WATERSHED IMPLEMENTATION PLAN

INDIAN BAYOU WATERSHED
SUBSEGMENT 030805

Dissolved Oxygen

Nonpoint Source Unit

EXECUTIVE SUMMARY

To meet the 60% reduction in man-made nonpoint loading in Indian Bayou Watershed as required by the TMDL, a concerted effort by residents, developers, agricultural producers, foresters, and government in the watershed is needed. Specifically, a high priority should be given to implementing construction and urban BMPs, as well as educational programs. As the population in the watershed is increasing, it is important that people are made aware of the importance of clean water and are aware of what they can do to help reduce nonpoint source pollution.

Since the primary land use in Indian Bayou is agriculture, additional attention should also be made to implement agricultural BMPs. Rice and soybeans are reported as the primary crops grown in Indian Bayou Watershed. Therefore, BMP implementation for these commodities is of utmost importance. It was also observed that land use in the watershed is changing from crops to pastureland. As this conversion is made, producers need to be made aware of steps that should be taken to prevent water quality degradation.

A consolidated list of recommended BMPs can be found in the State of Louisiana Water Quality Management Plan, Volume 6, *Louisiana's Nonpoint Source Management*, 2000.

1.0 INTRODUCTION 4
1.1 Ecoregion Description 4
1.2 Calcasieu Basin Description 5
1.3 Indian Bayou Watershed, Subsegment 030805 7
2.0 TMDL FINDINGS 7
3.0 WATER QUALITY DATA 10
3.1 Dissolved Oxygen In Indian Bayou 21
4.0 ANNUALIZED AGRICULTURE NONPOINT SOURCE MODEL 21
5.0 IDENTIFYING HIGH PRIORITY AREAS IN INDIAN BAYOU 22
5.1 Soil 23
5.2 Sediment Run-Off 23
5.3 Water Run-Off 29
5.4 Soil Erodibility K-Factor 31
5.5 Slope Length and Steepness Factor (LS-Factor) 31
5.6 Soils Summary 34
5.7 Nutrients and Organic Carbon 34
5.8 Nitrogen 34
5.9 Nitrogen Biochemical Oxygen Demand 35
5.10 Phosphorus 37
5.11 Organic Carbon 39
5.11 Organic Carbon 39
5.12 Nutrient Summary 39
6.0 WATERSHED LAND USES 41
6.1 New Development And Construction Sites 43
6.2 Urbanization 44
6.3 Pastureland Grazing 45
6.4 Agriculture 46
6.5 Forestry 47
6.6 Hydromodification 48
7.0 POINT SOURCES OF POLLUTION 49
8. 0 BEST MANAGEMENT PRACTICES 49
9.0 ACTIONS TO BE IMPLEMENTED BY LDEQ 50
10.0 ACTIONS TO BE IMPLEMENTED BY OTHER AGENCIES 51
2003 Farm Bill Conservations Programs and Potential Funding Sources. .. 51
Master Farmer Program 53
Master Logger Program 53
11.0 CONSERVATION PRACTICES IN INDIAN BAYOU WATERSHED 53
12.0 PUBLIC PARTICIPATION OF STAKEHOLDERS 54
13.0 TMDL TIMELINE FOR THE NPS IMPLEMENTATION PLAN 54
14.0 TRACKING AND EVALUATION 56
15.0 REGULATORY AUTHORITY 56
16.0 REFERENCES 57
Appendix 1 59
Appendix 2 69
Appendix 3 77

NPS IMPLEMENTATION PLAN FOR THE INDIAN BAYOU WATERSHED SUBSEGMENT 030805

1.0 INTRODUCTION

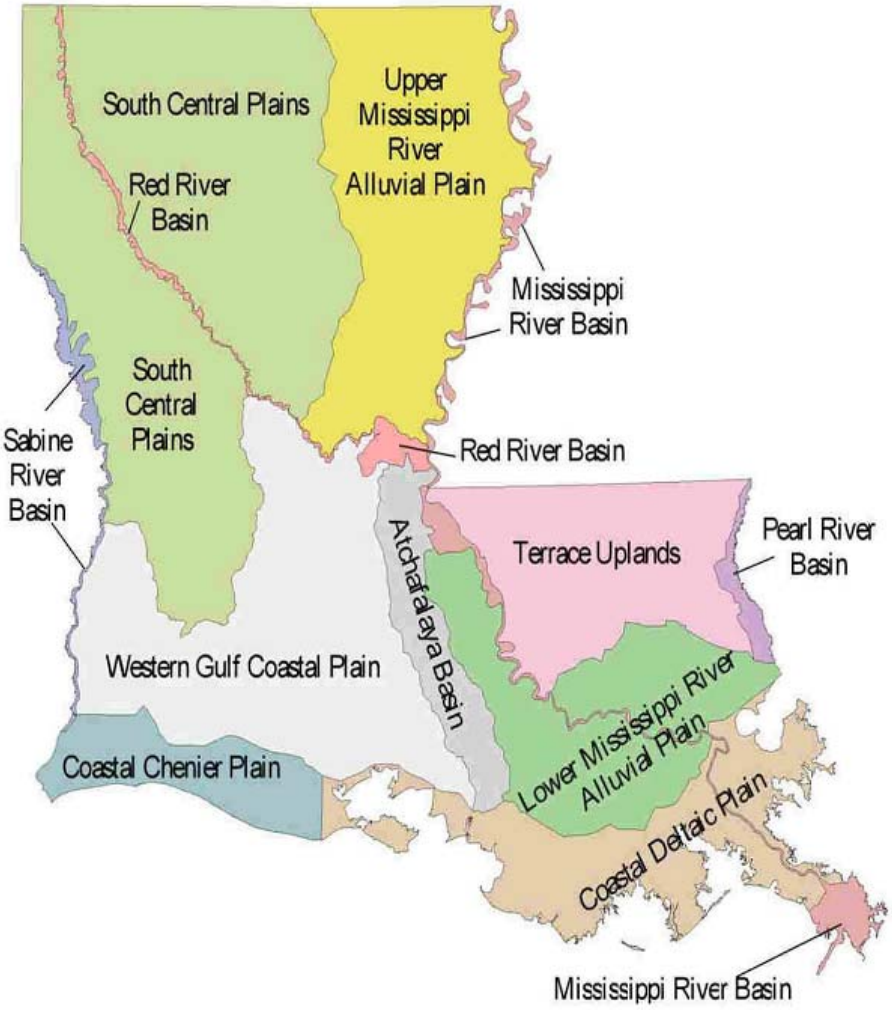
Nonpoint source pollution is a diffuse source of water pollution that flows across land transporting contaminants to a waterbody. Common land-use categories that contribute to water quality impairments from nonpoint sources of pollution include agriculture, forestry, urban runoff, construction, home sewerage systems, resource extraction, and hydromodification. Detailed explanations of each category can be found in the State of Louisiana Water Quality Management Plan, Volume 6, *Louisiana's Nonpoint Source Management*, 2000.

Section 319 of the Clean Water Act authorizes The Environmental Protection Agency (EPA) to issue grants to states to assist in implementing management programs to control nonpoint sources of water pollution. Highest priority is to be given to waterbodies included in the 303(d) List of Impaired Waters. A waterbody is entered into the 303(d) list when it surpasses the water quality standard 10% of the time during an assessment period. Indian Bayou (subsegment 030805) was found to not be meeting its designated use of Fish and Wildlife Propagation based on 1999 ambient sampling data and a Total Maximum Daily Load (TMDL) for oxygen-demand pollutants has been developed. Designated uses of Primary and Secondary Contact Recreation are being met in Indian Bayou. The purpose of this report is to outline a plan, which can be implemented with federal, state, and local funds, to reduce the amount of nonpoint source pollution entering Indian Bayou and thereby increasing water quality to a level where the bayou fully meets designated uses.

1.1 Ecoregion Description

Indian Bayou lies in the Western Gulf Coastal Plain Ecoregion (WGCPE) of southwest Louisiana (Figure 1). The WGCPE is rich in plant species and communities that include glades, barrens, bogs, outcrops, swamps, prairies, savannas, and pine and hardwood forests. An impermeable clay layer beneath shallow soil is common in the area and helped maintain the treeless plains that historically covered the region. The clay layer prevents percolation of water through the soil, allowing water to stand during the wet season and support the extensive rice fields in the region. Trees are prevalent along stream margins where breaks in the clay layer allow them to grow.

Figure 1. Map of Louisiana Ecoregions.



1.2 Calcasieu Basin Description

The Calcasieu River Basin is located in southwest Louisiana and is positioned in a north-south direction between the Mermentau and Sabine Rivers. The drainage area of the Calcasieu Basin comprises approximately 3,910 square miles. Headwaters of the Calcasieu River are in the hills west of Alexandria. The Calcasieu River flows south for about 160 miles to the Gulf of Mexico. The mouth of the river is about 30 miles east of the Texas-Louisiana state line. The landscape in this basin varies from pine forested hills in the upper end to brackish and salt marshes in the lower reaches around Calcasieu Lake and also includes the city of Lake Charles.

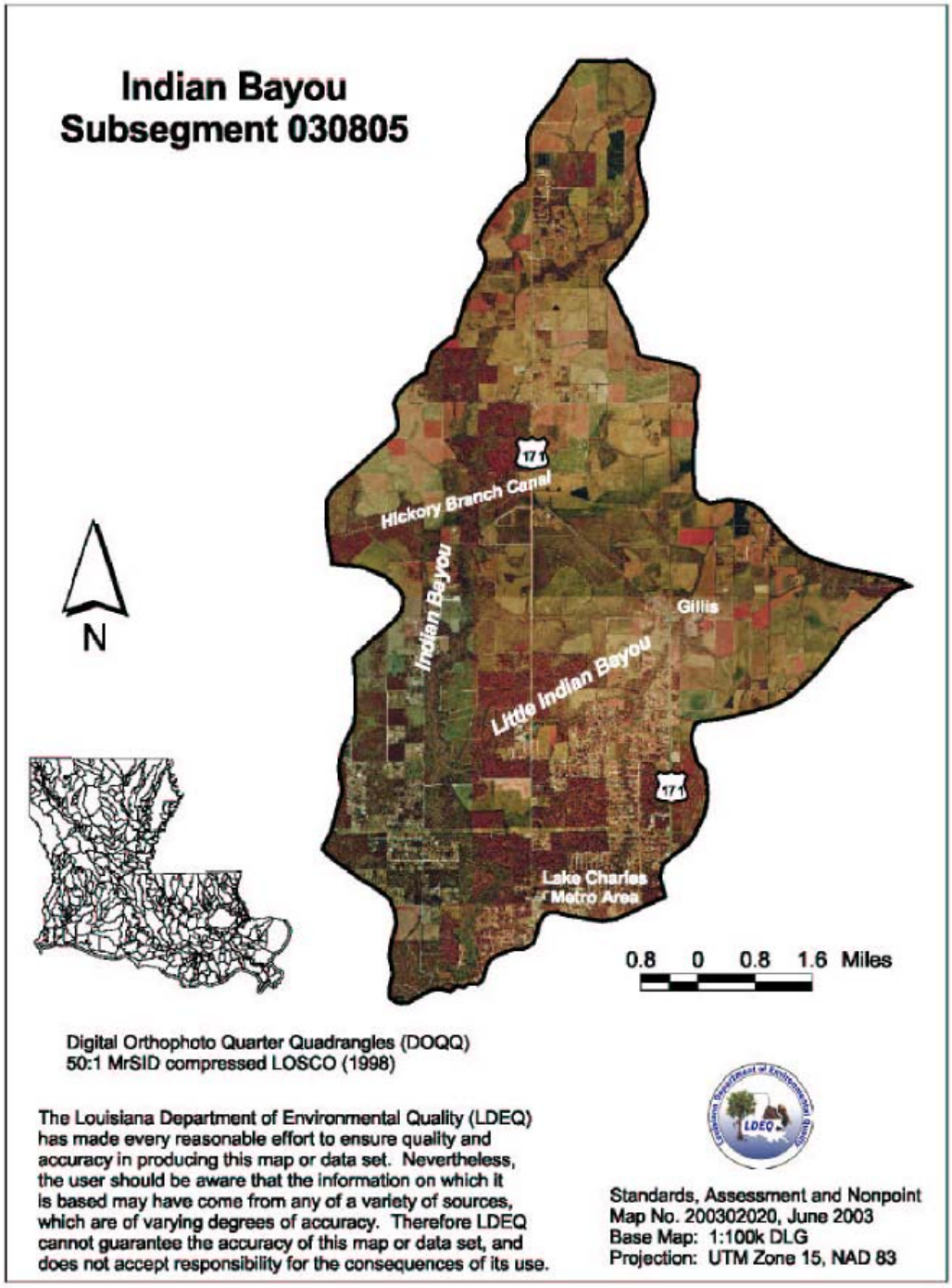


Figure 2. Digital Orthophoto Quarter Quadrangle map of Indian Bayou Watershed.

1.3 Indian Bayou Watershed, Subsegment 030805

Indian Bayou Watershed (figure 2) includes approximately 32,574 acres of Beauregard and Calcasieu Parishes in the central portion of the Calcasieu River Basin. Indian Bayou from its headwaters to its confluence with the West Fork Calcasieu River comprise the main stem of the watershed with Hickory Branch Canal, Little Indian Bayou, and several other unnamed tributaries contributing intermittent flow. Average annual precipitation in the segment is 62 inches, based on a 30-year record from the nearest Louisiana Climatic Station in Lake Charles (LSU, 2000).

2.0 TMDL FINDINGS

Total Maximum Daily Loads (TMDLs), are the maximum amount of a pollutant that can be discharged into a waterbody without causing the waterbody to become impaired and/or violate state water quality standards. TMDLs are the sum of the individual Wasteload Allocations (WLAs) for point sources, Load Allocations (LAs) for nonpoint and natural background sources, and a Margin of Safety (MOS).

TMDL Allocation = WLA + LA + MOS

Water quality standards are defined based on the designated uses of the waterbody in question. The designated uses for Indian Bayou from its headwaters to the Calcasieu River (waterbody subsegment 030805) include primary contact recreation, secondary contact recreation, agriculture, and propagation of fish and wildlife. Based upon 1999 ambient sampling data (appendix 1), Indian Bayou was found to not be meeting its designated use of Fish and Wildlife Propagation. Fish and wildlife propagation includes the use of water for preservation and reproduction of aquatic biota such as indigenous species of fish and invertebrates, as well as reptiles, amphibians, and other wildlife associated with the aquatic environment (LDEQ, 2003). This use also includes the maintenance of water quality at a level that prevents contamination of aquatic biota consumed by humans (LDEQ, 2003).

Water sampling for development of the Indian Bayou Watershed TMDL was conducted on June 27 - 28, 2000. Sites sampled included the West Fork Calcasieu River below confluence of Indian Bayou, Indian Bayou above confluence of West Fork Calcasieu, Indian Bayou at Coffey Road, Indian Bayou at Hickory Branch Road, and Indian Bayou at Boy Scout Road. No flow was observed at Little Indian Bayou, which is a tributary of Indian Bayou, at North Perkins Ferry Road. Data collected included cross-section, drogue

measurement, pH, temperature, dissolved oxygen, conductivity, and dissolved oxygen percent saturation.

The TMDL report for Indian Bayou Watershed was originated on January 4, 2001 and revised on March 13, 2001 by LDEQ. According to the TMDL Report, the suspected causes of impairment in Indian Bayou Watershed are organic enrichment/low Dissolved Oxygen (DO). The largest percentage of the load in Indian Bayou is attributed to nonpoint load (Figure 3). The DO standard for Indian Bayou is 3.0 mg/L March through November and 5.0 mg/L December through February. Projections show that compliance with the current dissolved oxygen criteria will require a 60% reduction of man-made nonpoint loading. The summer TMDL is 7,024 lbs/day and the winter TMDL is 7,070 lbs/day.

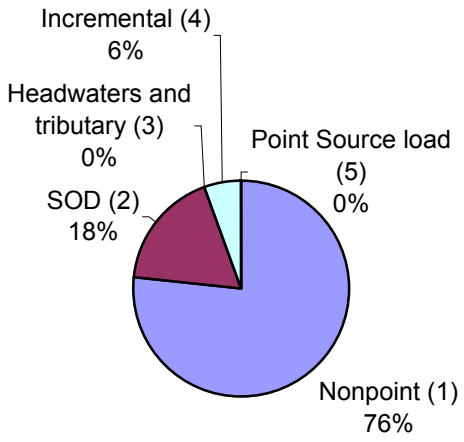


Figure 3. TMDL Load Distribution of Oxygen Demanding Substances for Indian Bayou Watershed. (1) Nonpoint load is the material suspended in the water column. (2) Sediment oxygen demand (SOD) is the benthic load that resides on the stream bottom. (3) Headwaters and tributaries are the loading from tributaries and headwater. (4) Incremental load includes ground water, NPS from rain events, and tributaries. (5) Waste loads are the amount of pollutants discharge in from industrial and municipal point sources in the waterway.

For modeling purposes, Indian Bayou was divided into 4 reaches (table 1). The load distribution by reach (Figure 4) indicates that reach 1 has an elevated amount of nonpoint load. Additionally, the partitioned BOD load (Figure 5) for the Indian Bayou watershed indicates that a disproportionate amount of the BOD load occurs between 6.8 and 0.2 km from the confluence with the West Fork Calcasieu River (reach 4). Since modeling data is not available to compare land

usage and the slope and velocity of stream flow, the exact sources of loading cannot be determined. However, it is recommended that the areas surrounding reach 1 and 4 should be major focal points for reducing nonpoint source pollution in Indian Bayou Watershed.

Table 1. Calibration model reach descriptions.

REACH NUMBER	REACH DESCRIPTION	CALIBRATION MODEL REACH LENGTH (km)	CALIBRATION MODEL AVERAGE REACH WIDTH (m)	ENDING RIVER KILOMETER OF REACH
1	Headwater to RKM 14	8.80	3.51	14.00
2	RKM14 to Conf of Hickory Branch Canal	3.60	5.09	10.40
3	Conf of Hickory Branch Canal to Conf of Little Indian Bayou	3.20	10.67	7.20
4	Little Indian Bayou to Conf of West Fork	7.20	49.68	0.00

Figure 4. Distribution of load by reach in Indian Bayou Watershed

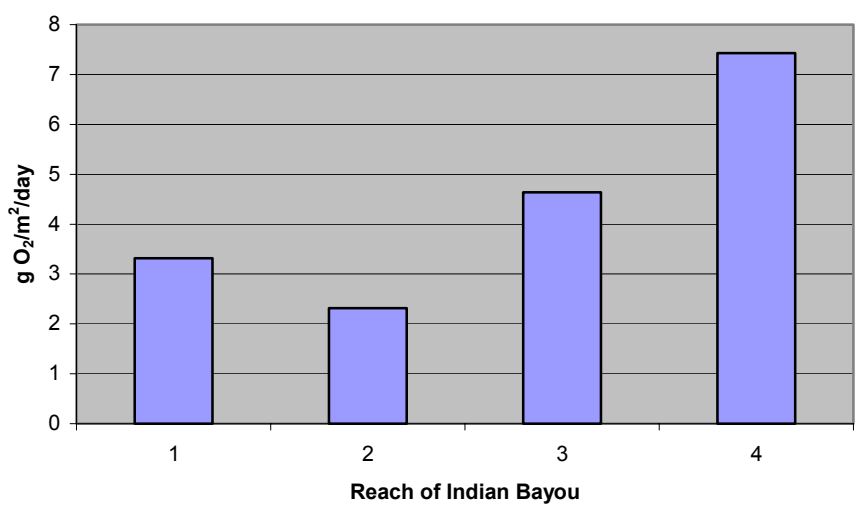
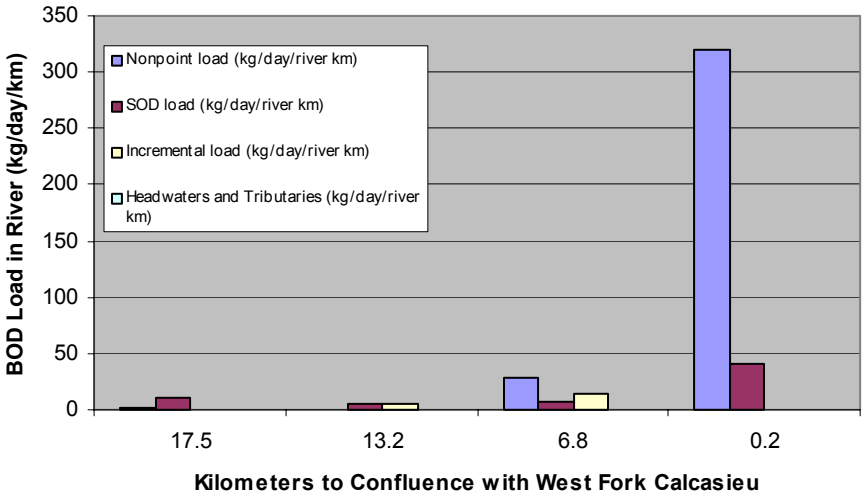


Figure 5. Partitioned BOD Load (kg/day/km) in Indian Bayou Watershed



The largest contributing nonpoint source load in Indian Bayou Watershed is the benthic load, which is comprised of the organic material that has accumulated on the bottom of the bayou. Benthic material utilizes the dissolved oxygen that exists within the water column for biochemical degradative processes. Therefore, in order to improve water quality, it will be necessary to reduce the amount of benthic material that has accumulated, and continues to accumulate, within the waterbodies. In order to do this, the annual sediment, nutrient and organic load that enters the waterbody will need to be reduced. Programs and projects that reduce nonpoint source water pollution need to be implemented in Indian Bayou Watershed to reduce the amount of pollutants entering the waterbody.

3.0 WATER QUALITY DATA

Only one year of ambient data is available for the Indian Bayou Watershed. Since it is difficult to establish trends based on such a small data set and many of the changes in water quality data throughout the year are unexplainable by the information available, historical data from additional sites in the Calcasieu Basin has been included.

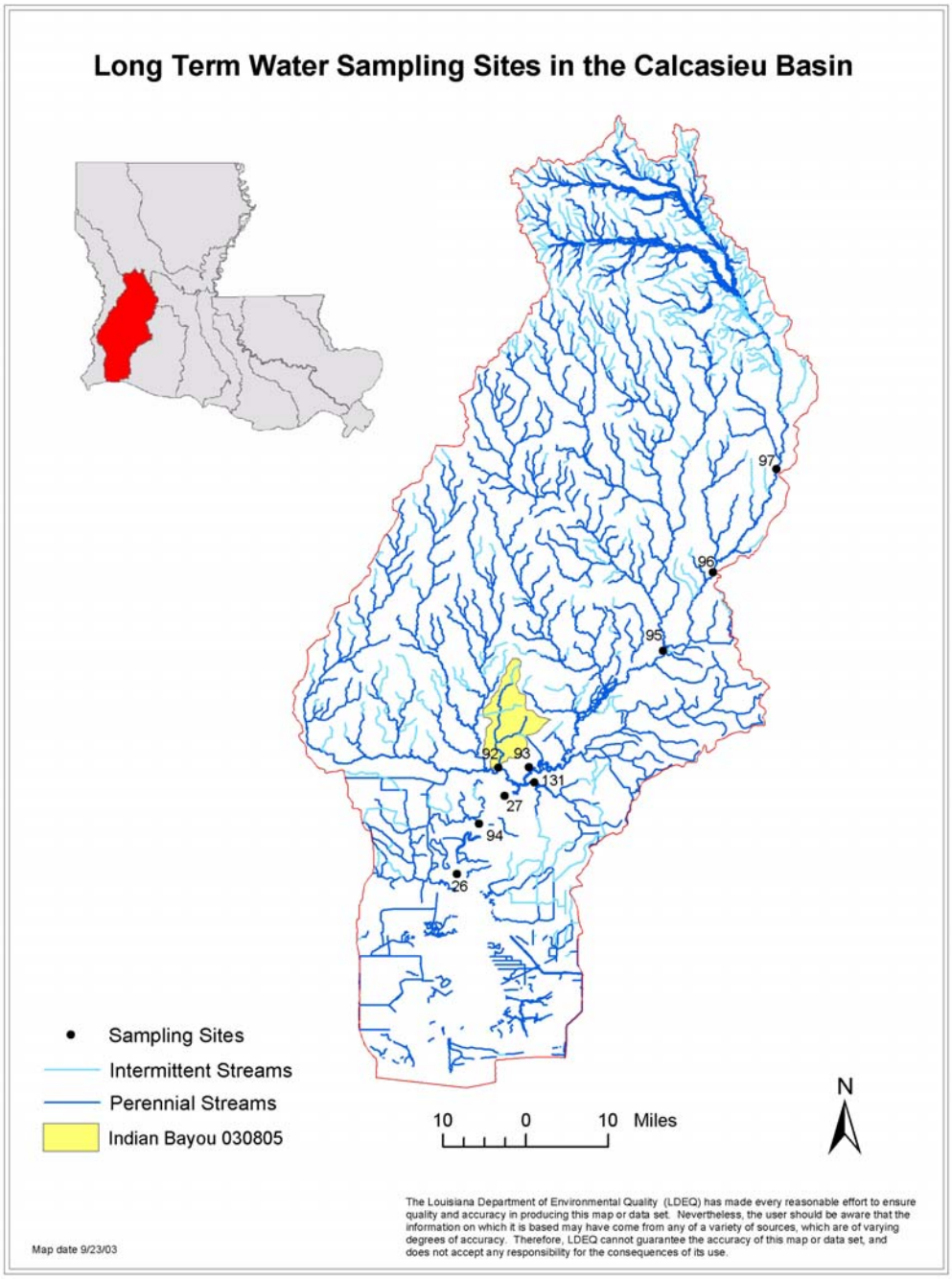
There are nine historic water quality network sites in the Calcasieu Basin (table 2), some of which have data from as far back as 1958. For comparison, sampling sites were split into three groups: Upper Calcasieu, Lower Calcasieu,

and Tributaries. The Upper Calcasieu consists of sites 93, 95, 96, and 97, which are on the Calcasieu River upstream of the saltwater intrusion barrier. The Lower Calcasieu consists of sites 26 and 27, which are on the Calcasieu River downstream of the saltwater intrusion barrier. Sites 92, 94, and 131 are on the tributaries to the Calcasieu River and make up the Tributary group for analysis. Land use in Indian Bayou Watershed appears to be most similar to that in the Upper Calcasieu.

