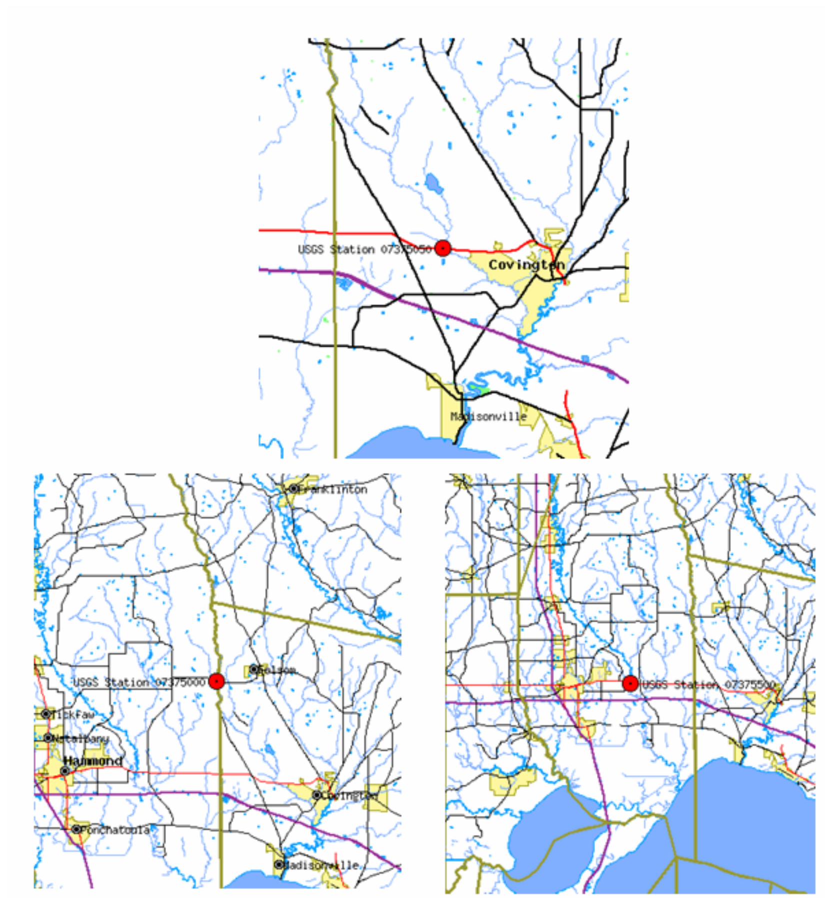

Figure 4.1: United States Geological Survey Stations 07375050, Tchefuncte River near Covington, 07375000, Tchefuncte River near Folsom and 07375500, Tangipahoa River at Robert, respectively [USGS website: http://waterdata.usgs.gov/la]

Stream Flow and Stage monitoring stations are located at Folsom and Covington on the Tchefuncte River. A regional flow analysis approach was used to estimate the flow in the Bogue Falaya and at the Lake Pontchartrain outfall of the combined rivers. The hydrologic data from the adjacent Tangipahoa River were used in the regional analysis. The drainage areas and the mean daily flows for the individual subareas are given in Table 4.3.

Table 4.3: Drainage areas from the rivers used in the Regional Analysis of Flows for North Shore Tributaries

	DRAINAGE AREA mi^2	DRAINAGE AREA ft^2	DISCHARGE cfs
FOLSUM	95.5	2,662,387,200.00	133.7976218
COVINGTON	145	4,042,368,000.00	149.5884175
TANGIPAHOA	646	18,009,446,400.00	1095.168559
∑	886.5		

The flow area relationship was:

(Flow in cubic feet per second)= 0.22 (Drainage Area in square miles) $^{0.5}$ (Eq.4.1)

A correlation for the flow at the mouth of the Tchefuncte was developed using flow from the Covington gauge by watershed analysis. Figure 4.2 shows the Flow Area curve. Figure 4.3 shows the extrapolated flow record of the Tchefuncte River at Lake Pontchartrain, Covington and Folsum for the 2003 period of the field survey.

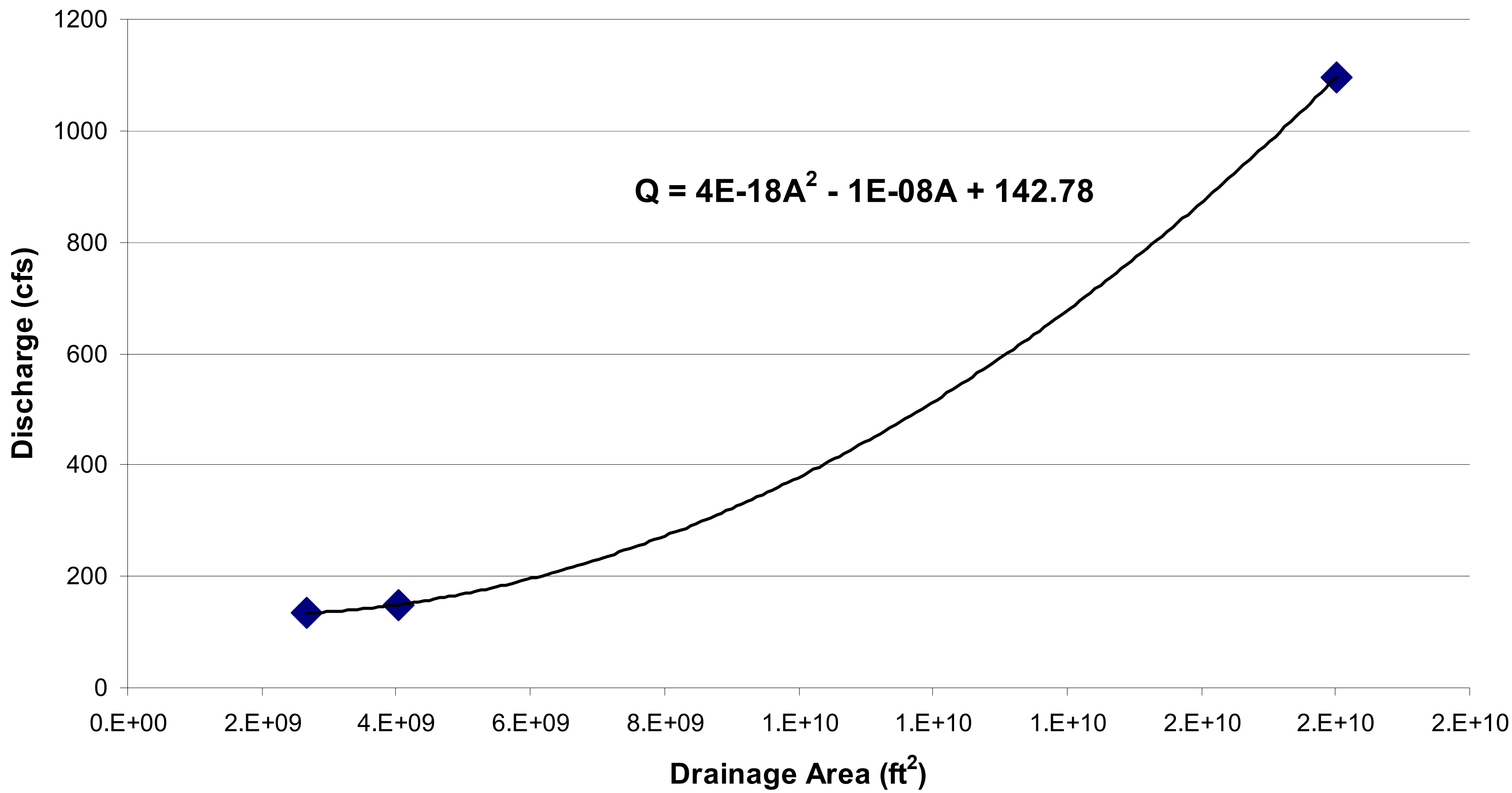

Figure 4.2: Regional Analysis of Flows for North Shore Tributaries (Discharge – Area Curve)

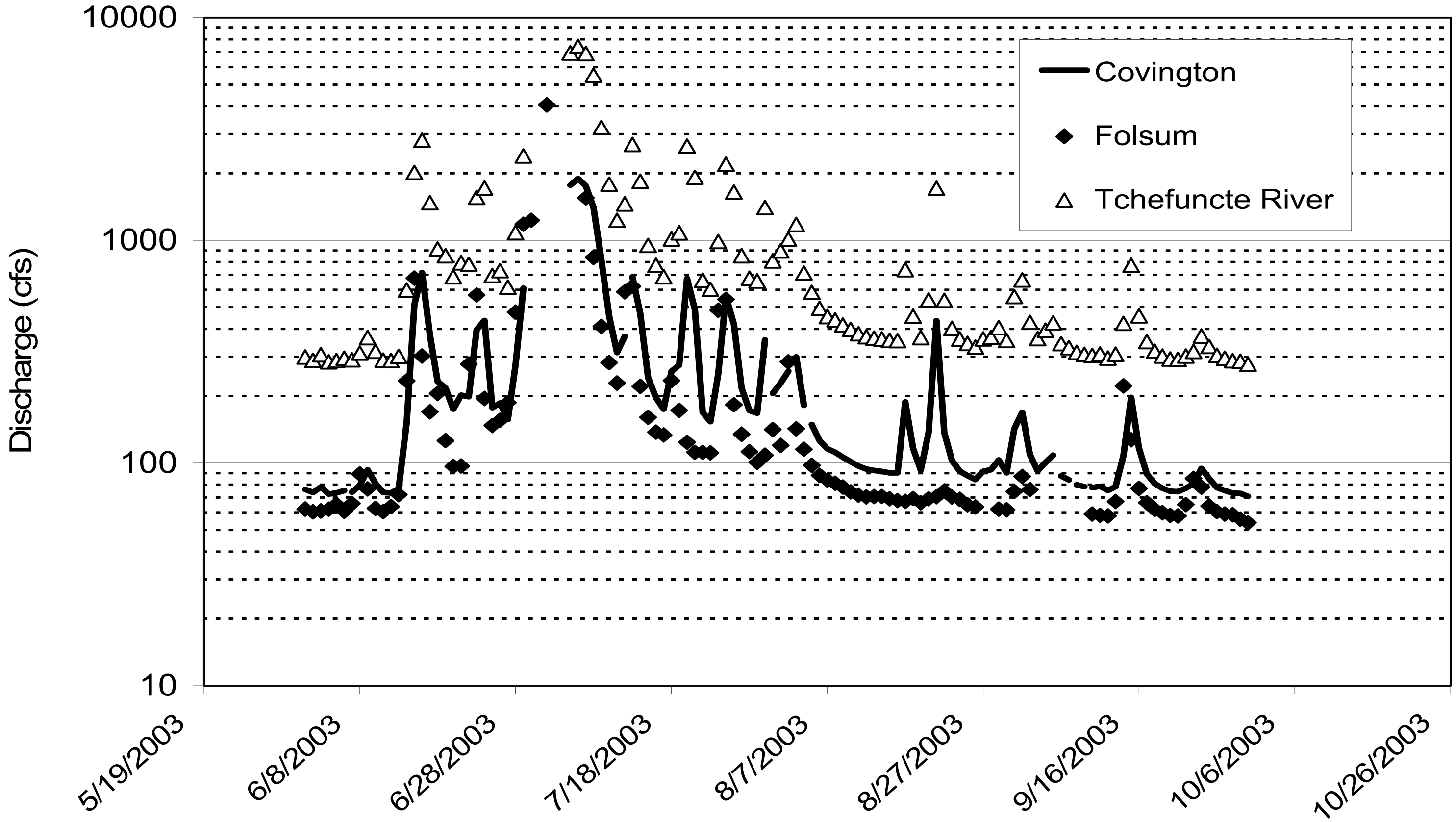

Figure 4.3: Daily Flows in the Tchefuncte River at Lake Pontchartrain during 2003 Period.

4.2. Lake Background Water Quality

Background samples were taken on the lake when there had been no rain the three consecutive days prior to the sampling day. These samples were representative of the conditions in the lake under dry conditions. In 2003, Background samplings were collected and analyzed on June 7, July 12, August 4 and September 5. No background samples were collected in 2004.

The YSI 85 probe was not functioning properly in the field during the second background survey (July 12). Therefore, the data were rejected: Dissolved oxygen, Salinity, Conductivity, Specific Conductivity and Temperature.

Nutrient analysis: Nitrogen as Ammonia and Nitrogen as Nitrate were performing for the samples collection on July 12, August 4, and September 5.

The data collected are summarized in Table 4.4 below. All raw data are located in Appendix B.

Table 4.4: Summary of Background Surveys

Event	Parameters	Mean	Median	Min	Max
Background #1	Dissolved Oxygen (mg/L)	7.80	7.85	6.47	9.00
	Temperature (ºC)	28.27	28.20	27.80	28.80
	Salinity (ppt)	1.01	1.00	0.70	1.40
	Conductivity (uS/cm)	2122.00	2132.00	1433.00	2835.00
	Specific Conductivity (uS/cm)	2007.20	2040.50	1344.00	2680.00
	Secchi Disk (ft)	2.29	2.29	1.50	3.00
	pH	6.90	6.90	6.70	7.20
	Turbidity (NTU)	11.30	11.56	5.94	18.61
	Fecal Coliform (MPN/100)	<63.4	17.00	<2	280

Table 4.4: Summary of Background Surveys (cont)

Event	Parameters	Mean	Median	Min	Max
Background #2	Dissolved Oxygen (mg/L)	YSI	YSI	YSI	YSI
	Temperature (ºC)	YSI	YSI	YSI	YSI
	Salinity (ppt)	YSI	YSI	YSI	YSI
	Conductivity (uS/cm)	YSI	YSI	YSI	YSI
	Specific Conductivity (uS/cm)	YSI	YSI	YSI	YSI
	Secchi Disk (ft)	2.14	2.00	1.00	3.00
	pH	7.50	7.60	7.00	7.80
	Turbidity (NTU)	9.62	9.43	6.95	13.30
	Fecal Coliform (MPN/100)	QA/QC	QA/QC	QA/QC	QA/QC
	N as Ammonia (mg/L)	0.05	0.03	0.01	0.12
	N as Nitrate (mg/L)	0.03	0.01	0.00	0.12
	Total Suspended Solids (mg/L)	10.48	10.00	1.00	26.00
Background #3	Dissolved Oxygen (mg/L)	6.76	7.07	4.12	8.54
	Temperature (ºC)	30.42	30.55	27.10	31.70
	Salinity (ppt)	0.42	0.50	0.00	0.70
	Conductivity (uS/cm)	958.00	1053.00	41.00	1487.00
	Specific Conductivity (uS/cm)	862.10	944.50	39.00	1337.00
	Secchi Disk (ft)	1.39	1.33	0.50	2.33
	pH	6.90	6.90	6.30	7.50
	Turbidity (NTU)	17.71	17.05	11.22	26.20
	Fecal Coliform (MPN/100)	QA/QC	QA/QC	QA/QC	QA/QC
	N as Ammonia (mg/L)	0.04	0.04	0.01	0.06
	N as Nitrate (mg/L)	0.05	0.04	0.02	0.09
	Total Suspended Solids (mg/L)				
Background #4	Dissolved Oxygen (mg/L)	5.98	6.07	3.95	7.38
	Temperature (ºC)	29.63	29.70	28.70	30.30
	Salinity (ppt)	1.77	1.60	0.30	3.40
	Conductivity (uS/cm)	3625.00	3787.00	668.00	4445.00
	Specific Conductivity (uS/cm)	3336.40	3472.00	617.00	4345.00
	Secchi Disk (ft)	6.04	6.00	2.75	10.50
	pH	6.90	6.90	6.70	7.00
	Turbidity (NTU)	4.01	3.56	1.33	10.12
	Fecal Coliform (MPN/100)	<9.8	<2	<2	170.00
	N as Ammonia (mg/L)	0.01	0.01	0.00	0.05
	N as Nitrate (mg/L)	0.03	0.03	0.00	0.06
	Total Suspended Solids (mg/L)	20.07	18.50	2.00	57.00

YSI = YSI 85 Probe was not functioning properly in the field
QA/QC = The QA/QC organisms indicated a problem with the procedure

4.2.1 Dissolved Oxygen

According to the Louisiana Department of Environmental Quality, the dissolved oxygen concentrations in estuarine waters shall not be less than 4 mg/L.

Naturally occurring variations below the criterion specified may occur for short periods. These variations reflect such natural phenomena as the reduction in photosynthetic activity and oxygen production by plants during hours of darkness. However, no waste discharge or human activity shall lower the DO concentration below the specified minimum. These DO criteria are designed to protect indigenous wildlife and aquatic life species associated with the aquatic environment (LDEQ, 2000).

The DO values for the Madisonville Bridge samples were typically the lowest values recorded each day of sampling (Background mean: 4.04 and 5.60 mg/L (or 52.% and 75% of the saturation value). This indicates that the health of the Tchefuncte River was poor which also affected the status of the lake waters at the mouth of the river.

The mean DO values decreased from June to September. The mean DO value for the 7^{th} of June was 7.80 mg/L (or 102%); while the mean DO value for the 5^{th} of September was 5.98 mg/L (80 %). This information is also provided in Appendix B

4.2.2 Temperature

The temperature of the water is important as it exerts a major influence on the biological activity and growth of aquatic organisms from bacteria to bacteria. Temperature is also important because of its influence on water chemistry. The rate of chemical reactions generally increases at higher temperature, which in turn affects biological activity. An important example of the effects of temperature on water chemistry is its impact on oxygen. Warm water holds less oxygen than cool water, so it may be saturated with oxygen but still not contain enough for survival of aquatic life.

Some compounds are also more toxic to aquatic life at higher temperatures. Temperature is reported in degrees Celsius (^{o}C). Un-ionized ammonia increments with temperature, becoming toxic to both plants and animals.

The mean temperature peaked in August with an average temperature of 30.42°C on August 4th. The mean temperature at the Bridge 1 and Station 5 had the two lowest means, as was expected since the river water was cooler than lake water. Otherwise, no obvious trend in water temperature was revealed, the mean temperature during the all background surveys was 29.44°C. Figure 4.4

There was a remarkable difference in measurement between Bridge 1 and 2. Bridge 1 was typically taken early in the morning around 7:30 am, while Bridge 2 was taken at about noon. The average temperature at Bridge 1 was 27.9°C and at Bridge 2 was 29.85°C. The influence of solar energy to heat the top layer of the water is evident.

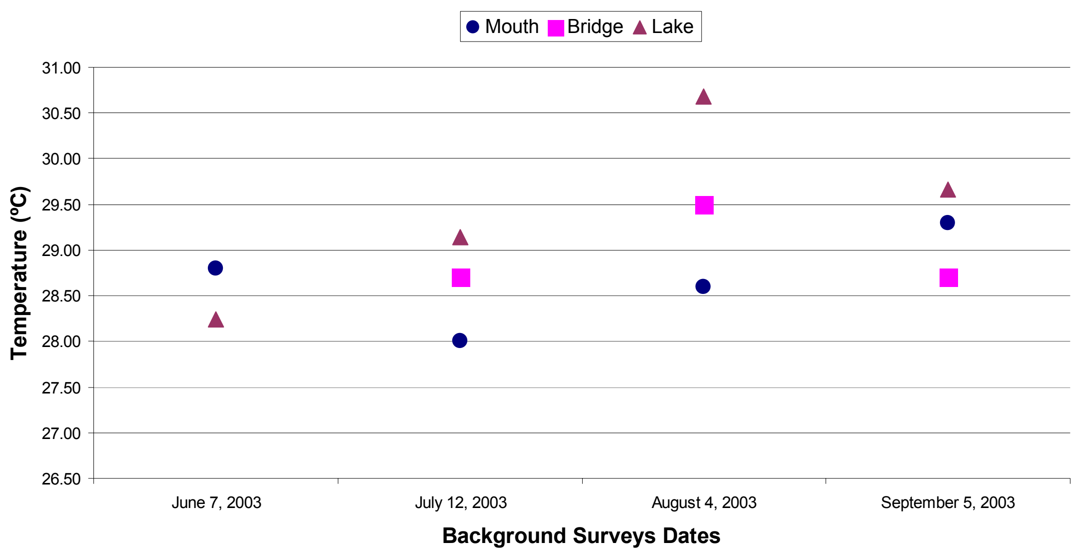

Figure 4.4: Lake and River Temperature during the Background survey

4.2.3 Salinity

The mean Salinity values were lowest at the Bridge and Station 5 (0.23 and 0.68, respectively). The salinity in the Tchefuncte River was low due to its freshwater sources. The stations with low salinity values were positioned at or near the mouth of the river. Therefore, it was expected that these Stations would have lower salinity values than Stations further from the river. (Figure 4.5 through 4.8)