Table 2. Sampling Locations in Calcasieu Basin

SITE NUMBER	SUBSEGMENT	DESCRIPTION	YEAR SAMPLING BEGAN	LAST YEAR SAMPLED
26	030304	Calcasieu River near Burton Landing, Louisiana	1971	2001
27	030301	Calcasieu River near Lake Charles, Louisiana	1971	1998
92	030801	Calcasieu River (West Fork) near Lake Charles, Louisiana	1971	1999
93	030201	Calcasieu River at Moss Bluff, Louisiana	1958	2001
94	030901	Bayou D'Inde near Lake Charles, Louisiana	1978	1998
95	030103	Calcasieu River near Kinder, Louisiana	1958	1999
96	030103	Calcasieu River northwest of Oberlin, Louisiana	1967	1998
97	030103	Calcasieu River near Oakdale, Louisiana	1958	1998
131	030702	English Bayou near Lake Charles, Louisiana	1984	1998

Figure 6. Long Term Water Sampling Sites in the Calcasieu Basin.



The data from all sites and all years reveals some characteristic seasonal trends. From March to August, dissolved oxygen values (figure 7) decline and appear to correspond to increasing water temperature. The turbidity data (figure 8) was similar to what one might expect with higher values during the winter and spring months and dropping off in the summer through the fall, possibly corresponding to rainfall events and field activity. Whereas April does not seem to show a spike or elevated level for turbidity, it did seem to have a higher value for TKN (figure 9), nitrate/nitrite (figure 10) and total phosphorus (figure 11) that may be related to rice discharge or fertilization of crops, forests, and lawns. Water clarity, as measured by the secchi disk (figure 12), seemed to also exhibit a seasonal pattern of lower clarity during the winter and spring months and higher clarity during the summer and fall months. Total organic carbon (figure 13) appears to have a seasonal pattern similar to the TSS pattern (figure 14). TDS (figure 15) trends probably result from saltwater intrusion or increased salinities during the fall months.

Overall, water quality seems a little better in the upper Calcasieu than in the lower Calcasieu and the tributaries. The monthly median values for the lower Calcasieu and the tributaries drop below the 5 ppm dissolved oxygen standard, but the median vales in the upper Calcasieu do not (figure 16). A saltwater intrusion barrier separating the upper and lower Calcasieu can account for the higher TDS values in the lower Calcasieu than in the tributaries or in the upper Calcasieu (figure 17).

In general, nutrient values are consistently higher in the lower Calcasieu and the tributaries. The lower Calcasieu and tributaries drain areas that are primarily pastureland, forested, or urban with the city of Lake Charles comprising a large portion of this area. The peak in nutrients, such as nitrate/nitrite (figure 18), that occurs in April is possibly a result of the fertilization of lawns, forests, or pasture, which is often done during the spring. The turbidity pattern is also interesting with the lower Calcasieu and the tributaries peaking in April and the upper Calcasieu values exceeding them in June through November (figure 19). Additional historic data can be found in appendix 2.

Figure 7. Dissolved Oxygen Medians for all SamplingYears
Stations 26, 27, 92, 93, 94, 95, 96, 97, and 131

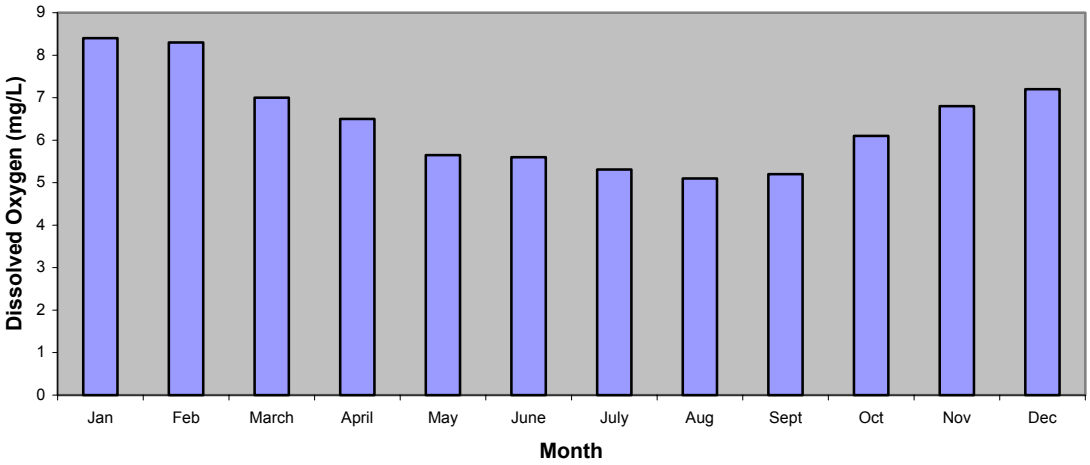


Figure 8. Turbidity Medians for all SamplingYears
Stations 26, 27, 92, 93, 94, 95, 96, 97, and 131

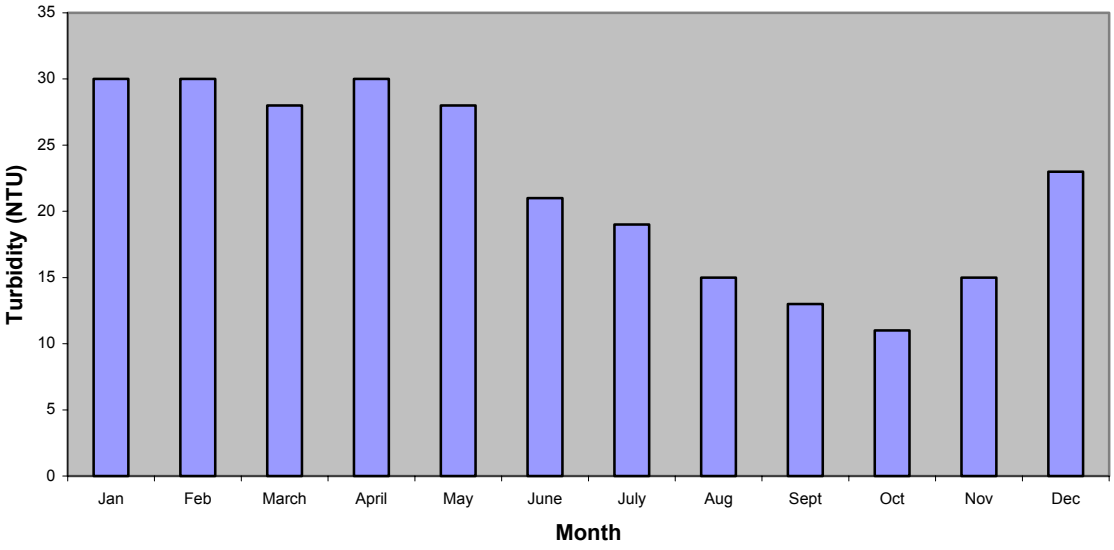


Figure 9. Total Kjeldahl Nitrogen (T.K.N) Medians for all Sampling Years Stations 26, 27, 92, 93, 94, 95, 96, 97, and 131

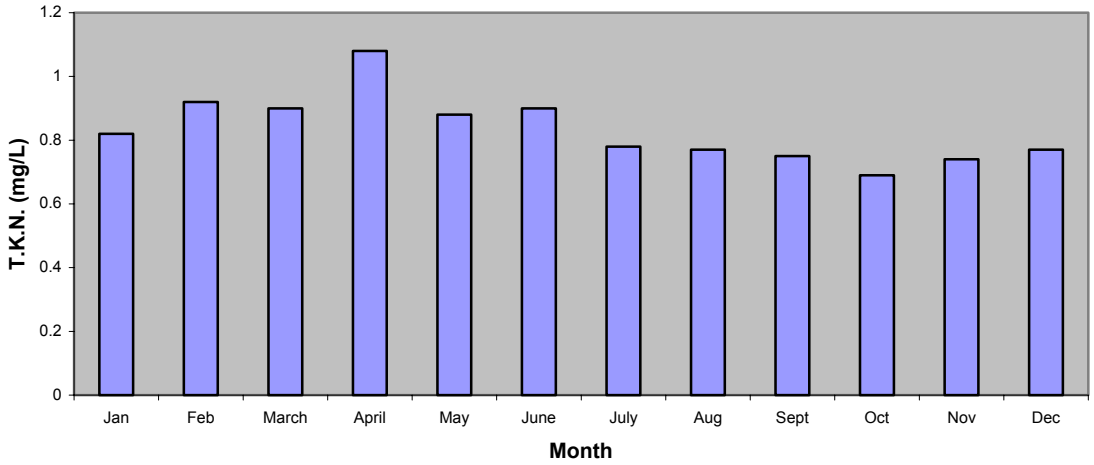


Figure 10. N02 + NO3 Medians for all Sampling Years Stations 26, 27, 92, 93, 94, 95, 96, 97, and 131

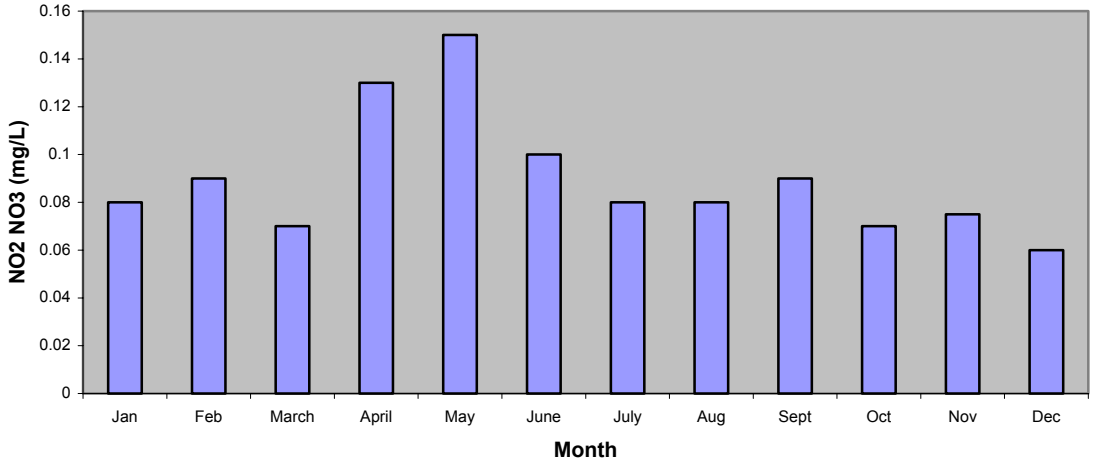


Figure 11. Total Phosphorus Medians for all Sampling Years
Stations 26, 27, 92, 93, 94, 95, 96, 97, and 131

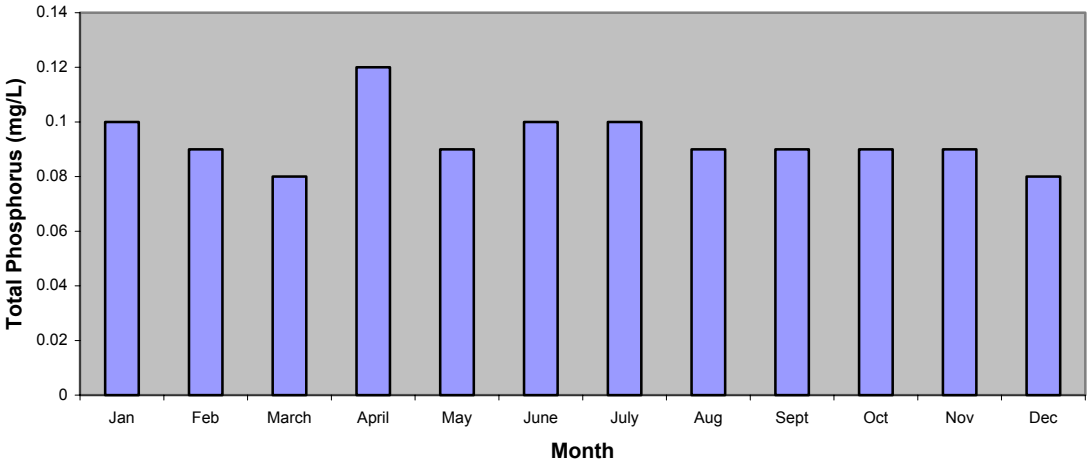


Figure 12. Secchi Disk Medians for all Sampling Years
Stations 26, 27, 92, 93, 94, 95, 96, 97, and 131

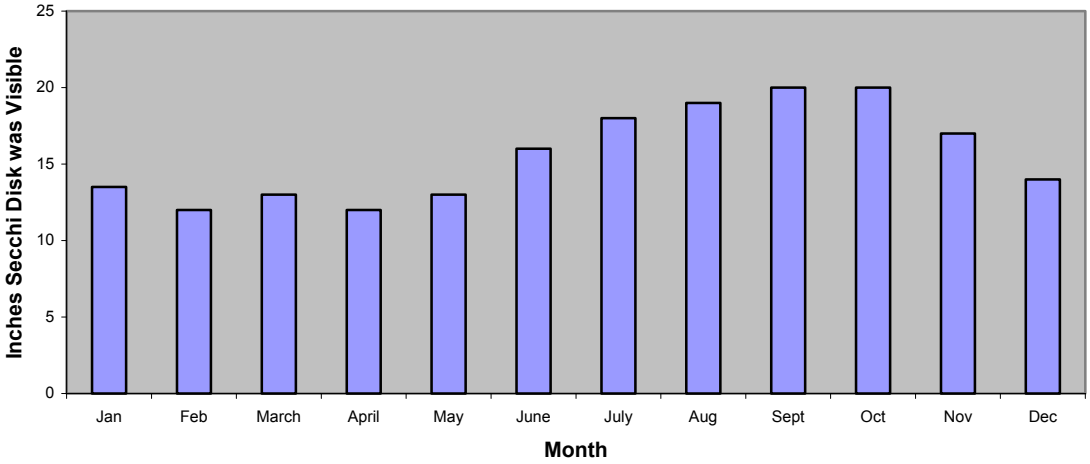


Figure 13. Total Organic Carbon (T.O.C.) Medians for all SamplingYears Stations 26, 27, 92, 93, 94, 95, 96, 97, and 131

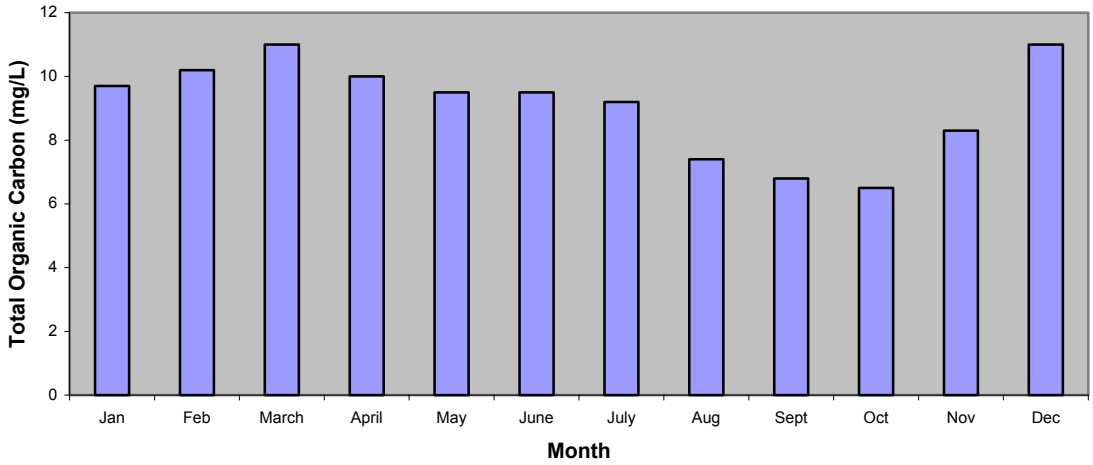


Figure 14. Total Suspended Solids Medians for all Sampling Years Stations 26, 27, 92, 93, 94, 95, 96, 97, and 131

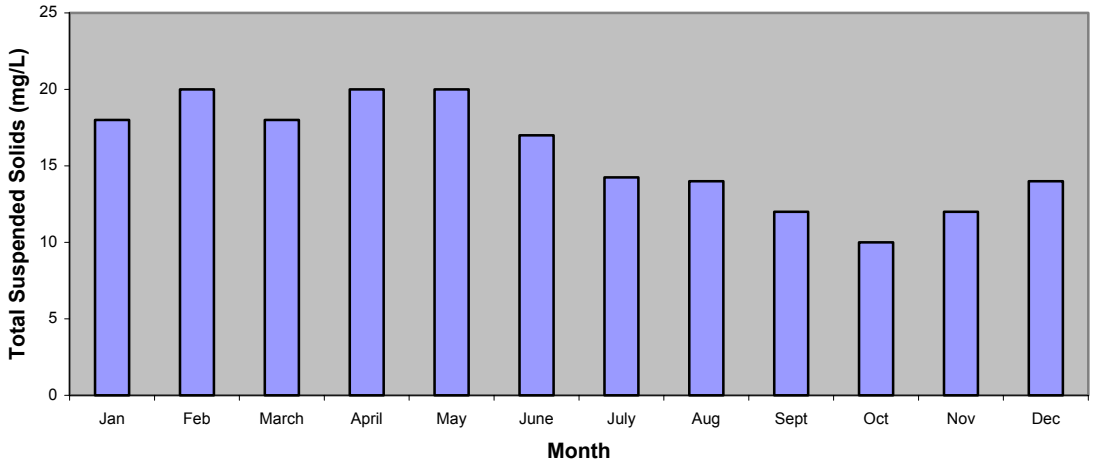


Figure 15. Total Dissolved Solids (TDS) Medians for all Sampling Years Stations 26, 27, 92, 93, 94, 95, 96, 97, and 131

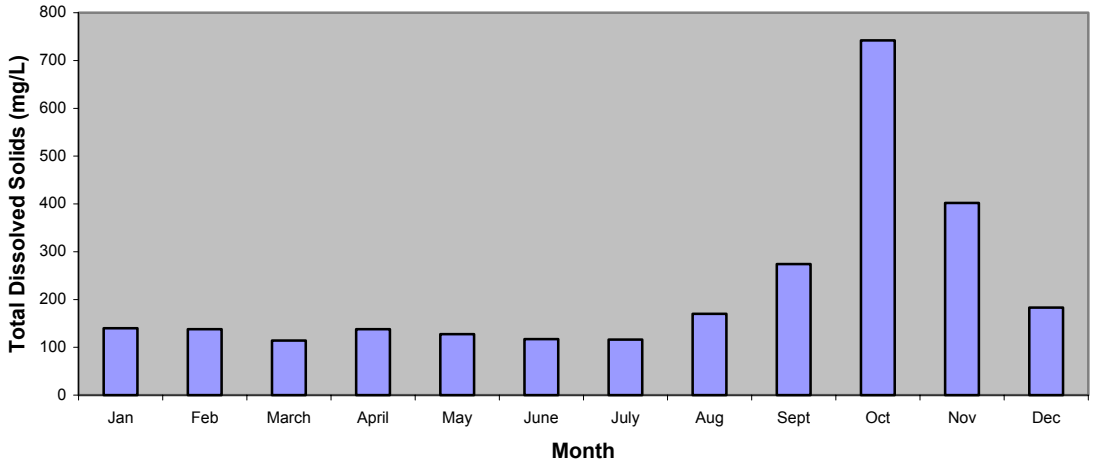


Figure 16. Dissolved Oxygen Median Values from all Sampling Years in the Calcasieu River Basin

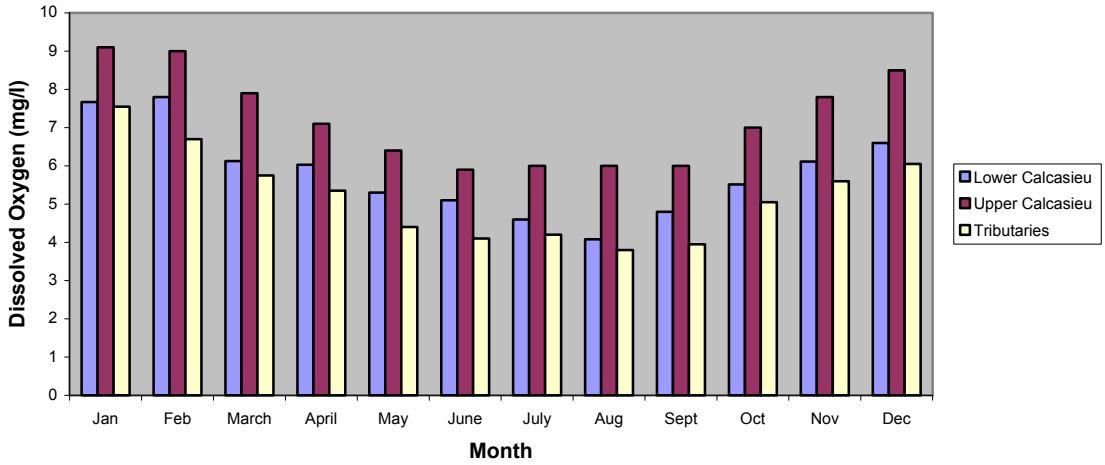


Figure 17. Total Disolved Solids (TDS) Median Values from all Sampling Years in the Calcasieu River Basin

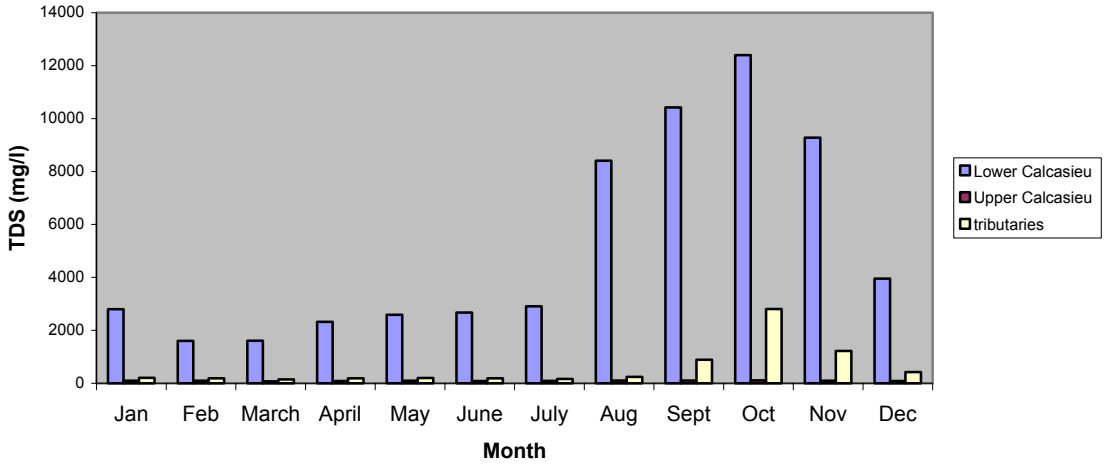


Figure 18. NO2 + NO3 Median from all Sampling Years in the Calcasieu River Basin

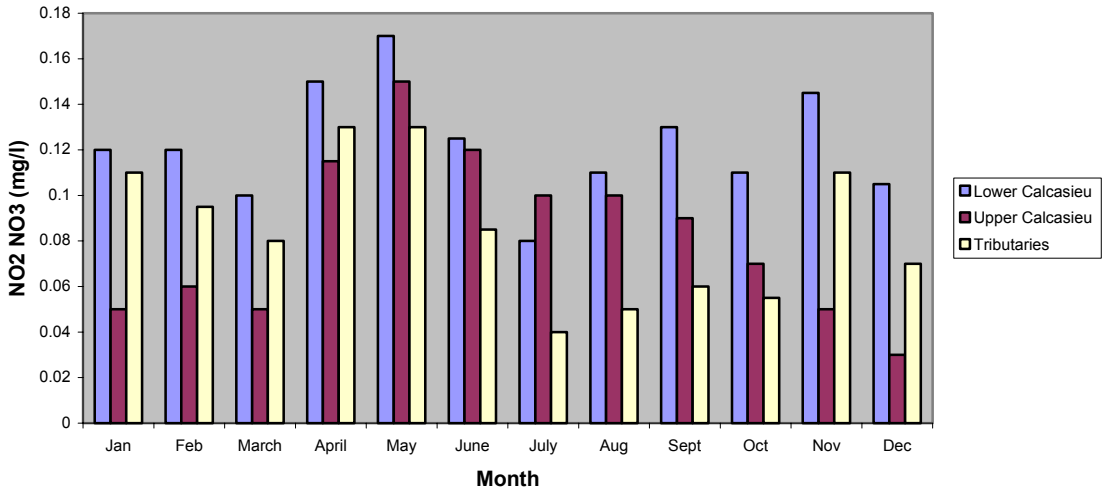
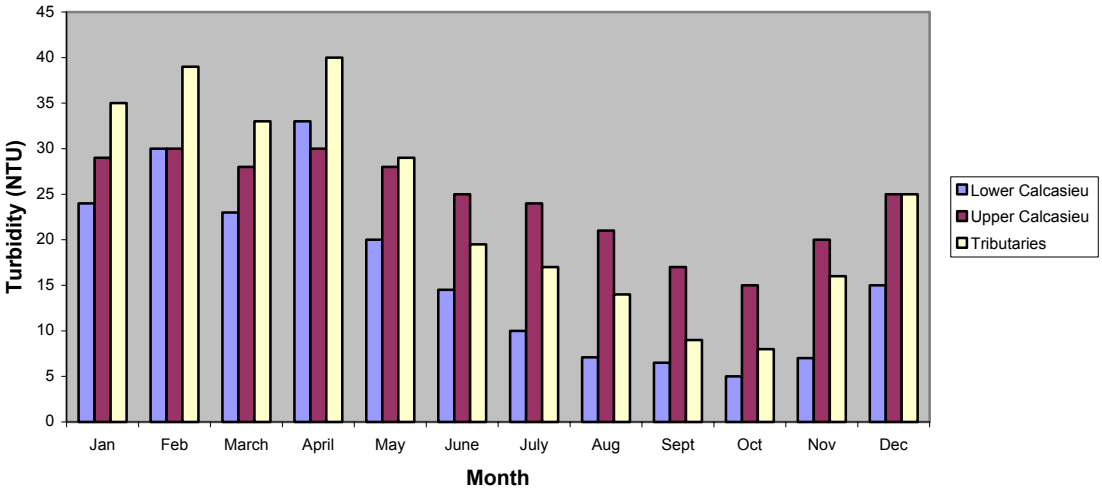


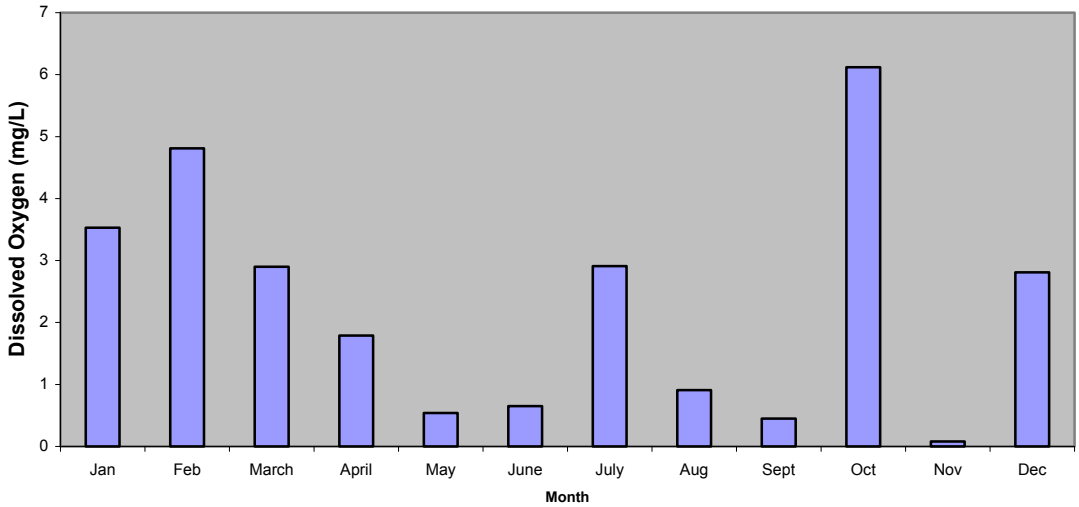
Figure 19. Turbidity Median Values from all Sampling Years in the Calcasieu River Basin



3.1 Dissolved Oxygen In Indian Bayou

Dissolved oxygen is gaseous oxygen that is dissolved in an aqueous solution. Oxygen gets into water by diffusion from the surrounding air and as a byproduct of photosynthesis. Oxygen in water is used by fish and other organisms for respiration and by aerobic bacteria during the decomposition of organic material. Dissolved oxygen in Louisiana's waterbodies is naturally lower during the summer months. Since DO naturally can vary throughout the year, use attainability studies are often conducted. Use attainability studies assess chemical, physical, biological and economic factors within a watershed to evaluate and determine the ability of the waterbody to attain the designated uses and to develop appropriate water quality criteria. The use attainability analysis for Indian Bayou determined the DO standard for Indian Bayou is 3.0 mg/L March through November and 5.0 mg/L December through February. The development of summer and winter standards is in part because of the variations of DO throughout the year (figure 20).

Figure 20. Seasonal variations of DO in Indian Bayou Watershed for the year 1999.



4.0 ANNUALIZED AGRICULTURE NONPOINT SOURCE MODEL

LDEQ is utilizing a model called Annualized Agriculture Non-Point-Source (AnnAGNPS), a Natural Resources Conservation Service (NRCS) sponsored model, to evaluate current sediment loadings in the watershed. The model produces results on sediment, phosphorus, nitrogen, and organics as the

constituents travel overland, through the reaches and out the watershed outlet. Cells (land area representations) of a watershed are used to provide landscape spatial variability. Each cell represents the landscape within its respective land area boundary as one homogeneous unit. The physical or chemical constituents are routed from their origin within the land area and are either deposited within the stream channel system or transported out of the watershed. Pollutant loadings can then be identified at their source and tracked as they move through the watershed system.

Type of Model Results	Results	Units	Description
Sediment Erosion	**0.996**	**tns/ac/yr**	**Overland erosion**
Sediment Yield	**0.270**	**tns/ac/yr**	**Sediment deposited in streams**
Sediment Load	**0.1037**	**tns/ac/yr**	**Sediment that moves through stream reaches**
Nitrogen Load	**3.887**	**lbs/ac/yr**	**Nitrogen moving through reaches**
Phosphorus Load	**23.255**	**lbs/ac/yr**	**Phosphorus moving through reaches**
Organic Carbon Load	**12.186**	**lbs/ac/yr**	**Organic carbon moving through reaches**
Water Load	**11.016**	**in/ac/yr**	**Amount of water running of cells into the stream reaches**

Table 3 The AnnAGNPS modeling results above for Indian Bayou Watershed are "average annual" runoff of materials over a 30 yr simulation period.

5.0 IDENTIFYING HIGH PRIORITY AREAS IN INDIAN BAYOU

Watersheds are not homogeneous with regards to their potential for soil erosion. Soil type, the slope of the land, and land use are each important factors in determining the risk to water quality from a given area. Therefore, when determining priority for conservation measures within a watershed both location and activity must be considered. Soils data, sediment loading models, and land use data, are valuable tools that can provide clues as to where potential sources of water pollution may be and which problems can most easily be corrected.

5.1 Soil

Erosion of soil and transportation to waterbodies can cause a plethora of water quality problems. The addition of soil to surface water can decrease the amount of light reaching submerged vegetation. This decreases photosynthesis and therefore the amount of oxygen being released into the water. Furthermore, when the vegetation dies, bacteria will consume additional oxygen from the water as they degrade the plant material. Chemicals such as pesticides, fertilizers, and metals can attach to soil particles and be transported to waterbodies. These chemicals have the potential to directly harm aquatic species or may result in decreased DO as bacteria degrade the compounds.

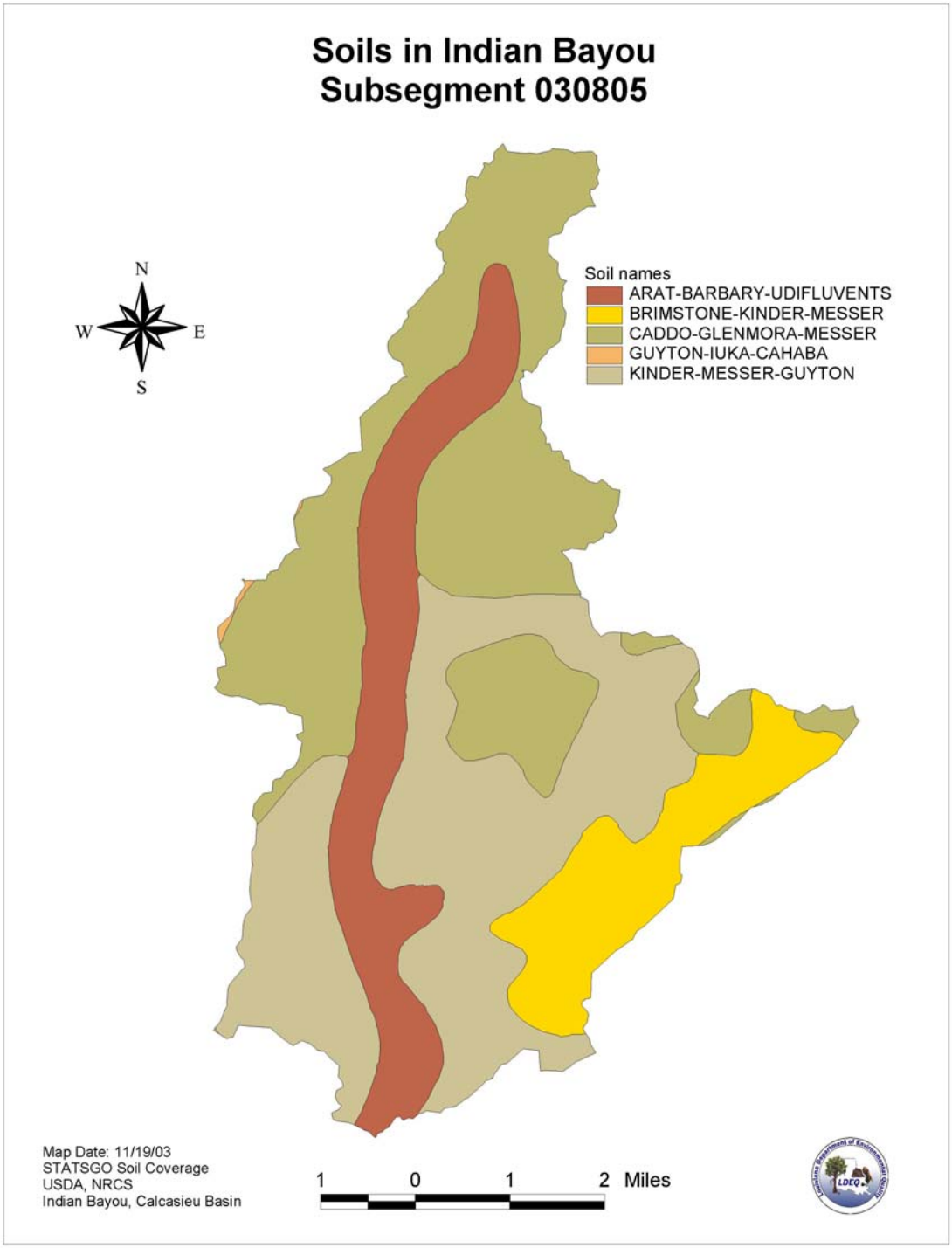
The soils in Indian Bayou watershed are primarily silt loams (figure 21). In general, Glenmore, Caddo, Messer, and Brimstone soils dominate the terraces and uplands and Guyton and Ouachita soils are the dominant soils on flood plains on the portion of the watershed in Beauregard Parish. In the portion of the watershed in Calcasieu Parish, the predominant soils are Acadia, Arat mucky, Basil, Brimstone, Caddo, Glenmora, Gore, Guyton, Kinder, and Messer silt loams (figure 21).

5.2 Sediment Run-Off

Sediment run off is principally related to land use, slope (LS Factor), soil erodibility (K-Factor), and rainfall intensity. These variables are the most significant factors affecting agricultural NPS pollution. AnnAGNPS estimates three general types of soil erosion: sheet, rill, and gully. In AnnAGNPS, sheet erosion is considered to be removed uniformly from every part of the cell. Rill and gully erosion create small or large ravines by undermining and downward cutting of soils. Gully erosion is larger and more pronounced rill erosion. Gullies eventually produce ditches or ravines exposing subsoils to erosion. AnnAGNPS estimates sheet, rill, and gully erosion for each cell. The results for sediment erosion (figure 23), sediment load (figure 24), and sediment yield (figure 25) indicate were these activities are most likely to occur.

The AnnAGNPS model produces sediment loss by particle size class and source of erosion and divides the runoff into 3 categories: Sediment Erosion, Sediment Yield, and Sediment Load. Sediment Erosion is the amount of sediment that travels overland to the edge of the cell. Sediment Yield is the amount of sediment that is deposited into the stream network. Sediment Load is the amount of sediment that travels through the stream network and out the outlet (figure 22). The results are rendered in standard tons/acre/year. Similarly, the model produces runoff and loading for nitrogen, phosphorus, and organic carbon. The nutrient and organic results are rendered in lbs/acre/yr (table 3). In addition, the model predicts how much water runs off a watershed cell (table 3).

Figure 21. Soils in Indian Bayou Watershed



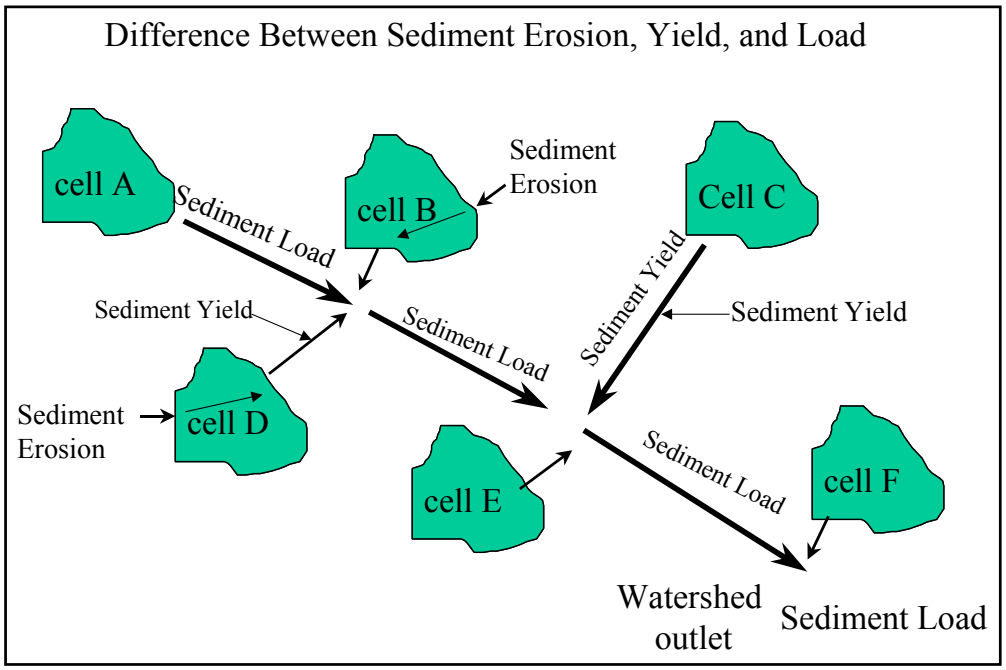


Figure 22 AnnAGNPS describes soil run-off in 3 basic categories: 1) Sediment Erosion is soils moving across the cells; 2) Sediment Yield is the soils of the cell depositing into the stream; 3) Sediment Load is the soil moving through the stream from reach to reach.

Figure 23. Sediment erosion in Indian Bayou Watershed.

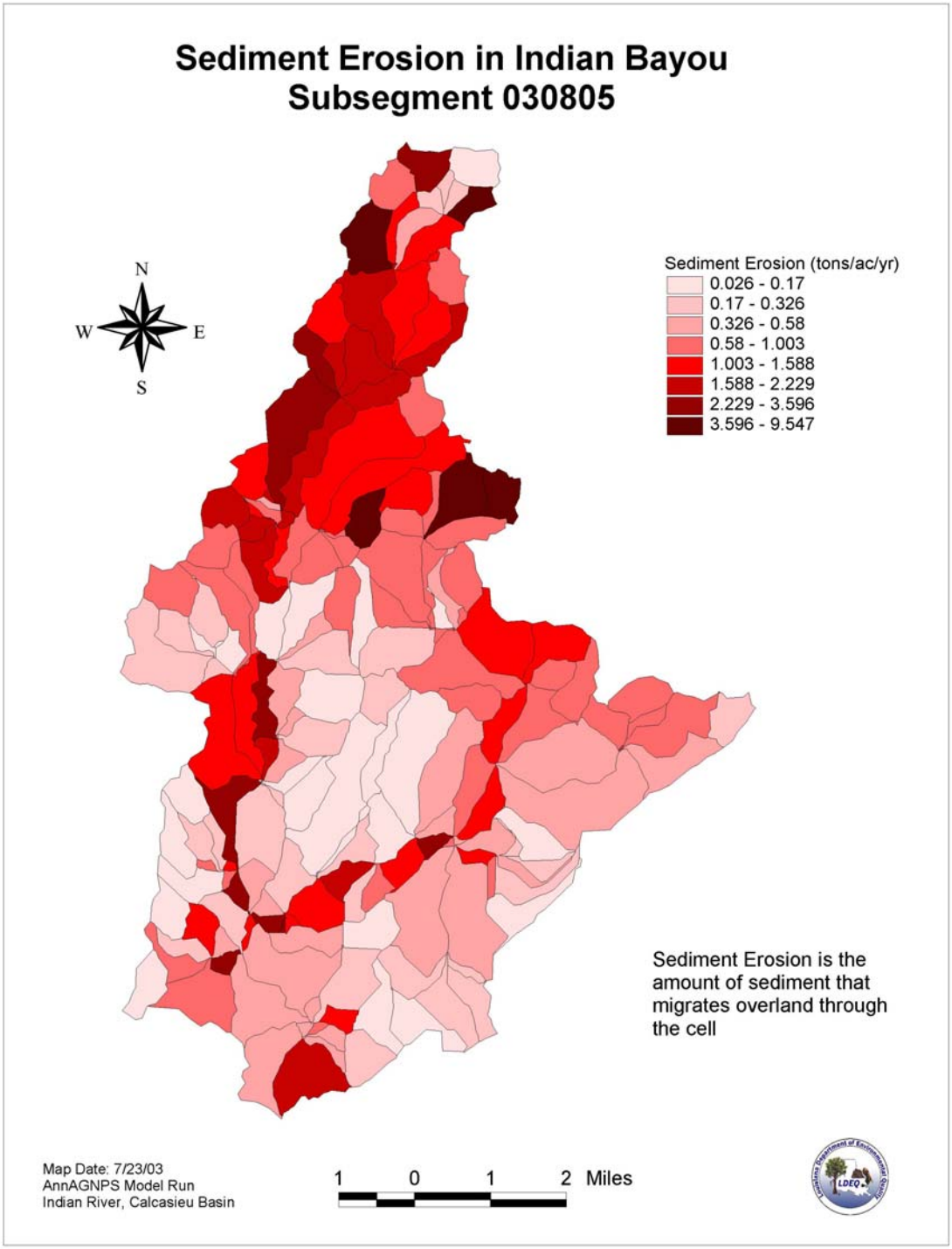


Figure 24. Sediment Loading in Indian Bayou Watershed.