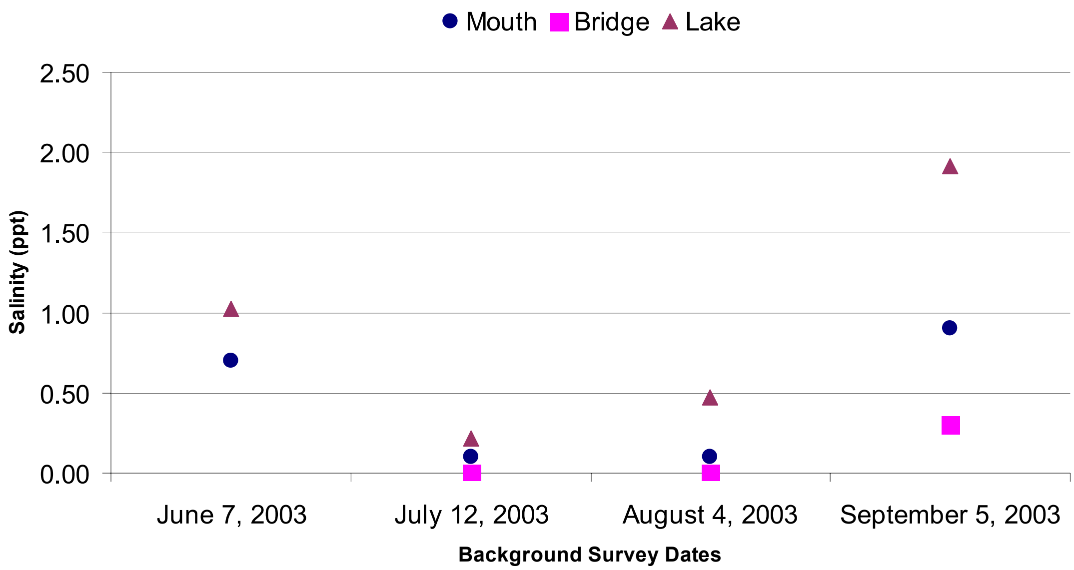

Figure 4.5: Salinity from Lake and River during the Background survey

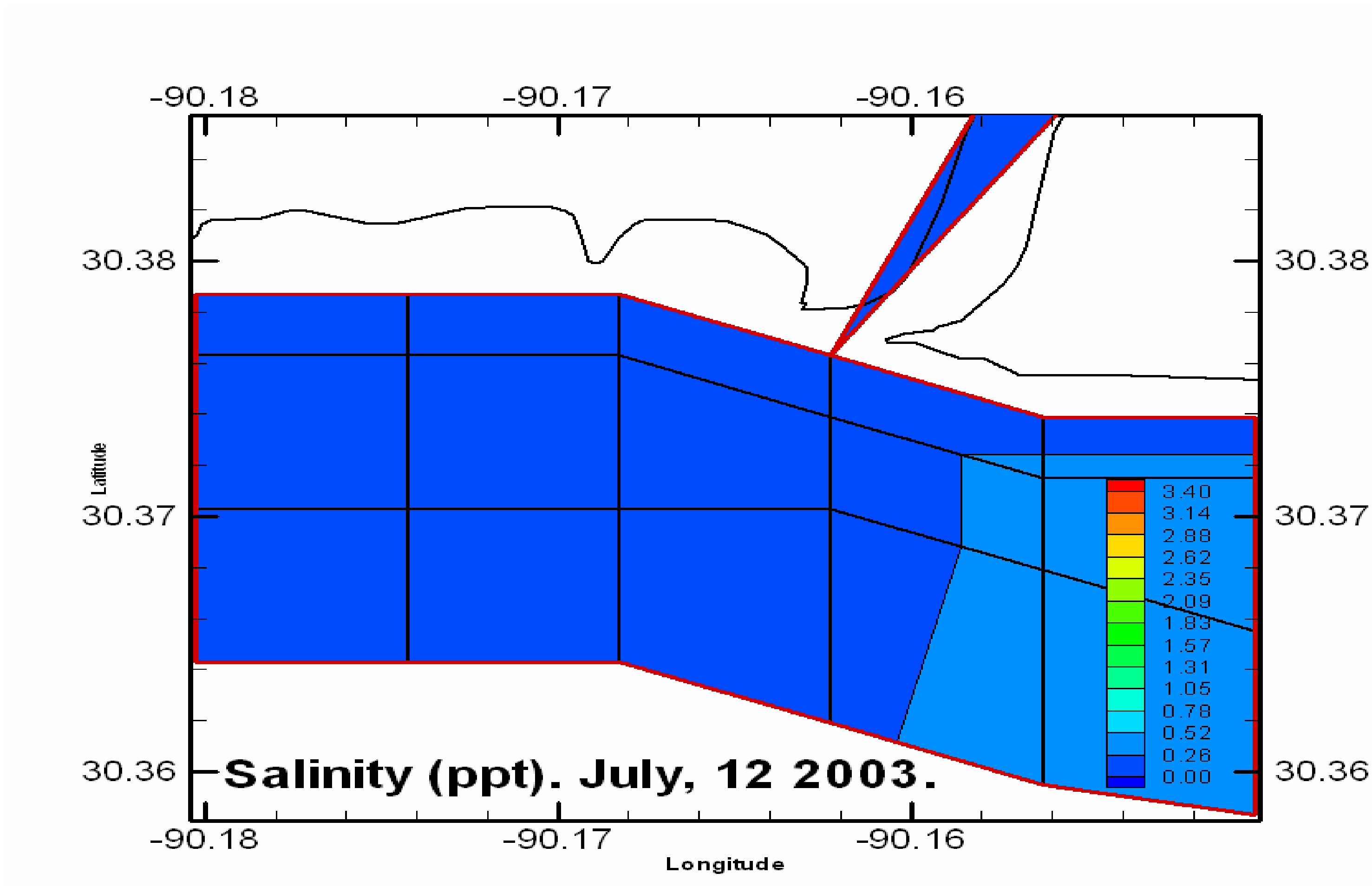

Figure 4.6: Salinity data during Background 2

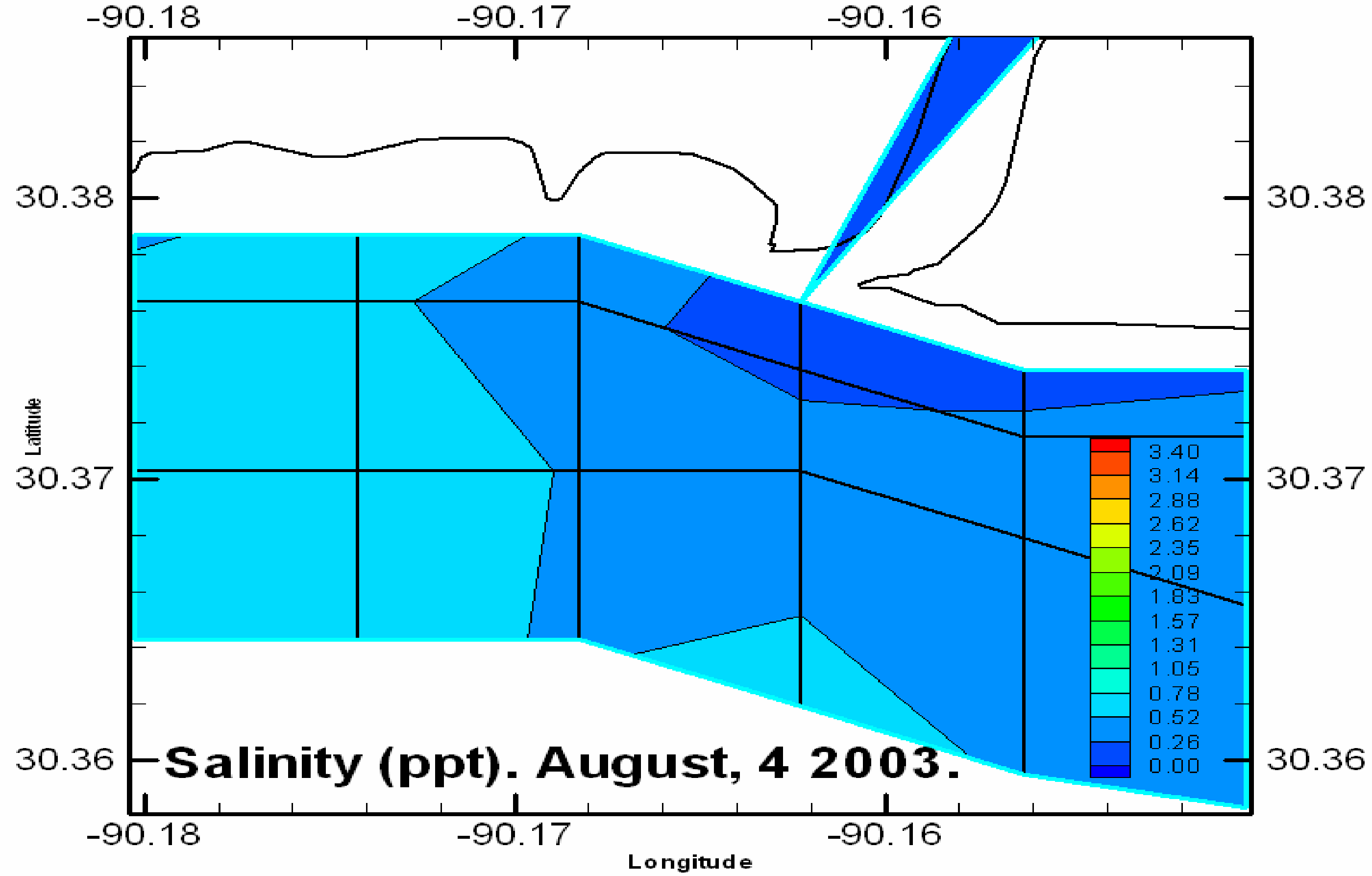

Figure 4.7: Salinity data during Background 3

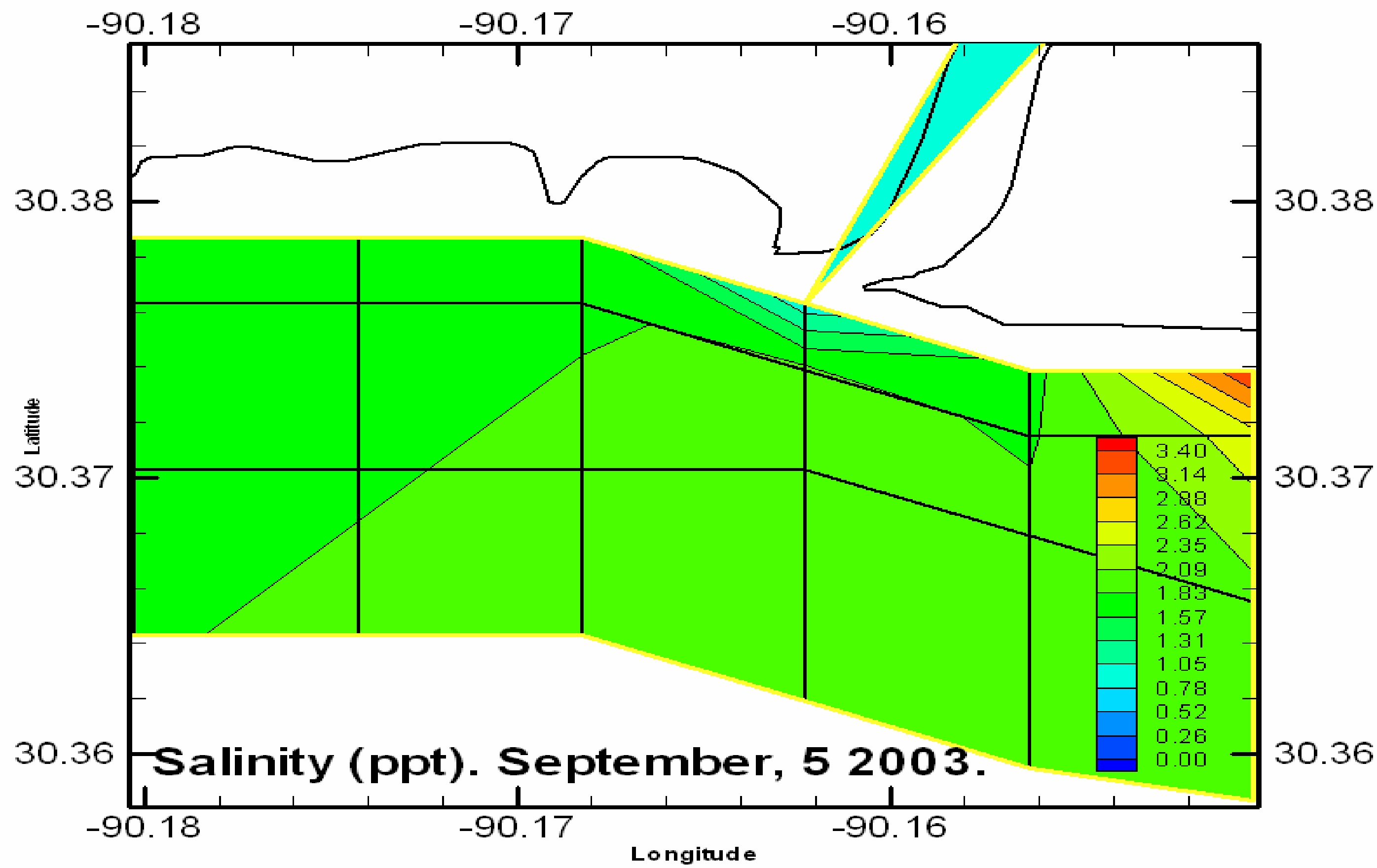

Figure 4.8: Salinity data during Background 4

4.2.4 Conductivity

The mean Conductivity and Specific Conductivities values were lowest at the Bridge and stations 5, 11 and 12. This can be explained due to the proximity of these Stations to the mouth of the river where freshwater enters the lake. This indicates that the lake water contained more dissolved salts, which are good conductors. Also, the highest mean values for Conductivity were at station 1, 8, 15 and 22, which were on the western edge of the sampling grid. These stations contained the highest amounts of salt content and were the least influenced by the river.

4.2.5 Secchi Disk

The mean Secchi Disk values at the Madisonville Bridge were the lowest observed. It was often noted that the river was murky or that algae growth was observed on the surface of the river. The highest mean values were stations 1, 8, 15 and 22, which were all located on the western edge of the sampling grid. This indicates that the movement of water out of the river was typically towards the east. Therefore, the river water appears to have little influence on the area to the west of the mouth of the river.

4.2.6 pH

The mean pH values for the Bridge stations, as well as the stations near the mouth of the river, were the lowest observed. The pH values increased as one moved out and away from the mouth. The water in the Tchefuncte River is typically slightly acidic due to the high volume of pine trees lining its shores. Pine needles and debris lower the pH of the water (Englande et al. 2004). Therefore, this explains the observations made in the river and water samples.

4.2.7 Nutrients

Nutrient levels during the background surveys were generally low with median concentrations of 0.03 mg/L for both, ammonia as N and nitrate as N. The flow-weighted concentration of nitrate exceeded 0.1 mg/L in only the bridge and at the intersection between Tchefuncte River and Bogue Falaya River; lake stations were consistently low by and in a range of 0 – 0.08 mg/L. The concentration of ammonia exceeded 0.1 mg/L in only two Stations: at the intersection of both rivers and at Station 20 (Figures 4.9 through 4.14). Data less than 1 mg/L in all stations reflect the typical concentrations in lakes or stream according to Typical Municipal Wastewater Characteristic, EPA Municipal Discharge Standards, and Typical Stream Characteristics [Ray, 1995].

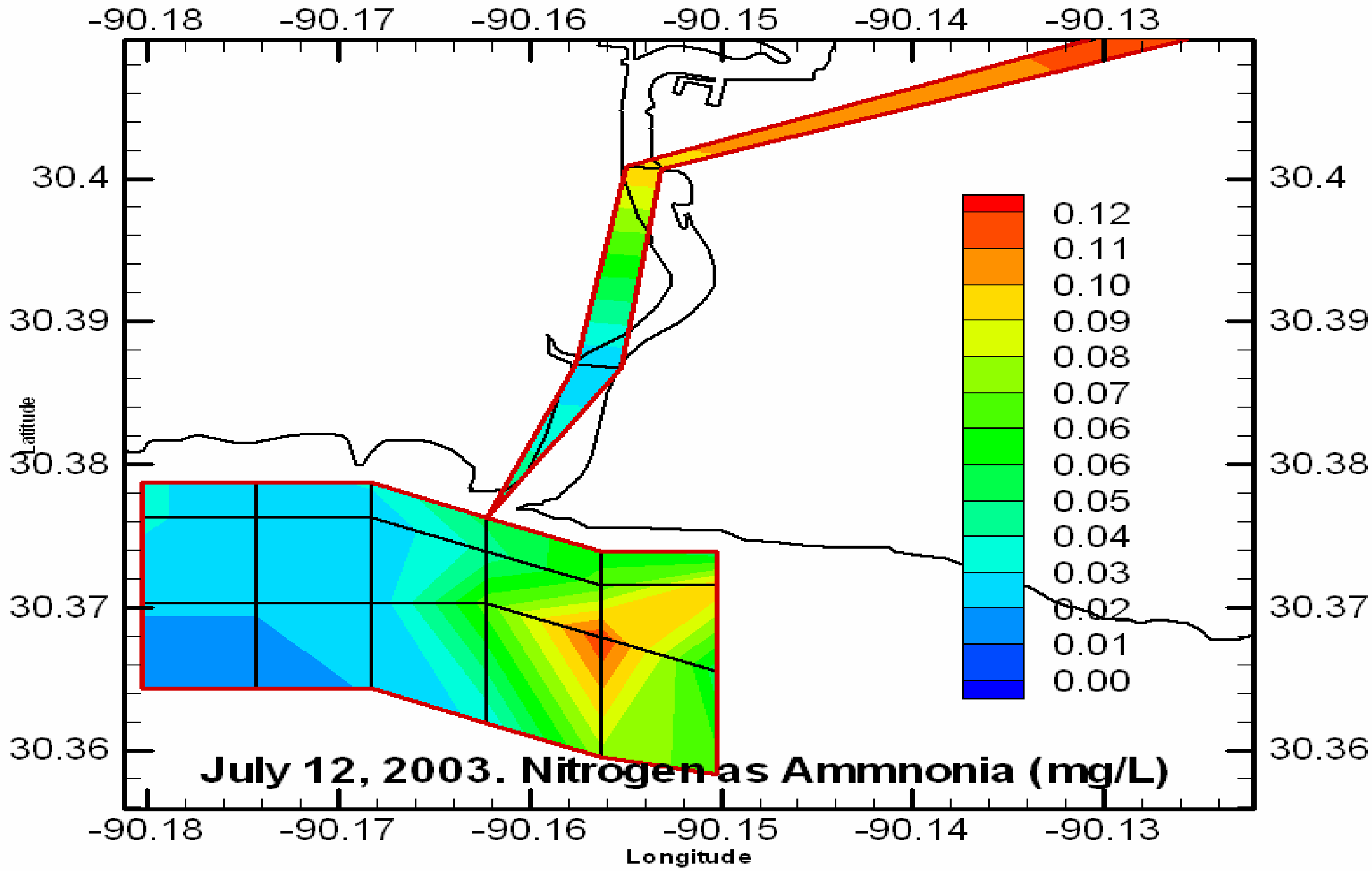

Figure 4.9: N- as Ammonia data during Background 2

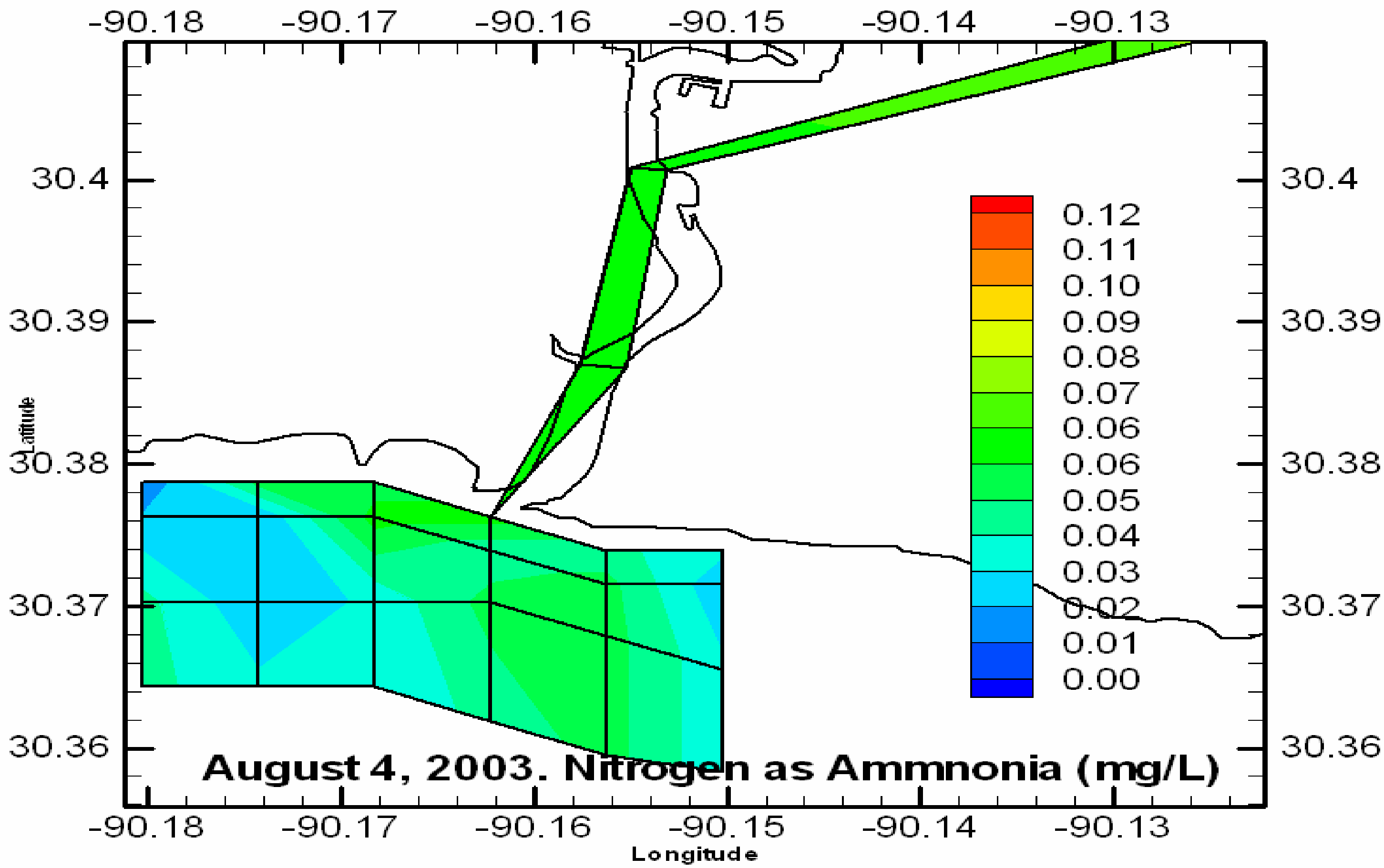

Figure 4.10: N- as Ammonia data during Background 3

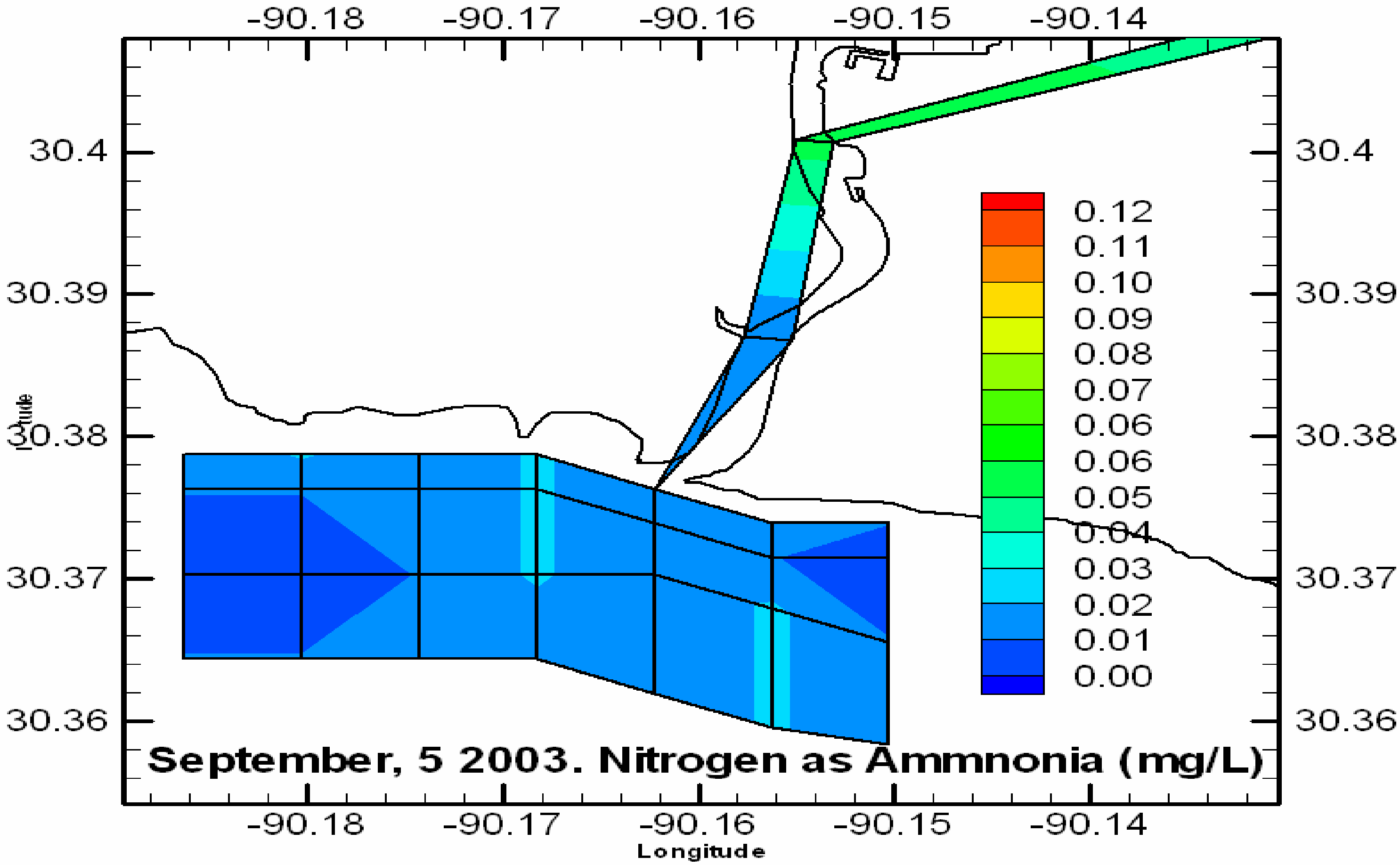

Figure 4.11: N- as Ammonia data during Background 4

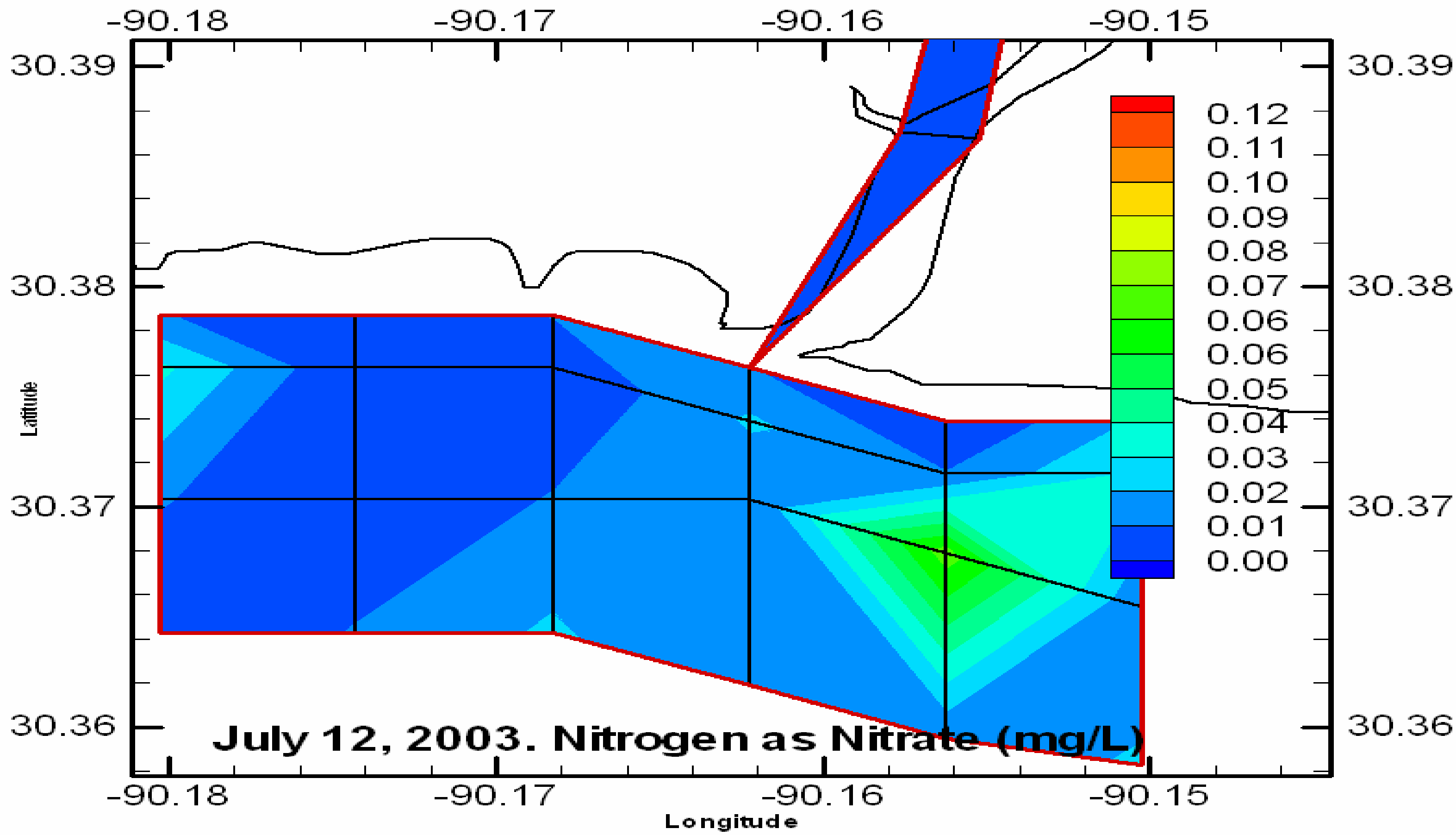

Figure 4.12: N- as Nitrate data during Background 2

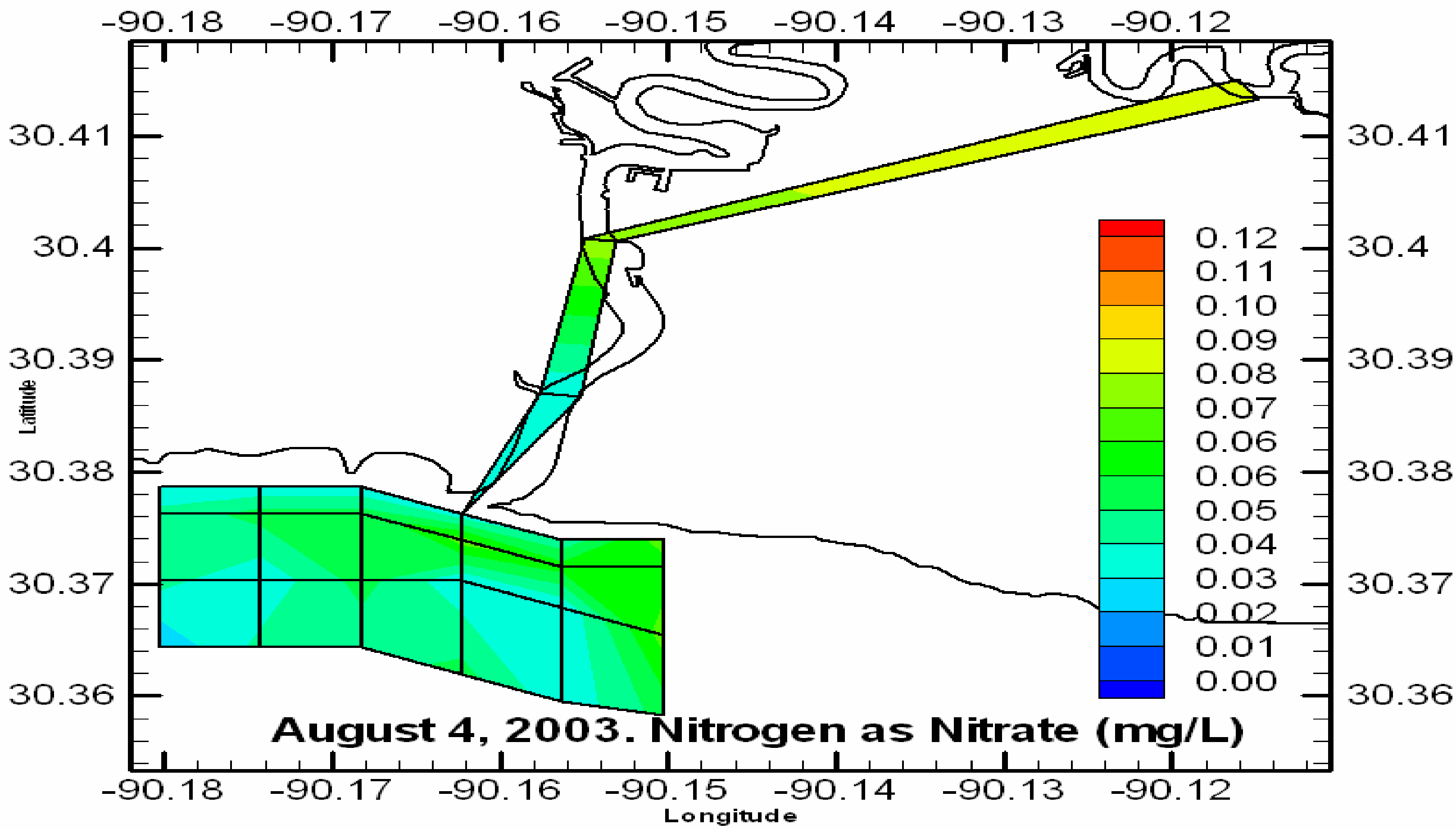

Figure 4.13: N- as Nitrate data during Background 3

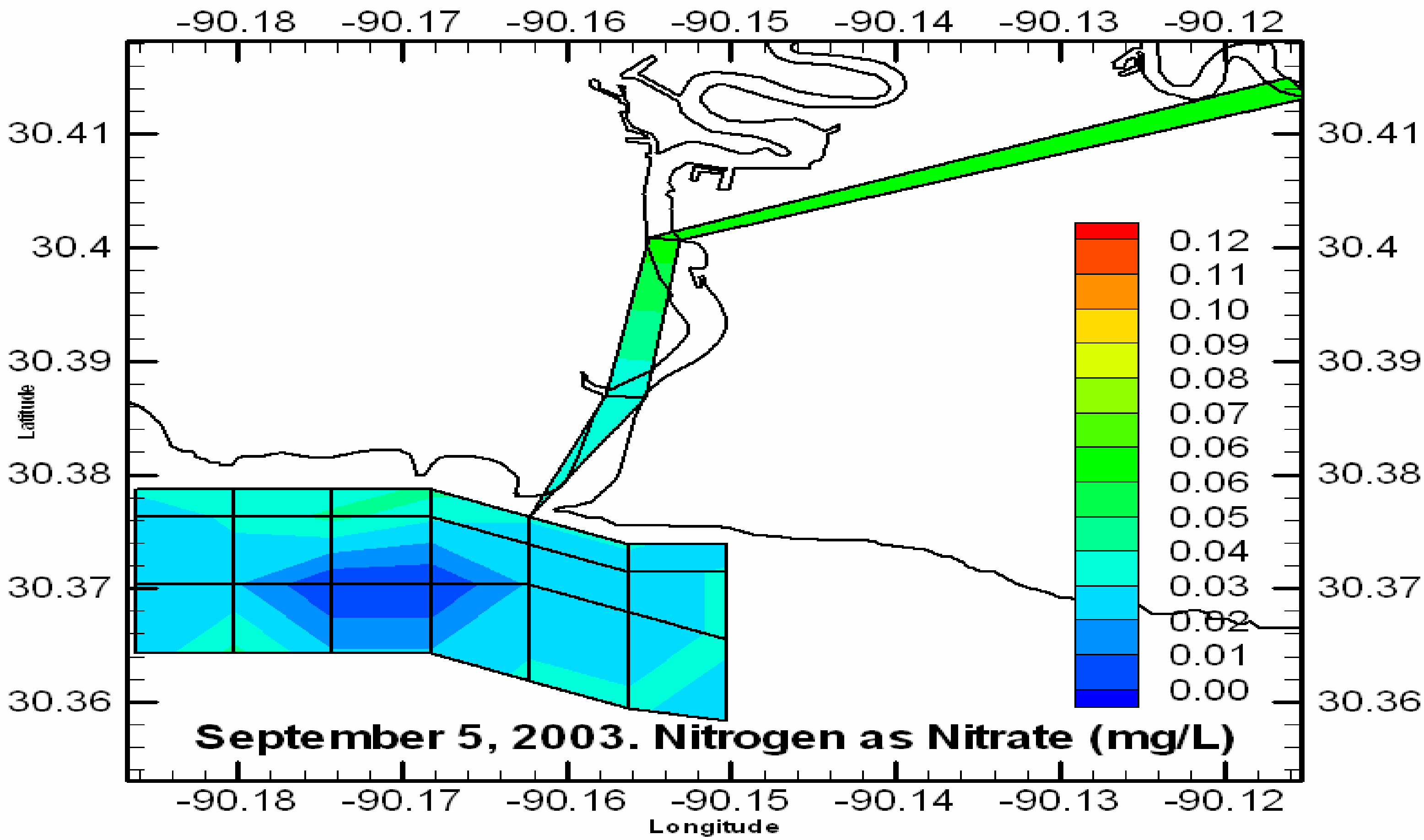

Figure 4.14: N- as Nitrate data during Background 4

The un-ionized ammonia values at the lake, mouth of the River and the Madisonville Bridge were generally low in comparison with the 20 ug/L chronic toxicity limit (Great Lakes Water Quality Agreement). It indicates that the Station of Study is healthy according this parameter during dry weather. (Table 4.5)

Table 4.5: Summary of Un-ionized Ammonia Data during Background Survey

	7/12/2003 **ug/L**	**8/4/2003** **ug/L**	**9/5/2003** **ug/L**
Mouth	1.27	0.17	0.06
Bridge		0.08	
Lake	1.31	0.27	0.07

4.2.8 Summary of Bacterial Contamination with Fecal Coliform

- At the Madisonville Bridge (Two Samples)

Samples were taken from the Madisonville Bridge on only one occasion. On September 5th, the fecal coliform concentration at the bridge was 170 and 30 MPN/100ml. On that day, for all samples the median value was < 2 and the mean was 9.79. The mean was skewed due to the high concentrations at the bridge. The mean for all lake samples was < 4. Even though it is clear that the bridge concentrations were higher than lake samples, it is imperative to collect more data before making any broad assumptions about the background water quality.