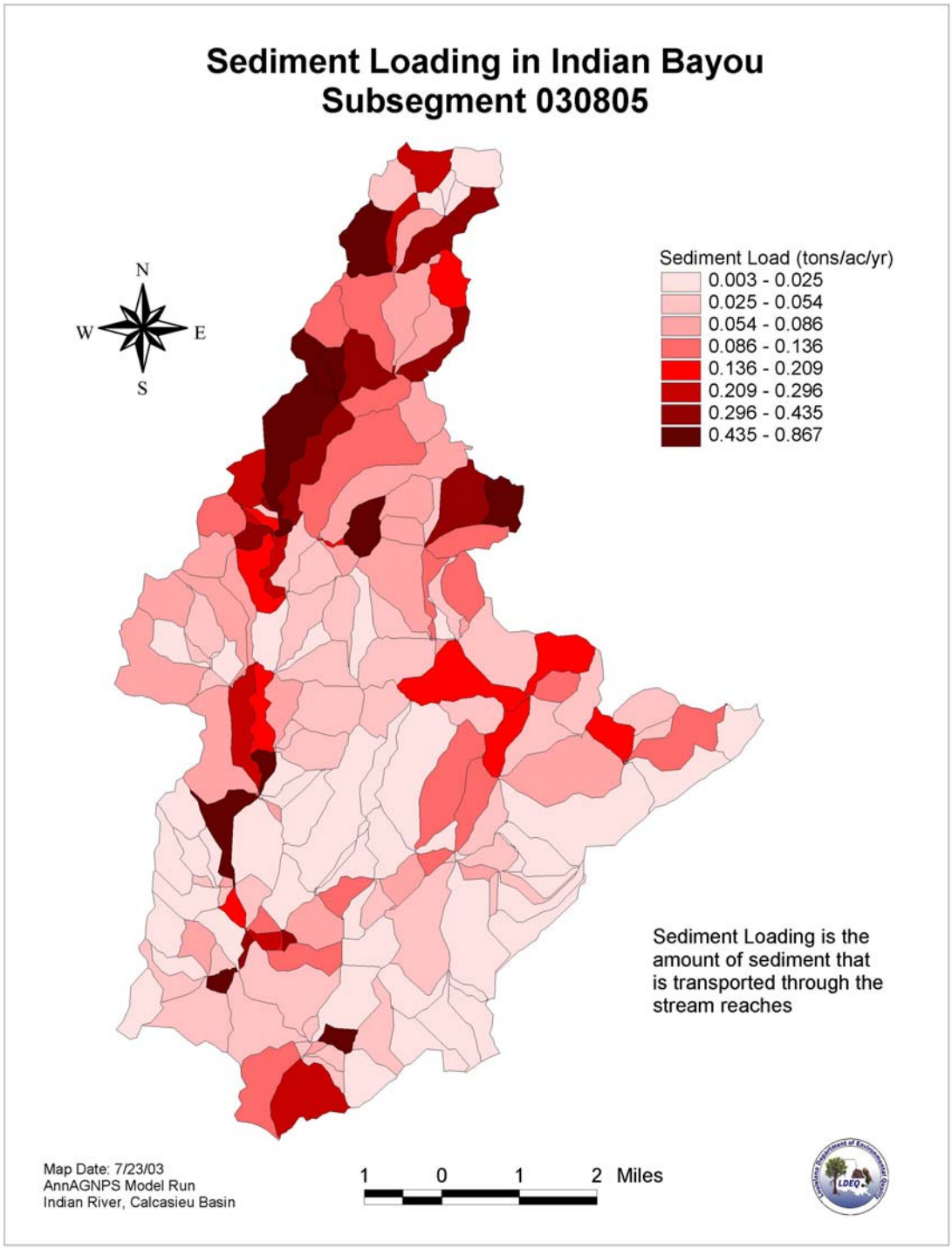
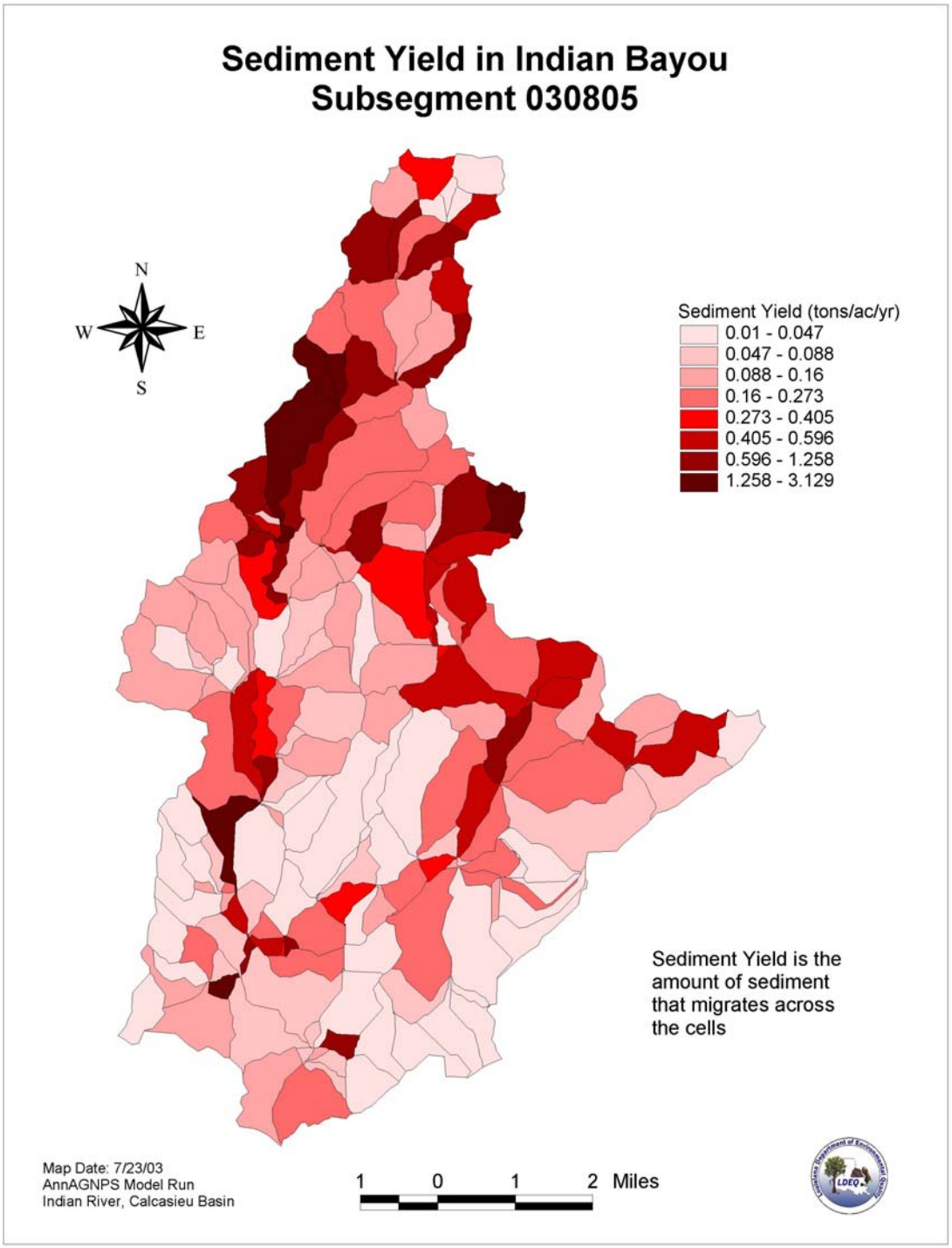


Figure 25. Sediment Yield in Indian Bayou Watershed.



5.3 Water Run-Off

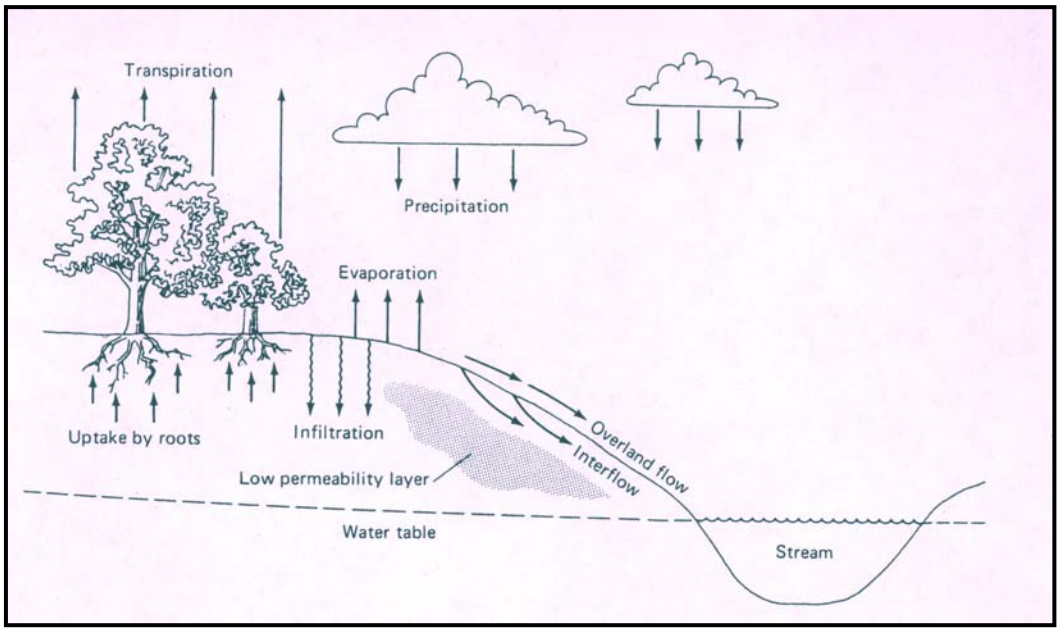
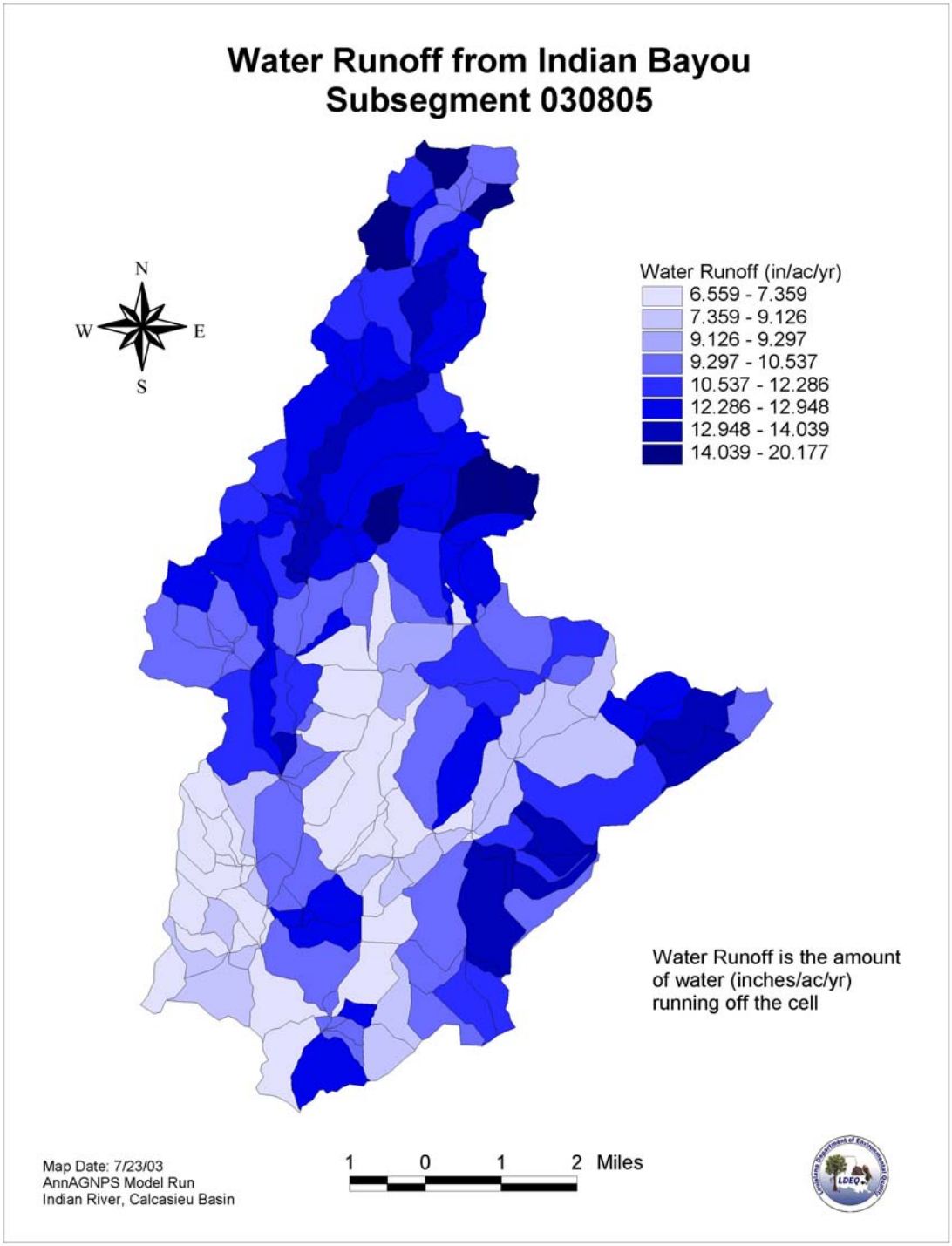


Figure 26 **The figure above illustrates the hydrologic cycle. When rainfall falls on land, the water can follow several pathways. Some of the water will remain attached to vegetation and soil and soon evaporate after rainfall. Some of it is taken up by the roots of the plants and is evaporated through the leaves, a process called transpiration. Some of the rainfall will infiltrate into the soil where it migrates laterally toward a stream, a process called interflow. The water will also infiltrate into a permanent groundwater system. During heavy rainfall event, water will migrate overland to local waterbodies. Illustration and text provide by Drever, J.I. 1997.**

The average annual rainfall in the Indian Bayou watershed is ~62 inches a year. Water runoff is influenced by a number of factors including soil chemical and physical properties, presence of impermeable surfaces, slope of the land, climate, type of vegetative cover, and root mass. Based on many of these factors (figure 26), AnnAGNPS estimates the average annual amount of water (in/ac/yr) running off of the cells.

The model estimates that some cells are experiencing runoff amounts in excess of 14 in/ac/yr (figure 27). The stream reaches in these areas may be experiencing bed and bank erosion along the stream network. In watersheds with large areas of impervious surfaces, upward of 50% of the sediment load can be attributed to stream erosion. In this case, water rushes overland and scours existing streambeds. Hydraulic modifications to bayous and rivers can also create an unstable system.

Figure 27. Water runoff from Indian Bayou Watershed



5.4 Soil Erodibility K-Factor

When planning for soil conservation and water management, it is important to understand that all soils are not the same and that some are more susceptible to erosion than others. The Revised Universal Soil Loss Equation (RUSLE) can be used to predict soil loss and the effectiveness of management practices. One of the factors used in the RUSLE is the K factor. The K factor is a numeric value attributed to the susceptibility of a soil to sheet and rill erosion. The K value for specific soils can be found in parish soil survey books published by the United States Department of Agriculture (USDA). Values for K range from 0.02 to 0.64 with soils having higher values being more susceptible to sheet and rill erosion. In Indian Bayou Watershed, K values range from 0.304 to 0.466 (figure 28)

5.5 Slope Length and Steepness Factor (LS-Factor)

An important tool for determining the effect of topography on soil loss is the slope length and steepness factor (LS factor). LS values are not absolute values, but represent the ratio of soil loss in a specific area to a value of 1.0 that is given to a slope with 9% steepness and is 72.6 ft long. LS factors are utilized as part of the RUSLE soil erosion equation and can be generated by AnnAGNPS for each cell to determine areas that have high potential for soil erosion. LS values in Indian Bayou watershed range from 0.042 to 2.722 (figure 29) with the highest values tending to be near the bayou and tributaries.

Figure 28. K values in Indian Bayou Watershed.

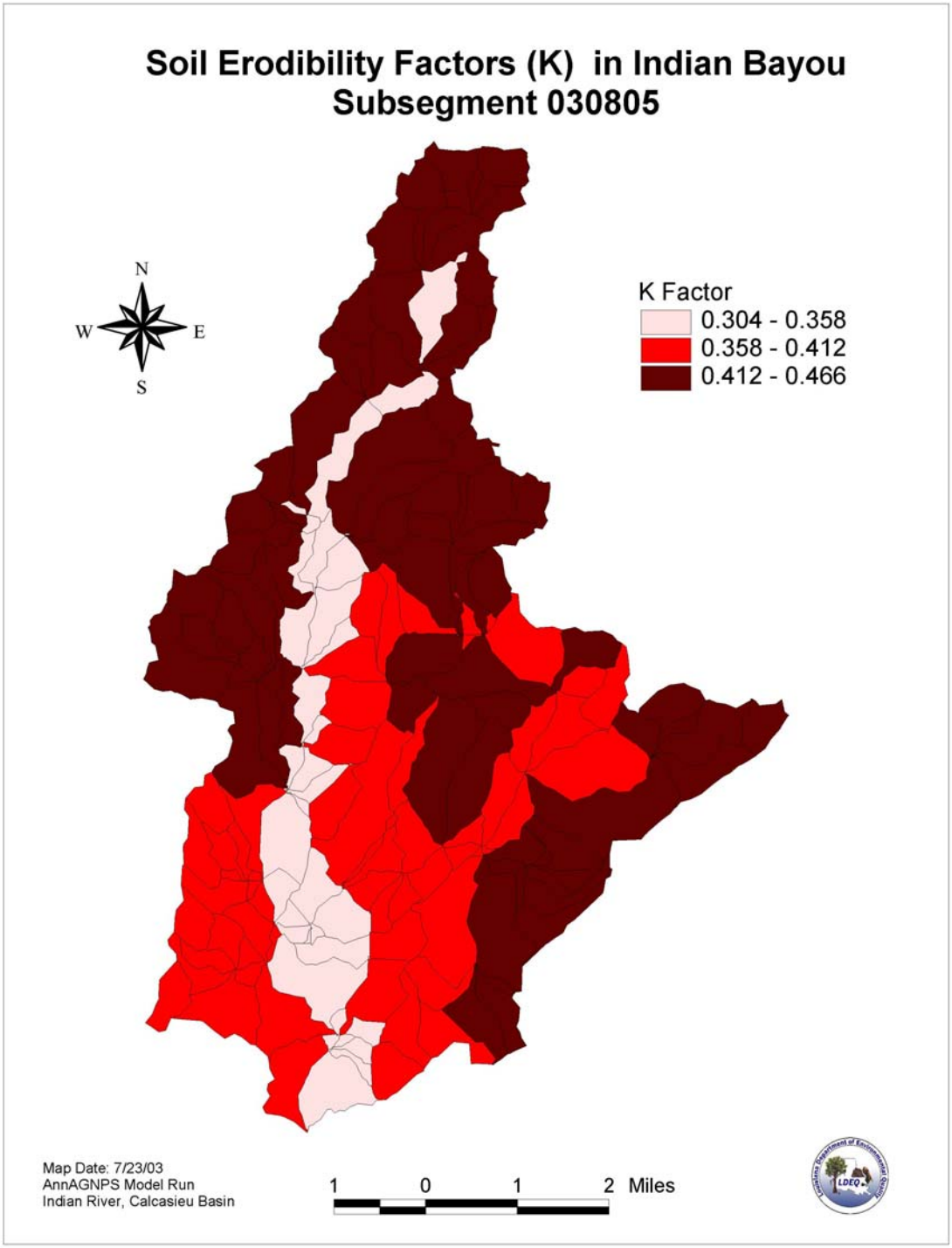
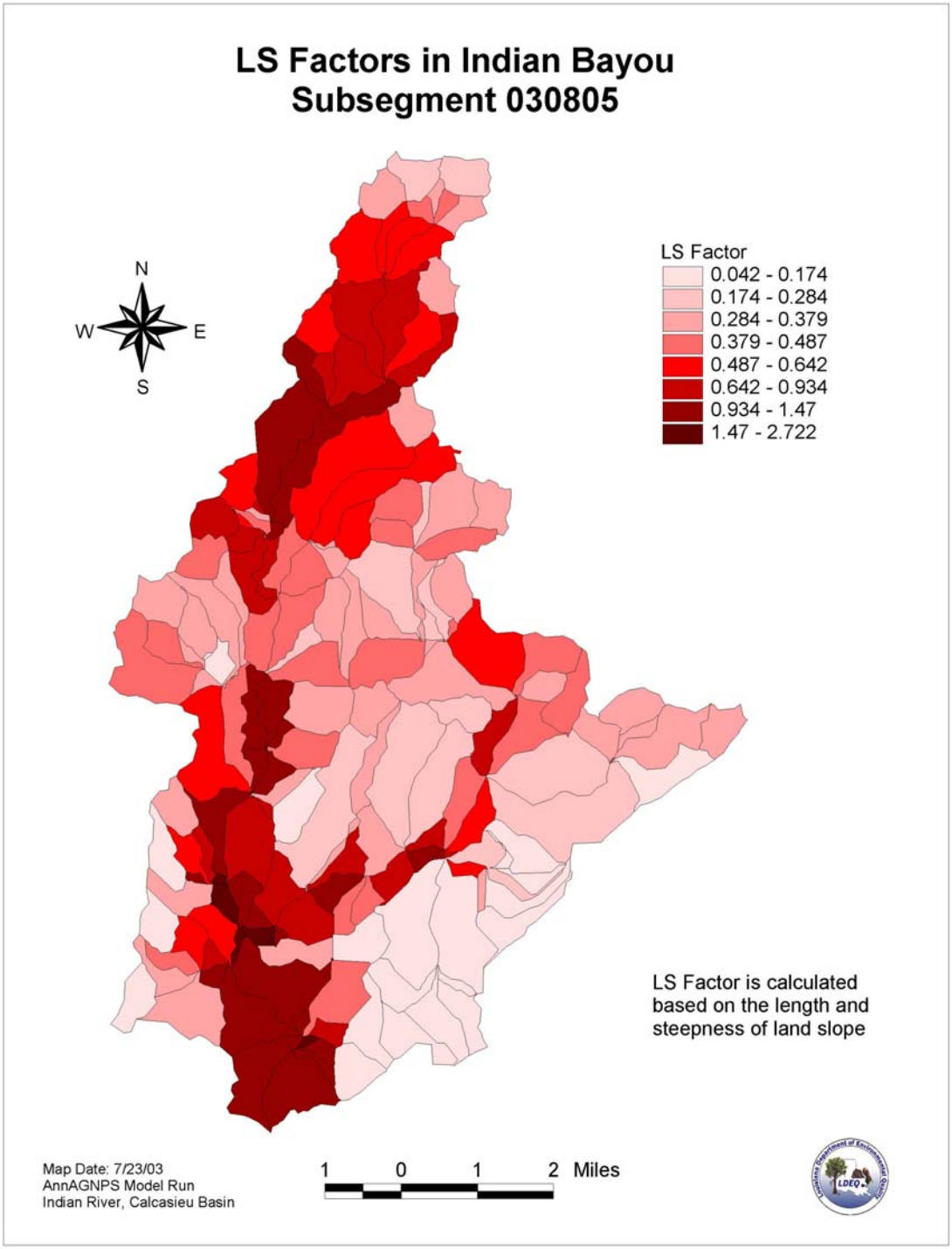


Figure 29. LS factors in Indian Bayou Watershed.



5.6 Soils Summary

When comparing the sediment, soil, and water maps, it becomes clear that the land in the northern portion of the watershed has the highest potential for nonpoint source pollution if not managed correctly. This area corresponds to reach 1 from the TMDL model that indicates a higher amount of the load is coming from this area of the watershed.

5.7 Nutrients and Organic Carbon

Although nutrients are necessary to plant growth in a water body, over-enrichment leads to excessive algae growth, an imbalance in natural nutrient cycles, changes in water quality and a decline in the number of desirable fish species. Nutrients may reach surface water when soil particles they are adsorbed to are eroded or when the nutrients are dissolved in runoff water. Factors influencing nutrient losses are precipitation, temperature, soil type, land use, and soil chemical and biochemical reactions. Chronic symptoms of over-enrichment include low dissolved oxygen, fish kills, murky water, and depletion of desirable flora and fauna. Excessive amounts of nutrients can also stimulate the activity of microbes, such as Pfisteria, which may be harmful to human health.

5.8 Nitrogen

Organic nitrogen is the nitrogen incorporated into organic compounds, primarily unassimilated proteins. Bacterial action on such organic matter results in its degradation and the release of ammonia (NH_3). The NH_3 may then be further oxidized to nitrite (NO_2^-) by bacteria such as *Nitrosomonas,* and the NO_2^- produced from this reaction can be oxidized to nitrate (NO_3^-) by other bacteria such as *Nitrobacter.* These biologically mediated reactions are collectively referred to as *nitrification.* In areas subject to reasonably fast currents, the dilution of nitrogen occurs down current and oxidation of ammonia to nitrate prevents accumulation of soluble nitrogenous wastes in the water column.

In aquatic systems excessive concentrations of nitrogen compounds result in both direct and indirect problems. The primary adverse effects are as follows: 1. Organic nitrogen compounds can be mineralized in aquatic systems which results in a loss of dissolved oxygen from the water. 2. In instances where nitrogen is limiting to growth in a particular aquatic ecosystem, discharge of nitrogen compounds can promote the growth of nuisance plankton and algae. 3. When ingested, NO_3^- can be transformed to NO_2^- and result in Methemoglobinemia (Blue Baby Syndrome). 4. Both NH_3 and NO_2^- are toxic to some aquatic species.