- Station 1 through 3 (First three points at the west)

For Stations 1, 2 and 3, only one sample was taken. On June 6, samples from all these 3 stations were not collected due to a fast-approaching thunderstorm. During July 12 and August 4 the QA/QC procedure produced unsatisfactory results. On September 5th, the fecal coliform concentrations for these Stations were < 2. Under dry conditions, these Stations showed little evidence of bacterial contamination.

- Stations 4, 5, 11, 12a, 12b, 13a and 13b (At the mouth)

Under dry conditions, the flow of the water appears to flow from the river, following the path of the dredged canal and spreading out from there. The Background mean MPN/100ml values for Stations 4, 5, 11, 12a, 12b and 13 were 143.75, 25.5, < 121, < 121, < 56, 111 and 95, respectively. It is clear that even under dry conditions, these Stations exhibit elevated fecal bacteria levels. However, these levels are below the acceptable levels for primary contact activities. Therefore, from these limited data, it can be concluded that it could be safe to swim in the lake under dry conditions.

- Stations 18, 19 and 20 (Farther from the mouth)

The mean fecal coliform concentrations for Stations 18, 19 and 20 were < 49.5, < 17.5 and < 40.5, respectively. This illustrates the pattern of contamination spreading from the mouth of the river, with values decrease as one move out and away from the mouth.

- Other Stations: 6, 7, 8, 9, 10, 14, 15, 16, 17, 21, 22, 23, 24, 25, 26, 27 and 28

The mean MPN/100ml values for these Stations were low and presented little evidence of fecal contamination.

- Sediment at Stations 5, 18, and 20

Under dry conditions, the mean MPN/100ml values for Sediment Stations 5, 18 and 20 were 6, < 7.5 and <2, respectively.

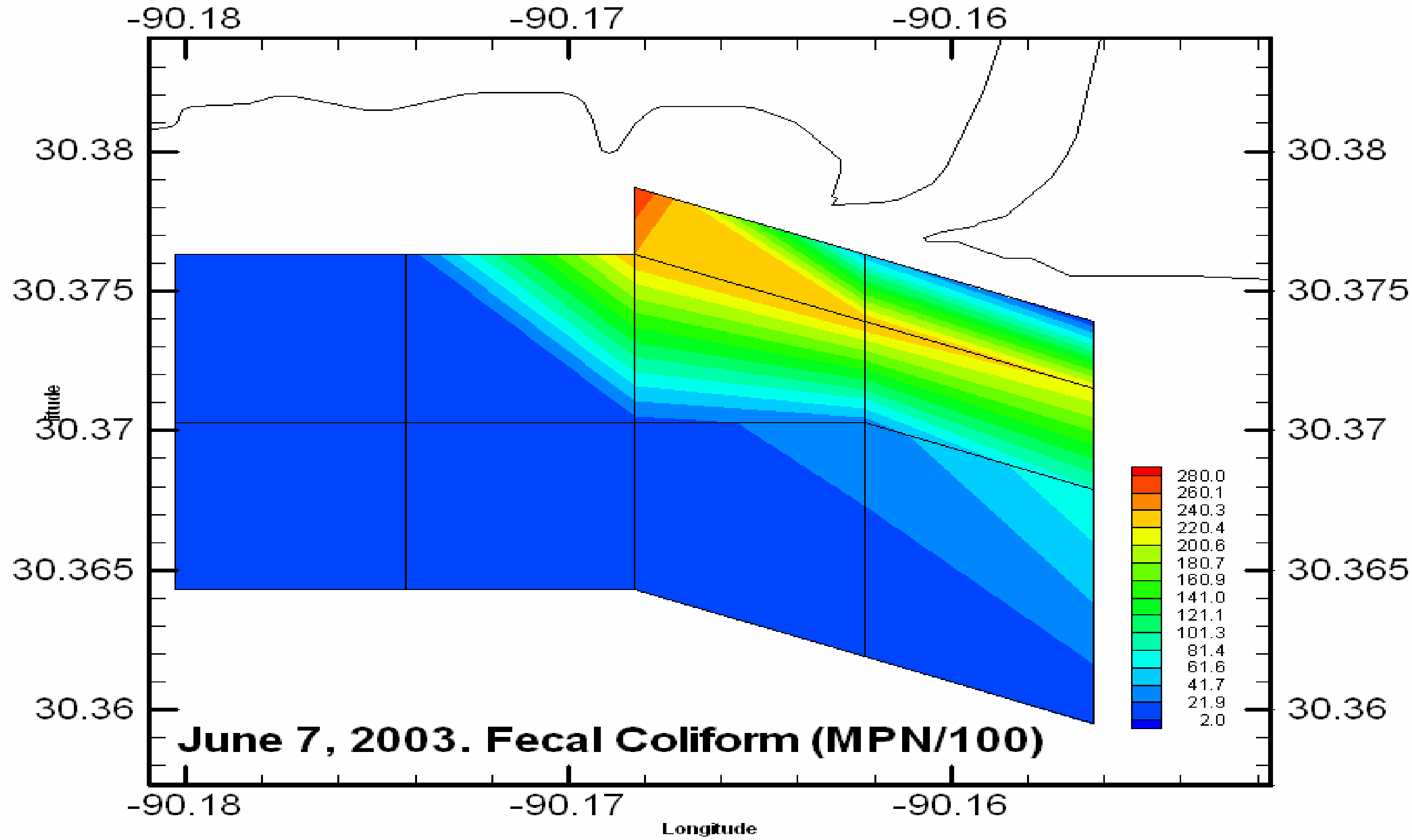

Figure 4.15: Fecal Coliform data during Background 1

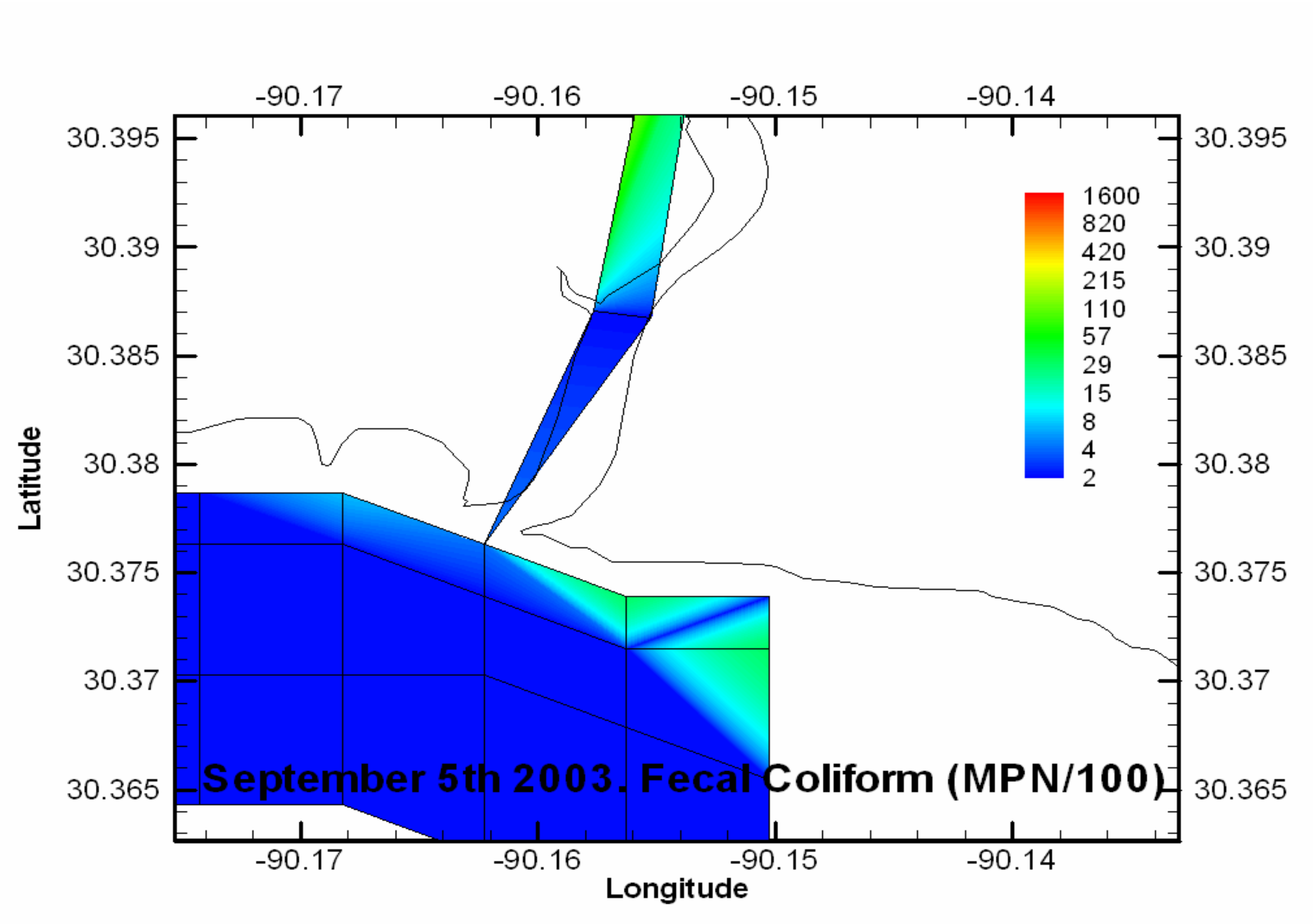

Figure 4.16: Fecal Coliform data during Background 4

4.3. Rain Events/Plume Characterization

4.3.1. Microbiological Analysis

4.3.1.1. Rain Event 1: September 5, 7 and 9 2003

The Fecal Coliform counts are low for the first and third days of sampling during Rain Event #1. Day 1 of sampling had very low values and is considered a "Background". The mean and log mean values were < 9.09 and 0.96, respectively.

On Day 2 of sampling, the fecal coliform levels at the Madisonville Bridge were high, 300 and 1600 for the beginning and end of the survey on September 7. The fecal coliform levels in the lake were higher in comparison with the first day of sampling, especially at Station 12, which is about 1500 meters south of the mouth. The sediment values for Stations 5 and 18 were 900 and 170, respectively.

By Day 3, the level of indicator bacteria in the water was at acceptable levels for primary contact activities. The mean and log mean values for fecal coliform are summarized in Tables 4.6 and 4.7. The MPN/100ml values for each day are listed in Appendix B and illustrated on Figures 4-17 through 4.19.

Table 4.6: Mean and Log Mean values for Fecal coliform for Rain Event #1

	5 Sept 2003	**7 Sept 2003**	**9 Sept 2003**
Mean	**9.09**	**171.34**	**8.00**
log mean	**0.96**	**2.23**	**0.90**

Table 4.7: Fecal coliform (MPN/100ml) values for Rain Event #1

Sample #	mean*	log mean*
Bridge 1	160.33	2.21
Bridge 2	549.00	2.74
1*	2.67	0.43
2*	5.66	0.75
3*	2.00	0.30
4*	3.66	0.56
5	32.33	1.51
5 sediment	303.33	2.48
6*	12.00	1.08
7*	2.67	0.43
8*	2.00	0.30
9*	7.00	0.85
10*	12.33	1.09
11*	28.66	1.46
12a*	544.00	2.74
12b*	171.66	2.23
13	28.00	1.45
14*	20.67	1.32
15*	2.00	0.30
16*	2.00	0.30
17*	4.00	0.60
18*	3.33	0.52
18 sediment*	58.00	1.76
19*	2.00	0.30
20*	38.00	1.58
20 sediment*	5.67	0.75
21*	2.67	0.43
22*	5.67	0.75
23*	5.67	0.75
24*	2.00	0.30
25*	2.00	0.30
26*	2.00	0.30
27*	2.00	0.30
28*	7.00	0.85

*** For mean and log mean calculations, when at least one of the datum includes a < sign, then the mean and log mean value should also indicate a < sign.**

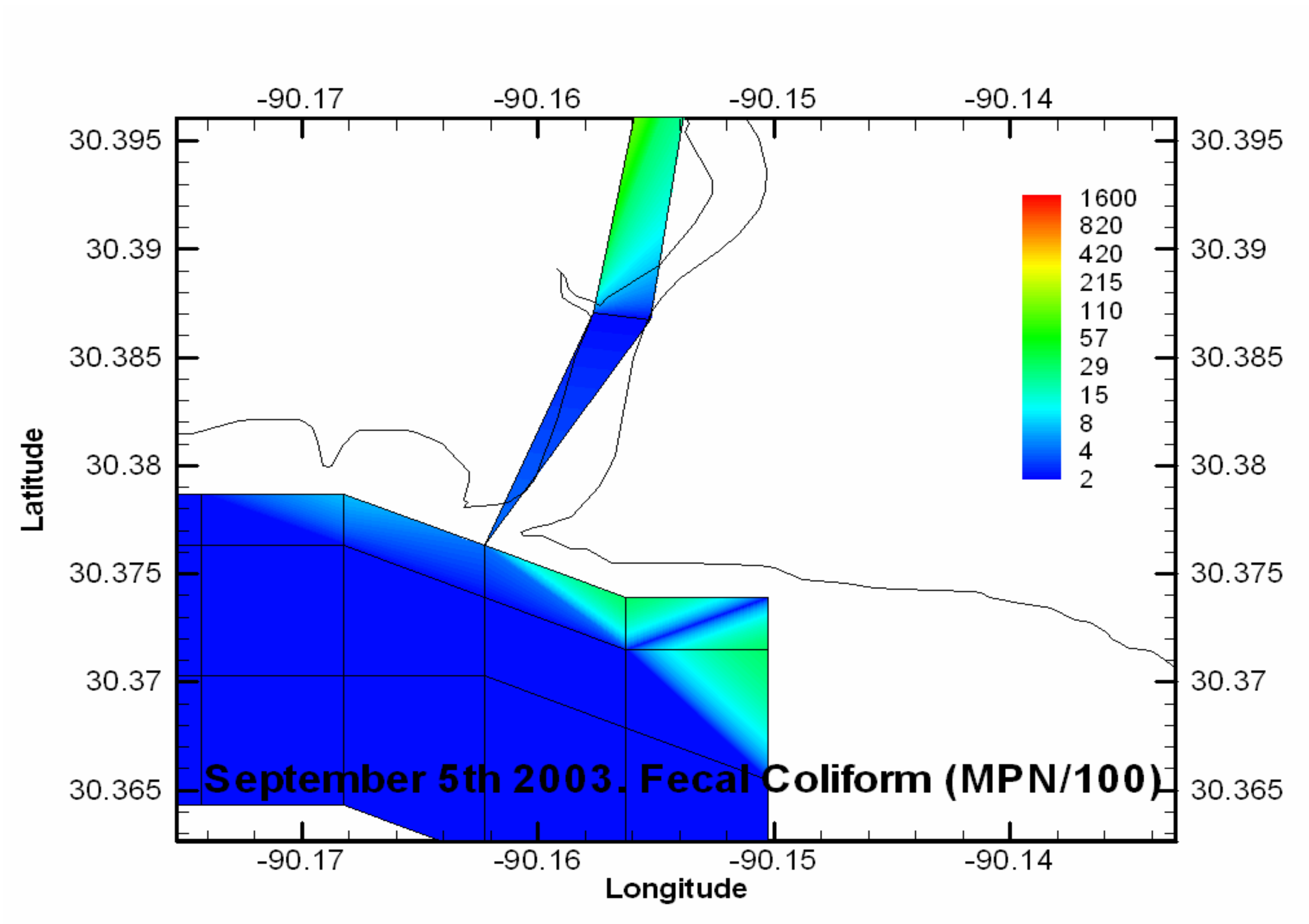

Figure 4.17: Fecal Coliform data during Rain Event 1 Day 1

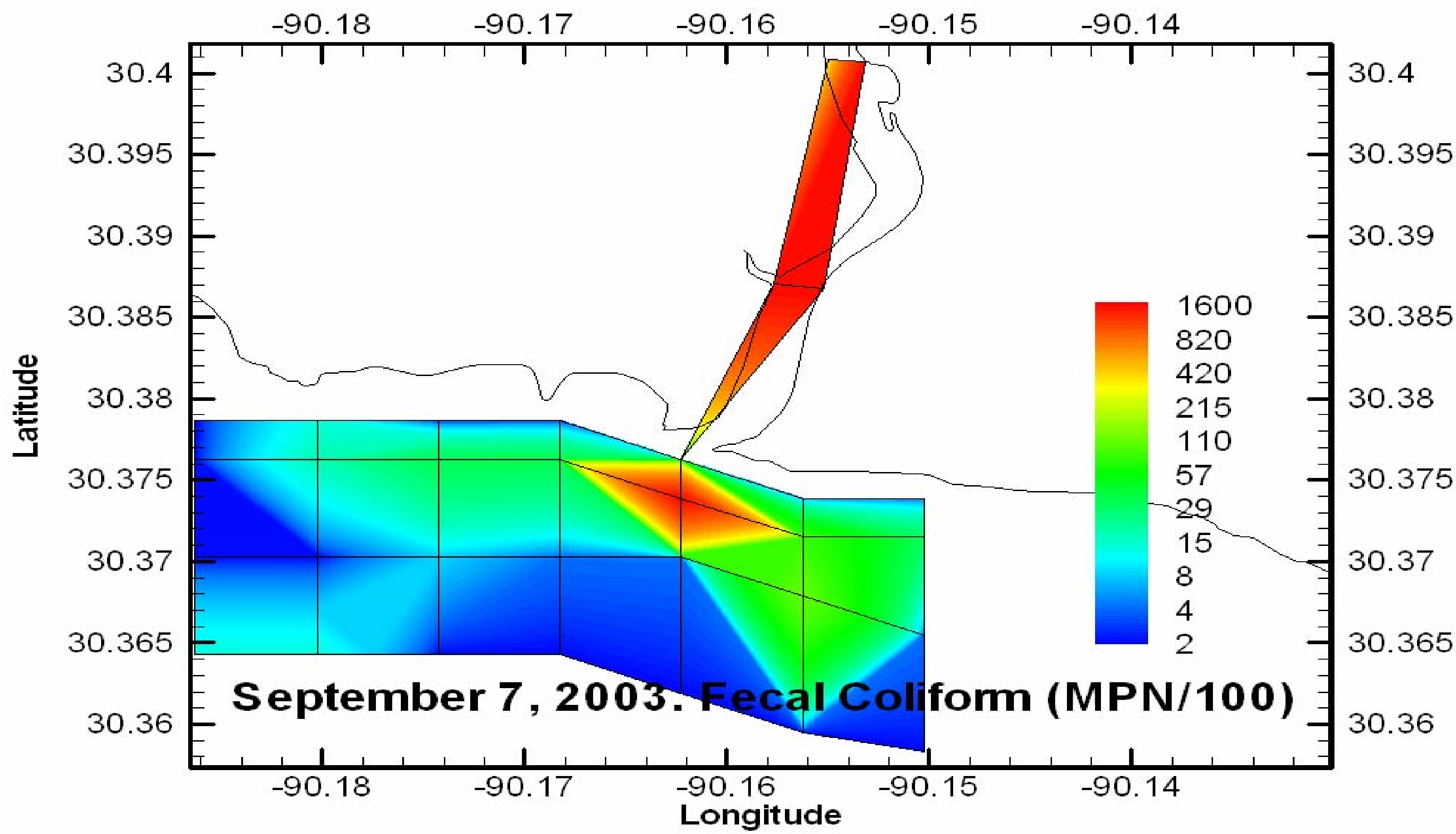

Figure 4.18: Fecal Coliform data during Rain Event 1 Day 2

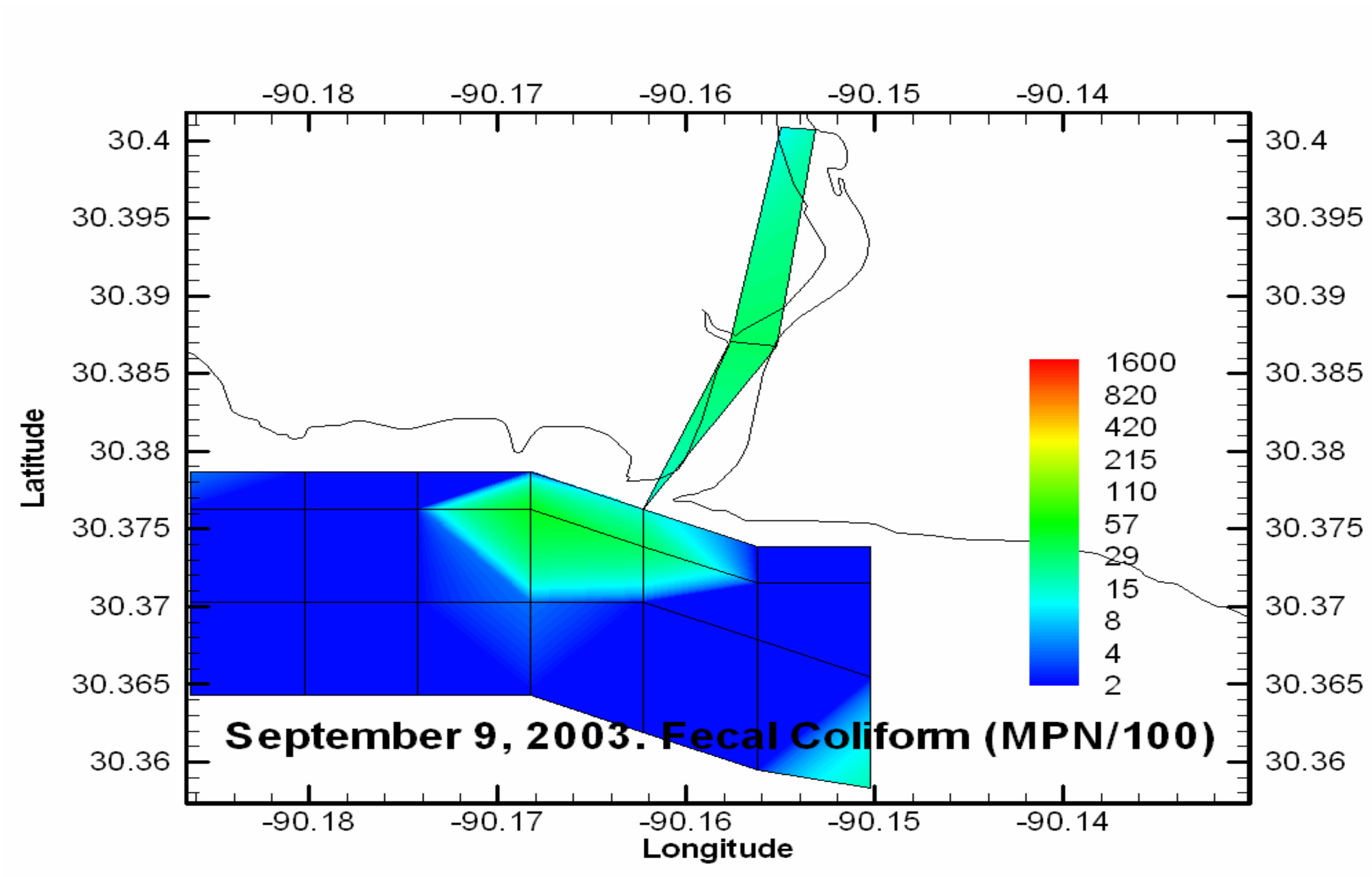

Figure 4.19: Fecal Coliform data during Rain Event 1 Day 3

4.3.1.2. Rain Event 2: April 27 and 28 2004

On the 27th of April, a twenty-nine foot boat was used to collect samples. Due to its size, it was impossible to gather water samples from stations 1-3, 6 and 7 (near the shoreline). At these locations, the depth readings were typically less than 3 feet.

On the 28th of April, a smaller boat was utilized to collect samples and the shallow regions of the lake were sampled with no difficulties. The problem on this day was the weather. In the early morning, the winds were calm out of the North. When samples collection began at the third row (station15), the winds became strong out of the Southeast. The water was quite rough and there were white caps. It was only able to collect samples 15 through 22 before the situation became unsafe and we headed into shore.

The Fecal Coliform values were high on the first day of sampling, especially at the bridge and near the mouth. On the second day, the MPN/100ml values were still high at the mouth but had dropped to safe levels in most of the other parts of the lake. The mean and log mean values for fecal coliform are summarized in Table 4.8. A summary among the river, mouth and lake water concentration is shown in 4.9 and illustrated in Figures 4.20 and 21.