Nitrogen loading in Indian Bayou Watershed is generally the highest in the northern portion of the watershed, which is near the headwaters of Indian Bayou. Nitrogen loading ranges from 0.043 to 15.001 lbs/ac/yr in Indian Bayou Watershed (figure 30)

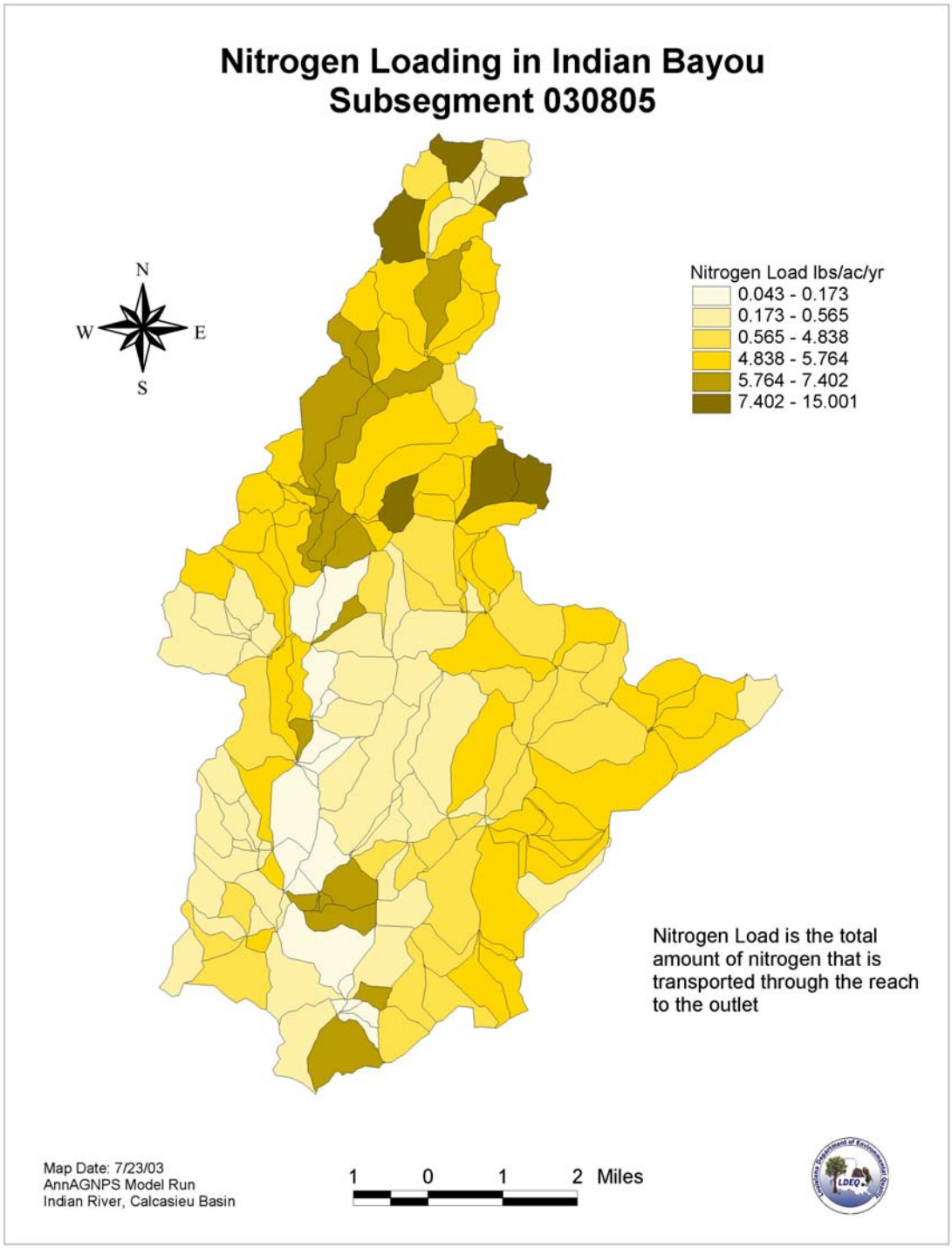
5.9 Nitrogen Biochemical Oxygen Demand

Nitrogen is important in water quality assessments for reasons other than its role as a nutrient. For example, the oxidation of NH_3 to NO_3^- during the nitrification process consumes oxygen and may represent a significant portion of the total BOD. Stoichiometrically, 3.43 g of oxygen are consumed for each gram of ammonium-nitrogen oxidized to nitrite-nitrogen. During the second stage of nitrification, the nitrobacter bacteria oxidize nitrite to nitrate and 1.14 g of oxygen are consumed per gram of nitrite-nitrogen oxidized. If the two reactions are combined, the complete oxidation of ammonia can be represented by:

$$NH_4^+ + 2\ O_2 \rightarrow N_O^3- + H_2O + 2H^+$$
$$(14\ g)\ (64\ g)$$

As seen, 64/14 or 4.57 g of oxygen are required for the complete oxidation of one gram of ammonia. In the reactions above, the organic-nitrogen form does not appear, since organic-nitrogen is hydrolyzed to ammonia, and does not consume oxygen in the process.

Figure 30. Nitrogen Loading in Indian Bayou Watershed



5.10 Phosphorus

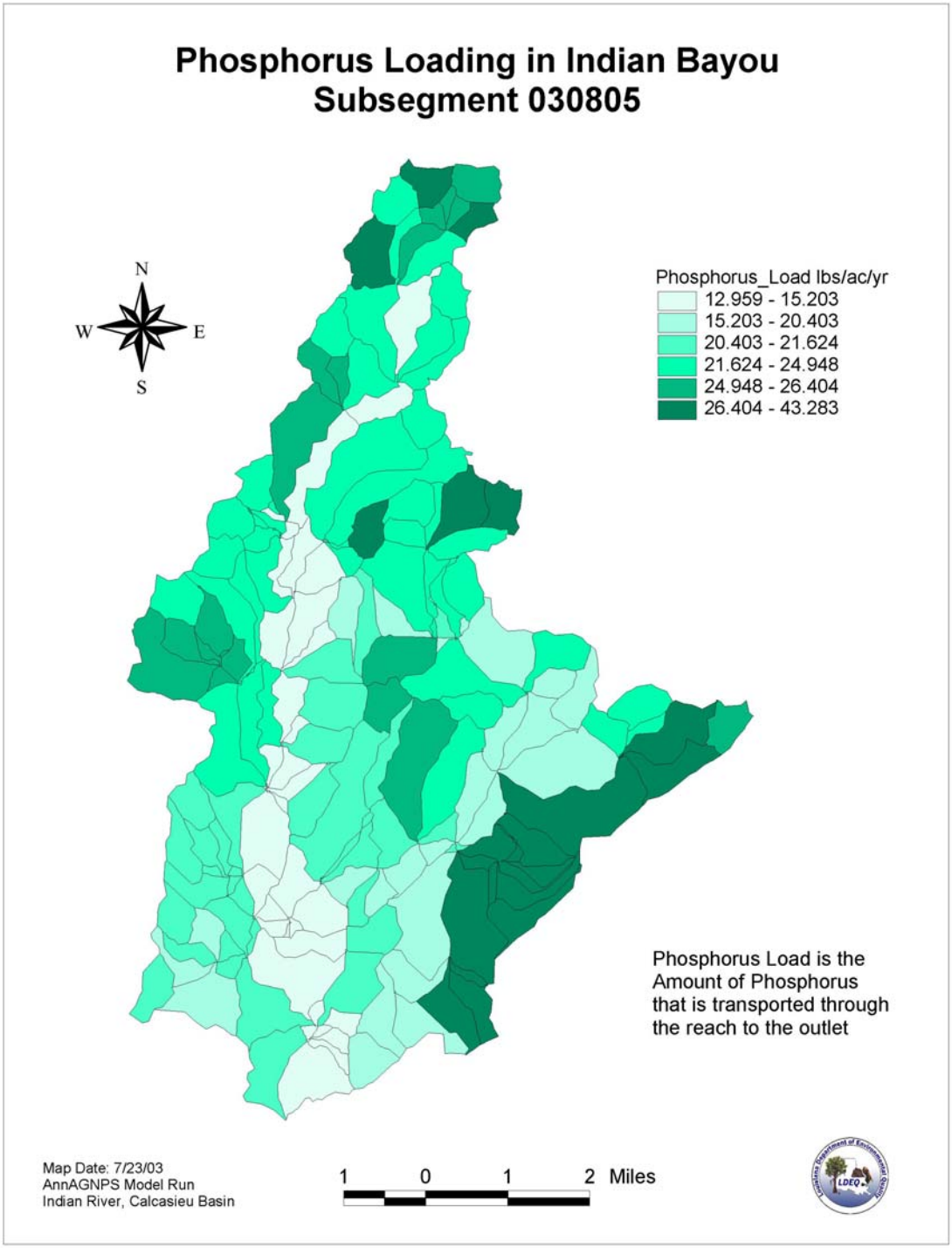
Phosphorus is typically the most limited nutrient in freshwater systems for plant growth. Therefore, when it is introduced to phosphorus limited water, algal blooms can occur. Algae consume dissolved inorganic phosphorus and convert it to the organic form. When the algae die and decompose, dissolved oxygen in the water can decrease and result in fish kills.

Natural sources of P in water include leaching from phosphate-bearing rocks, and organic matter decomposition. Runoff and erosion can carry additional phosphorus to water bodies in the form of manmade fertilizers, domestic sewage, animal manure, and detergents. Numerous Phosphorus compounds exist in soil, but most are insoluble. Dissolved inorganic phosphorus (orthophosphate) is the major form of P directly available to algae. Phosphorus in forms that have very low solubilities that get washed into water bodies may later be released and become available to algae if the water chemical properties, such as pH, change.

Total P levels in unpolluted waters are usually less than 0.1mg per liter and inorganic (orthophosphate) soluble P is often less than 0.01 mg per liter (Lind, 1979). Phosphorus is rarely found in concentrations that are toxic to higher organisms.

Phosphorus loading in Indian Bayou Watershed is similar to nitrogen loading in that the northern portion of the watershed has increased amounts of loading. The southeastern edge of the watershed also exhibits increased loading rates (figure 31).

Figure 31. Phosphorus Loading in Indian Bayou Watershed.



5.11 Organic Carbon

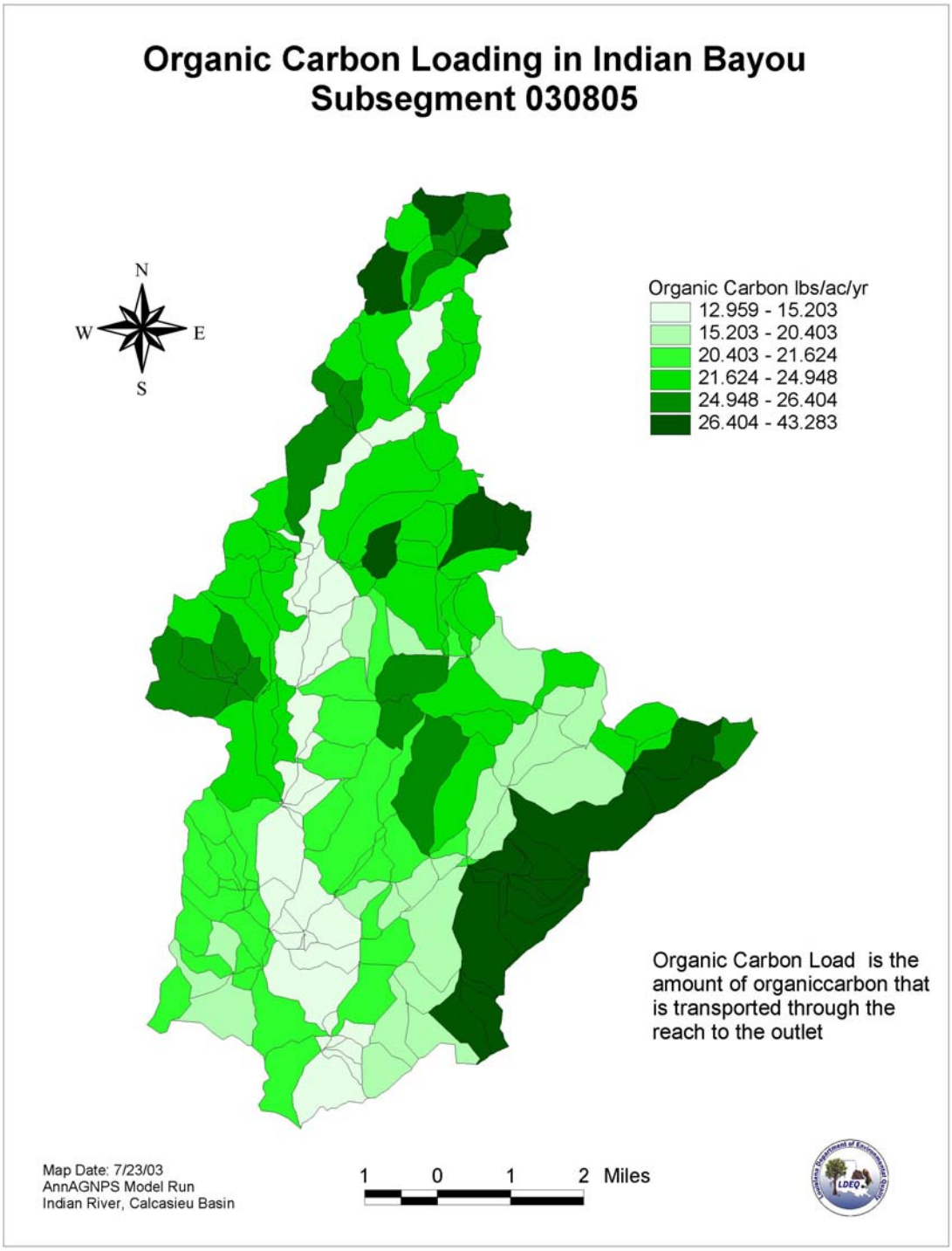
BOD in Louisiana waterways and sediments is largely composed of Carbonaceous BOD (CBOD). Animal waste, crop debris, oil and grease from roadways and boats, sewage, lawn clippings, and natural sources of plant and animal material all have the potential to enter water bodies and place an oxygen demand on them upon decomposition. If dissolved oxygen levels decrease to low levels and remain low, fish and other aquatic species can die. Often this occurs on a seasonal basis in Louisiana, during periods of low flow and warm water.

Organic carbon loading in Indian Bayou Watershed (figure 32) is almost identical to phosphorus loading. Both phosphorus and organic carbon loading are elevated in the northern portion and the southeastern edge of the watershed. Both also have additional areas within the watershed where loading is elevated.

5.12 Nutrient Summary

AnnAGNPS calculations for nitrogen, phosphorus, and organic carbon loads also appear to be the highest in reach 1 and 4 of Indian Bayou Watershed. The high loading areas near reach 4 appear to correspond to the Brimstone – Kinder – Messer soil types. This further confirms the importance of protecting both the headwaters and the final reach of Indian Bayou.

Figure 32. Organic Carbon Loading in Indian Bayou Watershed.



6.0 WATERSHED LAND USES

Nonpoint source pollution comes from various sources within a watershed including agriculture, forestry, urban runoff, construction, hydromodification, home sewage and resource extraction. Practices that result in the exposure of bare soil to precipitation events result in greater runoff than land which the surface soils have a healthy root system and dense canopy cover. Forested and pasture areas generally have lower loading rates than bare or tilled ground.

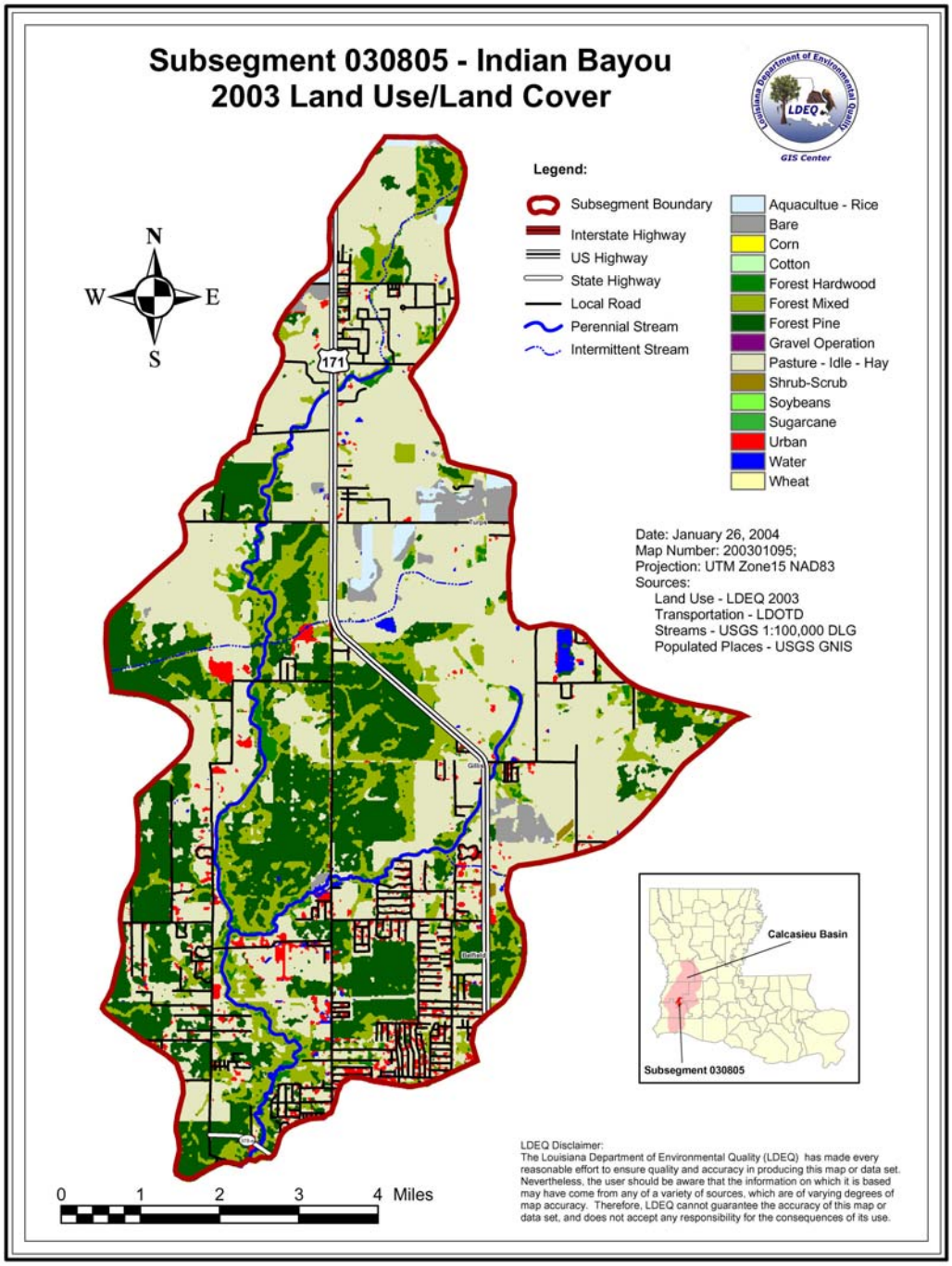
Land use data from 2003 in Indian Bayou Watershed are summarized in table 4. The primary land cover is pasture, with forest comprising the second largest land use. Rural residential areas in the watershed appear to be increasing. The communities of Belfield; Gillis; Turps; and part of Moss Bluff, which is expected to increase from 7,850 people in 2000 to 8,610 people in 2010 (9.7%) (Louisiana Census Data, 1997), are within the watershed. Although not evident on the land use map (figure 33), several subdivisions have been developed in the watershed and others are expected to follow.

On May 15, 2003 a tour of Indian Bayou watershed revealed that residential development, cattle grazing on the banks and wading in the bayou, the pumping of water from a land excavation site to the bayou, and rice and soybean agriculture are probable sources of NPS pollution in Indian Bayou Watershed.

Table 4. Land uses in Subsegment 030805 of the Calcasieu Basin

Land Use	Area (acres)	Percent of Watershed
Water	262	0.80
Pasture - Idle - Hay	17041	52.04
Forest	12959	39.58
Shrub-Scrub	27	0.08
Aquaculture - Rice	307	0.94
Soybeans	466	1.42
Corn	0	0.00
Cotton	0	0.00
Wheat	6	0.02
Sugarcane	0	0.00
Urban	1123	3.43
Bare	553	1.69
TOTAL	32,744	100

Figure 33. Land use in Indian Bayou Watershed.



6.1 New Development And Construction Sites

Image 1. The ditch in front of this new house drains directly into Indian Bayou.

The southern portion of Indian Bayou watershed has a large number of new homes and subdivisions being built. Development often occurs in critical or sensitive areas of watersheds such as riparian and wetland areas. These areas act as filters and remove nutrients and sediment from runoff before entering the waterbodies. In addition to the decreased filtering of runoff that can occur when natural areas are developed, soils are exposed and susceptible to erosion during construction. The direct impact of raindrops on the bare soil and the force of flowing water across the ground can dislodge soil particles resulting in sediment runoff. Construction sites greater than or equal to one acre are regulated by NPDES Phase II Stormwater Permits, which require utilization of BMPs for managing stormwater runoff. Sites less than one acre are not covered by NPDES Phase II, therefore stormwater management and erosion control will require voluntary implementation of BMPs. Without use of BMPs, new construction sites and developments can result in NPS loading. A site visit on May 15, 2003 revealed that construction BMPs, such as silt fences, were failing to prevent sediment from entering storm drains and ditches in Indian Bayou Watershed.

Image 2. A failing silt fence in Indian Bayou Watershed

To effectively reduce erosion from construction sites, an erosion protection plan should be created before work begins. Developments should be made on sites which require a minimum of clearing and grading, preserve the existing natural drainage patterns and vegetation as much as possible, disturb the soil for as short a time as possible, and keep disturbed areas small by doing phased development.

6.2 Urbanization

In addition to the nonpoint source pollution associated with new construction, urban areas can contribute significant amounts of nonpoint source pollution from runoff. As precipitation falls on urban areas, it picks up contaminants from littered streets and sidewalks, petroleum residues from automobiles, heavy metals and tar from roads, fertilizers and pesticides from yards, and sediments from construction sites. The increase in impervious surfaces, such as streets, parking lots, and rooftops, associated with urban areas often have increased runoff volumes and pollutant loading as they allow little or no detention or infiltration of stormwater.

Impervious surfaces also change the hydrologic characteristics of watersheds. In undeveloped natural drainage areas, the volume and rate of stormwater runoff from a particular rainfall event is primarily determined by the natural detention and infiltration characteristics of the land and is related to topography, soil types, and vegetative cover. With less detention and infiltration due to impervious surfaces, runoff volume increases, as well as the rate of stormwater runoff. When streams overflow their banks, there is an increased opportunity for pollutants, such as trash and debris, to enter the flow of water. Furthermore,

flooding can damage and remove vegetation along stream banks. Destruction of streamside vegetation reduces the pollutant assimilation capacity of a stream and makes banks less stable. Erosion of the stream banks represents a significant source of sediment pollution and the flooding and stream channel degradation in urbanized watersheds have obvious adverse impacts upon public convenience, safety, aesthetics, and water quality.

Since portions of Indian Bayou Watershed are rapidly being urbanized, it is an ideal time to incorporate strategies for managing stormwater runoff in new developments. Education of city officials, engineers, planners, developers, and the general public as to how to incorporate urban BMPs, such as water gardens and pervious asphalt paving, into urban areas could minimize the negative effects of urbanization to water quality.

6.3 Pastureland Grazing

Image 3. Cattle grazing on the banks of Indian Bayou

Grazing cattle on pastureland is a common practice in Indian Bayou watershed. Livestock often seek the shade offered in the riparian zone around streams and use the stream itself as a water source. When livestock are not fenced out of riparian zones, water quality has the potential to decrease.

When allowed inside the riparian zone, livestock can directly degrade water quality in multiple ways. Fecal matter can be deposited into the water adding nutrients and bacteria directly to the stream. The undigested organic material associated with fecal matter also has the potential to decrease DO as bacteria

degrade it. Furthermore, the trampling by hooves can collapse stream banks and increase turbidity by churning up the streambed.

Livestock allowed in riparian zones also have the potential to indirectly degrade water quality if not managed properly. Groundcover within the riparian zone can be decreased as a result of overgrazing and from being trampled by hooves. The loss of groundcover results in unstable banks that can be easily eroded and fill streambeds in with sediment. It also decreases the filtering capabilities of the riparian zone. Maintaining quality riparian zones in pasturelands is especially important for filtering fertilizers and pesticides that are applied to pastures out of runoff.

A number of cattle are already allowed in and on the banks of Indian Bayou (image 3) and appear to be destroying the banks and decreasing water quality. Convincing producers to reduce livestock access to the bayou and riparian zones should help improve water quality. Furthermore, as the current trend in South Louisiana is to convert cropland to pastureland, it is important for producers to be aware of the water quality issues associated with livestock production and install BMPs before cattle are stocked. These measures should help prevent further degradation of water quality in Indian Bayou Watershed.

6.4 Agriculture

In 1996, agriculture was listed as the dominant land use in Indian Bayou watershed. The May 15, 2003 field trip revealed that many fields were idle and possibly taken out of production or converted to pastureland. This is reflected in the 2003 land use data, which lists pastureland as the primary land cover in the watershed. The most common crops currently grown in the watershed are soybeans, wheat, sorghum, and rice. Common agricultural practices, such as tillage and chemical applications, for these crops can both directly and indirectly affect water quality. Tilled soil is void of vegetation which can hold it in place and is therefore more susceptible to being washed away by rainfall and ending up in waterbodies. Soil tillage can also affect soil bulk density and reduce soil moisture content, each of which can affect the microorganisms needed to convert nutrients into plant available forms. Furthermore, tillage can delay infection of arbuscular mycorrhiza, which has been shown to transfer P, N, ZN, C, and S to plants. Plants grown with reduced arbuscular mycorrhiza infection due to tillage have been shown to have lower P uptake and lower yields relative to no till (Paul and Clark, 1989). Reduced P uptake is of importance because excess soil P is readily transported in runoff as dissolved P or attached to soil particles. Therefore, soil practices that help keep soil particles from washing away, such as no till, are beneficial in both improving crop production and in reducing nonpoint pollution.

Management practices for rice are different than those for the other agronomic crops. One of the major problems rice producers face is control of red rice. Red rice is closely related to commercial rice and many pesticides that kill red rice also kill commercial rice. Therefore, management practices, such as water seeding, are often used to control red rice. When water seeding, the flooded rice field is tilled to muddy the water and to kill germinated red rice that would otherwise emerge through the clear water. The muddy water is released from the rice fields in April and can contribute sediment and nutrients to waterbodies. Since water seeding is primarily done to control red rice, advances made in red rice control could decrease water seeding and therefore reduce nonpoint load.

It should also be noted that rice production also has the potential to increase dissolved oxygen in watersheds. Since rice grows best when its roots are submerged, the plants are grown in flooded fields. Sediment has time to settle out of this water during the growing season and the rice growth keeps DO in the water high. This good water is periodically released during the growing season and right before harvest in July and again in October and can result in increased DO in the receiving waterbodies.

6.5 Forestry

Image 4. A cleared forest near Indian Bayou. The tree line in the back is the riparian buffer of Indian Bayou.

Indian Bayou Watershed is 39.58% forestry with most of it occurring in the riparian buffer zone along Indian Bayou and its tributaries or in the central and southern portions of the watershed. There are several large blocks of timber remaining and some silviculture occurring in the area.

As the southern part of the watershed is becoming more developed, it appears as though forested land is being cleared and replaced with houses. As this occurs, it is important from a water quality standpoint, to maintain the riparian buffer zones. The riparian buffer areas are areas adjacent to and including the banks of natural waterways that include sufficient vegetation to prevent sediment, chemicals, and organic matter from entering waterbodies and help stabilize banks. The land is also cleared for both extraction of fill material and depositing excavated soil from construction sites. The site pictured above (image 4) is a cleared area of forest where dump trucks were depositing material. The tree line in the back is the riparian buffer around Indian Bayou. No apparent measures had been taken at this site to prevent the bare soil from entering the bayou in the event of a rainfall event.

6.6 Hydromodification

Hydromodification did not appear to be a problem on Indian Bayou. The stream segments observed were in a natural meandering state and were undredged and unpaved. Two man-made canals are, however, present in the watershed and apparently used for irrigation or release of water from agricultural land. On May 15, 2003, no apparent flow was observed in either canal and one was completely dry.

7.0 POINT SOURCES OF POLLUTION

Image 5. A point source outfall into Little Indian Bayou

In addition to nonpoint sources, there are also 6 permitted point sources of discharge within Indian Bayou Watershed. These facilities were deemed either intermittent stormwater or minor discharges on unnamed tributaries and were represented in the nonpoint loading via benthic loads. These discharges are primarily treated sanitary wastewater, stormwater, and equipment washwater. An additional outfall from collected stormwater in a construction and demolition debris landfill was noticed on the May 15, 2003 surveillance trip that was contributing a considerable amount of sediment. The developers of the TMDL for Indian Bayou Watershed were not aware of the above discharge (image 5) and the permit status is being investigated.

These point sources discharge bacteria, sediment, organic materials, and nutrients, all of which can lead to decreased DO in the watershed. It is important that permits for these sites are enforced and that unpermitted discharges are reported. Citizens need to be made aware of the importance of maintaining water quality and informed of how to report suspicious discharges.

8. 0 BEST MANAGEMENT PRACTICES

Best management practices (BMPs) are “schedules of activities, prohibitions of practices, maintenance procedures and other management practices designed to prevent or reduce the pollution of the waters of the state, including treatment

requirements, operating procedures, and practices to control plant site runoff, spillage or leaks, sludge, or waste disposal, or drainage from raw material storage" (LDEQ 2003). BMPs are one of the most important methods for controlling nonpoint source pollution where runoff occurs from diffuse sources making regulations in the form of discharge permits unpractical.

Many entities have been involved in recommending the most effective and up-to-date BMP practices possible. These BMP practices are often the culmination of years of research and demonstrations conducted by agricultural research scientists and soil engineers (LSU Agricultural Center, 2000). A summary of the effectiveness of favorable BMPs is provided in Louisiana's Nonpoint Source Management Plan (LDEQ, 2000).

For Indian Bayou, BMPs need to be implemented to reduce manmade nonpoint pollution by 60% and increase the D.O. to levels that comply with the standards and allow it to support its designated uses. As previously indicated, reducing runoff from construction sites is a primary concern in Indian Bayou Watershed. Effective BMPs for construction activities include diversion dikes, vegetative buffer strips, seeding and mulching, hay bale dikes, silt fencing, vegetative cover, sediment basins, and sediment traps (http://nonpoint.deq.state.la.us/). LSU AgCenter has produced BMP manuals for agronomic crops, rice, poultry, sugar cane, dairy, sweet potato, swine, beef, and aquaculture which are available on their website (http://www.lsuagcenter.com/Subjects/bmp/index.asp). For all entities involved in silvicultural operations, the "Recommended Forestry Best Management Practices for Louisiana" manual has been and will continue to be an invaluable source of information and recommendations (Louisiana Department of Environmental Quality, 2000). Appendix 3 lists other BMP sources and their references.

Additionally, as technology advances, certain farming practices and BMPs may gradually become obsolete or replaced by other methods. For example, the recent development, through genetic engineering, of herbicide resistant rice may change the way that rice is produced in Louisiana (Williams et. al, 2002). If the practice of "mudding in" were no longer needed to control red rice, a significant decrease in the nonpoint source load would be expected. Also, a reduction in the quantity of water used would likely result.

9.0 ACTIONS TO BE IMPLEMENTED BY LDEQ

The LDEQ is presently designated the lead agency for implementation of the Louisiana Nonpoint Source Program. The LDEQ Nonpoint Source Unit provides USEPA §319(h) funds to assist in implementation of BMPs and to address water quality problems on subsegments listed on the §303(d) list. USEPA §319(h)

funds are utilized to sponsor cost sharing, monitoring, and education projects. These monies are available to all private, for profit, and nonprofit organizations that are authenticated legal entities, or governmental jurisdictions including: cities, counties, tribal entities, federal agencies, or agencies of the State. Presently, LDEQ is cooperating with such entities on approximately 60 nonpoint source projects that are active throughout the state.

10.0 ACTIONS TO BE IMPLEMENTED BY OTHER AGENCIES

The U.S. Department of Agriculture (USDA) and Natural Resource Conservation Service (NRCS) offer landowners financial, technical, and educational assistance to implement conservation practices and/or BMPs on privately owned land to reduce soil erosion, improve water quality, and enhance crop land, forest land, wetlands, grazing lands and wildlife habitat. The 2003 Farm Bill provides funding to various conservation programs for each state by way of the NRCS and local Soil and Water Conservation Districts (SWCD). The following includes a brief summary of the programs available through the local SWCD under the oversight of USDA and NRCS. The descriptions of the programs are general and are subject to change.

2003 Farm Bill Conservations Programs and Potential Funding Sources.
Environmental Quality Incentive Program (EQIP) provides 75% - 90% cost share for environmentally beneficial structural and management alterations, primarily 60% to livestock operations. Applications prioritized for benefits. Considered the "Working Lands" program.

Wildlife Habitat Incentive Program (WHIP) provides 75% - 90% cost share for the costs of wildlife habitat restoration and enhancement on private lands. Eligible to private property owners and lessees for installing riparian buffers, native pine & hardwoods, wildlife corridors, and other wildlife enhancing measures, 5 – 10 year contracts.

Wetland Reserve Program (WRP) is a voluntary program for wetland restoration, enhancement, and protection on private lands. WRP provides annual payments and restoration costs for 10 year, 30 year, or perpetual easements on prior converted wetlands. Louisiana leads the US in WRP participation. 2002 Farm Bill total funding allocation is 1.5 billion and expanded the program to purchase long-term easements and cost sharing to agriculture producers.

Conservation Reserve Program (CRP)
The 1985 Farm Bill established CRP as a voluntary program to protect highly erodible and environmentally sensitive lands. CRP places a positive value on

rural environment by improving soil, water, and wildlife, and extends a pilot sub-program called the Conservation Reserve Enhancement program

Conservation Security Program (CSP) is a new national incentive payment program for maintaining and increasing farm and ranch stewardship practices. The CSP is designed to correct a policy disincentive in which independently conducted resource stewardship has disqualified many farmers from receiving conservation program assistance. CSP features an optional "tiered" level of farmer participation where higher tiers receive greater funding for greater conservation practices.

Farmland Protection Program (FPP) provides funding to states, tribes, or local governments and to nonprofit organizations to help purchase development rights and protect farmlands with prime, unique, or productive soil; historical or archaeological significance; or farmlands threatened by urban sprawl. Louisiana does not currently have any FPP contracts.

Grassland Reserve Program (GRP) is a new program to enroll up to 2 million acres of virgin and improved pastureland. GRP easements would be divided 40/60 between agreements of 10, 15, or 20-years and agreements and easements for 30-years and permanent easements to restore grassland, rangeland, and pasture through annual rental payments.

Small Watershed Rehabilitation Program (SWRP) provides essential funding for the rehabilitation of aging small watershed impoundments and dams that have been constructed over the past 50 years.

In addition to the programs mentioned, the following organizations have signed an MOU with LDEQ within the state's NPS Management Plan that each will aid LDEQ in achieving the goals of the management plan:

Louisiana Department of Agriculture and Forestry
Louisiana Department of Health and Hospitals
Louisiana Department of Wildlife and Fisheries
Louisiana Department of Transportation and Development
Louisiana Department of Natural Resources
Louisiana State University Agricultural Center
Natural Resources Conservation Service
USDA – Farm Services Agency
Louisiana Forestry Association
US Fish and Wildlife Service
USDA Forest Service
US Army Corps of Engineers
US Geological Survey
Federal Emergency Management Agency
Louisiana Farm Bureau Federation

Master Farmer Program
The Master Farmer Program (developed by Louisiana State University Agricultural Center) is to encourage on-the-ground BMP implementation with a focus on environmental stewardship. The LSU AgCenter is promoting the Master Farmer Program to help farmers address environmental stewardship through voluntary, effective, and economically achievable BMPs. The program will be implemented through a multi-agency/organization partnership including the Louisiana Farm Bureau (LFBF), the Natural Resources Conservation Service (NRCS), the Louisiana Cooperative Extension Service (LCES), USDA-Agriculture Research Service (ARS), LDEQ, and agricultural producers.

The Master Farmer Program has three components: environmental stewardship, agricultural production, and farm management. The environmental stewardship component has three phases. Phase I focuses on environmental education and implementation of crop-specific BMPs. Phase II of the environmental component includes in-the-field viewing of implemented BMPs on Model Farms. Phase III involves the development and implementation of farm-specific, comprehensive conservation plans by the participants. A member must participate in all three phases in order to gain program status and receive the distinction of being considered a master farmer.

This program can help to initiate and distribute the use of BMPs throughout Indian Bayou Watershed. Participants will set an example for the rest of the agricultural community and will work closely with NRCS staff and other Master Farmers to identify potential problem areas in the watershed. They will receive information on new and innovative ways to reduce soil and nutrient loss from their fields. They will be kept informed of the water quality monitoring occurring in the watershed and alerted of any degradation or improvements.

Master Logger Program
The master logger program served as a model for development of the master farmer program, and has been very successful at educating foresters as to BMP implementation. This program was developed by the Louisiana Forestry Association, which is a private organization, along with the Louisiana Department of Agriculture and Forestry Office of Forestry.

11.0 CONSERVATION PRACTICES IN INDIAN BAYOU WATERSHED

Although information is not currently available for conservation treatments specifically in Indian Bayou Watershed, they are available for Calcasieu and Beauregard parishes which is where the watershed is located. It is reported that 18,746 acres in these two parishes were engaged in conservation treatments

through programs, such as EQIP, WHIP, CRP, and WRP, during fiscal year 2003 (NRCS PRMS Report). This includes total conservation buffers, erosion reduction, irrigation water management, nutrient management, pest management, prescribed grazing, residue management, tree and shrub establishment, and wildlife habitat.

12.0 PUBLIC PARTICIPATION OF STAKEHOLDERS

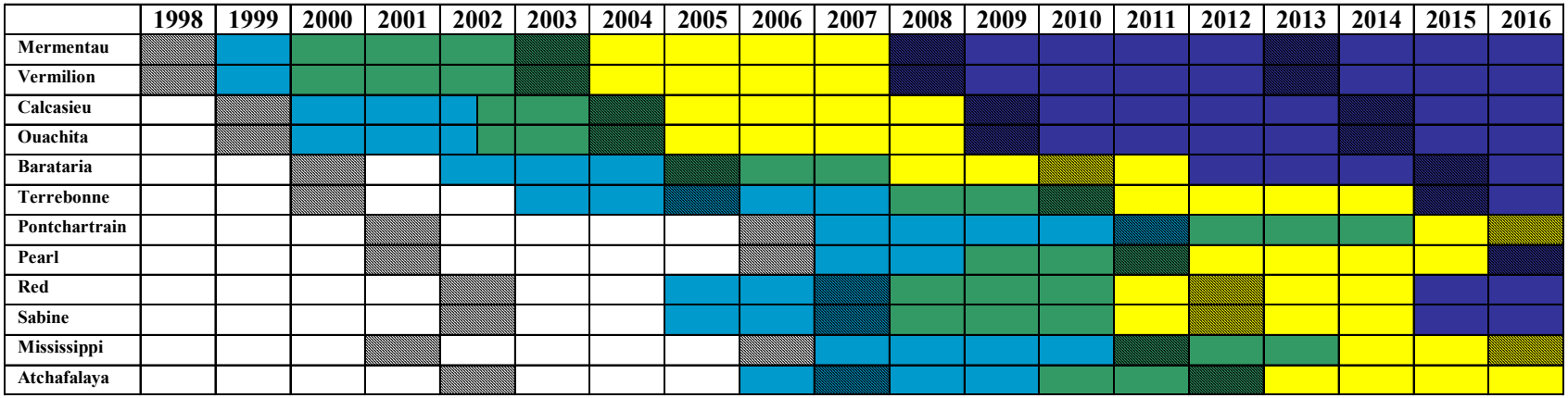
Presently, the only requirement for public participation is that there be a 30–day comment period after the TMDL is issued. Therefore, stakeholders are informed by mailed public notices and notices in newspapers. Ultimately, the public needs to be the most important part of the implementation of TMDLs, especially in the arena of nonpoint source pollution where there are few regulations. This is one of the areas where programs such as Master Farmer will be beneficial in getting information to landowners and farmers and building participation.

13.0 TMDL TIMELINE FOR THE NPS IMPLEMENTATION PLAN

The NPS Implementation Plan for Indian Bayou Watershed outlines a 5-year management plan to reduce NPS pollutants reaching the waterway. LDEQ intensively samples each watershed in the state once every 5 years to see if the waterbodies are meeting water quality standards. The 5-year cyclic sampling began during 1999 for the Calcasieu Basin, including Indian Bayou, and will occur again in 2004, 2009, and 2014 (Table 3). The data from 1999 will be used as a baseline to measure the rate of water quality improvement in samples taken in subsequent years. If no improvement in water quality is witnessed by the 2009 sampling, LDEQ will revise the NPS Implementation Plan to include additional corrective actions to bring the waterway into compliance. Additional BMPs and or other options will be employed, if necessary, until water quality standards are achieved and Indian Bayou is restored to its designated uses.

Table 3.

Revised Timeline for Watershed Planning and Implementation



1- Black Stripes = Collect Water Quality Data to Develop Total Maximum Daily Loads (TMDLs) and to Track Water Quality Improvement at the Watershed Level **[Objective 1**]
2- Light Blue = Develop Total Maximum Daily Loads for the Watersheds on the 303(d) List [**Objective 2]**
3- Green = Develop Watershed Management Plans to Implement the NPS Component of the TMDL **[Objective 3]**
4- Yellow = Implement the Watershed Management Plans **[Objectives 4-8]**
5- Dark Blue = Develop and Implement Additional Corrective Actions Necessary to Restore the Designated Uses to the Water Bodies **[Objective 9-10]**

14.0 TRACKING AND EVALUATION

As Stated in the Louisiana Nonpoint Management Plan, program tracking will be done at several levels to determine if the watershed approach is an effective method to reduce nonpoint source pollution and improve water quality:

1. Tracking of actions outlined with the Watershed Restoration Action Strategy (short-term)
2. Tracking of BMPs implemented as a result of Section 319, EQIP, or other sources of cost-share ant technical assistance within the watershed (short term);
3. Tracking progress in reducing nonpoint source pollutants, such as solids, nutrients, and organic carbon from the various land uses (rice, soybeans, crawfish farms) within the watershed (short-term);
4. Tracking water quality improvement in the bayou (i.e. decreases in total organic carbon, total dissolved oxygen) (short and long term)
5. Documenting results of the tracking to the Nonpoint Source Interagency Committee, residents within the watershed, and EPA (short and long term);
6. Submitting Semi-annual and annual reports to EPA which summarize results of the watershed restoration actions (short and long term)
7. Revising LDEQ's web-site to include information on the progress made in watershed restoration actions, nonpoint source pollutant load reductions, and water quality improvement in the bayou (short and long term).

15.0 REGULATORY AUTHORITY

Federal Authority

Section 319 of the Clean Water Act (PL 100-4, February 4, 1987) was enacted to specifically address problems attributed to nonpoint sources of pollution. Its objective is to restore and maintain the chemical, physical, and biological integrity of the Nation's waters (Sec. 101; PL 100-4), instructed the Governor of each State to prepare and submit a Nonpoint Source Management Program for reduction and control of pollution from nonpoint sources to navigable waters within the State by implementation of a four-year plan (submitted within 18 months of the day of enactment).

State Authority

In response to the federal law, the State of Louisiana passed Revised Statute 30:2011, signed by the Governor in 1987 as Act 272. Act 272 designated the Louisiana Department of Environmental Quality as the "Lead Agency" for development and implementation of the State's Nonpoint Source Management

Plan. The Louisiana Revised Statutes R.S. 30:2011.D (20) include the following provision as the authority for LDEQ to implement the State's NPS Program.

To develop and implement a non-point source management and ground water quality protection program and a conservation and management plan for estuaries, to receive federal funds for this purpose and provide matching state funds when required, and to comply with terms and conditions necessary to receive federal grants. The nonpoint source conservation and management plan, the groundwater protection plan, and the plan for estuaries shall be developed in coordination with, and with the concurrence of the appropriate state agencies, including but not limited to, the Department of Natural Resources, the Department of Wildlife and Fisheries, the Department of Agriculture and Forestry and the State Soil and Water Conservation Committee in those areas pertaining to their respective jurisdictions.

16.0 REFERENCES

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Appendix 1

Ambient water quality data. (http://www.deq.state.la.us/surveillance/wqdata/wqdata.aspx)
Indian Bayou at Moss Bluff, Louisiana

DATE	TIME	DEPTH meters	FIELD PH	WATER TEMP (C)	D.O. mg/l	FIELD COND. umhos	SECCHI DISK inches	SALIN-ITY ppt
12/01/99	0855	1.0	7.21	10.37	2.81	431.0	16.0	.2
11/23/99	0850	1.0	7.22	15.50	.08	446.0	8.0	.2
10/26/99	0945	1.0	7.42	12.78	6.12	422.0	10.0	.2
09/28/99	0925	1.0	7.24	22.29	.45	344.0	.	.1
08/24/99	0945	1.0	7.40	27.49	.91	276.0	12.0	.1
07/27/99	0910	1.0	6.81	27.43	2.91	146.0	8.0	.
06/22/99	0930	1.0	7.07	25.26	.65	225.0	10.0	.1
05/25/99	0925	1.0	7.30	23.01	.54	399.0	6.0	.1
04/28/99	0900	1.0	7.32	23.16	1.79	421.0	8.0	.2
03/23/99	0925	1.0	6.83	16.11	2.90	176.0	6.0	.
02/22/99	0940	1.0	6.94	10.89	4.81	221.0	12.0	.1
01/26/99	0850	1.0	7.00	12.50	3.53	259.0	16.0	.1

Indian Bayou at Moss Bluff, Louisiana

DATE	TIME	DEPTH meters	ARSENIC ug/l	CADMIUM ug/l	CHROMIUM ug/l	COPPER ug/l	MERCURY ug/l	LEAD ug/l	NICKEL ug/l
12/01/99	0855	1.0	.	.	.	.	.	.	.
11/23/99	0850	1.0	K 5.00	K .50	K 2.50	K 2.50	K .0500	K 5.00	K 5.00
10/26/99	0945	1.0	.	.	.	.	.	.	.
09/28/99	0925	1.0	.	.	.	.	.	.	.
08/24/99	0945	1.0	K 5.00	K .50	K 2.50	K 2.50	K .0500	K 5.00	K 5.00
07/27/99	0910	1.0	.	.	.	.	.	.	.
06/22/99	0930	1.0	.	.	.	.	.	.	.
05/25/99	0925	1.0	K 5.00	K .50	K 2.50	K 2.50	K .0500	K 5.00	K 5.00
04/28/99	0900	1.0	.	.	.	.	.	.	.
03/23/99	0925	1.0	.	.	.	.	.	.	.
02/22/99	0940	1.0	K 5.00	K .50	K 2.50	K 2.50	K .0500	K 5.00	K 5.00
01/26/99	0850	1.0	.	.	.	.	.	.	.