Table 4.8: Mean and Log Mean values for Fecal coliform

	27 April 2004	28 April 2004
Mean	170.13	55.68
Log Mean	2.23	1.75

Table 4.9: Summary of Fecal Coliform data: at the Madisonville Bridge, Mouth of and the River and Lake Stations, during Rain Event 2. April 27 and 28 2004

	Day 1	Day 2
Bridge	3.20	NO SAMPLED
Mouth	2.38	2.23
Lake Stations	2.10	1.71

NO SAMPLED = The water was rough, the situation became unsafe for continuing sampling

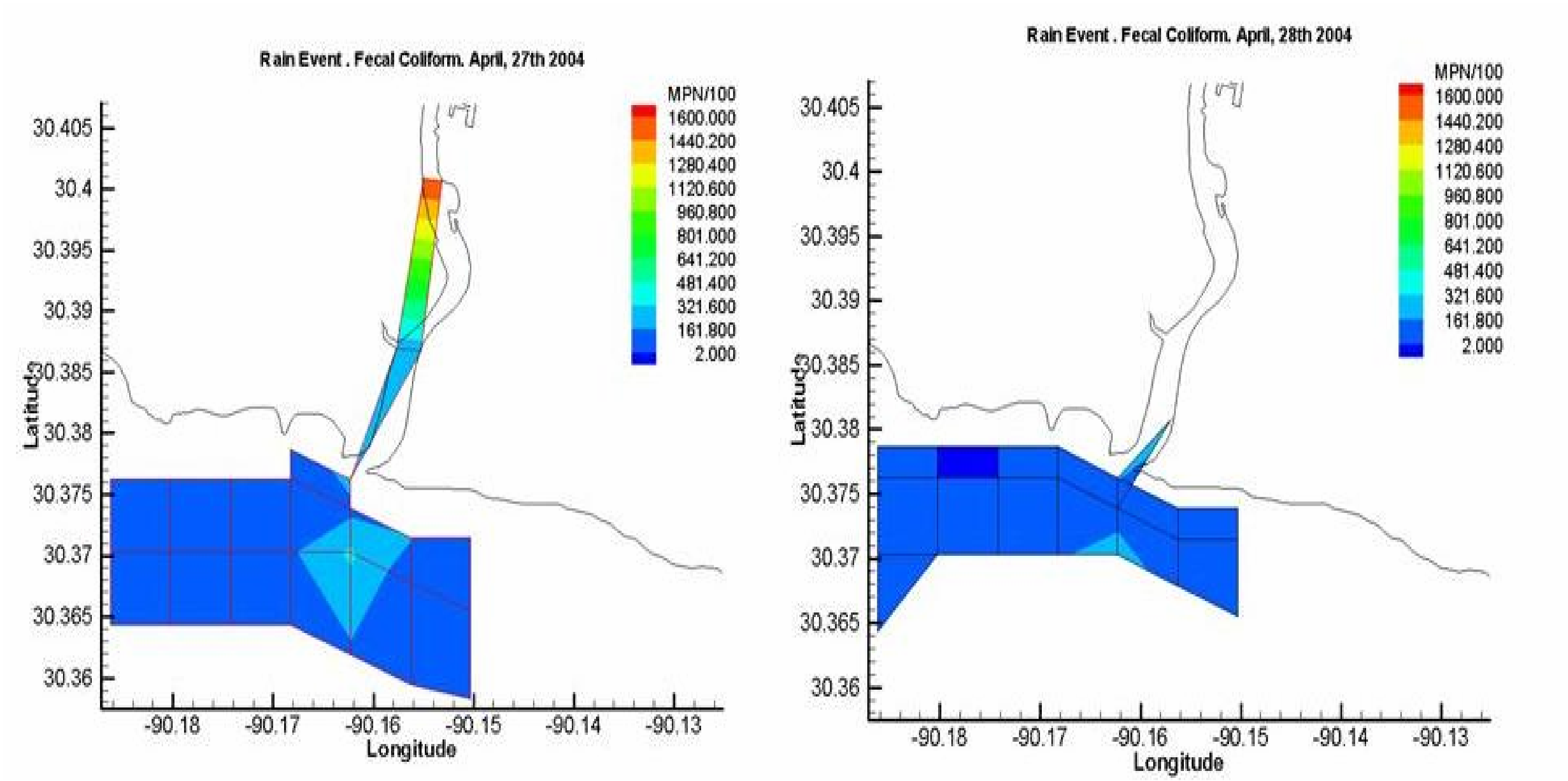

Figure 4.20: Fecal Coliform Levels for Rain Event 2
April 27 and 28, 2004

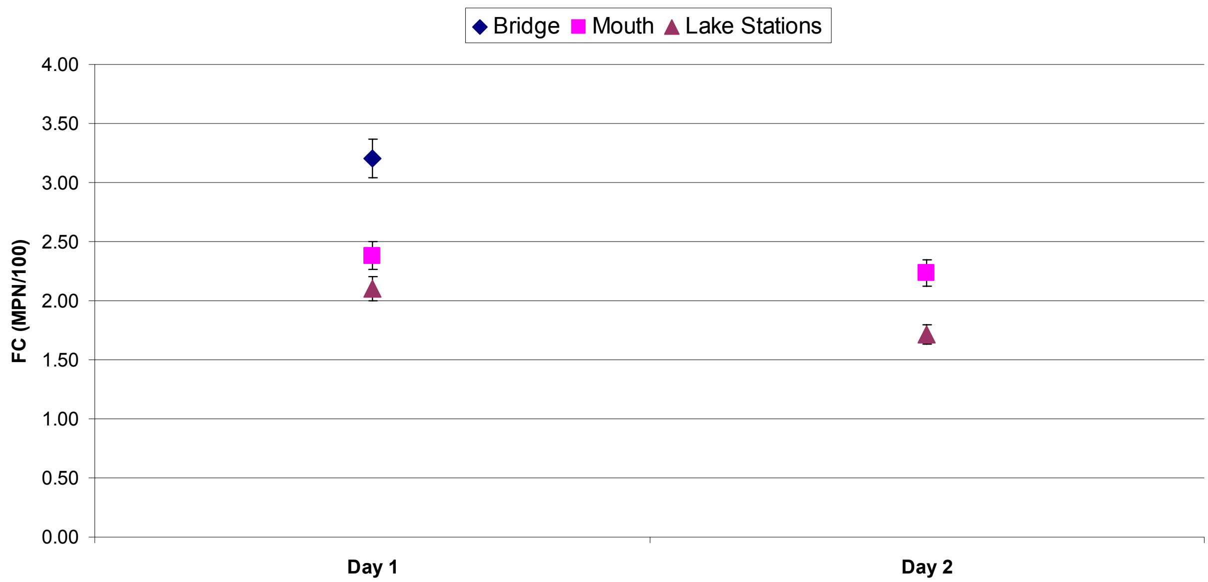

Figure 4.21: Summary of Fecal Coliforms concentrations at the Mouth of the river, Madisonville Bridge and Lake Stations. Rain Event 2: April 27 and 28, 2004

4.3.2. Nutrients

The Madisonville Bridge N as Nitrate concentrations were higher in comparison with the lake and mouth water concentrations during the days of the event (Figure 4.22 through 4.33), but the dilution effect of the lake and the increased river volume would almost certainly bring the nitrate nutrient levels down. Whole site data were consistently lower than the typical concentrations of nitrate in Lakes and Streams (< 1 mg/L). [Ray, 1995].

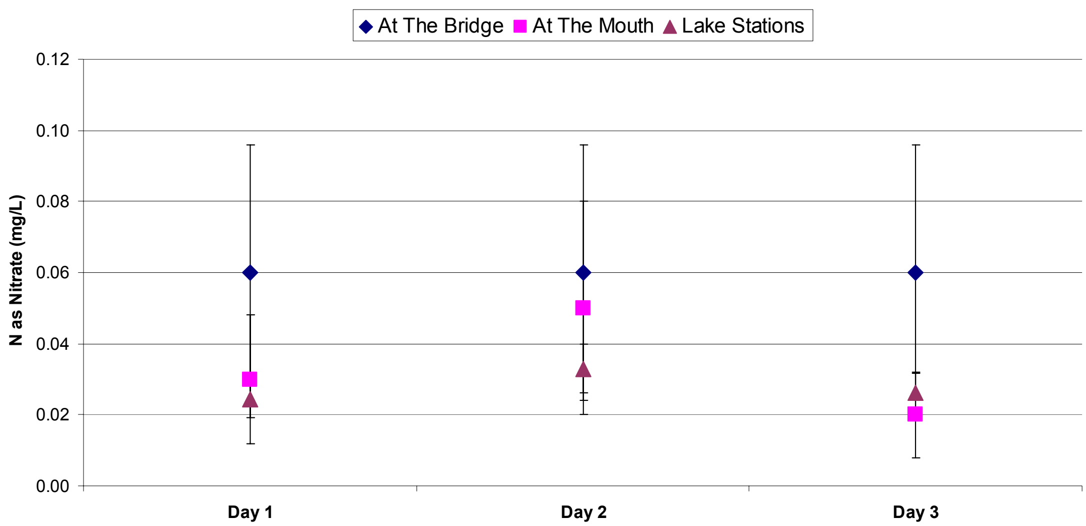

Figure 4.22: Lake, Mouth and River N as Nitrate levels during Rain Event 1 September 5, 7, and 9 2003

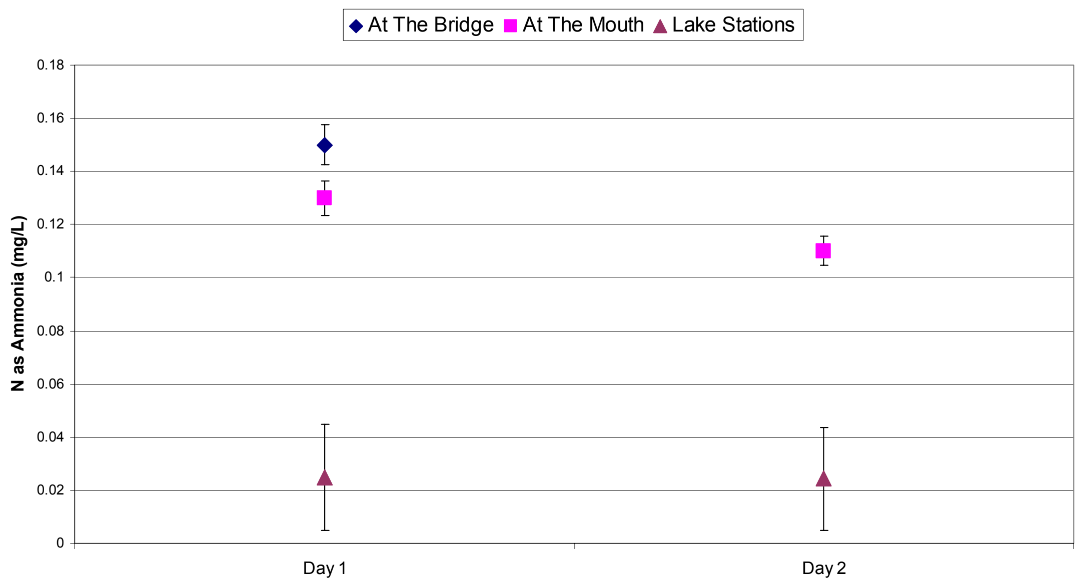

Figure 4.23: Lake, Mouth and River N as Nitrate levels during Rain Event 2 April 27 and 28, 2004

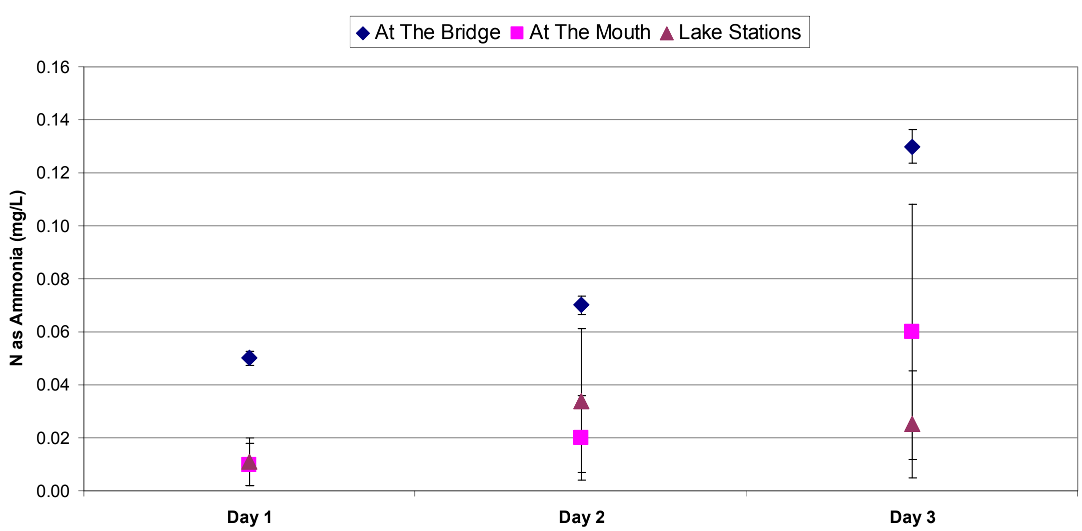

Figure 4.24: Lake, Mouth and River N as Ammonia levels during Rain Event 1 September 5, 7, and 9 2003

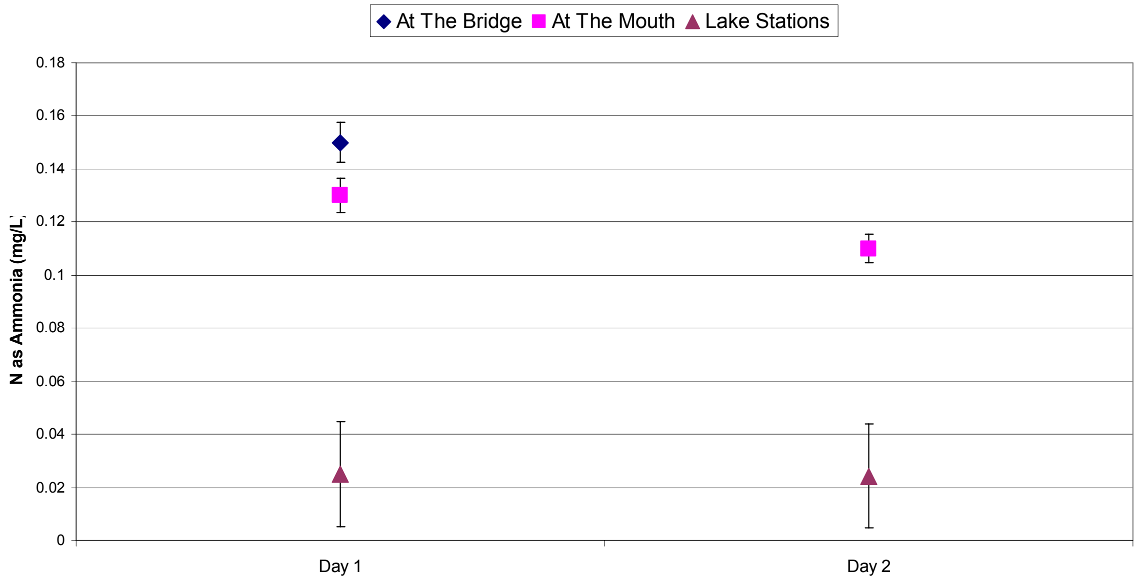

Figure 4.25: Lake, Mouth and River N as Ammonia levels during Rain Event 1 April 27 and 28, 2004