Indian Bayou at Moss Bluff, Louisiana

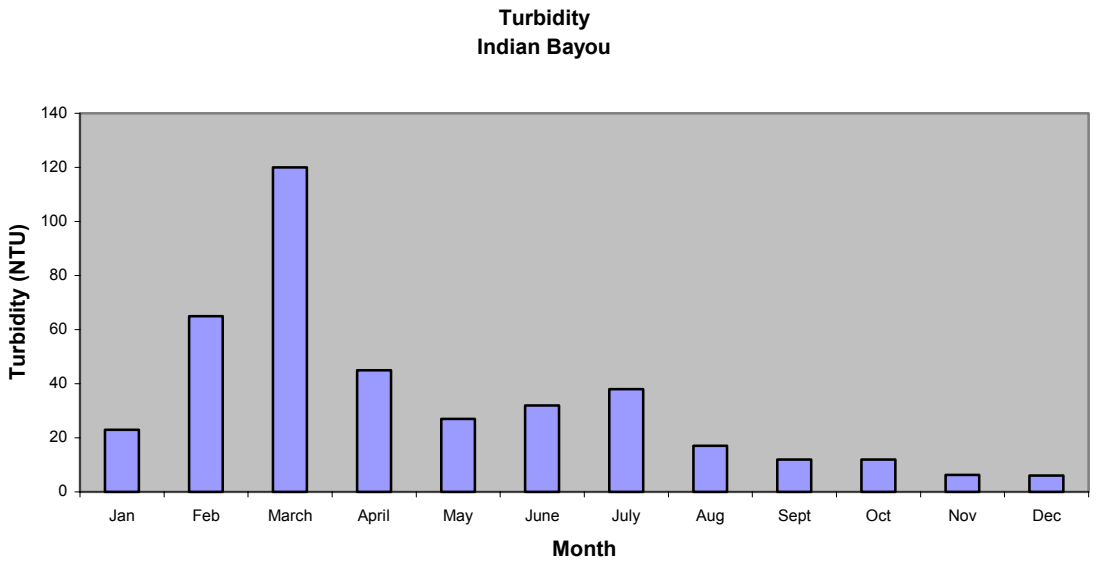
DATE	TIME	DEPTH meters	NO2+NO3 mg/l	T.K.N. mg/l	PHOS. TOTAL mg/l	T.O.C. mg/l
12/01/99	0855	1.0	K .020	.56	.33	8.20
11/23/99	0850	1.0	K .020	.35	.23	8.30
10/26/99	0945	1.0	.340	.45	K .05	12.70
09/28/99	0925	1.0	.070	.80	.30	4.20
08/24/99	0945	1.0	.040	1.32	.38	10.90
07/27/99	0910	1.0	.130	1.04	.30	9.67
06/22/99	0930	1.0	.090	.83	.28	10.20
05/25/99	0925	1.0	.110	1.55	.30	10.60
04/28/99	0900	1.0	.210	.59	.24	7.30
03/23/99	0925	1.0	.300	.93	.29	10.70
02/22/99	0940	1.0	.410	1.57	.29	12.20
01/26/99	0850	1.0	.330	1.08	.18	11.40

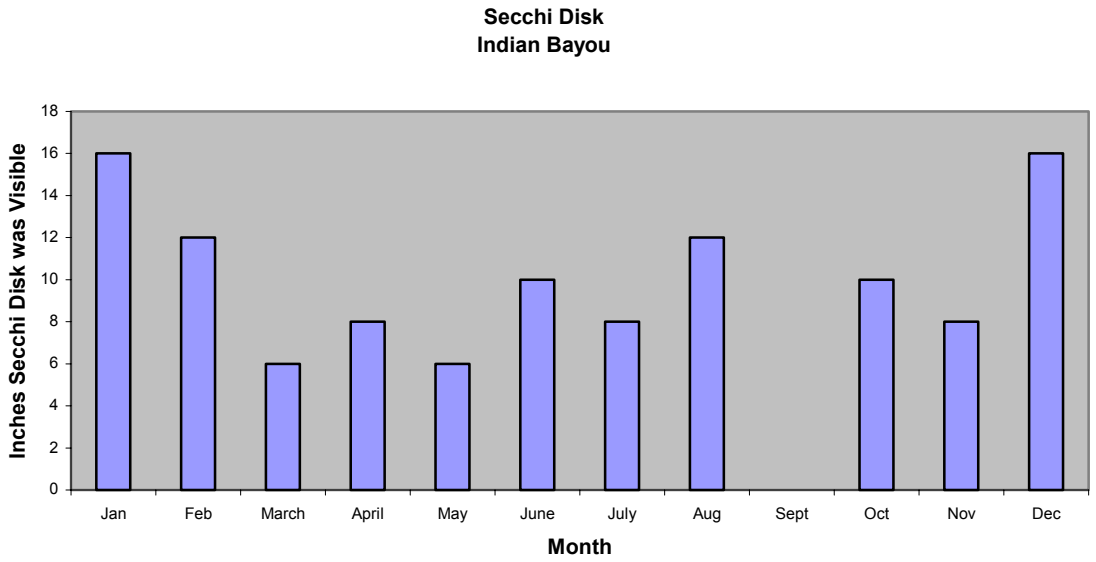
Indian Bayou at Moss Bluff, Louisiana

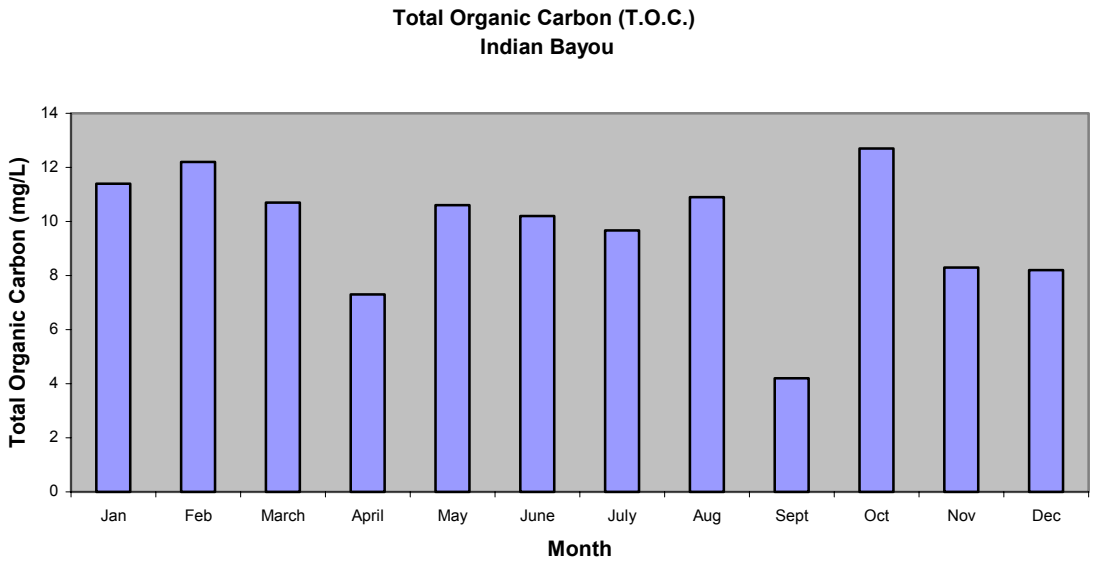
DATE	TIME	DEPTH meters	ALKA-LINITY mg/l	HARD-NESS mg/l	TURB-IDITY NTU	COLOR PT-CO units	CHLOR-IDES mg/l	SULFATE mg/l		T.S.S. mg/l	T.D.S. mg/l
12/01/99	0855	1.0	132.0	91.8	6.0	40.0	46.8	8.2		5.0	246.0
11/23/99	0850	1.0	129.0	91.2	6.3	45.0	49.8	10.0	K	4.0	278.0
10/26/99	0945	1.0	100.0	85.5	12.0	65.0	56.5	8.3		6.5	276.0
09/28/99	0925	1.0	101.0	76.0	12.0	40.0	39.1	6.0		8.0	192.0
08/24/99	0945	1.0	88.5	68.4	17.0	60.0	28.0	6.2		6.0	195.0
07/27/99	0910	1.0	37.5	38.8	38.0	90.0	20.4	3.2		11.0	154.0
06/22/99	0930	1.0	71.3	61.0	32.0	60.0	25.3	7.8	K	4.0	192.0
05/25/99	0925	1.0	113.0	93.7	27.0	50.0	54.8	27.0		12.0	273.9
04/28/99	0900	1.0	126.0	91.6	45.0	40.0	52.3	10.0		7.5	294.0
03/23/99	0925	1.0	49.7	49.4	120.0	50.0	18.8	7.2		19.0	264.0
02/22/99	0940	1.0	57.7	57.1	65.0	60.0	23.3	14.1		11.0	364.0
01/26/99	0850	1.0	77.5	67.0	23.0	50.0	29.3	12.1		6.5	212.0

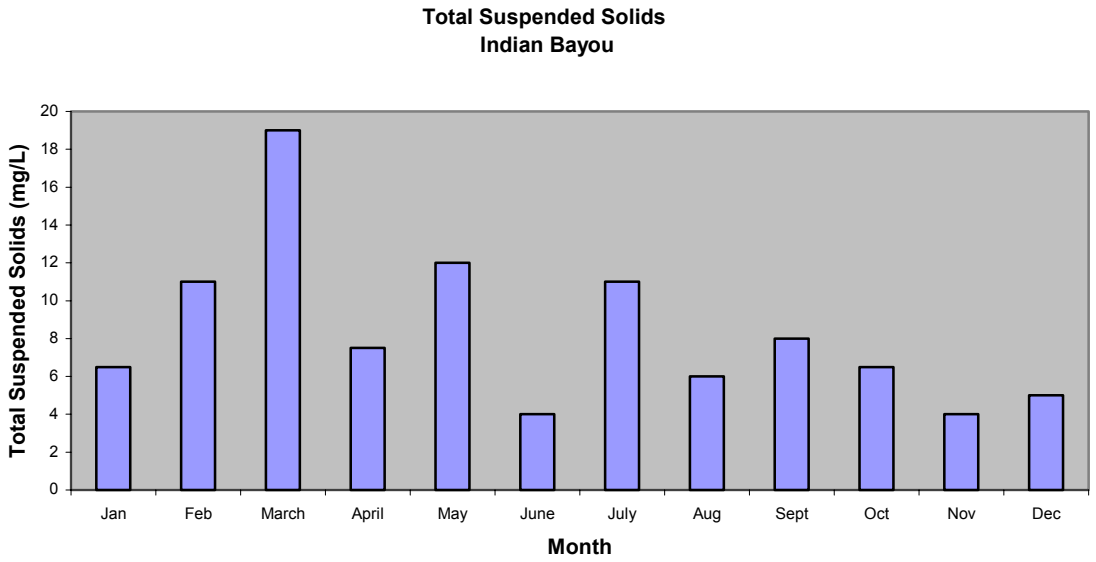
Indian Bayou at Moss Bluff, Louisiana

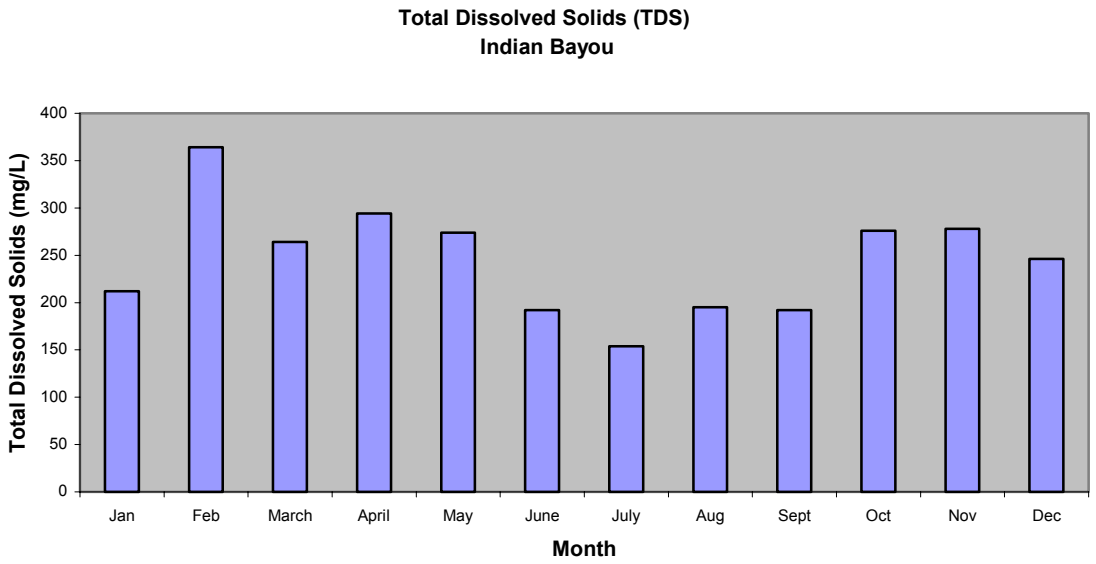
DATE	TIME	FECAL COLIFORM MPN/100ML	TOTAL COLIFORM MPN/100ML
12/01/99	0855	130	.
11/23/99	0850	300	.
10/26/99	0945	170	.
09/28/99	0925	80	.
08/24/99	0945	60	.
07/27/99	0910	80	.
06/22/99	0930	900	.
05/25/99	0925	300	.
04/28/99	0900	80	.
03/23/99	0925	240	.
02/23/99	0940	170	.
01/26/99	0850	170	.

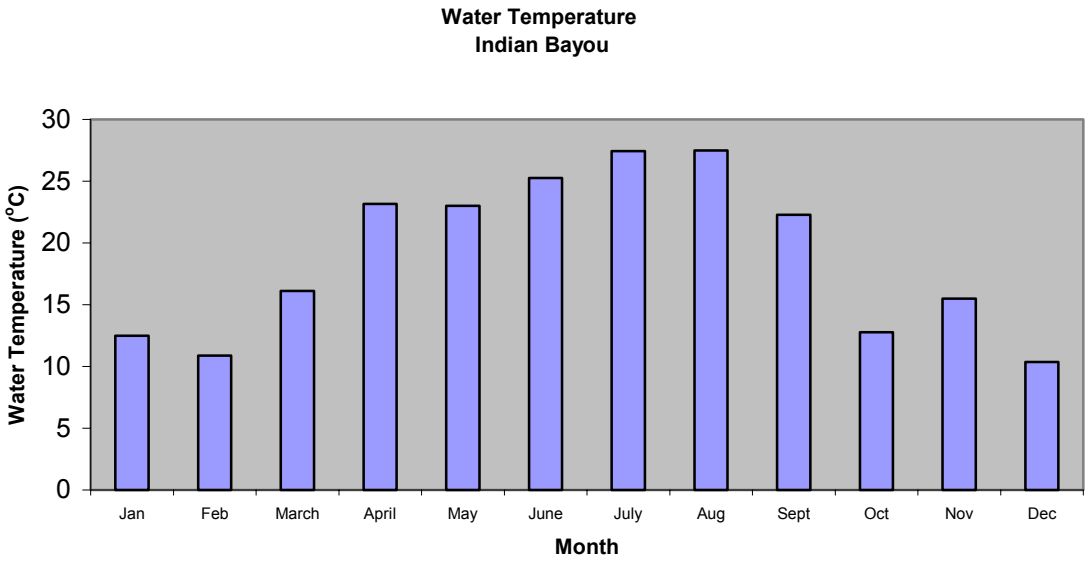

Turbidity
Indian Bayou
Turbidity (NTU)
140
120
100
80
60
40
20
0
Jan
Feb
March
April
May
June
July
Aug
Sept
Oct
Nov
Dec
Month

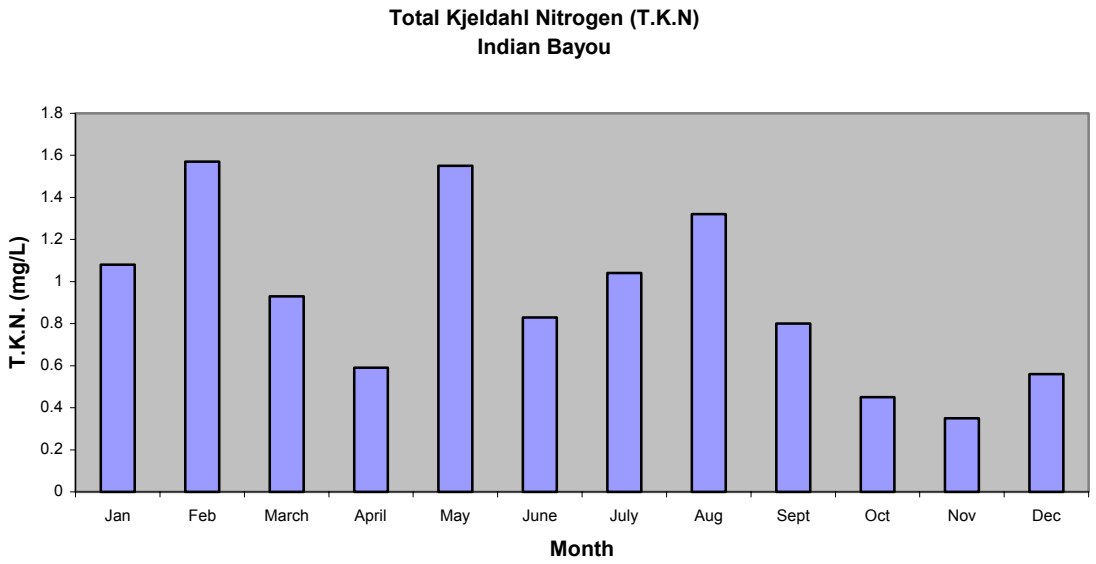

Secchi Disk
Indian Bayou
Inches Secchi Disk was Visible
18
16
14
12
10
8
6
4
2
0
Jan
Feb
March
April
May
June
July
Aug
Sept
Oct
Nov
Dec
Month

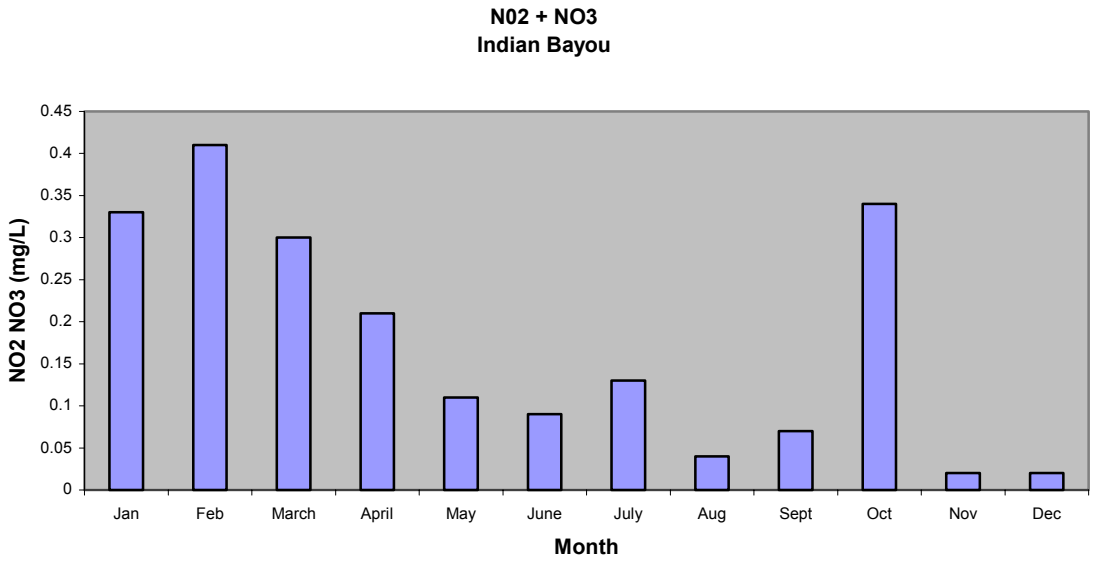

Total Organic Carbon (T.O.C.)
Indian Bayou
Total Organic Carbon (mg/L)
0
2
4
6
8
10
12
14
Jan
Feb
March
April
May
June
July
Aug
Sept
Oct
Nov
Dec
Month

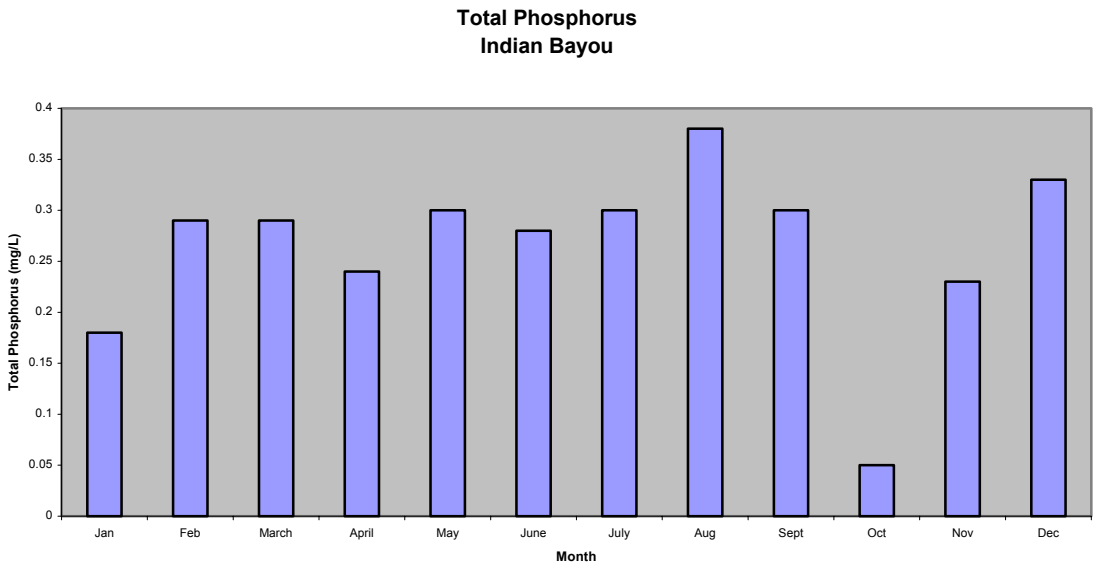

Total Suspended Solids
Indian Bayou
Total Suspended Solids (mg/L)
0
2
4
6
8
10
12
14
16
18
20
Jan
Feb
March
April
May
June
July
Aug
Sept
Oct
Nov
Dec
Month


Total Dissolved Solids (TDS)
Indian Bayou
Total Dissolved Solids (mg/L)
400
350
300
250
200
150
100
50
0
Jan
Feb
March
April
May
June
July
Aug
Sept
Oct
Nov
Dec
Month


Water Temperature
Indian Bayou
Water Temperature (°C)
30
25
20
15
10
5
0
Jan
Feb
March
April
May
June
July
Aug
Sept
Oct
Nov
Dec
Month

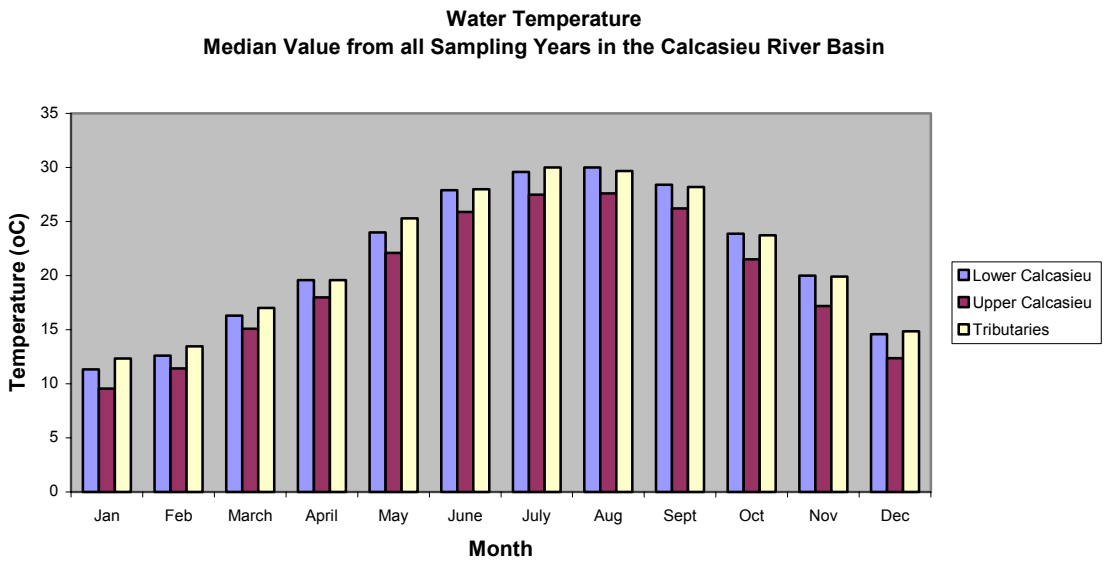

Total Kjeldahl Nitrogen (T.K.N)
Indian Bayou
T.K.N. (mg/L)
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Jan
Feb
March
April
May
June
July
Aug
Sept
Oct
Nov
Dec
Month

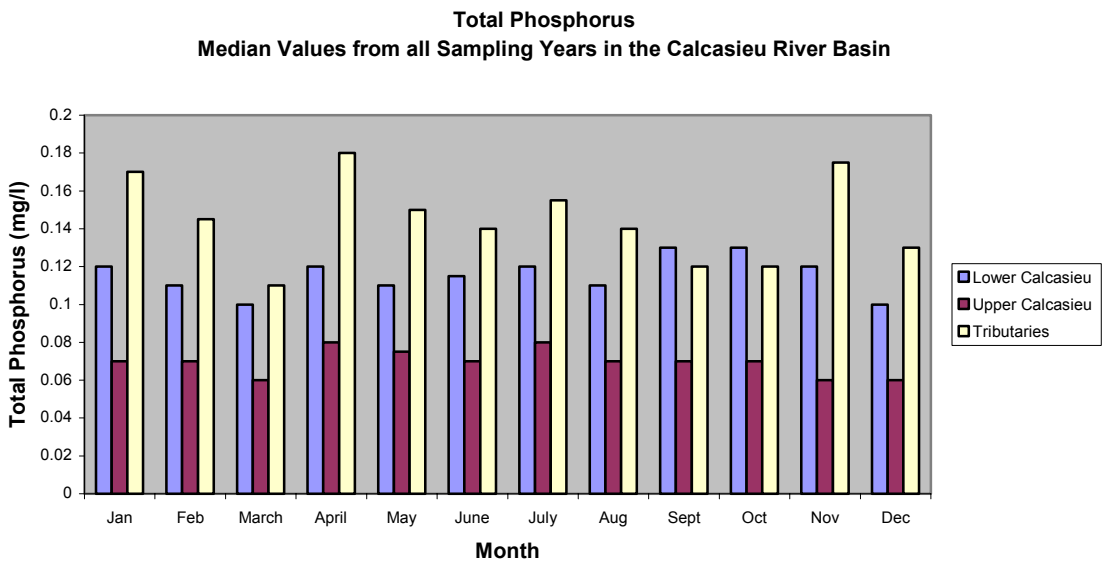

N02 + NO3
Indian Bayou
NO2 NO3 (mg/L)
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Jan
Feb
March
April
May
June
July
Aug
Sept
Oct
Nov
Dec
Month


Total Phosphorus
Indian Bayou
Total Phosphorus (mg/L)
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Jan
Feb
March
April
May
June
July
Aug
Sept
Oct
Nov
Dec
Month

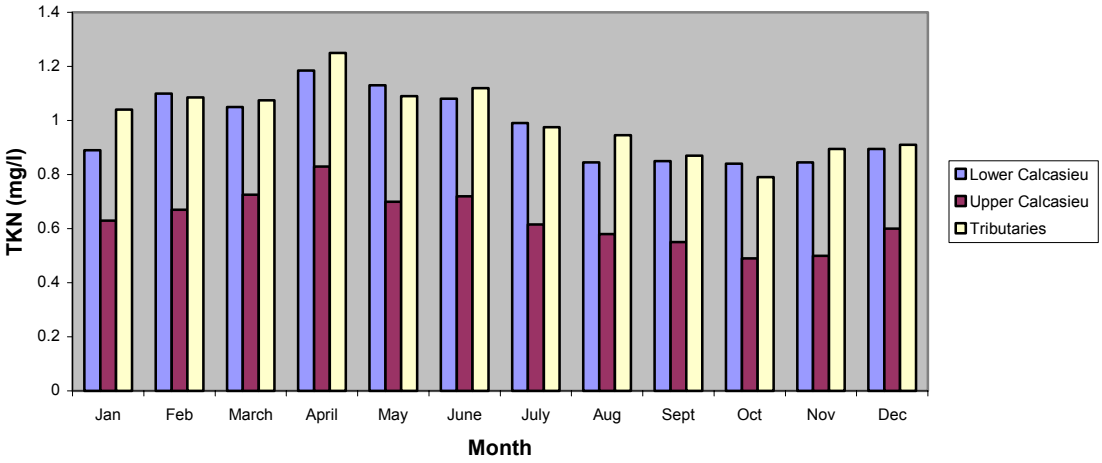
Appendix 2

Historic water quality data from the Calcasieu River Basin

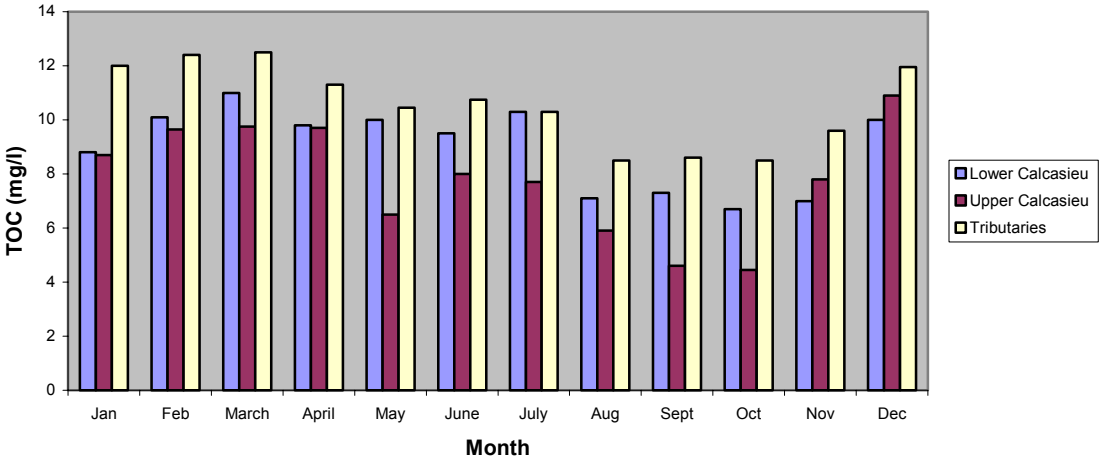




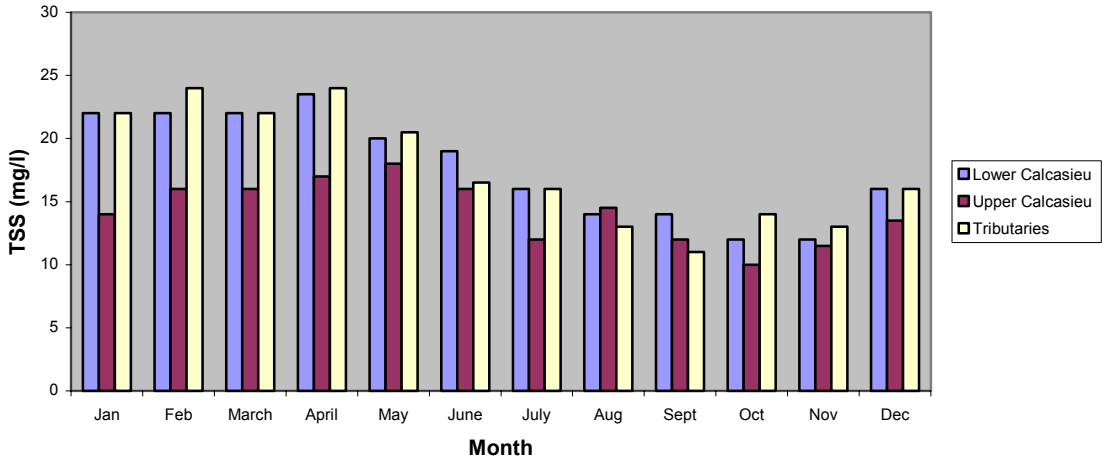
Total Kjeldahl Nitrogen (TKN)
Median Values from all Sampling Years in the Calcasieu River Basin



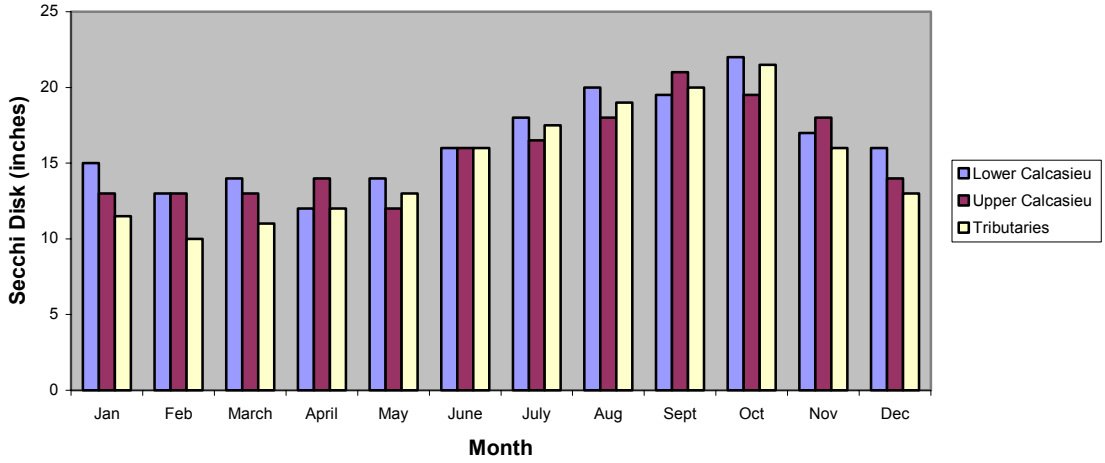
Total Organic Carbon (TOC)
Median Values from all Sampling Years in the Calcasieu River Basin



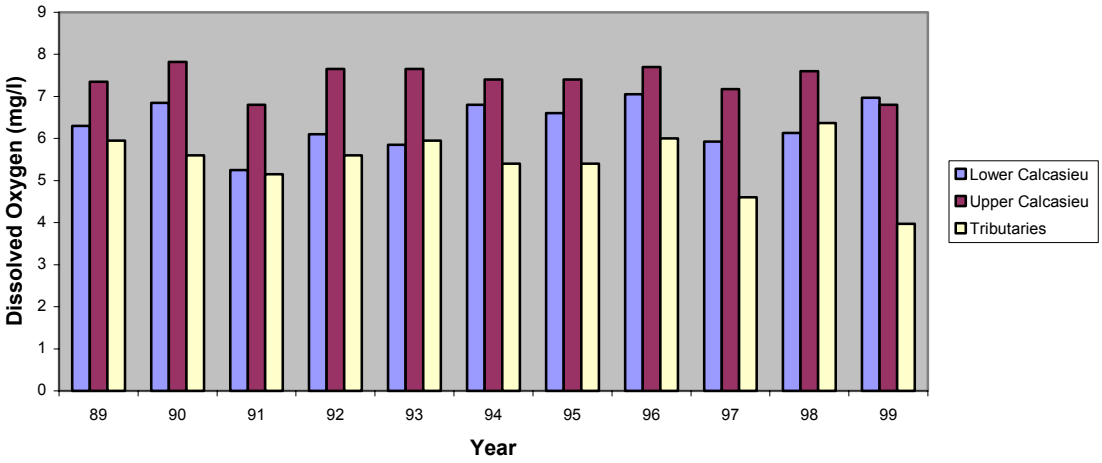
Total Suspended Solids (TSS)
Median Values from all Sampling Years in the Calcasieu River Basin



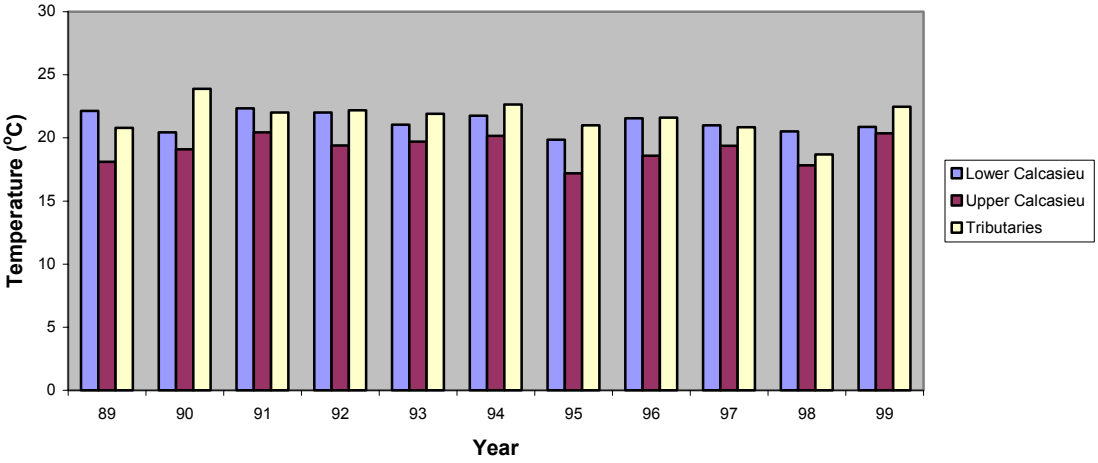
Secchi Disk
Median Value from all Sampling Years in the Calcasieu River Basin



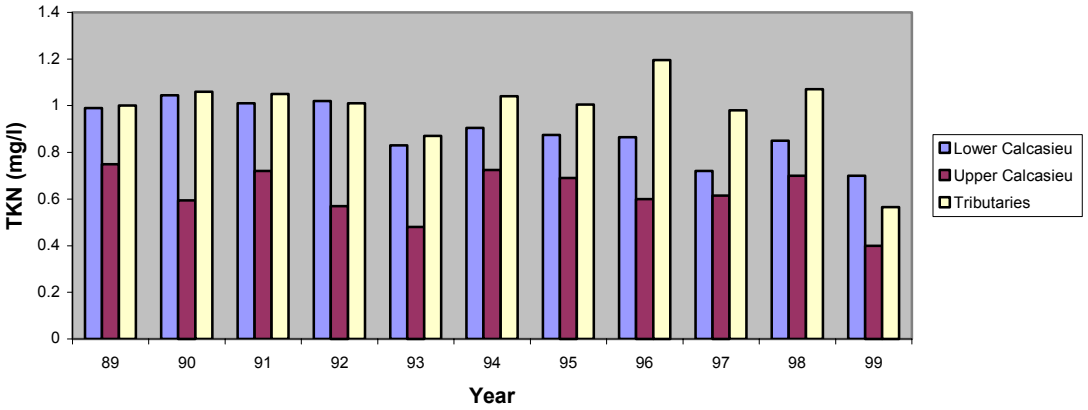
Dissolved Oxygen
Median Value from all Sampling Years in the Calcasieu River Basin



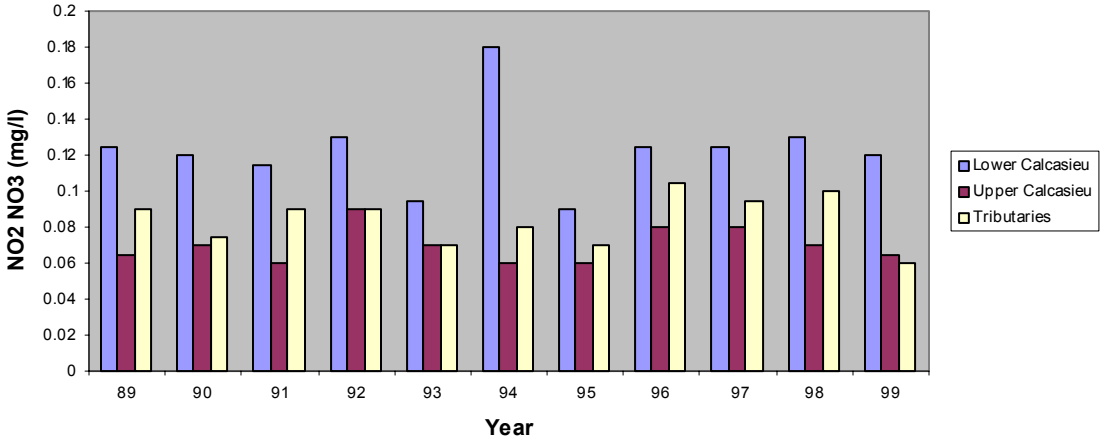
Water Temperature
Median Value from all Sampling Years in the Calcasieu River Basin



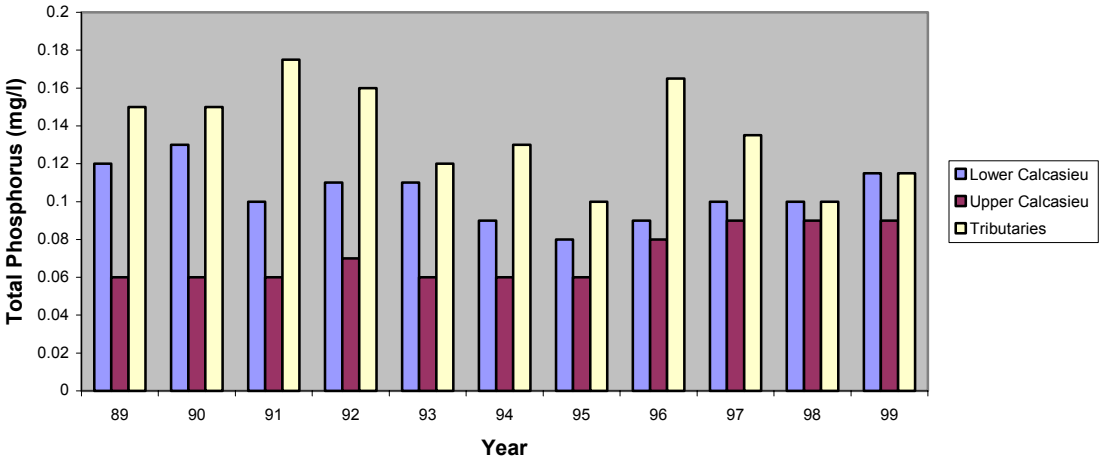
Total Kjeldahl Nitrogen (TKN)
Median Values from all Sampling Years in the Calcasieu River Basin



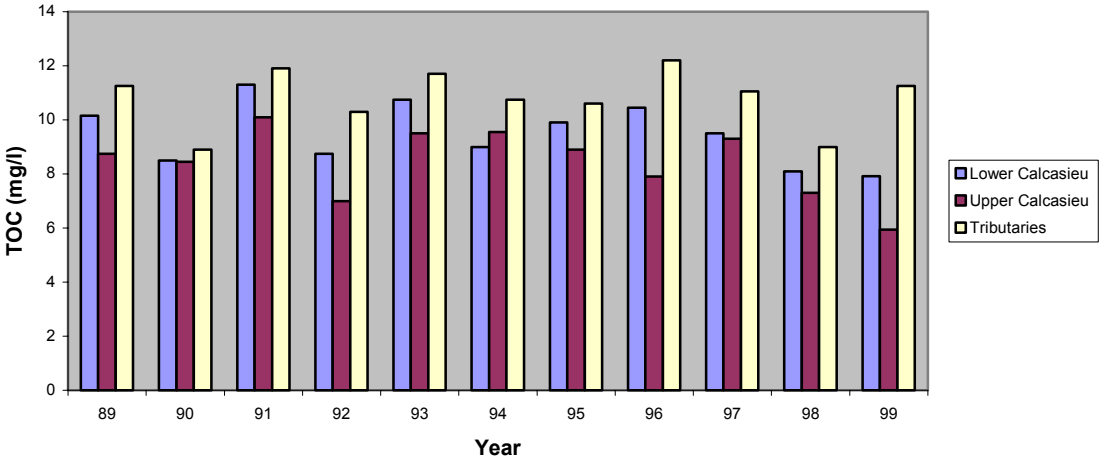
NO2 + NO3
Median from all Sampling Years in the Calcasieu River Basin



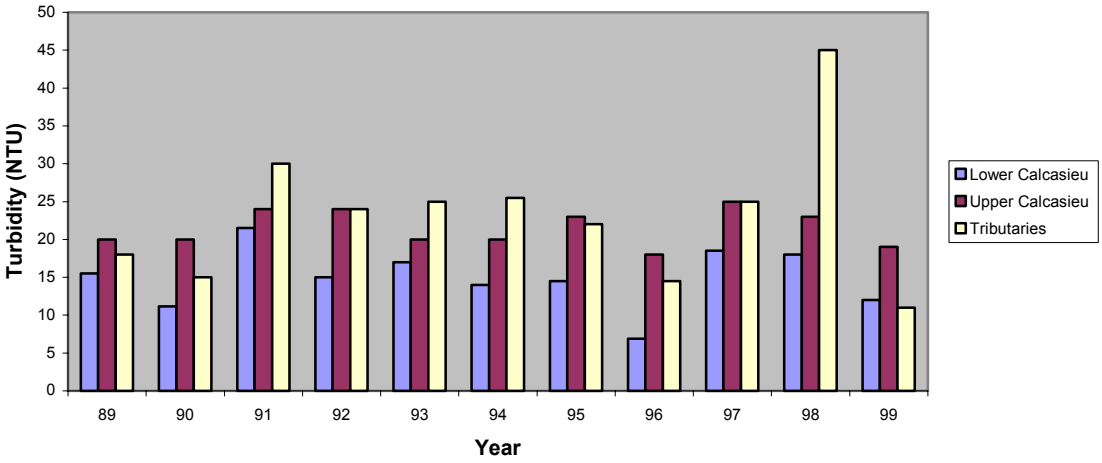
Total Phosphorus
Median Values from all Sampling Years in the Calcasieu River Basin



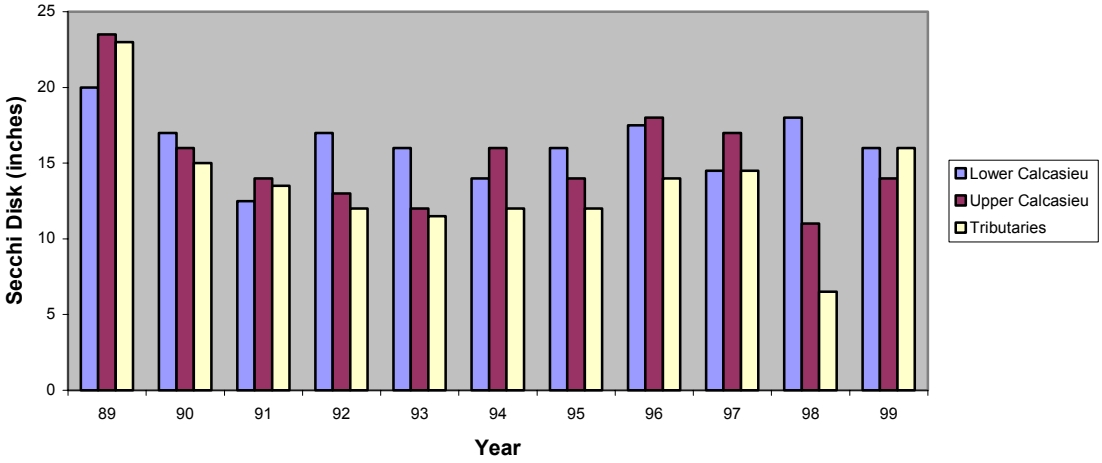
Total Organic Carbon (TOC)
Median Values from all Sampling Years in the Calcasieu River Basin



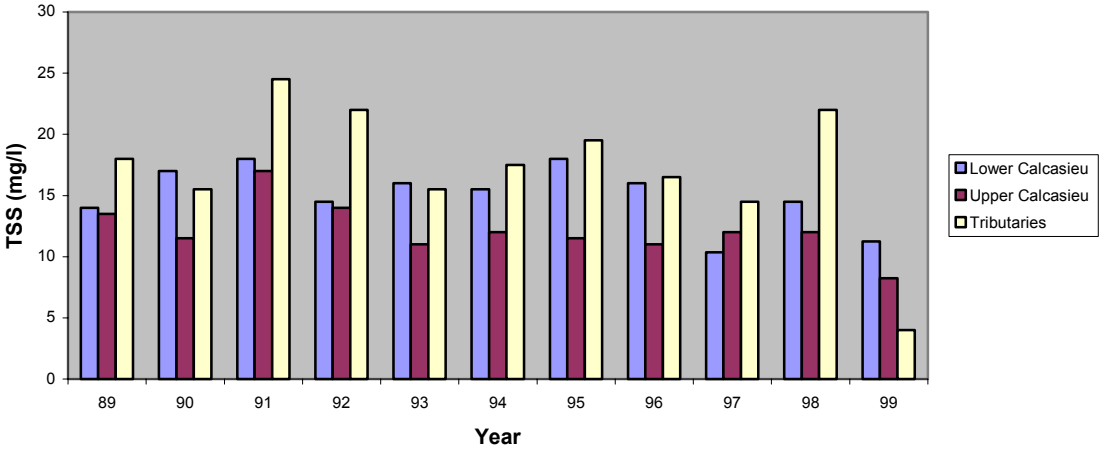
Turbidity
Median Values from all Sampling Years in the Calcasieu River Basin



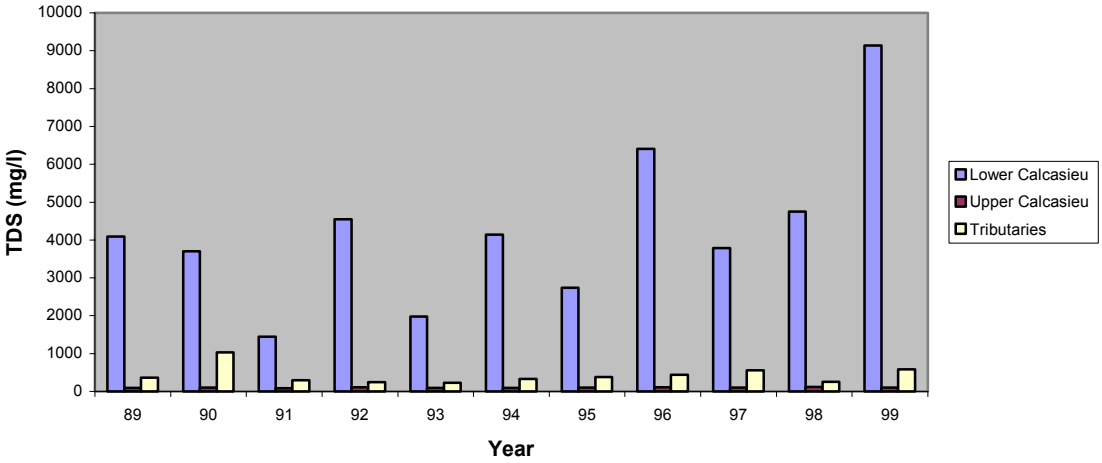
Secchi Disk
Median Value from all Sampling Years in the Calcasieu River Basin



Total Suspended Solids (TSS)
Median Values from all Sampling Years in the Calcasieu River Basin



Total Disolved Solids (TDS)
Median Values from all Sampling Years in the Calcasieu River Basin



Appendix 3

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