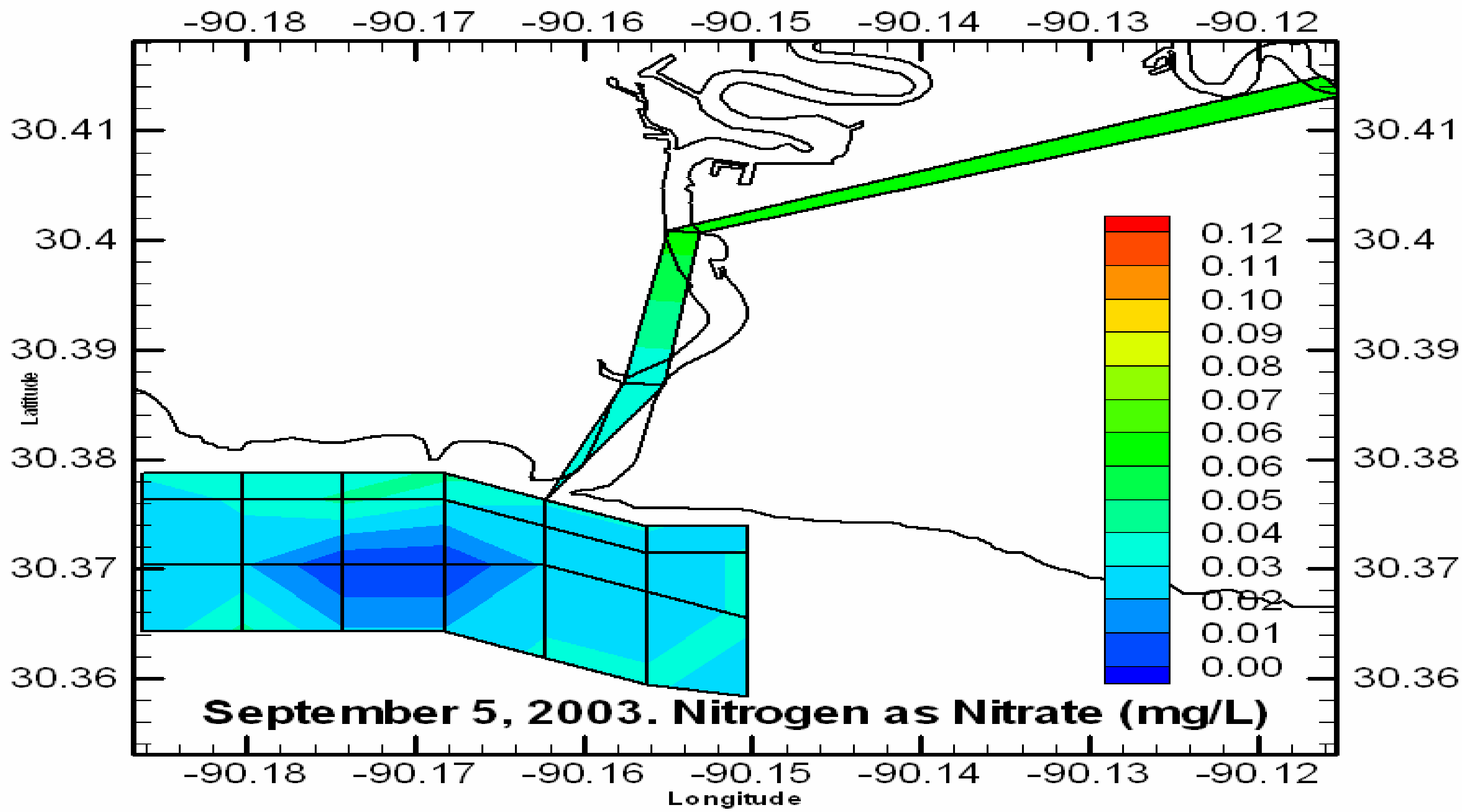

Figure 4.26: Nitrogen as Nitrate data during Rain Event 1. Day 1

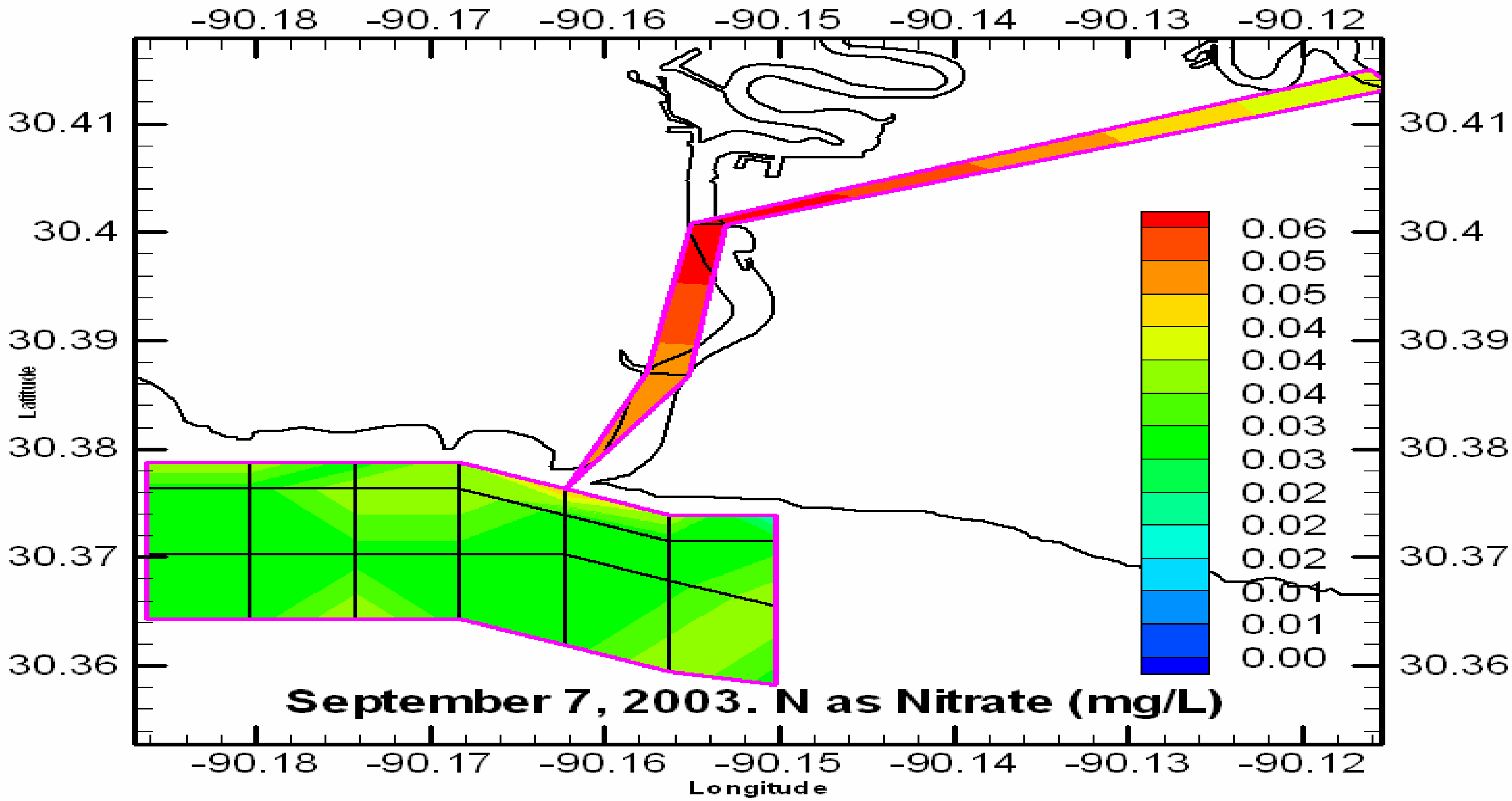

Figure 4.27: Nitrogen as Nitrate data during Rain Event 1. Day 2

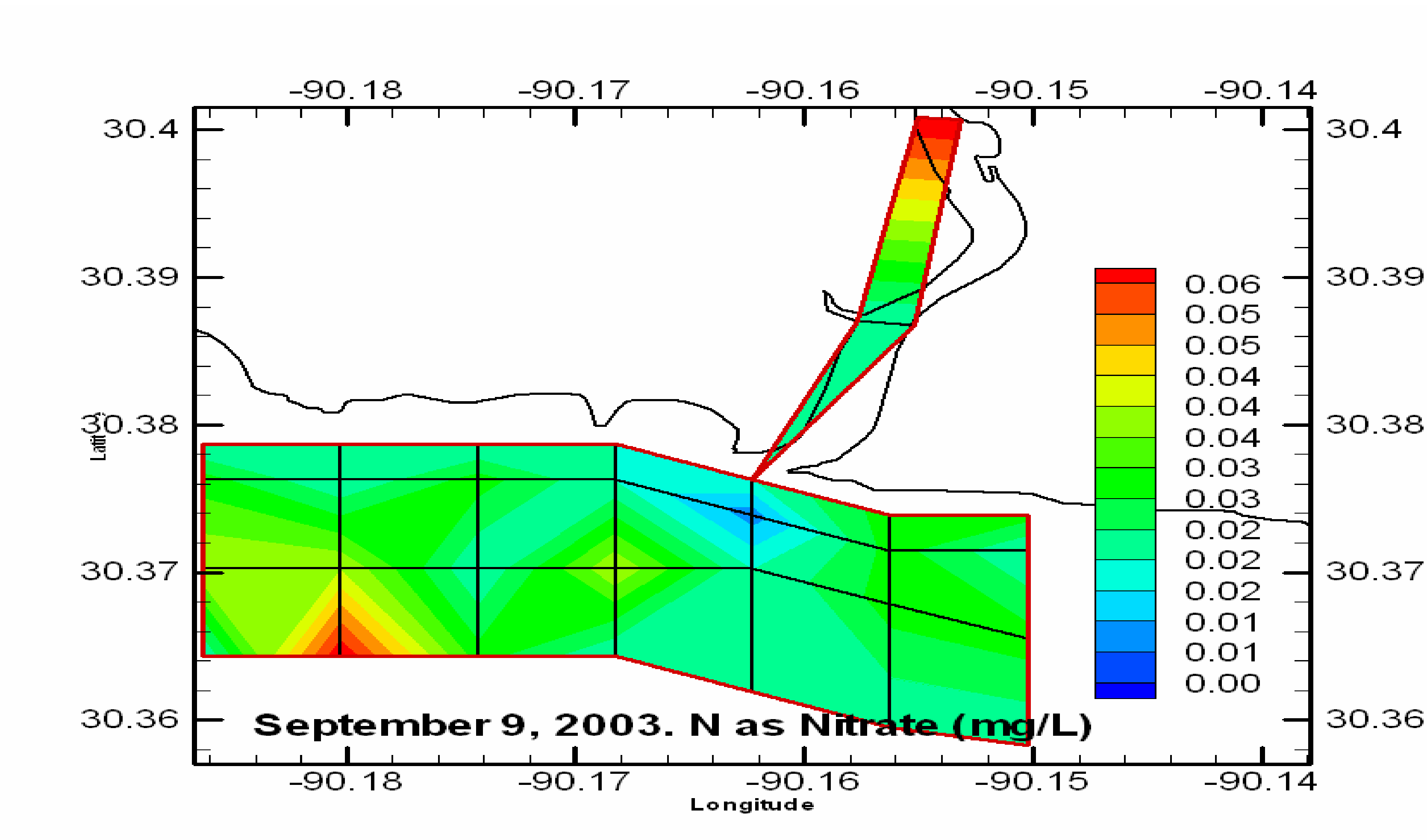

Figure 4.28: Nitrogen as Nitrate data during Rain Event 1. Day 3

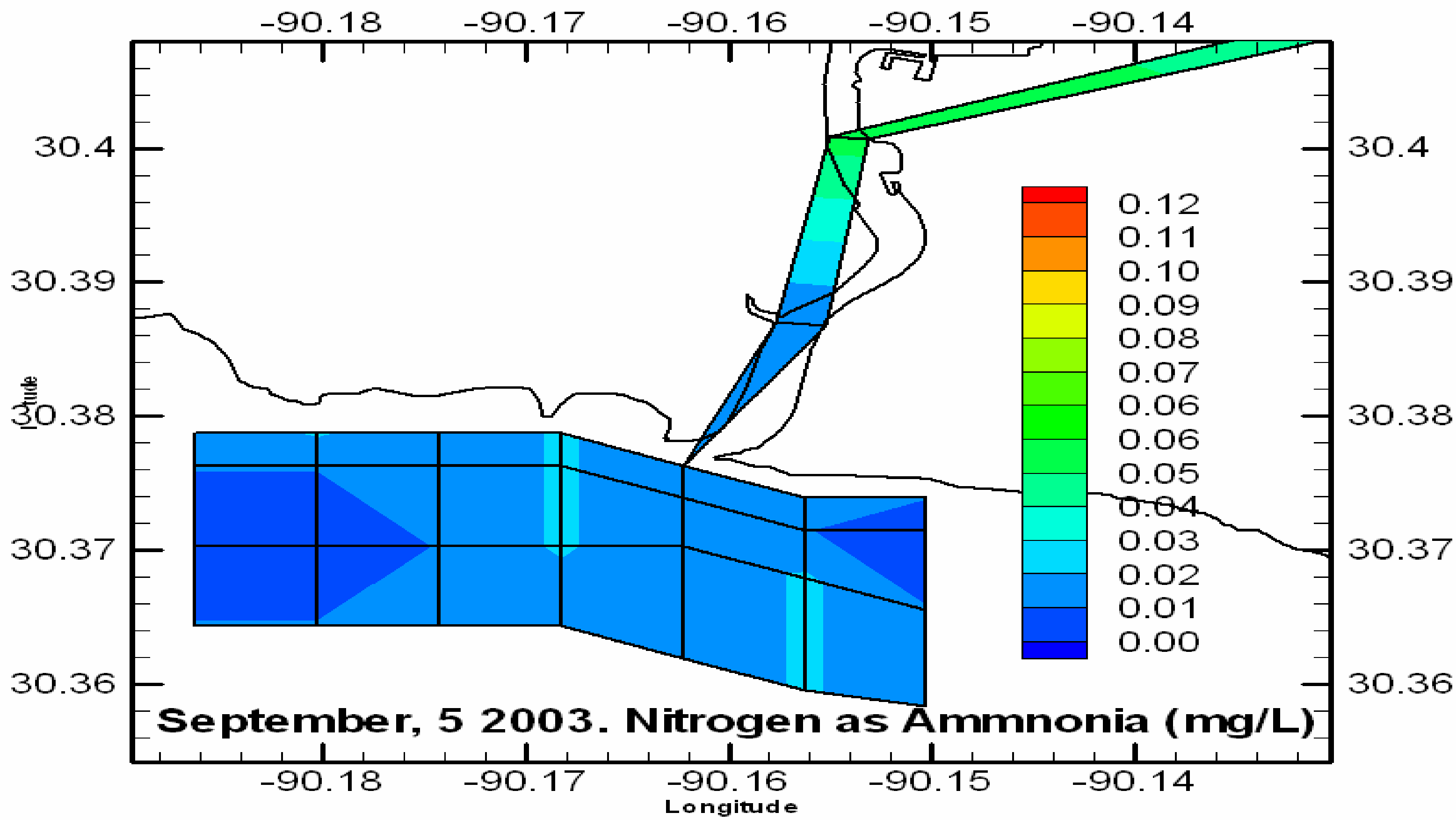

Figure 4.29: Nitrogen as Ammonia data during Rain Event 1. Day 1

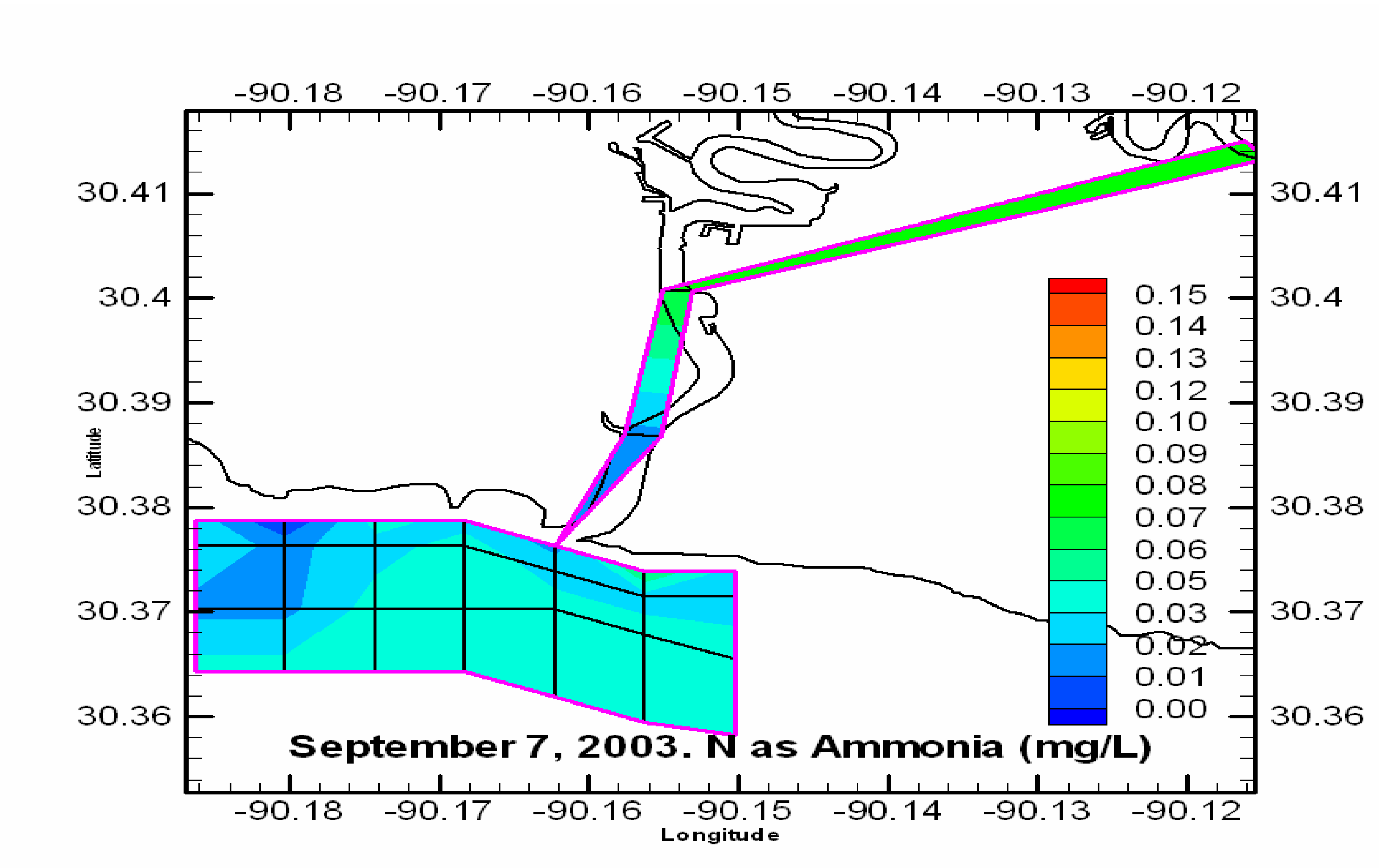

Figure 4.30: Nitrogen as Ammonia data during Rain Event 1. Day 2

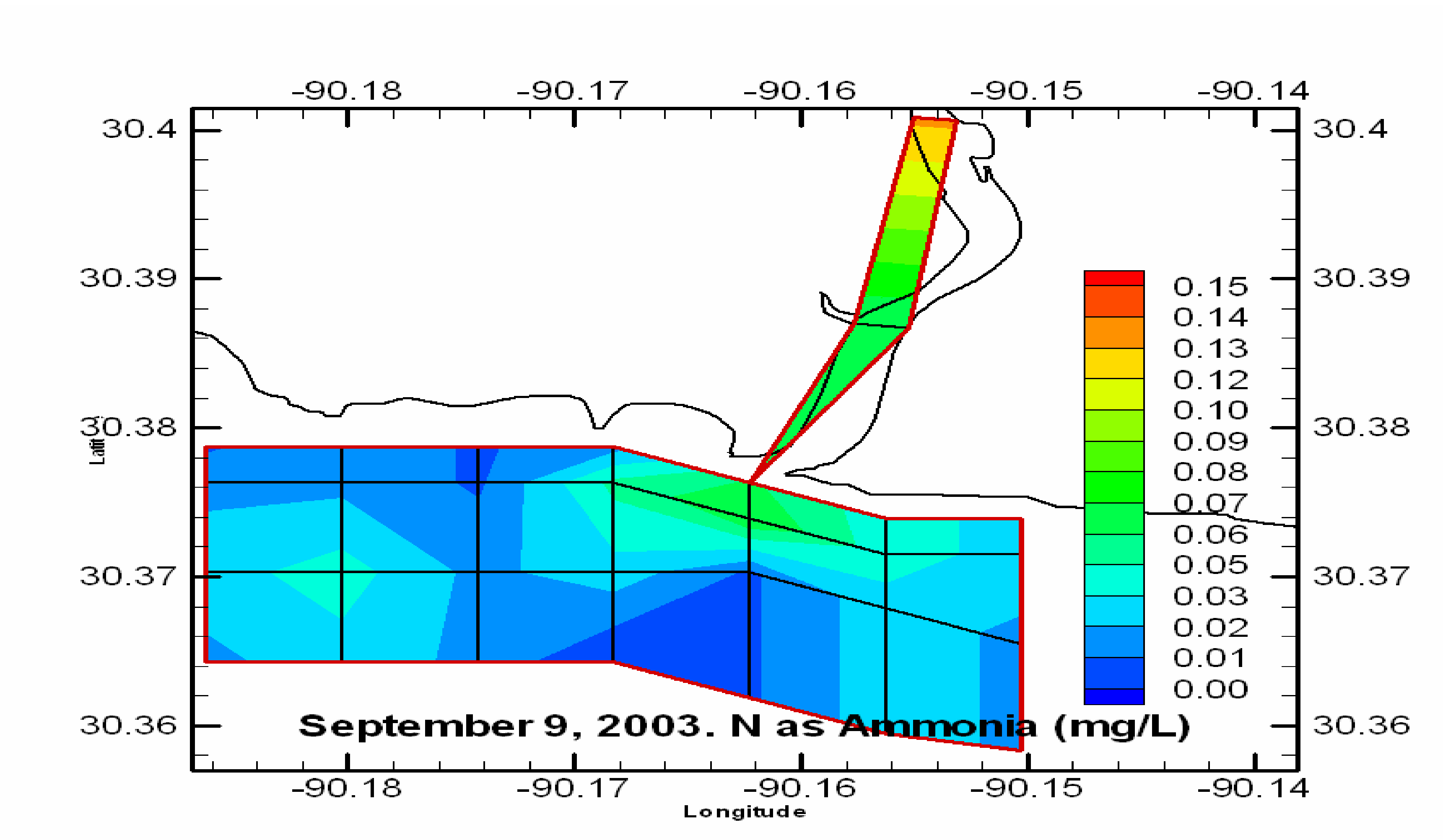

Figure 4.31: Nitrogen as Ammonia data during Rain Event 1. Day

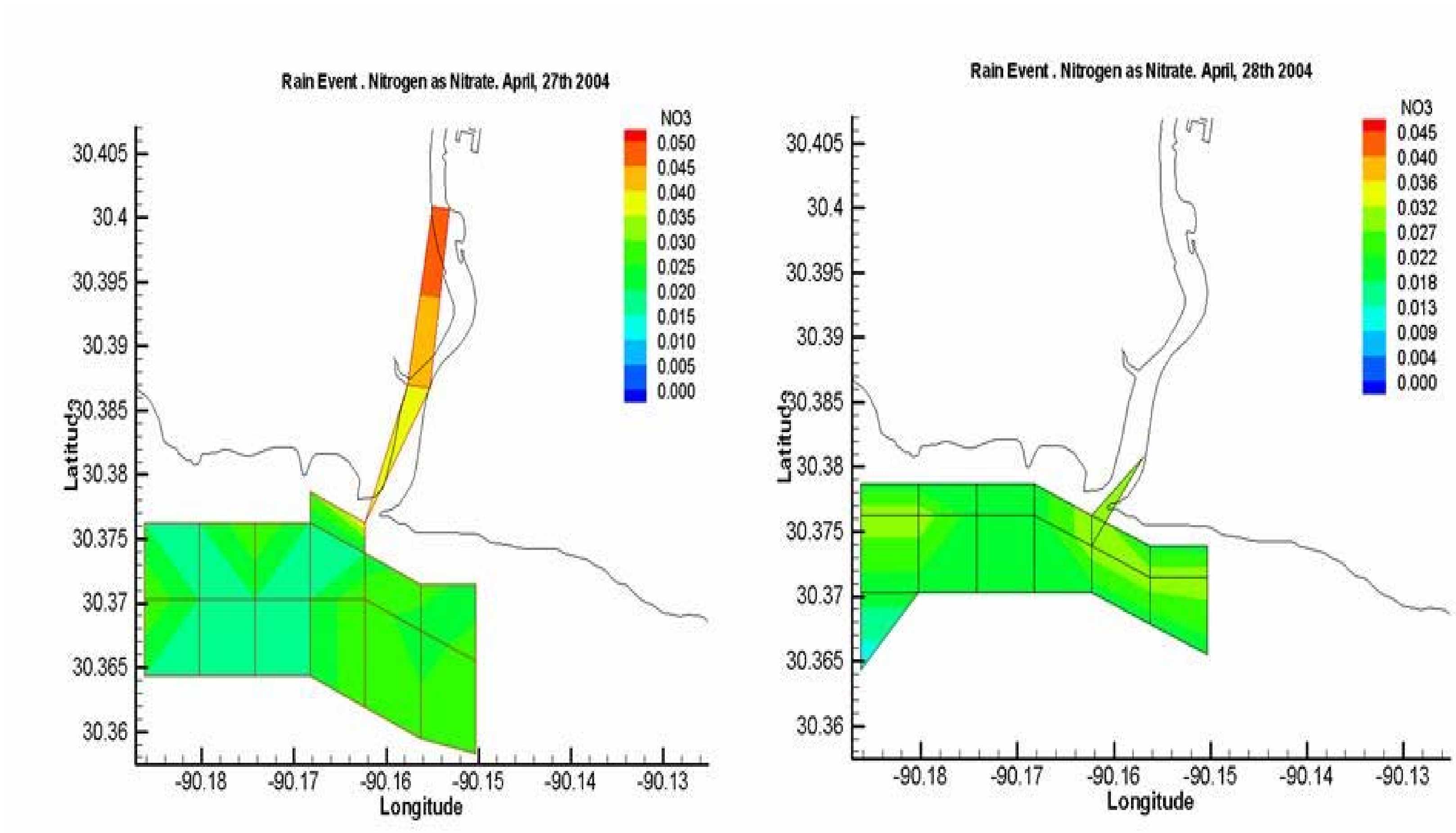

Figure 4.32: N – as Nitrate Levels for Rain Event 2
April 27 and 28, 2004

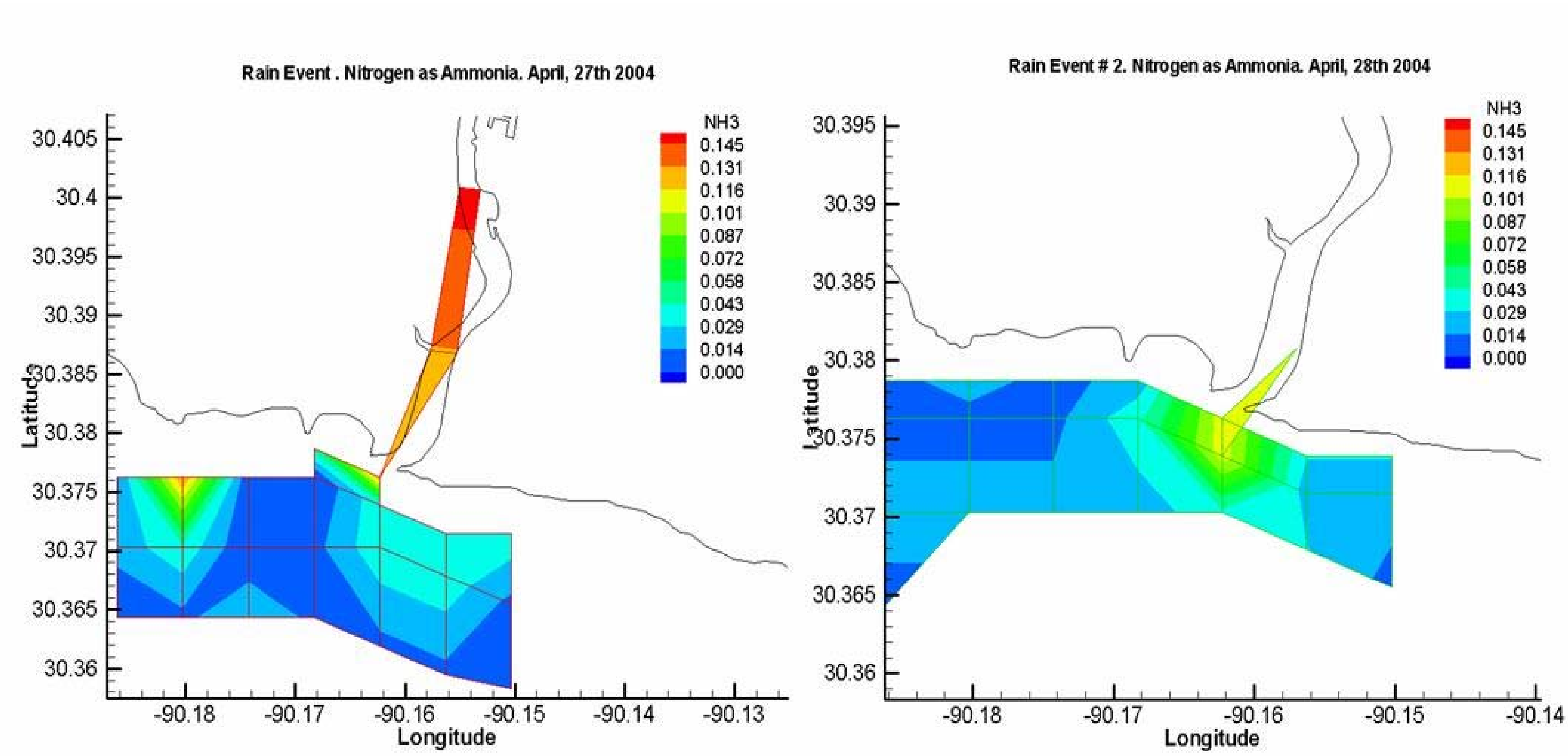

Figure 4.33: N – as Ammonia Levels for Rain Event 2
April 27 and 28, 2004

The un- ionized ammonia values in whole site were constantly low in comparison with the 20 ug/L chronic toxicity limit. It represents that the site of study is healthy according this parameter during wet weather. Table 4.10 shows a summary of the un-ionized ammonia values collected during this study, all raw data are presented in Appendix B

Table 4.10: Summary of Un-ionized Ammonia Values during Rain Events

	9/5/2003	9/7/2003	9/9/2003	4/27/2004	4/28/2004
Bridge	0.19	0.75	0.64	0.46	NS
Mouth	0.06	0.14	0.41	0.27	0.27
Lake	0.07	0.17	0.16	0.12	0.13

NO SAMPLED = The water was rough, the situation became unsafe for continuing sampling

4.3.3. Physical-Chemical Parameters

The data for Rain Event 1 are summarized in Tables 4.11. The first day of sampling was considered a background, as the water quality parameters were representative of dry weather conditions. The water quality data collected on the second and third day of sampling indicated effects from the rainfall. Each physico-chemical parameter is discussed. All raw data are presented in Appendix B.

Table 4.11: Mean Values for Physico-Chemical Parameters

Event		Parameters	Mean	Median	Min	Max
Rain Event #1	Day 1	Dissolved Oxygen (mg/L)	5.98	6.07	3.95	7.38
		Temperature (ºC)	29.63	29.70	30.30	28.70
		Salinity (ppt)	1.77	1.60	0.30	3.40
		Conductivity (uS/cm)	3625.00	3787.00	668.00	4445.00
		Specific Conductivity (uS/cm)	3336.40	3472.00	617.00	4345.00
		Secchi Disk (ft)	6.04	6.00	2.75	10.50
		pH	6.90	6.90	6.70	7.00
		Turbidity (NTU)	4.01	3.56	1.33	10.12
	Day 2	Dissolved Oxygen (mg/L)	5.47	5.87	2.50	6.48
		Temperature (ºC)	28.18	28.20	27.50	28.60
		Salinity (ppt)	1.57	1.60	0.40	2.40
		Conductivity (uS/cm)	3209.00	3226.00	989.00	4853.00
		Specific Conductivity (uS/cm)	3013.00	3032.00	915.00	3350.00
		Secchi Disk (ft)	4.57	5.00	3.00	6.50
		pH	6.87	6.95	6.35	7.17
		Turbidity (NTU)	3.34	3.32	1.75	5.07
	Day 3	Dissolved Oxygen (mg/L)	5.40	5.76	3.03	6.35
		Temperature (ºC)	28.29	28.30	27.70	28.90
		Salinity (ppt)	1.54	1.60	0.40	2.00
		Conductivity (uS/cm)	3156.00	3314.00	818.00	4143.00
		Specific Conductivity (uS/cm)	2964.00	3110.00	762.00	3894.00
		Secchi Disk (ft)	3.88	4.00	3.00	6.50
		pH	6.93	6.96	6.58	7.20
		Turbidity (NTU)	4.78	4.77	2.88	6.66

The average values for the Physico-Chemical parameters for Rain Event #2 are summarized in Table 4.12. All raw data is presented in Appendix B.

Table 4.12: Summary for Physico-Chemical Parameters during Rain Event 2 April 27 and 28, 2004

		27-Apr-04	**28-Apr-04**
Temperature	**ºC**	23.2	22.2
Salinity	**ppt**	2.6	2.6
Conductivity	**us/cm**	4709	4560
Specific Conductivity	**us/cm**	4877	4857
Secchi Disk	**ft**	5	3.8
pH		7	7.1
Turbidity	**NTU**	2.8	5

4.3.3.1. Temperature

On Day 1 of the Rain Event 1 (September 5) the mean temperature was 29.6 ºC. The following two days of sample collection found cooler water temperatures of 28.2 and 28.3 ºC, respectively (Figure 4.34.)

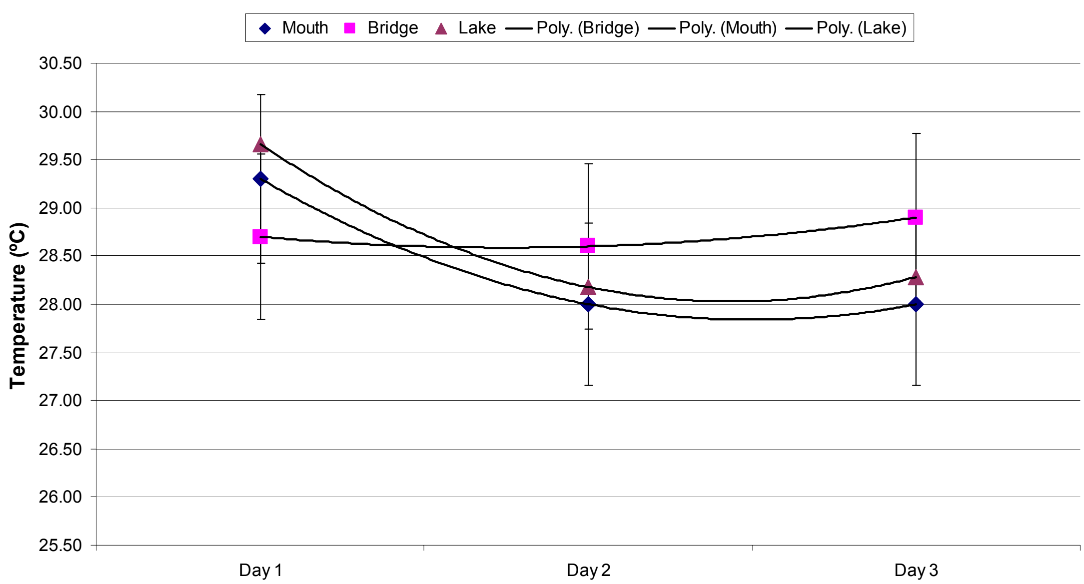

Figure 4.34: Lake, Mouth and River Temperatures during Rain Event 1 September 5, 7, and 9 2003

On the day 1 of the second rain event (April, 27), the mean temperature was 23.2 ºC. On the second day of sampling, April 28, the water temperatures averaged 22.2.

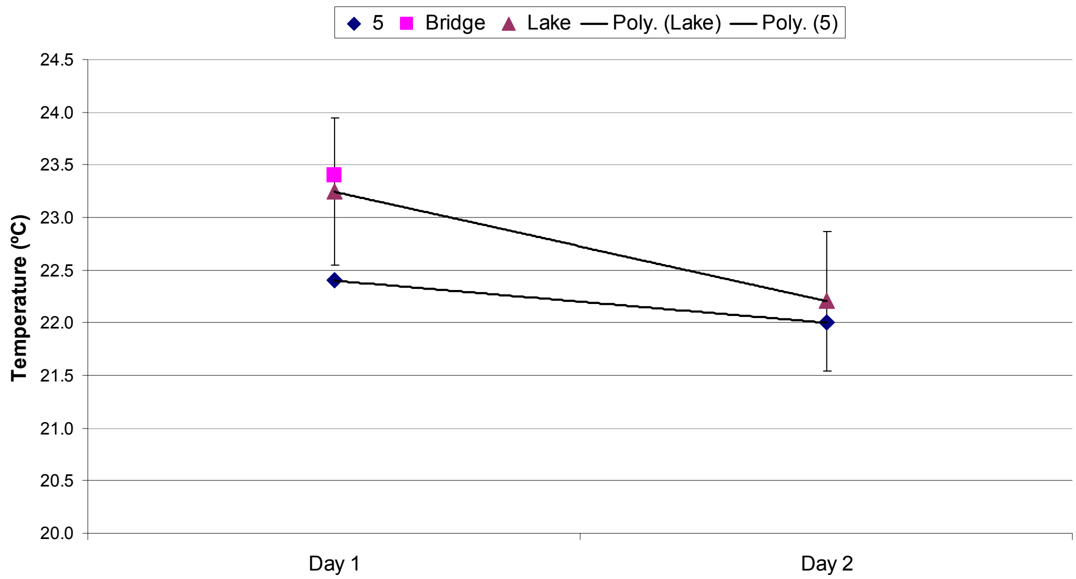

Figure 4.35: Lake, Mouth and River Temperatures during Rain Event 2 April 27, 28 2004

4.3.3.2. pH

The mean pH values for the three days of sample did not change significantly. There is a significant increase at the bridge during rain event 1 from September 5 to September 7 with a ΔpH = 0.4 (Tables 4.13 and 4.14).

Table 4.13: Mean Values for pH at the Mouth, River and Lake Stations. Rain Event 1. September 5, 7 and 9 2003

	Day 1	Day 2	Day 3
Bridge	6.72	7.17	6.82
Mouth	6.86	6.99	6.99
Lake Stations	6.70	6.85	6.95

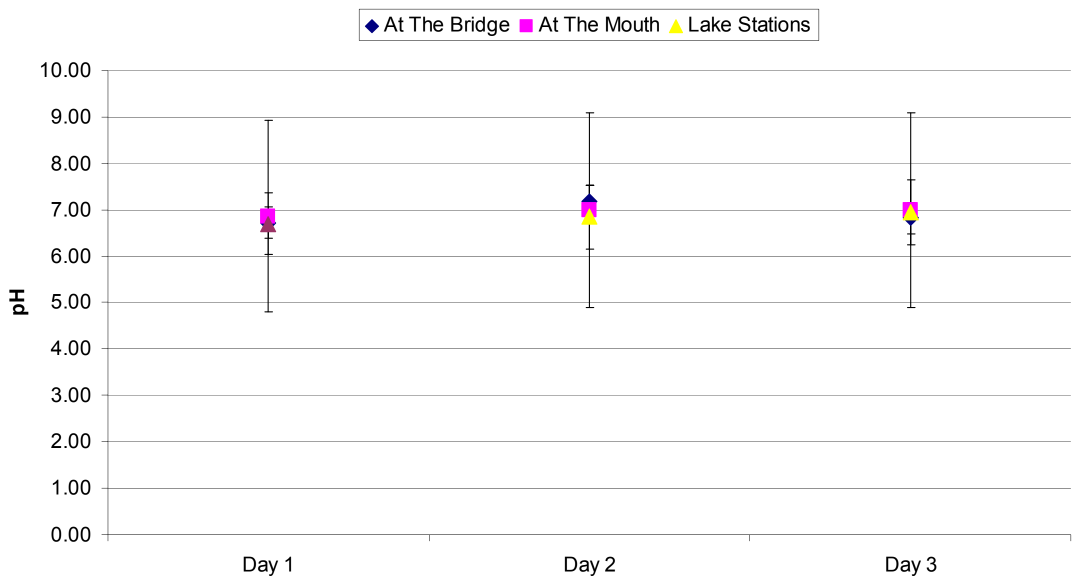

Figure 4.36: Lake, Mouth and River pH readings during Rain Event 1 September 5, 7, and 9 2003

Table 4.14: Mean Values for pH at the Mouth, River and Lake Stations. Rain Event 2.April 27 and 28 2004

	Day 1	Day 2
Bridge	6.78	NO SAMPLED
Mouth	6.65	6.73
Lake Stations	7.02	7.14

NO SAMPLED = The water was rough, the situation became unsafe for continuing sampling

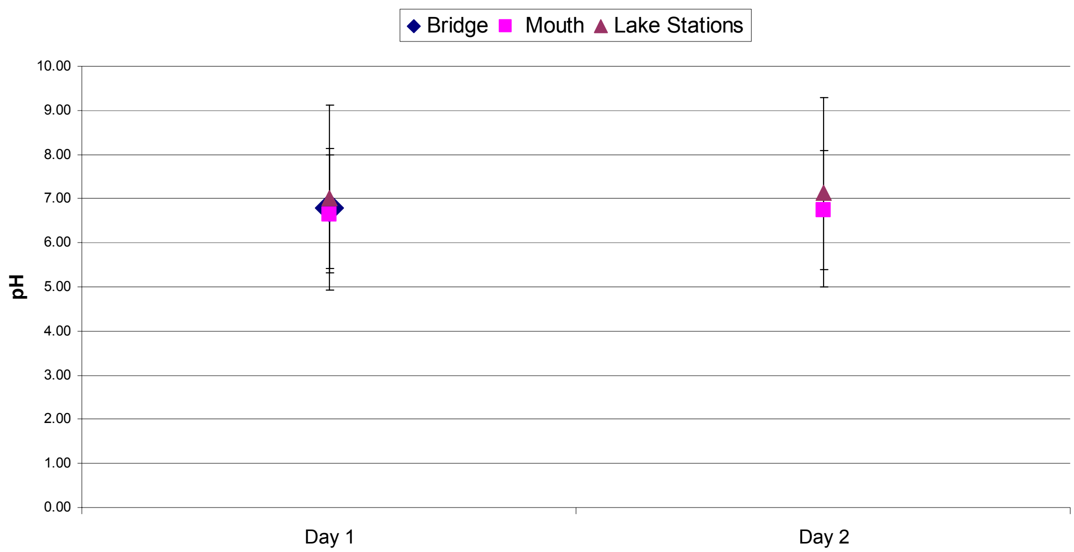

Figure 4.37: Lake, Mouth and River pH readings during Rain Event 2 April 27 and 28, 2004

4.3.3.3. Dissolved Oxygen

The values for DO at the sampling sites close to the mouth of the river were more affected than those further from the mouth. In particular, stations 5, 6, 12, 13 and 14 indicated the greatest amount of change, especially station 5. At station 5, the Dissolved Oxygen values for the three days were 7.38, 3.72 and 3.72 mg/L, (or 98.06, 48.54 and 48. 54%) respectively.

4.3.3.4. Salinity

On all three days in Rain Event 1, the value for salinity at stations 7, 14, 21 and 28 are the highest seen. These are located at the eastern most edge of the grid and are closest to the Gulf of Mexico. The mean values decreased between the first and second day of sampling and stayed consistent at the third day. (Figure 4.38 and 39)

During Rain Event 2 there is no significant difference between the average salinity for the two days of sampling (Figure 4.40 and 41.)

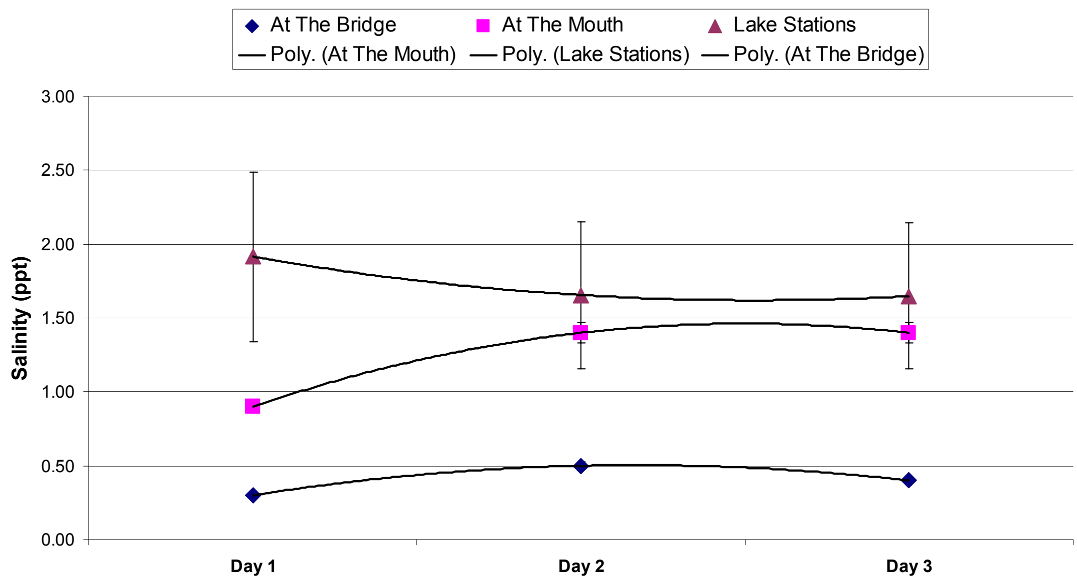

Figure 4.38: Lake, Mouth and River Salinity readings during Rain Event 1 September 5, 7, and 9 2003

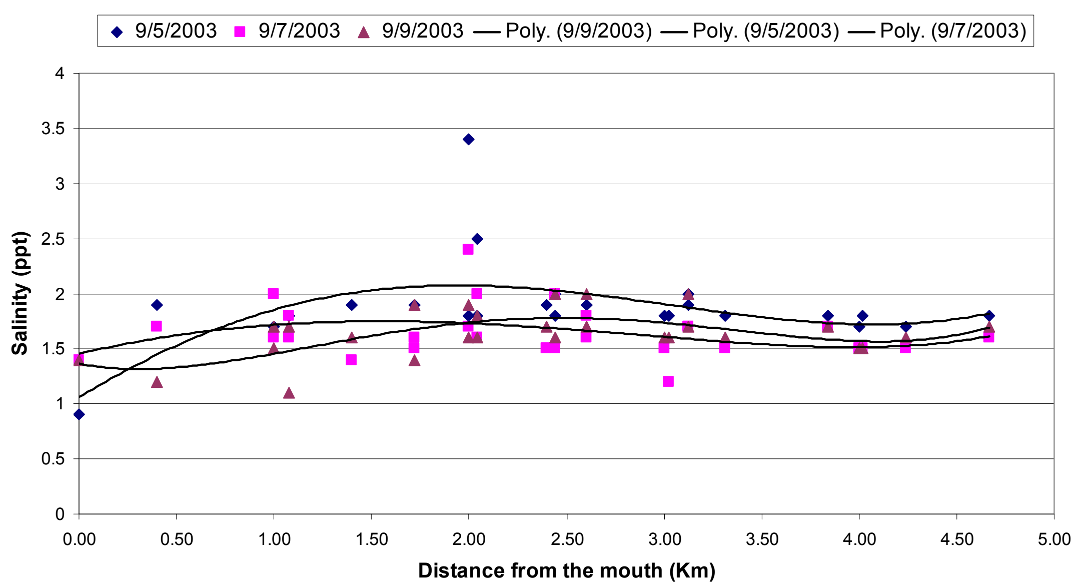

Figure 4.39: Salinity vs. Distance from the mouth of the River Rain Event 1

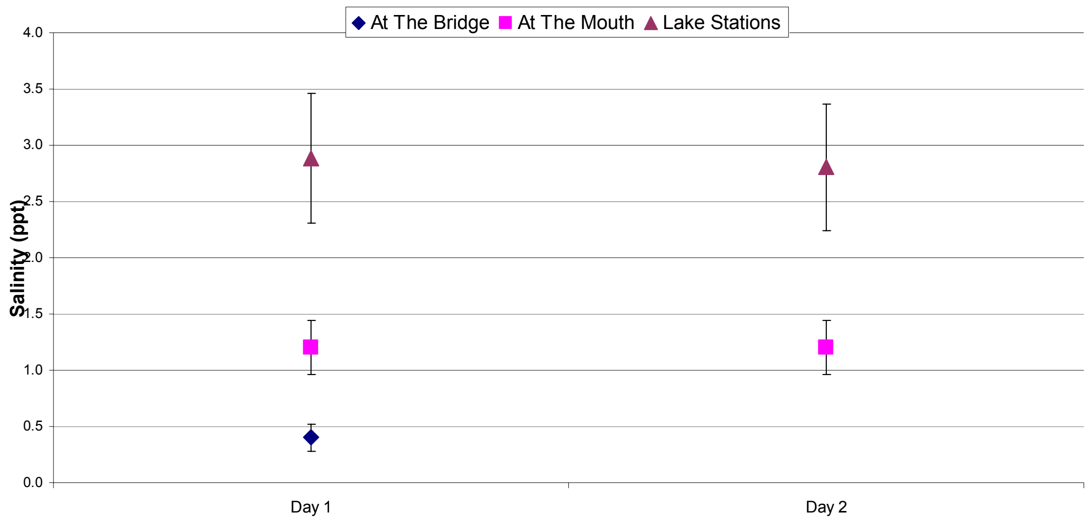

Figure 4.40: Lake, Mouth and River Salinity readings during Rain Event 2 April 27 and 28 2004

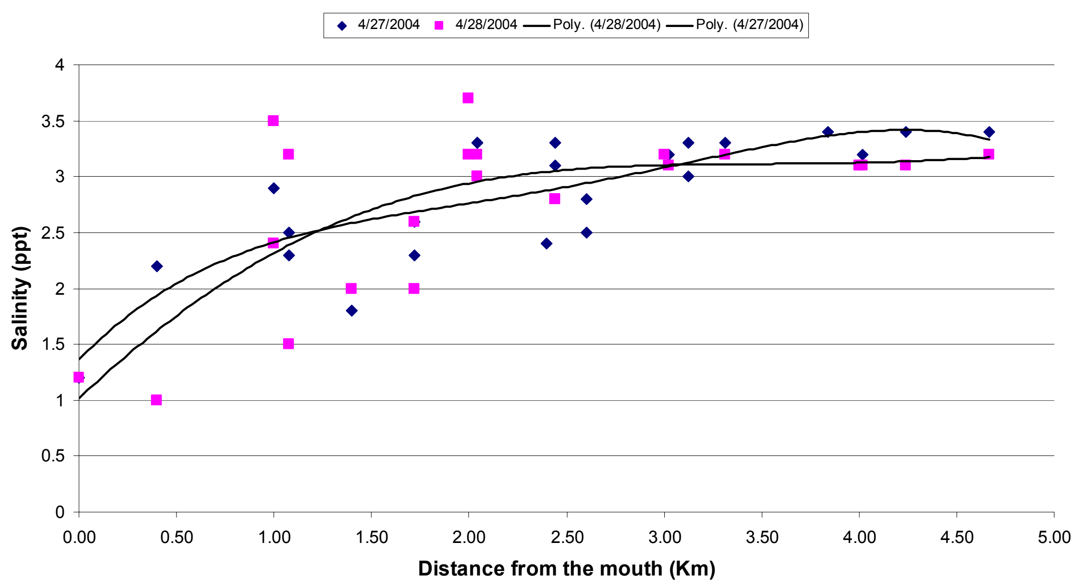

Figure 4.41: Salinity vs. Distance from the mouth of the River Rain Event 2

4.4. Water Quality Parameters: Rain Event vs. Background Surveys

In 2003, the Background samples were collected on June 7, July 12, August 4 and September 5. Rain Event 1 samples were collected on September 7th and 9th, 2003. Rain Event 2 samples were collected on April 27th and 28th, 2004. A called NON EVENT was also performed during July 30th and August 2nd, but because the QA/QC procedure produced unsatisfactory results, it was not considered for microbiological analysis.

The background samples provide a good representation of the water quality in Lake Pontchartrain during the summer months. On the other hand, the rain event samples were collected in mid-spring and late summer. There is great seasonal variation within the lake. The most obvious difference is the temperature. This variable itself may not be important, yet the temperature may effect the following: bacteria growth and die-off rates, microorganisms present in the water column, rate of photosynthesis, dissolved oxygen concentration, fraction of un-ionized ammonia and solubility of compounds. Therefore, the comparison of rain events and background events is limited due to the inherent differences in the water quality due to seasonal effects.

One of the objectives of this project is to determine if certain parameters measured in the water quality study are dependent upon significant rainfall events. The manner in which an attempt was made to verify this hypothesis is outlined in the following section.

4.4.1. Application of Student's t-test

The student's t-test is a statistical tool used to determine the probability that two data sets (samples) belong to the same underlying population. The sample means are compared to determine if the observed difference should be considered statistically significant or not, i.e. if the sample belongs to the same population mean even where there is not a normal distribution within the samples [Neville and

Kennedy, 1964]. The null hypothesis assumed by the Student's t-test is that the two samples are likely to have come from the same two underlying populations that have the same mean.

Table 4.15: Results of Statistical comparison of all "Background" and "Rain Events" data for the Water Quality Study.

						Probability α		
			Average	Std. Dev.	º Freedom	0.050	0.100	T-Test
Madisonville Bridge	log FC	Background	2.23	2.26	4	2.776	2.132	0.59
		Rain Event	2.85	2.92				
	Salinity	Background	0.10	0.17	4	2.776	2.132	1.03
		Rain Event	0.43	0.06				
	Water Temperature	Background	28.97	0.46	5	2.571	2.015	0.98
		Rain Event	27.40	0.15				
	NH_3-N	Background	0.07	0.03	6	2.447	1.943	1.28
		Rain Event	0.10	0.05				
	NO_3-N	Background	0.08	0.02	7	2.365	1.895	0.89
		Rain Event	0.07	0.02				
Mouth of the Tchefuncte River	log FC	Background	1.29	1.38	5	2.571	2.015	1.77
		Rain Event	2.17	2.08				
	Salinity	Background	0.45	0.41	6	2.450	1.943	3.97
		Rain Event	1.30	0.12				
	Water Temperature	Background	28.97	0.46	5	2.570	2.015	0.98
		Rain Event	25.10	3.35				
	NH_3-N	Background	0.04	0.03	7	2.370	1.895	1.49
		Rain Event	0.08	0.04				
	NO_3-N	Background	0.02	0.01	7	2.370	1.895	1.01
		Rain Event	0.03	0.01				
Lake Pontchartrain	log FC	Background	1.35	1.77	156	1.970	1.654	0.82
		Rain Event	1.62	2.24				
	Salinity	Background	0.94	0.73	185	1.970	1.654	6.61
		Rain Event	2.18	0.73				
	Water Temperature	Background	29.51	1.01	186	1.970	1.654	12.01
		Rain Event	25.79	2.78				
	NH_3-N	Background	0.03	0.02	211	1.970	1.654	0.73
		Rain Event	0.03	0.01				
	NO_3-N	Background	0.03	0.02	237	1.970	1.654	0.30
		Rain Event	0.03	0.01				

The null hypothesis is rejected at the level of 5 percent; if the calculated t is greater than the tabulated value at the specified level of significance, the null hypothesis is rejected and concludes that the difference is significant; such is the case of the salinity at the mouth of the river which is influenced by the current position of the tidal cycle in the lake, i.e. flood or ebb.

When calculated t is not greater than the tabulated t at 5 percent level of significance, the hypothesis is accepted. Table 4.8 shows that there is not strong correlation between significant rainfall events and the presence of fecal coliform bacteria at the three stations mentioned.

Another analysis was performed using the geometric mean of the 10 highest counts of fecal coliform and the 10 lowest salinity stations, during wet and dry weather in the lake waters at 5 and 10 percent of level significance, obtaining the same result for salinity, which implies that salinity is dependent of rainfall, however the null hypothesis for fecal coliform counts in this analysis is rejected at 5 and 10 percent level resulting also dependent of rain events.

Table 4.16: Results of Statistical comparison among the highest 10 Fecal Coliform counts during “Background” and “Rain Events” in the lake’ stations

						Propability α		
			Average	Std. Dev.	º Freedom	0.050	0.100	T-Test
Lake Pontchartrain	log FC	Background	1.16	0.66	68	1.99	1.67	6.20
		Rain Event	2.85	2.92				
	Salinity	Background	0.78	0.64	78	1.990	1.660	8.17
		Rain Event	1.92	0.60				

4.4.2. Bacteria Probability Plot

A fecal coliform bacteria probability plot was created as tool to estimate how often a given bacteria count can be expected to be exceeded at the mouth of the Tchefuncte River.

It represents the complete set of bacteria data collected in this study at the mouth of the river plus the station number 7 from LPBF monitoring program. LPBF data are presented in Appendix C.

The Figure 4.42 shows the probability of exceedance of fecal coliform concentrations in all weather conditions at the mouth of the Tchefuncte River. It indicates a 10 % of probability of exceeding a count of approximately 110 MPN/100 ml of fecal coliform. If an extrapolation too the highest concentration showed in the figure is performed (red line), indicates that it approximates a 7% of probability for exceeding the maximum allowed by the LDEQ for primary contact recreation (200 MPN ml)

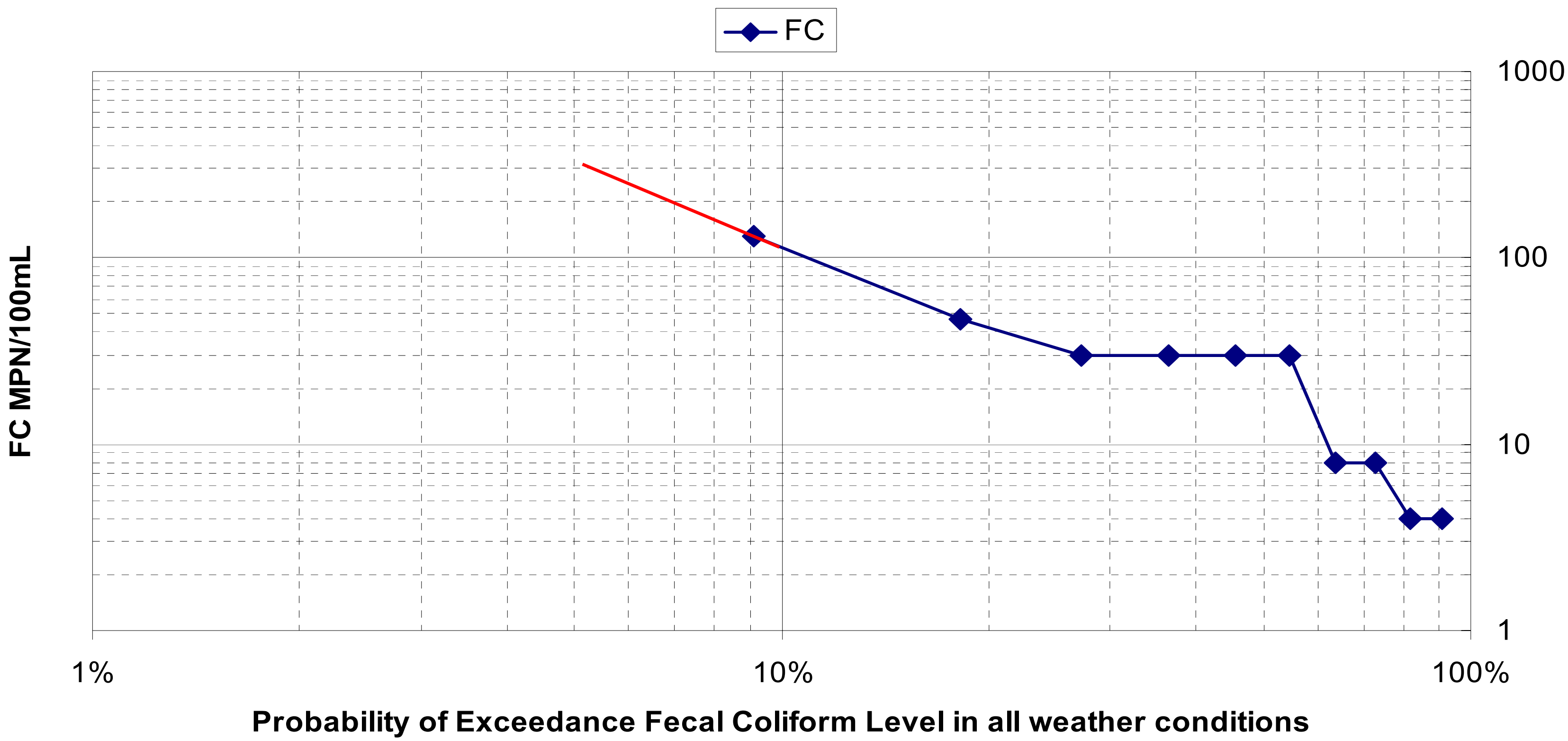

Figure 4.42: Fecal Coliform Bacteria Probability Plot for all weather conditions at the mouth of the Tchefuncte River [Data from this study and LPBF Monitoring Program]

CHAPTER 5
MODEL DEVELOPMENT

5.1. Hydrodynamic and Transport

One of the general goals of the study is to develop and test a modeling framework for forecasting the probable presence and transport of fecal coliform bacteria in Lake Pontchartrain at the mouth of the Tchefuncte River. This study used the Coupled Hydrodynamic-Ecological Model for Regional and Shelf Seas (COHERENS) to asses the hydrodynamic. COHERENS has been also tested to compare its performance with models such as Estuarine, Coastal and Ocean Modeling System (ECOMSED) and Princeton Ocean Model (POM), which have been applied to Lake Pontchartrain by the modeling group at the University of New Orleans to study the fate of pathogens in storm water plumes (McCorquodale et al. 2004); and to ensure applicability to future lake projects.

The horizontal diffusion terms have been simplified according to the recommendations of Mellor and Blumberg (1985). This means that a series of terms have been omitted to avoid unrealistic diffusion across iso-σ surfaces which may become comparable or larger than the diffusion induced by vertical mixing.

The equations of temperature and salinity represent scalar transport equations of the Advection-diffusion type. A whole series of scalar quantities are defined in the program for which a similar transport equation must be solved. These quantities may represent temperature, salinity, turbulence variables.

COHERENS allows simulation of conservative contaminant transport. One of its limitations is that it does not have an option to simulate the decay of the contaminants. In order to determine the fate of pathogen in the lake water, the following equations were used to simulate the dilution and decay effects of the fecal coliform. These equations were applied during the post processing of the salinity transport data generated by the model.

$$R = \frac{1}{S_o} = \frac{C_{back} - C_{local}}{C_{back} - C_{river}} \tag{5.1}$$

where R = reciprocal dilution, S_o = dilution, C_{back} = salinity during background surveys, C_{local} = salinity in the local point, C_{river} = salinity at the mouth of the river.

$$FC_{\max} = (FC_{river} * R) * e^{-k(\frac{\partial s}{\overline{u}})} \tag{5.2}$$

where FC_{max} = corrected concentration of Fecal Coliform (MPN/100 ml)after decay, FC_{river} = maximum counts of FC at the mouth of the river, k = - $2*10^{-5}$ sec^{-1} decay rate, ∂s = distance between the two points of evaluation and u = average velocity.

5.2. Computational Grid.

The computational domain, shown in Figure 5.1 is a rectilinear grid which has 80 cells along west to east and 21 cells along north to south. The horizontal resolution is 100 m and the vertical resolution has 5 vertical layers with thicknesses determined by sigma coordinate transformation. The constant depth of 2 m is assumed through out the basin.

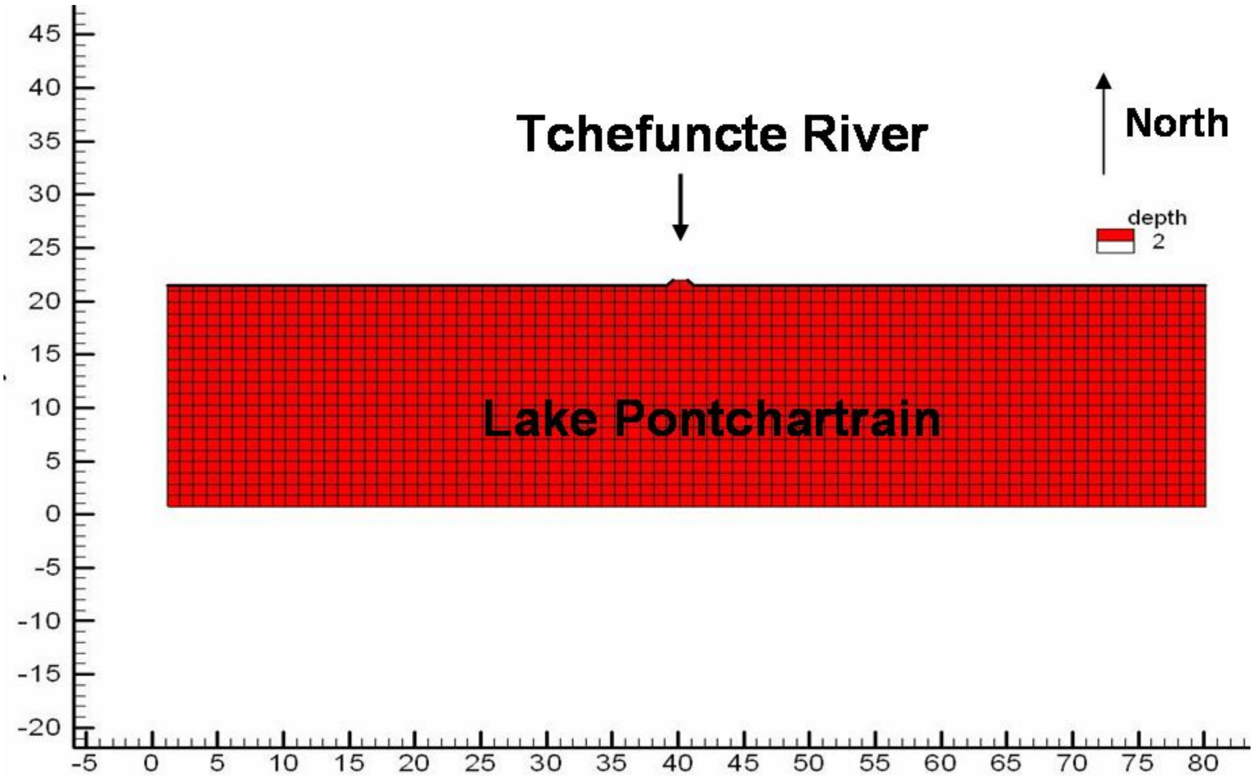

Figure 5.1: Computational Grid.

5.3. Boundary Conditions

The modeling system for the lake at the north shore simulates the evolution of the tidally modulated Tchefuncte River plume, using the idealized conditions of a uniform water depth and no wind or waves forcing.

The rectangle grid is enclosed by a coastal (solid) boundary in the northern, two radiation boundaries on the southern side and western and one open tidal boundary on the eastern. The basin has a length of 8 km, and width of 2 Km and a depth of 2 m. The area is filled initially with lake water having uniform salinity of 2.5 ppt.

Tidal forcing is imposed in the form of a frictionless Kelvin wave entering at the eastern boundary and propagating along the coast (Ruddick et al., 1995). The incoming Riemman variable, specified at the western boundary, then takes the form:

$$R_+ = \overline{U} + c\zeta = 2cF_{har} = 2cAe^{-fx_2/c}\cos w_2 t \quad (5.3)$$

where the Coriolis frequency is evaluated at a latitude of 30º, ω_2 is the M_2 tidal frequency, A = 0.04m and Ū, c, ζ are the depth-integrated alongshore current, the barotropic wave speed and the surface elevation. The amplitude $(Ae^{-fx_2/c})/2$ of the harmonic function F_{har} is applied in the model since the Lake Pontchartrain tide is semidiurnal.

A zero normal gradient condition is selected at the western and southern, i.e.

$$\frac{\partial}{\partial x_1}(\overline{U} - c\zeta) = 0 \quad \text{and} \quad \frac{\partial}{\partial x_2}(\overline{V} - c\zeta) = 0 \quad (5.4)$$

The latter condition is justified by the fact that the width of the basin is smaller than the external Rossby radius c/*f*.

Since the value of ζ is unknown at the river mouth, the open boundary condition at the inlet is no longer defined in terms of the incoming Riemann variable but by specifying the cross-shore component of the depth integrated current. This is given as the sum of a residual value, representing the river discharge, and a tidal component

$$\overline{V} = cF_{har} = \frac{Q_d}{W} + A_r H\cos(\omega t - \varphi_r) \quad (5.5)$$

where Q_d = 10 m^3/s is the river discharge, W = 100 m is the width of the inlet and A_r = 0.03 m/s the amplitude of the tidal current at the mouth of the river.

5.4. Modeling Results and Analysis

The scenario presented in this simulation considers the highest count of fecal coliform obtained at the mouth of the Tchefuncte River (240 MPN/100 ml) during the field studies and it does not consider any previous concentration on lake water. Its goal is to predict the counts of fecal coliform in lake waters, once the same conditions are presented.

During the salinity simulation, it can be observed that the net movement of the fresh water plume from the river is westward. The reason can be attributed to the bottom friction in the basin. During the flood tide the plume is pushed towards west. This water would recede back during the ebb tide, i.e. move east. Because of the bottom friction, the flow moved to west during the flood tide, would not move back causing a net westward movement of the freshwater plume.

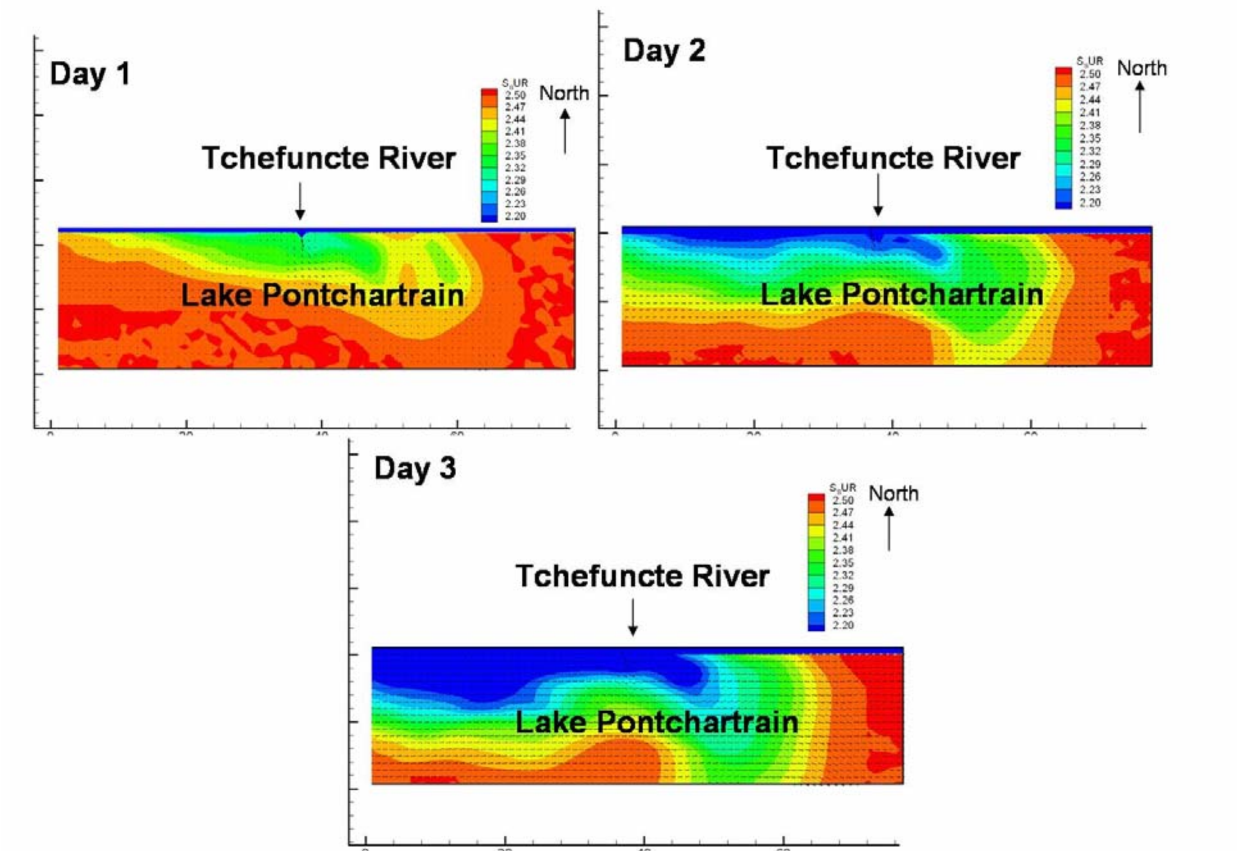

Figure 5.2: Fresh Water Plume Behavior during 3 days simulation of surface Salinity.
8 km x 2 km grid

From the simulation is observed that at the end of Day 1 the plume is not diffused in the lake water, by the end of the day 2 the fecal coliform plume extend to around 2 Km, with concentrations around 70 MPN/100 ml. At the end of third day there is the plume tends to expand more in east-west direction than towards south. The concentration at the middle of the basin is around 50 MPN/100 ml and at the mouth there is a concentration of 215 MPN/100 ml.

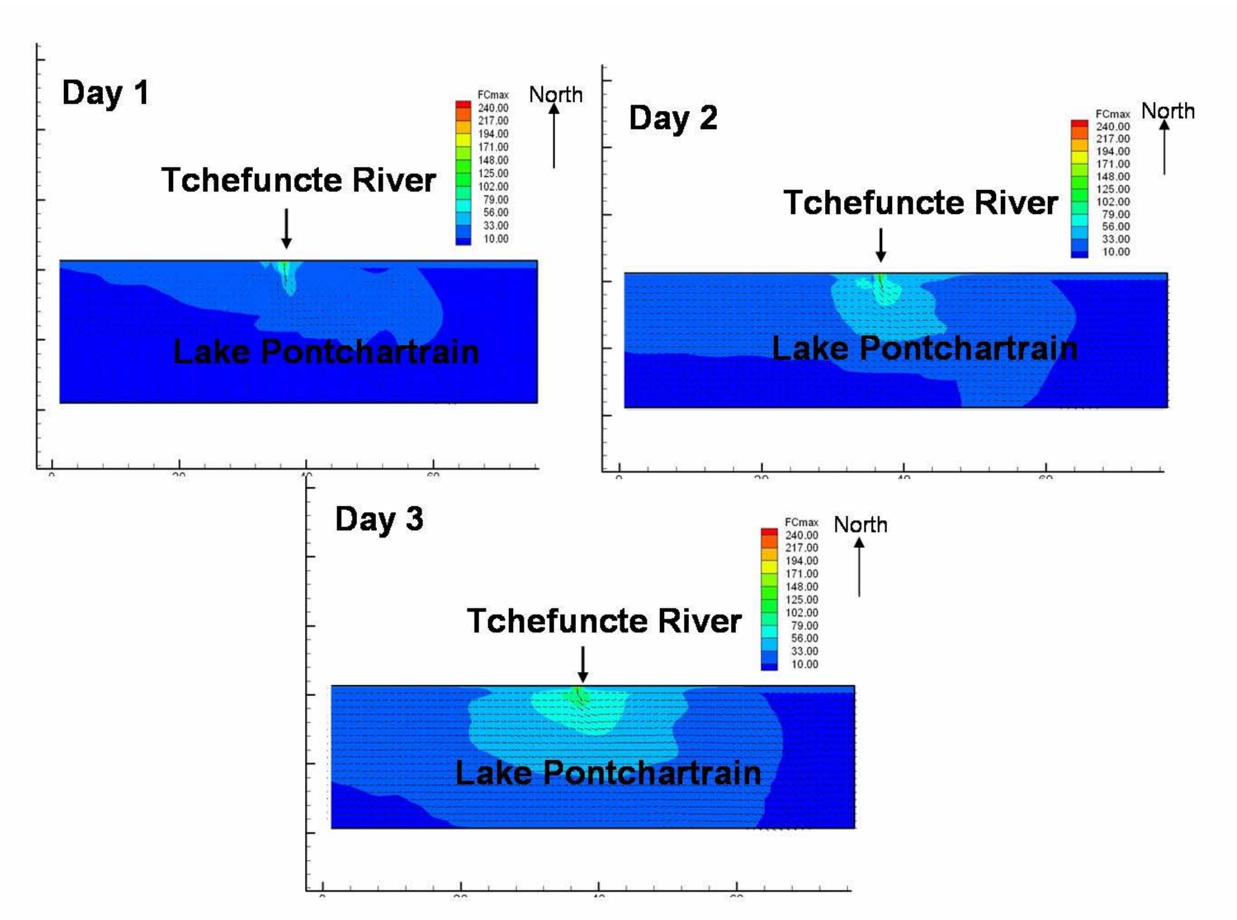

Figure 5.3: Fecal Coliform Plume Behavior during 3 days simulation
8 km x 2 km grid

Based on the limited field data, there is a high uncertainty about the source of fecal coliform at the mouth of the Tchefuncte River. However, forcing the maximum observed fecal coliform concentration at the mouth station (240 MPN/100 ml) in the model; it was observed that the levels in lake waters were always below the maximum allowed by LDEQ (57 MPN/100 ml).

Also, it was observed that the concentration right at the mouth was above the limit at the end of the three days simulation (215 MPN/100 ml).

5.5. Model Validation

The model performs well in predicting FC plumes resulting from the stormwater discharges to the north shore area of Lake Pontchartrain (at the mouth of the Tchefuncte River). Field observations for Fecal Coliforms in stormwater outfall plumes indicate that the model predicted FC concentrations are reasonable.

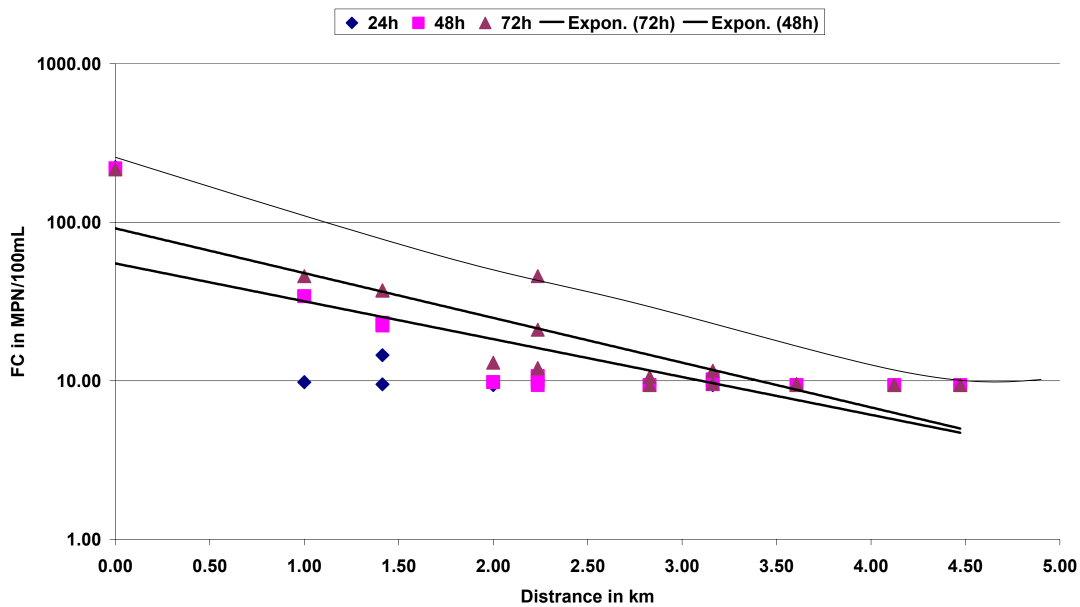

Figure 5.4: Fecal Coliform Trend based on the model

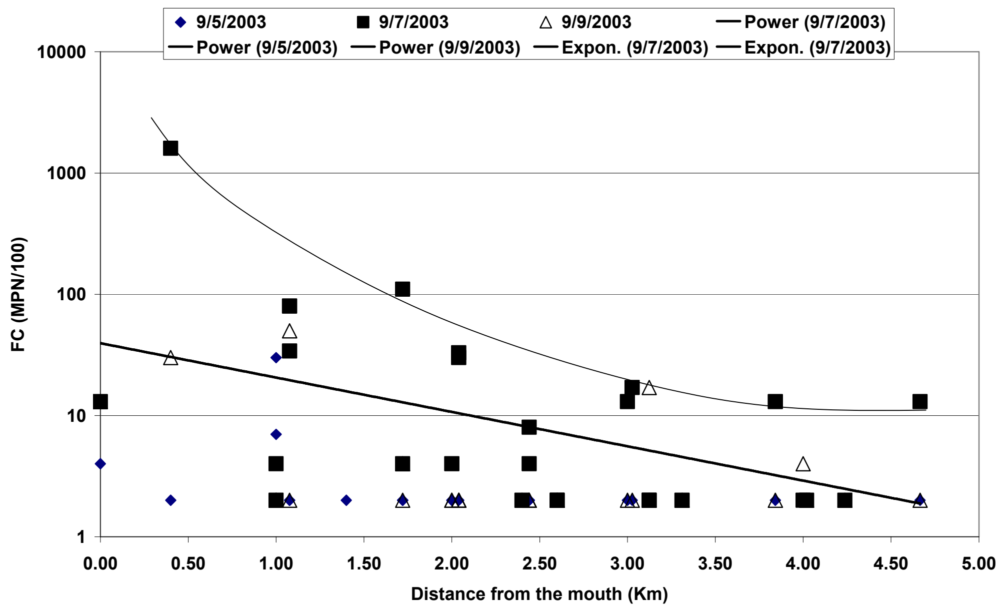

Figure 5.5: Fecal Coliform Trend based on the field study

The upper limits predicted by the model and those measured in the field are in good agreement. The response of the plumes is not forced by winds; it is forced by the lake tides and the flow of the river. The model verifies the typical two to three-day wet weather effect of stormwater discharges at the mouth of the river.

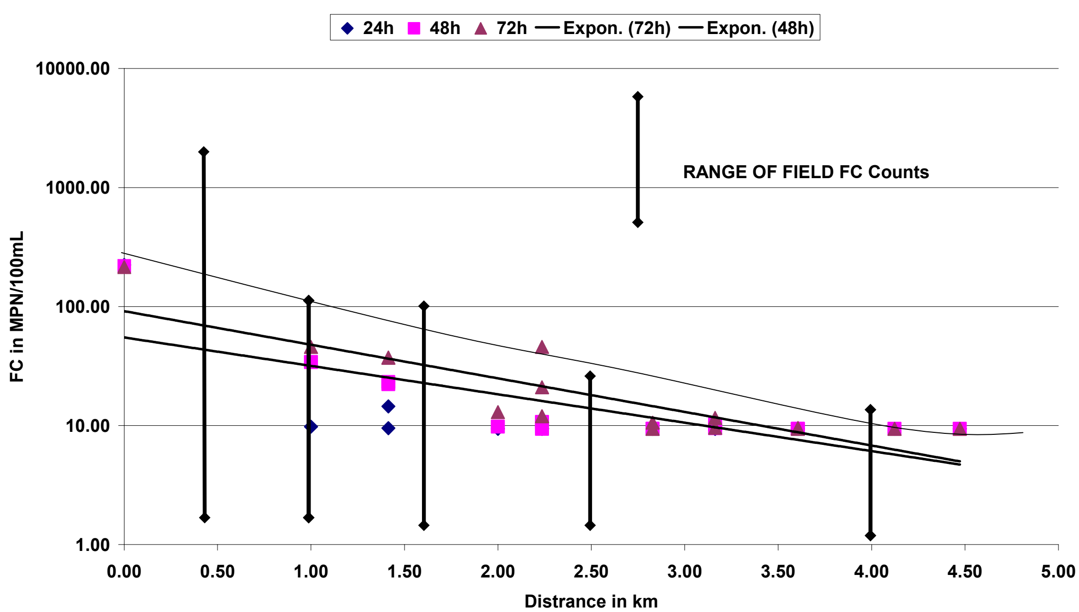

Figure 5.6: Fecal Comparison between model and field study trends

CHAPTER 6
CONCLUSION AND RECOMMENDATIONS

6.1. Conclusions

The field data obtained through the shoreline study yielded information regarding the current state of the water quality of the north shore of Lake Pontchartrain, specifically at and near the mouth of the Tchefuncte River in terms of the safety for recreational uses.

- During background surveys the highest counts of fecal coliform (as a pathogen indicator) were most frequently observed at the stations closer to the mouth (4, 5, 11, 12, and 13) where the mean MPN/100 ml were 144, 25, < 122 and 95, respectively. It shows that even under dry conditions, this site exhibits elevated fecal bacteria levels. However, these levels are below the maximum allowed for primary contact activities by the LDEQ (200 MPN/100 ml). The Fecal Coliform counts (MPN/100mL < 100) for the Lake stations were generally low for dry weather conditions. Swimming could be allowed in the Lake at a distance of 500 m from the mouth of the River.
- The limited data from Madisonville and the mouth of the river support that the finding that entire Tchefuncte River should continue to be listed on the "Louisiana Final 2002 Section 303 (d) List of Impaired Waters Requiring a TMDL" for violation of Total Fecal Coliforms. More data are needed to make a decision regarding the conditions at the mouth of the river during dry weather.
- Nutrient levels during wet weather were constantly low in lake waters (below 0.2 mg/l). N – as ammonia and nitrate data from this study were compared with USGS monitoring data at the gage station 07375050 (Tchefuncte River near Covington) obtaining equal geometric mean of 0.3 mg/L of $N - NH_3$ with a standard deviation of 0.01; but a different geometric mean of 0.2 mg/L of $N - NO_3$ from the mean obtained in this study (0.03 mg/L) therefore a dilution effect could be taking place.
- The Rain Event data show an increase in the fecal coliform contamination in the lake, near to the mouth of the Tchefuncte River. For Rain Event #1, the highest contamination levels were seen three days after the rain. The maximum FC values were ….. For Rain Event #2, which was a very strong, intense rain event, the levels peaked during the second and third

days after the rainfall. With limited microbiological data; it is difficult to make any conclusions based on rainfall alone. There are many factors that play a role in the bacterial contamination at the mouth of the river. These include, but are not limited to, rainfall intensity, river flow, wind direction and speed, and sediment resuspension.

- A statistical comparison among the ten highest fecal coliform counts in the lake for wet and dry datasets indicates in a significant difference in the wet and dry weather log weighted means at the 10% level. Although the wet weather fecal coliforms were generally less than 200 MPN/100mL, the fecal coliforms in the river plumes are about 10 times higher that the dry weather counts.
- The frequency analysis indicates a 10 % of probability of exceeding a count of approximately 110 MPN/100 ml of fecal coliform at the mouth of the river during all weather conditions. There is a 7% chance of reaching the maximum allowed (200 MPN/100 ml) by the LDEQ for primary contact.
- The model performs well in predicting FC plumes resulting from the stormwater discharges to the north shore area of Lake Pontchartrain (at the mouth of the Tchefuncte River). Field observations for Fecal Coliforms in storm water outfall plumes indicate that the model predicted FC concentrations are reasonable. The upper limits predicted by the model and those measured in the field are in good agreement. The response of the plumes is not forced by winds; it is forced by the lake tides and the flow of the river. The model verifies the typical two to three-day wet weather effect of stormwater discharges at the mouth of the river.
- Finally, the hypothesis that a pathogen model for stormwater discharges must be developed/modified based on site-specific conditions is supported by this north shore study.

6.2 Recommendations

Several recommendations are made to improve the modeling of pathogens in the stormwater discharges to the north shore. The following recommendations for improving the field and laboratory studies may result in a more accurate decay sub-model for FC:

- More field data are required for the River and River Mouth to establish the bacterial loading to the Lake. These studies should include the present LDEQ indicator (Fecal Coliform) as well E.Coli and Enterococci since the US EPA is planning to require these as indicators of pathogen contamination.
- More model development is required to incorporate the resuspension of bacteria that are resident in the sediment. This requires that wind and waves be added to model as well as the implementation of a sediment transport model.
- Field data are required for wind/wave events to confirm or reject the hypothesis that bacteria in the sediment may be contributing to the impairment of the water quality.

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APPENDICES

Appendix A1: United States Geological Survey in the Stream Gage 07375050 Tchefuncte River near Covington

Table A1: Nutrient data collected by USGS

DATES	TIME	NH_3	NO_3
11/19/1998	0915	0.02	0.22
12/7/1998	1430	<.02	0.14
1/19/1999	0930	0.03	0.23
2/16/1999	1345	<.02	0.17
3/16/1999	1430	0.03	0.33
4/5/1999	0945	0.04	0.26
5/20/1999	1115	<.02	0.28
6/3/1999	0900	0.04	0.27
6/10/1999	0930	<.02	0.19
6/18/1999	1200	<.02	0.24
7/13/1999	0930	0.03	0.54
7/27/1999	0930	<.02	0.43
8/12/1999	0900	<.02	0.2
9/7/1999	1030	<.02	0.14
10/14/1999	0940	0.05	0.43
11/8/1999	0930	<.02	0.2
12/16/1999	0900	<.02	0.39
1/18/2000	1300	<.02	0.25
2/15/2000	1000	0.03	0.17
3/27/2000	1145	0.03	0.26
4/10/2000	1200	<.02	0.29
5/22/2000	1330	0.03	0.13
6/19/2000	1230	0.03	0.13
7/24/2000	1100	<.02	0.25
8/21/2000	1300	<.02	0.07
10/3/2000	1415	<.02	0.07
10/24/2000	1300	<.04	<.05
11/10/2000	0900	<.04	E.04
12/18/2000	1100	<.04	0.13
1/22/2001	1630	0.08	0.54
2/22/2001	1145	E.04	0.36
3/26/2001	1200	E.02	0.27
4/12/2001	0915	<.04	0.29
5/14/2001	1230	<.04	0.2
6/18/2001	1245	<.04	0.22
7/17/2001	1145	0.05	0.3
8/20/2001	0945	0.05	0.23
9/4/2001	1515	E.03	0.2
	Mean	0.04	0.21
	Median	0.03	0.20

Appendix A2: United States Geological Survey Data in the Stream Gage 07375050 Tchefuncte River near Covington

Table A2: Discharge, Gage Height and Precipitation data collected by USGS

DATE	Q Tchefuncte River (cfs)	Covington GAGE HEIGHT (FEET) D07375050	Covington PRECIPITATION (INCHES) D07375050
6/7/2003	290.59	9.96	1.24
6/8/2003	311.60	10.06	0.00
6/9/2003	365.89	10.30	0.00
6/10/2003	317.42	10.08	0.00
6/11/2003	289.75	9.96	0.26
6/12/2003	288.47	9.95	0.10
6/13/2003	301.23	10.01	0.27
6/14/2003	598.47	10.89	2.26
6/15/2003	2015.64	14.39	1.17
6/16/2003	2814.76	15.85	1.33
6/17/2003	1475.64	13.29	0.31
6/18/2003	914.07	11.99	0.00
6/19/2003	851.88	11.81	0.16
6/20/2003	686.08	11.34	0.15
6/21/2003	792.78	11.65	0.11
6/22/2003	780.27	11.62	0.00
6/23/2003	1557.66	13.47	0.00
6/24/2003	1716.14	13.78	0.04
6/25/2003	695.15	11.38	0.01
6/26/2003	730.37	11.48	0.00
6/27/2003	615.97	11.14	1.46
6/28/2003	1082.96	12.39	0.00
6/29/2003	2393.76	15.06	0.69

Appendix A2: continued

Table A2: Discharge, Gage Height and Precipitation data collected by USGS

DATE	Q Tchefuncte River (cfs)	Covington GAGE HEIGHT (FEET) D07375050	Covington PRECIPITATION (INCHES) D07375050
7/5/2003	6942.00	21.52	0.57
7/6/2003	7434.13	22.08	0.41
7/7/2003	6894.27	21.45	0.03
7/8/2003	5516.61	19.77	0.10
7/9/2003	3210.09	16.43	0.00
7/10/2003	1788.01	13.97	0.00
7/11/2003	1230.10	12.76	0.05
7/12/2003	1456.40	13.23	0.00
7/13/2003	2693.27	15.64	0.01
7/14/2003	1840.92	14.02	0.01
7/15/2003	948.68	12.08	0.00
7/16/2003	772.41	11.60	0.00
7/17/2003	686.12	11.36	0.24
7/18/2003	1013.50	12.22	0.01
7/19/2003	1081.49	12.41	0.82
7/20/2003	2648.65	15.18	3.30
7/21/2003	1919.32	14.03	0.00
7/22/2003	661.92	11.28	0.00
7/23/2003	602.20	11.10	0.60
7/24/2003	987.81	12.15	0.00
7/25/2003	2200.06	14.76	0.10
7/26/2003	1645.69	13.63	0.00
7/27/2003	852.74	11.82	0.00
7/28/2003	675.51	11.32	0.00
7/29/2003	657.12	11.26	1.50
7/30/2003	1402.99	13.14	0.00
7/31/2003	808.42	11.70	0.30

Appendix A2: continued

Table A2: Discharge, Gage Height and Precipitation data collected by USGS

DATE	Q Tchefuncte River (cfs)	Covington GAGE HEIGHT (FEET) D07375050	Covington PRECIPITATION (INCHES) D07375050
8/1/2003	897.30	11.94	0.20
8/2/2003	1012.67	12.22	0.00
8/3/2003	1177.55	12.62	0.00
8/4/2003	712.58	11.43	0.00
8/5/2003	584.31	11.05	0.00
8/6/2003	494.90	10.76	0.00
8/7/2003	454.35	10.62	0.10
8/8/2003	438.76	10.56	0.00
8/9/2003	417.01	10.49	0.00
8/10/2003	398.38	10.42	0.00
8/11/2003	380.34	10.35	0.00
8/12/2003	368.71	10.31	0.00
8/13/2003	363.32	10.29	0.00
8/14/2003	360.25	10.27	0.00
8/15/2003	354.95	10.25	0.00
8/16/2003	354.51	10.25	0.40
8/17/2003	738.90	11.50	0.10
8/18/2003	456.52	10.62	0.00
8/19/2003	365.72	10.30	0.00
8/20/2003	539.31	10.74	3.02
8/21/2003	1711.29	13.74	0.20
8/22/2003	537.22	10.89	0.20
8/23/2003	402.39	10.43	0.00
8/24/2003	360.57	10.28	0.00
8/25/2003	344.52	10.21	0.00
8/26/2003	331.09	10.15	0.00
8/27/2003	360.85	10.26	0.60
8/28/2003	366.54	10.30	0.00
8/29/2003	405.19	10.44	0.30
8/30/2003	354.92	10.25	0.70
8/31/2003	558.59	10.93	0.20
9/1/2003	663.86	11.27	0.00
9/2/2003	428.14	10.53	0.00
9/3/2003	361.86	10.28	0.00
9/4/2003	394.66	10.39	0.90
9/5/2003	426.10	10.51	0.00
9/6/2003	343.50	10.20	0.00
9/7/2003	329.69	10.14	0.00
9/8/2003	313.89	10.07	0.00
9/9/2003	307.28	10.04	0.00

Appendix B1: Water Quality Study Field Data

Table B1: Data Collected in Water Quality Study

	Background DO (mg/L)					
Sample	**6/6/2003**	**7/12/2003**	**7/30/2003**	**8/2/2003**	**8/4/2003**	**9/5/2003**
1	–	–	–	–	–	6.05
2	–	–	–	–	7.74	6.42
3	–	–	–	–	7.37	6.14
4	6.47	–	–	–	8.54	6.13
5	6.85	–	–	–	4.19	7.38
6	7.70	–	–	–	7.30	5.96
7	–	–	–	–	5.65	6.12
8	–	–	–	–	–	6.09
9	7.85	–	–	–	7.35	6.31
10	7.76	–	–	–	7.24	6.02
11	7.10	–	–	–	6.50	6.19
12	7.40	–	–	–	6.05	5.59
13	7.40	–	–	–	6.85	7.15
14	–	–	–	–	6.90	5.52
15	–	–	–	–	–	5.92
16	7.85	–	–	–	7.65	5.92
17	7.90	–	–	–	6.54	5.94
18	7.85	–	–	–	6.90	5.65
19	7.80	–	–	–	7.23	5.62
20	8.10	–	–	–	7.70	6.12
21	–	–	–	–	5.45	5.35
22	–	–	–	–	–	6.14
23	9.00	–	–	–	7.60	6.15
24	8.35	–	–	–	7.25	5.97
25	8.35	–	–	–	6.40	6.12
26	8.15	–	–	–	7.25	6.15
27	8.45	–	–	–	7.52	6.10
28	–	–	–	–	6.84	5.75
Bridge	–	–	–	–	5.74	3.95
Interception	–	–	–	–	4.12	5.45

Appendix B1: continued

Table B1: Data Collected in Water Quality Study

	Rain Events DO (mg/L)				
Sample	**9/5/2003**	**9/7/2003**	**9/9/2003**	**4/27/2004**	**4/28/2004**
1	6.05	5.78	5.91	–	–
2	6.42	6.24	5.26	–	–
3	6.14	5.60	5.44	–	–
4	6.13	4.62	6.08	–	–
5	7.38	3.72	3.72	–	–
6	5.96	5.90	5.52	–	–
7	6.12	5.63	5.61	–	–
8	6.09	5.54	5.14	–	–
9	6.31	5.35	5.79	–	–
10	6.02	5.75	5.64	–	–
11	6.19	4.61	3.62	–	–
12	5.59	4.33	3.75	–	–
13	7.15	5.03	5.84	–	–
14	5.52	5.91	5.78	–	–
15	5.92	6.13	5.98	–	–
16	5.92	6.00	5.71	–	–
17	5.94	5.90	6.02	–	–
18	5.65	6.26	4.77	–	–
19	5.62	5.84	5.57	–	–
20	6.12	4.64	5.74	–	–
21	5.35	6.48	6.35	–	–
22	6.14	6.21	6.28	–	–
23	6.15	6.09	6.00	–	–
24	5.97	6.25	6.04	–	–
25	6.12	6.27	6.05	–	–
26	6.15	6.28	6.20	–	–
27	6.10	6.40	6.17	–	–
28	5.75	6.05	6.14	–	–
Bridge	3.95	2.67	3.09	–	–
Interception	5.45	2.50	–	–	–

Appendix B1: continued

Table B1: Data Collected in Water Quality Study

	Background Temperature (ºC)					
Sample	**6/6/2003**	**7/12/2003**	**7/30/2003**	**8/2/2003**	**8/4/2003**	**9/5/2003**
1	–	–	–	–	–	30.30
2	–	29.50	32.30	31.00	31.60	29.60
3	–	28.50	32.10	30.70	31.20	29.60
4	28.60	26.60	30.80	28.40	31.60	29.70
5	28.80	28.00	30.60	27.90	28.60	29.30
6	28.50	28.40	31.90	28.80	30.00	29.30
7	–	29.00	32.67	29.00	29.90	29.10
8	–	–	–	–	–	30.20
9	28.40	29.20	32.20	31.40	31.7	29.90
10	28.20	27.40	31.90	31.10	31.20	29.80
11	28.70	27.80	31.20	28.30	30.10	29.70
12	28.70	29.00	31.40	28.40	30.30	30.10
13	28.80	29.70	31.50	28.30	29.90	29.20
14	–	29.40	31.20	29.90	30.60	28.90
15	–	–	–	–	–	29.90
16	–	28.90	32.20	31.20	31.10	29.80
17	28.00	29.60	32.10	31.50	31.20	29.90
18	28.10	29.60	31.80	31.10	30.60	29.80
19	27.80	30.10	31.80	29.50	30.60	29.70
20	28.50	29.60	31.60	30.10	30.30	30.00
21	28.10	30.00	31.00	30.70	30.40	29.30
22	–	–	–	–	–	29.60
23	27.90	29.50	31.90	30.80	30.80	29.70
24	27.90	29.40	30.30	30.90	30.70	29.70
25	27.90	29.50	31.50	30.50	30.50	29.70
26	27.80	29.80	31.80	30.00	30.20	29.50
27	28.20	29.20	31.70	30.20	30.60	29.50
28	–	30.60	31.70	30.60	30.50	29.30
Bridge	–	28.70	30.10	27.80	29.50	28.70
Interception	–	26.50	–	27.90	27.10	30.20

Appendix B1: continued

Table B1: Data Collected in Water Quality Study

	Rain Event Temperature (ºC)				
Sample	**9/5/2003**	**9/7/2003**	**9/9/2003**	**4/27/2004**	**4/28/2004**
1	30.30	28.00	27.80	–	21.8
2	29.60	27.60	28.00	–	21.7
3	29.60	27.50	28.30	–	22.5
4	29.70	27.90	28.50	22.2	21.8
5	29.30	28.00	28.00	22.4	22.0
6	29.30	28.20	28.50	–	21.4
7	29.10	28.10	28.30	–	21.9
8	30.20	28.10	27.70	23.2	21.9
9	29.90	28.10	27.90	22.6	21.8
10	29.80	28.20	28.30	23.0	22.6
11	29.70	28.00	28.20	22.9	21.8
12	30.10	27.80	28.20	23.0	22.3
13	29.20	28.10	28.60	23.2	22.4
14	28.90	28.20	28.50	23.2	22.2
15	29.90	28.50	28.20	23.3	22.7
16	29.80	28.40	28.20	23.1	22.6
17	29.90	28.20	28.50	23.0	22.5
18	29.80	28.30	28.40	22.6	22.5
19	29.70	28.30	28.40	23.5	22.1
20	30.00	28.30	28.70	23.5	22.3
21	29.30	28.50	28.50	23.3	22.5
22	29.60	28.40	28.30	24.0	23.0
23	29.70	28.30	28.30	23.8	–
24	29.70	28.30	28.30	23.9	–
25	29.70	28.30	28.20	23.7	–
26	29.50	28.40	28.30	23.8	–
27	29.50	28.40	28.20	23.3	–
28	29.30	28.40	28.30	23.3	–
Bridge	28.70	28.60	28.90	23.4	–
Interception	30.20	28.20	–	–	–

Appendix B1: continued

Table B1: Data Collected in Water Quality Study

	Background Salinity (ppt)					
Sample	**6/6/2003**	**7/12/2003**	**7/30/2003**	**8/2/2003**	**8/4/2003**	**9/5/2003**
1	–	–	–	–	–	1.70
2	–	0.20	0.40	0.30	0.50	1.80
3	–	0.10	0.40	0.30	0.60	1.80
4	0.70	0.00	0.10	0.10	0.50	1.70
5	0.70	0.10	0.10	0.10	0.10	0.90
6	1.10	0.20	0.10	0.00	0.20	1.70
7	–	0.20	0.10	0.00	0.20	3.40
8	–	–	–	–	–	1.80
9	1.20	0.20	0.40	0.50	0.60	1.80
10	1.20	0.10	0.30	0.40	0.60	1.80
11	0.80	0.10	0.10	0.10	0.30	1.80
12	0.80	0.20	0.20	0.10	0.20	1.90
13	0.90	0.30	0.20	0.00	0.30	1.80
14	–	0.30	0.20	0.20	0.40	2.50
15	–	–	–	–	–	1.70
16	1.00	0.20	0.40	0.50	0.60	1.80
17	1.00	0.10	0.30	0.50	0.70	1.80
18	0.90	0.20	0.20	0.50	0.50	1.90
19	0.80	0.20	0.30	0.10	0.40	1.90
20	1.00	0.30	0.30	0.10	0.50	1.90
21	–	0.40	0.30	0.30	0.30	2.00
22	–	–	–	–	–	1.80
23	1.10	0.20	0.40	0.60	0.70	1.80
24	1.10	0.20	0.40	0.60	0.60	1.90
25	1.10	0.20	0.30	0.50	0.50	1.90
26	1.30	0.20	0.40	0.30	0.60	1.90
27	1.40	0.40	0.40	0.40	0.50	1.90
28	–	0.50	0.40	0.50	0.50	2.00
Bridge	–	0.00	0.00	0.00	0.00	0.30
Interception	–	0.00	–	0.00	0.00	0.30

Appendix B1: continued

Table B1: Data Collected in Water Quality Study

	Background Salinity (ppt)				
Sample	**9/5/2003**	**9/7/2003**	**9/9/2003**	**4/27/2004**	**4/28/2004**
1	1.70	1.50	1.50	–	3.1
2	1.80	1.50	1.60	–	3.2
3	1.80	1.70	1.60	–	3.2
4	1.70	1.60	1.50	2.9	2.4
5	0.90	1.40	1.40	1.2	1.2
6	1.70	2.00	1.70	–	3.5
7	3.40	2.40	1.90	–	3.7
8	1.80	1.50	1.50	3.2	3.1
9	1.80	1.20	1.60	3.2	3.1
10	1.80	1.60	1.60	3.3	3.2
11	1.80	1.60	1.10	2.3	1.5
12	1.90	1.70	1.20	2.2	1
13	1.80	1.80	1.70	2.5	3.2
14	2.50	2.00	1.80	3.3	3
15	1.70	1.50	1.60	3.4	3.1
16	1.80	1.50	1.60	3.3	3.2
17	1.80	1.50	1.60	3.3	2.8
18	1.90	1.50	1.40	2.3	2
19	1.90	1.40	1.60	1.8	2
20	1.90	1.60	1.90	2.6	2.6
21	2.00	2.00	2.00	3.1	2.8
22	1.80	1.60	1.70	3.4	3.2
23	1.80	1.70	1.70	3.4	–
24	1.90	1.70	1.70	3.3	–
25	1.90	1.60	1.70	2.5	–
26	1.90	1.50	1.70	2.4	–
27	1.90	1.80	2.00	2.8	–
28	2.00	1.70	2.00	3.0	–
Bridge	0.30	0.50	0.40	0.4	–
Interception	0.30	0.40	–	–	–

Appendix B1: continued

Table B1: Data Collected in Water Quality Study

	Background Fecal Coliform (MPN/100)					
Sample	**6/6/2003**	**7/12/2003**	**7/30/2003**	**8/2/2003**	**8/4/2003**	**9/5/2003**
1	–	–	–	–	–	2.00
2	–	–	–	–	–	2.00
3	–	–	–	–	–	2.00
4	280.00	–	–	–	–	7.00
5	47.00	–	–	–	–	4.00
6	7.00	–	–	–	–	30.00
7	–	–	–	–	–	2.00
8	–	–	–	–	–	2.00
9	21.00	–	–	–	–	2.00
10	7.00	–	–	–	–	2.00
11	240.00	–	–	–	–	2.00
12	240.00	–	–	–	–	2.00
13	220.00	–	–	–	–	2.00
14	–	–	–	–	–	30.00
15	–	–	–	–	–	2.00
16	17.00	–	–	–	–	2.00
17	2.00	–	–	–	–	2.00
18	13.00	–	–	–	–	2.00
19	33.00	–	–	–	–	2.00
20	79.00	–	–	–	–	2.00
21	–	–	–	–	–	2.00
22	–	–	–	–	–	2.00
23	2.00	–	–	–	–	2.00
24	2.00	–	–	–	–	2.00
25	2.00	–	–	–	–	2.00
26	2.00	–	–	–	–	2.00
27	–	–	–	–	–	2.00
28	–	–	–	–	–	2.00
Bridge	–	–	–	–	–	170.00
Interception	–	–	–	–	–	30.00

Appendix B1: continued

Table B1: Data Collected in Water Quality Study

Rain Event Fecal Coliform (MPN/100)					
Sample	**9/5/2003**	**9/7/2003**	**9/9/2003**	**4/27/2004**	**4/28/2004**
1	2.00	2.00	4.00	–	2
2	2.00	13.00	2.00	–	2
3	2.00	–	2.00	–	1.8
4	7.00	2.00	2.00	2	79
5	4.00	13.00	13.00	240	170
6	30.00	4.00	2.00	–	13
7	2.00	4.00	2.00	–	14
8	2.00	2.00	2.00	2	2
9	2.00	17.00	2.00	2	2
10	2.00	33.00	2.00	2	2
11	2.00	34.00	50.00	23	41
12	2.00	>1600	30.00	110	79
13	2.00	80.00	2.00	170	23
14	30.00	30.00	2.00	33	33
15	2.00	2.00	2.00	2	2
16	2.00	2.00	2.00	2	2
17	2.00	8.00	2.00	2	13
18	2.00	4.00	4.00	140	140
19	2.00	–	–	350	240
20	2.00	110.00	2.00	46	79
21	2.00	4.00	2.00	13	49
22	2.00	13.00	2.00	2	2
23	2.00	13.00	2.00	2	–
24	2.00	2.00	2.00	2	–
25	2.00	2.00	2.00	23	–
26	2.00	2.00	2.00	130	–
27	2.00	2.00	2.00	79	–
28	2.00	2.00	17.00	49	–
Bridge	170.00	1600.00	17.00	1600	–
Interception	30.00	–	–	–	–

Appendix B1: continued

Table B1: Data Collected in Water Quality Study

	Background NH_3 - N (mg/L)				
Sample	**7/12/2003**	**7/30/2003**	**8/2/2003**	**8/4/2003**	**9/5/2003**
1	–	–	–	–	0.01
2	0.03	0.01	0.03	0.01	0.02
3	0.02	0.05	0.04	0.05	0.01
4	0.03	0.05	0.04	0.05	0.02
5	0.05	0.06	0.09	0.06	0.01
6	0.06	0.04	0.06	0.04	0.01
7	0.05	0.03	0.07	0.03	0.01
8	–	–	–	–	0.01
9	0.03	0.02	0.05	0.02	0.01
10	0.02	0.02	0.03	0.02	0.01
11	0.02	0.06	0.08	0.06	0.02
12	0.04	0.04	0.09	0.04	0.01
13	0.07	0.05	0.08	0.05	0.01
14	0.10	0.02	0.04	0.02	0.00
15	–	–	–	–	0.00
16	0.02	0.04	0.05	0.04	0.00
17	0.02	0.02	0.02	0.02	0.01
18	0.02	0.03	0.04	0.03	0.02
19	0.07	0.05	0.07	0.05	0.01
20	0.12	0.05	0.04	0.05	0.02
21	0.05	0.03	0.03	0.03	0.01
22	–	–	–	–	0.01
23	0.01	0.04	0.06	0.04	0.01
24	0.01	0.03	0.05	0.03	0.01
25	0.02	0.03	0.05	0.03	0.01
26	0.03	0.04	0.07	0.04	0.01
27	0.08	0.05	0.06	0.05	0.02
28	0.07	0.03	0.04	0.03	0.01
Bridge	0.10	0.05	0.11	0.06	0.05
Interception	0.12	–	0.12	0.08	0.04

Appendix B1: continued

Table B1: Data Collected in Water Quality Study

	Rain Event NH_3 - N (mg/L)				
Sample	**9/5/2003**	**9/7/2003**	**9/9/2003**	**4/27/2004**	**4/28/2004**
1	0.01	0.03	0.01	–	0.01
2	0.02	0.00	0.02	–	0.02
3	0.01	0.04	0.01	–	0.01
4	0.02	0.03	0.02	0.05	0.02
5	0.01	0.02	0.06	0.13	0.11
6	0.01	0.06	0.04	–	0.03
7	0.01	0.03	0.03	–	0.03
8	0.01	0.03	0.02	0.01	0.01
9	0.01	0.02	0.02	0.13	0.01
10	0.01	0.03	0.01	0.00	0.01
11	0.02	0.04	0.05	0.00	0.04
12	0.01	0.03	0.07	0.04	0.11
13	0.01	0.03	0.04	0.04	0.02
14	0.00	0.03	0.03	0.04	0.02
15	0.00	0.02	0.03	0.02	0.02
16	0.00	0.02	0.04	0.04	0.02
17	0.01	0.04	0.02	0.00	0.02
18	0.02	0.04	0.03	0.01	0.02
19	0.01	0.04	0.01	0.04	0.04
20	0.02	0.04	0.03	0.04	0.03
21	0.01	0.04	0.02	0.01	0.01
22	0.01	0.04	0.02	0.00	0.01
23	0.01	0.04	0.03	0.01	–
24	0.01	0.04	0.02	0.03	–
25	0.01	0.04	0.00	0.01	–
26	0.01	0.04	0.01	0.01	–
27	0.02	0.04	0.03	0.01	–
28	0.01	0.04	0.02	0.01	–
Bridge	0.05	0.07	0.13	0.15	–
Interception	0.04	0.08	–	–	–

Appendix B1: continued

Table B1: Data Collected in Water Quality Study

Sample	NH3 7/12/2003	T 7/12/2003	pH 7/12/2003	ug/L unionized ammonia	NH3 8/4/2003	T 8/4/2003	pH 8/4/2003	ug/L unionized ammonia
1	–	–	–	–	–	–	–	–
2	0.03	29.50	7.55	0.81	0.01	31.60	7.49	0.27
3	0.02	28.50	7.22	0.24	0.05	31.20	7.10	0.55
4	0.03	26.60	6.97	0.18	0.05	31.60	7.27	0.83
5	0.05	28.00	7.57	1.27	0.06	28.60	6.58	0.17
6	0.06	28.40	7.62	1.75	0.04	30.00	6.72	0.17
7	0.05	29.00	7.62	1.52	0.03	29.90	6.79	0.15
8	–	–	–	–	–	–	–	–
9	0.03	29.20	7.65	0.99	0.02	31.7	6.93	0.15
10	0.02	27.40	7.20	0.21	0.02	31.20	6.96	0.16
11	0.02	27.80	7.26	0.25	0.06	30.10	6.85	0.34
12	0.04	29.00	7.60	1.16	0.04	30.30	6.69	0.16
13	0.07	29.70	7.44	1.49	0.05	29.90	6.72	0.21
14	0.10	29.40	7.83	4.98	0.02	30.60	6.79	0.10
15	–	–	–	–	–	–	–	–
16	0.02	28.90	7.16	0.21	0.04	31.10	6.94	0.30
17	0.02	29.60	7.33	0.33	0.02	31.20	7.01	0.18
18	0.02	29.60	7.46	0.44	0.03	30.60	6.92	0.21
19	0.07	30.10	7.43	1.50	0.05	30.60	6.86	0.30
20	0.12	29.60	7.66	4.16	0.05	30.30	6.84	0.28
21	0.05	30.00	7.72	2.03	0.03	30.40	6.81	0.16
22	–	–	–	–	–	–	–	–
23	0.01	29.50	7.59	0.29	0.04	30.80	6.88	0.26
24	0.01	29.40	7.51	0.24	0.03	30.70	6.99	0.25
25	0.02	29.50	7.63	0.64	0.03	30.50	6.86	0.18
26	0.03	29.80	7.70	1.15	0.04	30.20	6.90	0.26
27	0.08	29.20	7.65	2.64	0.05	30.60	7.00	0.42
28	0.07	30.60	7.71	2.90	0.03	30.50	7.02	0.26
Bridge	0.10	28.70	–	–	0.06	29.50	6.25	0.08

Appendix B1: continued

Table B1: Data Collected in Water Quality Study

Sample	NH3 9/5/2003	T 9/5/2003	pH 9/5/2003	ug/L unionized ammonia	NH3 9/7/2003	T 9/7/2003	pH 9/7/2003	ug/L unionized ammonia
1	0.01	30.30	6.85	0.06	0.03	28.00	6.96	0.19
2	0.02	29.60	6.99	0.15	0.00	27.60	7.03	0.00
3	0.01	29.60	7.00	0.08	0.04	27.50	6.91	0.22
4	0.02	29.70	6.93	0.13	0.03	27.90	6.88	0.16
5	0.01	29.30	6.86	0.06	0.02	28.00	6.99	0.14
6	0.01	29.30	6.66	0.04	0.06	28.20	6.87	0.32
7	0.01	29.10	6.88	0.06	0.03	28.10	6.90	0.17
8	0.01	30.20	6.84	0.06	0.03	28.10	7.00	0.21
9	0.01	29.90	6.91	0.06	0.02	28.10	6.95	0.13
10	0.01	29.80	6.95	0.07	0.03	28.20	7.00	0.21
11	0.02	29.70	6.93	0.13	0.04	28.00	6.64	0.12
12	0.01	30.10	6.94	0.07	0.03	27.80	6.93	0.18
13	0.01	29.20	6.85	0.05	0.03	28.10	6.55	0.08
14	0.00	28.90	6.66	0.00	0.03	28.20	6.90	0.17
15	0.00	29.90	–	–	0.02	28.50	7.02	0.15
16	0.00	29.80	6.92	0.00	0.02	28.40	6.97	0.13
17	0.01	29.90	6.65	0.04	0.04	28.20	6.97	0.26
18	0.02	29.80	6.86	0.11	0.04	28.30	6.96	0.26
19	0.01	29.70	6.90	0.06	0.04	28.30	7.01	0.29
20	0.02	30.00	6.95	0.14	0.04	28.30	6.57	0.11
21	0.01	29.30	6.92	0.06	0.04	28.50	6.66	0.13
22	0.01	29.60	–	–	0.04	28.40	7.00	0.29
23	0.01	29.70	6.81	0.05	0.04	28.30	6.70	0.14
24	0.01	29.70	6.92	0.07	0.04	28.30	6.66	0.13
25	0.01	29.70	6.86	0.06	0.04	28.30	6.35	0.06
26	0.01	29.50	6.90	0.06	0.04	28.40	6.57	0.11
27	0.02	29.50	6.94	0.13	0.04	28.40	6.92	0.24
28	0.01	29.30	6.98	0.07	0.04	28.40	6.96	0.26
Bridge	0.05	28.70	6.72		0.07	28.60	7.17	0.75

Appendix B1: continued

Table B1: Data Collected in Water Quality Study

Sample	NH3 4/27/2004	T 4/27/2004	pH 4/27/2004	ug/L unionized ammonia	NH3 4/28/2004	T 4/28/2004	pH 4/28/2004	ug/L unionized ammonia
1	–	–	–	–	0.01	21.8	7.15	0.06
2	–	–	–	–	0.02	21.7	7.31	0.18
3	–	–	–	–	0.01	22.5	7.34	0.10
4	0.05	22.2	6.55	0.08	0.02	21.8	7.06	0.10
5	0.13	22.4	6.65	0.27	0.11	22.0	6.73	0.27
6	–	–	–	–	0.03	21.4	7.10	0.16
7	–	–	–	–	0.03	21.9	7.22	0.22
8	0.01	23.2	7.14	0.07	0.01	21.9	7.16	0.07
9	0.13	22.6	6.77	0.36	0.01	21.8	7.26	0.08
10	0	23.0	7.03	0.00	0.01	22.6	7.33	0.10
11	0	22.9	6.90	0.00	0.04	21.8	6.89	0.14
12	0.04	23.0	6.87	0.15	0.11	22.3	6.70	0.26
13	0.04	23.2	6.69	0.10	0.02	22.4	7.08	0.11
14	0.04	23.2	7.00	0.20	0.02	22.2	7.03	0.10
15	0.02	23.3	7.26	0.18	0.02	22.7	7.36	0.22
16	0.04	23.1	7.41	0.50	0.02	22.6	7.35	0.21
17	0	23.0	7.22	0.00	0.02	22.5	7.14	0.13
18	0.01	22.6	6.78	0.03	0.02	22.5	6.93	0.08
19	0.04	23.5	6.80	0.13	0.04	22.1	6.96	0.17
20	0.04	23.5	7.06	0.23	0.03	22.3	7.04	0.15
21	0.01	23.3	6.83	0.03	0.01	22.5	7.11	0.06
22	0	24.0	7.25	0.00	0.01	23.0	7.36	0.11
23	0.01	23.8	6.94	0.05	–	–	–	–
24	0.03	23.9	7.21	0.25	–	–	–	–
25	0.01	23.7	7.26	0.09	–	–	–	–
26	0.01	23.8	6.96	0.05	–	–	–	–
27	0.01	23.3	7.47	0.15	–	–	–	–
28	0.01	23.3	7.18	0.08	–	–	–	–
Bridge	0.15	23.4	6.78	0.46	–	–	–	–

Appendix B1: continued

Table B1: Data Collected in Water Quality Study

	Background NO_3 (mg/L)				
Sample	**7/12/2003**	**7/30/2003**	**8/2/2003**	**8/4/2003**	**9/5/2003**
1.00	–	–	–	–	0.03
2.00	0.01	0.03	0.03	0.03	0.03
3.00	0.00	0.02	0.03	0.03	0.03
4.00	0.01	0.01	0.02	0.03	0.04
5.00	0.01	0.03	0.02	0.03	0.03
6.00	0.00	0.03	0.05	0.04	0.03
7.00	0.02	0.01	0.08	0.07	0.02
8.00	–	–	–	–	0.02
9.00	0.03	0.03	0.02	0.04	0.03
10.00	0.00	0.03	0.03	0.05	0.04
11.00	0.00	0.04	0.03	0.05	0.03
12.00	0.02	0.03	0.02	0.07	0.02
13.00	0.01	0.02	0.03	0.06	0.02
14.00	0.03	0.02	0.03	0.06	0.03
15.00	–	–	–	–	0.02
16.00	0.01	0.03	0.04	0.04	0.02
17.00	0.00	0.02	0.04	0.03	0.00
18.00	0.01	0.01	0.03	0.05	0.00
19.00	0.01	0.02	0.05	0.03	0.02
20.00	0.07	0.03	0.03	0.03	0.02
21.00	0.01	0.01	0.03	0.07	0.03
22.00	–	–	–	–	0.02
23.00	0.01	0.04	0.06	0.02	0.04
24.00	0.01	0.03	0.04	0.04	0.02
25.00	0.02	0.03	0.05	0.04	0.02
26.00	0.03	0.03	0.04	0.05	0.03
27.00	0.08	0.02	0.03	0.03	0.03
28.00	0.07	0.02	0.03	0.05	0.02
Bridge	0.10	0.06	0.14	0.08	0.06
Interception	0.12	–	0.08	0.09	0.06

Appendix B1: continued

Table B1: Data Collected in Water Quality Study

	Rain Event NO_3 (mg/L)				
Sample	**9/5/2003**	**9/7/2003**	**9/9/2003**	**4/27/2004**	**4/28/2004**
1.00	0.03	0.04	0.02	–	0.02
2.00	0.03	0.04	0.02	–	0.02
3.00	0.03	0.03	0.02	–	0.02
4.00	0.04	0.04	0.02	0.03	0.02
5.00	0.03	0.05	0.02	0.04	0.03
6.00	0.03	0.04	0.03	–	0.02
7.00	0.02	0.02	0.03	–	0.02
8.00	0.02	0.03	0.03	0.02	0.03
9.00	0.03	0.03	0.02	0.02	0.03
10.00	0.04	0.04	0.03	0.03	0.02
11.00	0.03	0.04	0.02	0.02	0.02
12.00	0.02	0.03	0.01	0.02	0.03
13.00	0.02	0.03	0.03	0.03	0.03
14.00	0.03	0.03	0.02	0.02	0.03
15.00	0.02	0.03	0.04	0.03	0.02
16.00	0.02	0.03	0.04	0.02	0.02
17.00	0.00	0.03	0.02	0.02	0.02
18.00	0.00	0.03	0.04	0.02	0.02
19.00	0.02	0.03	0.02	0.03	0.02
20.00	0.02	0.03	0.03	0.02	0.02
21.00	0.03	0.04	0.03	0.03	0.02
22.00	0.02	0.03	0.02	0.02	0.01
23.00	0.04	0.03	0.06	0.02	–
24.00	0.02	0.04	0.03	0.02	–
25.00	0.02	0.03	0.02	0.02	–
26.00	0.03	0.03	0.02	0.03	–
27.00	0.03	0.04	0.02	0.03	–
28.00	0.02	0.03	0.02	0.03	–
Bridge	0.06	0.06	0.06	0.05	–
Interception	0.06	0.04	–	–	–

Appendix B1: continued

Table B1: Data Collected in Water Quality Study

	Total Suspended Solids (mg/L)					
Sample	**7/30/2003**	**9/5/2003**	**9/7/2003**	**9/9/2003**	**4/27/2004**	**4/28/2004**
1	–	4	6	3	–	13
2	3.00	22	14	10	–	9
3	8.00	8	30	15	–	11
4	16.00	2	6	3	6	11
5	9.00	21	25	11	2	327
6	10.00	43	22	8	–	7
7	11.00	57	23	12	–	18
8	–	4	17	8	8	16
9	1.00	18	34	15	14	15
10	7.00	24	24	12	7	13
11	9.00	11	50	23	9	4
12	9.00	11	18	10	2	13
13	6.00	10	29	14	13	24
14	11.00	15	50	24	13	13
15	–	19	44	22	7	17
16	10.00	12	6	3	14	15
17	9.00	6	14	7	18	6
18	16.00	25	36	15	6	13
19	24.00	28	4	4	5	7
20	11.00	32	30	15	10	16
21	9.00	23	10	7	2	15
22	–	38	13	6	5	17
23	6.00	5	39	20	12	–
24	26.00	33	26	14	14	–
25	8.00	27	16	11	7	–
26	10.00	12	9	8	4	–
27	10.00	5	51	24	66	–
28	13.00	40	18	16	15	–
Bridge	10.00	32	6	4	3	–
Interception	–	15	8	–	–	–

Appendix C1: Lake Pontchartrain Basin Foundation Data at the mouth of the Tchefuncte River

Table C1: Data collected in Water Quality Study by LPBF at the mouth of the Tchefuncte River

Tchefuncte River Monitoring
Ambient/River Sites

Sites
TFR1= Mouth

January - December 2003
(Specific Conductance in uS)

Site	Date	Fec. Col.	E.coli	Water Temp	Diss. O2	Spec. Cond.	pH	Turbidity	Notes
TFR1	2/3/2003	11	8.25	12.5	10.19	2182	7.31	7.34	
TFR1	2/17/2003	90	90	12.3	8.02	1095	6.79	11.9	Rain, >1"
TFR1	3/17/2003	500	400	18.9	5.83	848	6.42	20.4	
TFR1	3/31/2003	17	17	18.4	6.68	1056	6.65	9.71	
TFR1	4/7/2003	500	500	21.3	4.92	919.7		13.6	
TFR1	4/21/2003	3000	240	24.6	6.85	779	6.47	9.22	
TFR1	5/5/2003	21	16.8	27.5	7.5	9.16	7.38	20.5	
TFR1	5/19/2003	30	30	28.9	7.8	495.5	7.37	9.35	
TFR1	6/3/2003	8	5	30.5	8.13	1270.3	7.39	7.16	
TFR1	6/16/2003	130	78	29.9	7.23	155.2	7.02	8.17	
TFR1	6/30/2003	300	180	25.1	4.56	357.9	6.36	19.9	
TFR1	7/14/2003	30	24	29.4	5.45	65.3	6.55	20.5	
TFR1	7/28/2003	30	18	30.9	5.27	189.8	6.49	19	
TFR1	8/11/2003	30	12	31.1	6.15	762	6.59	12.3	
TFR1	8/25/2003	4	4	31.7	6.38	1884.3	6.73	6.67	
TFR1	9/8/2003	30	18	30.2	5.23	2006	6.65	3.82	

VITA

Jeimmy Leal Castellano was born in Maracaibo, Zulia, Venezuela on October 28, 1979, the granddaughter of Aura Bohórquez, the second daughter of Rafael Leal and Aneida Castellano, the sister of Liezka Leal Castellano.

She graduated from the catholic High School “Sagrada Familia de Nazaret”, Maracaibo, Zulia in 1996, From 1997 to 2000 she attended the University “Rafael Urdaneta” for undergraduate study in Computer Engineering. During her last year of the program she was one year intern in Shell Venezuela where she performed and participated in various projects and developed her undergraduate thesis work. She received the degree of Bachelor of Applied Science in Computer Engineering from “Universidad Rafael Urdaneta” in May, 2000.

Following graduation, she went to Houston, Texas to attend the English as Second Language Program at Rice University for six months.

In February, 2001 she was employed as Programmer/System Analyst at the biggest Venezuelan Technology Company “INTesa”.

In August 2002, she began graduate studies at the University of New Orleans, New Orleans, Louisiana where she completed this thesis for partial fulfillment of the degree of Master of Science in Civil and Environmental Engineering. Her future plans are ongoing learning and working in a well recognized and competitive Engineering firm.